Sequential Ruthenium Catalysis for Olefin Isomerization and Oxidation: Application to the Synthesis of Unusual Amino Acids

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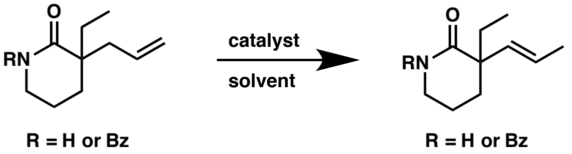
Materials and Methods

Unless otherwise stated, reactions were performed in flame-dried glassware under an argon or nitrogen atmosphere using dry, deoxygenated solvents. All commercially obtained reagents were used as received unless specified otherwise. Triethylamine was distilled from calcium hydride prior to use. Reaction temperatures were controlled using an IKAmag temperature modulator. Thin-layer chromatography (TLC) was conducted with E. Merck silica gel 60 F254 pre-coated plates (0.25 mm) and visualized using UV at 254 nm or potassium permanganate. TLC data include R_f and eluent. ICN silica gel (particle size 0.032-0.063 mm), SilliaFlash P60 Academic silica gel (0.040-0.063 mm), or Florisil (Aldrich) was used for flash column chromatography. All NMR spectra were recorded on Varian 400, 500 or 600 MHz spectrometers or on a Bruker 400 MHz spectrometer with a Prodigy broadband cryoprobe. ^{1}H NMR spectra are reported relative to the residual solvent peak (δ 7.26 ppm for $CDCl_3$ and 1.94 ppm for CD_3CN). Data for ^{1}H NMR spectra are reported as follows: chemical shift (δ ppm), multiplicity, coupling constant (Hz), and integration. ^{13}C NMR spectra are reported relative to the residual solvent peak (δ 77.0 ppm for $CDCl_3$ and 1.32 ppm for CD_3CN). Multiplicities are reported as follows: s = singlet, d = doublet, t = triplet, q = quartet, p = pentet, m = multiplet, br = broad, app = apparent. IR spectra were recorded on a Perkin Elmer Spectrum BXII spectrometer and are reported in frequency of absorption (cm^{-1}). High resolution mass spectra (HRMS) were acquired with an Agilent 6200 Series TOF with Agilent G1978A Multimode source in mixed ionization mode (MM: ESI/APCI) or with a JEOL JMS-600H double-focusing magnetic sector mass spectrometer by fast atom bombardment (FAB) in the positive ion mode using thioglycerol as FAB matrix. The FAB$^+$-MS was externally calibrated with PEG polymer in the Voltage scan mode. A drop of sample (kept in vial) was added to the probe tip and analyzed immediately. Melting points were determined on a Thomas-Hoover melting point apparatus and are uncorrected.

Catalyst Screening and Optimization

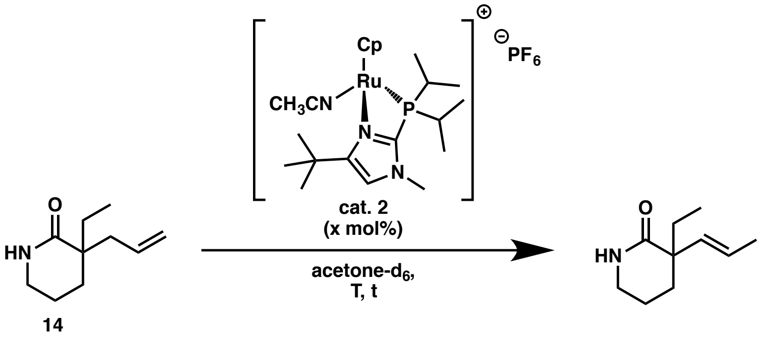
Screening of different transition metal catalysts for reactivity in olefin isomerization of our substrates:



Entry	R =	Catalyst	Loading [mol%]	Solvent	T [° C]	t [h]	M [mol/L]	Conv. [%]	Remarks
1	Bz	$Ir(PCy)_3XBPh_4$ [a]	6	CH_2Cl_2 / acetone	20	14	0.05	–	full conv. for reference substrate[b]
2	Bz	$Rh(cod)_2BF_4$ / PPh_3 [c]	5	dioxane	70	17	0.35	–	
3	H	$Pd(CH_3CN)_2Cl_2$ [d]	2 x 5	benzene / MeCN	75	15	0.28	–	2 cycles
4	Bz	$Pd(CH_3CN)_2Cl_2$ [d]	2 x 5	benzene / MeCN	75	15	0.25	78	2 cycles
5	Bz	$RhCl_3•3H_2O$ [e]	10	EtOH	78	16	0.10	100[f]	complete deprotection of Bz
6	H	$RhCl_3•3H_2O$ [e]	20	EtOH	78	2	0.62	93	77% yield, not reproducible
7	Bz	$RuCl_2(PPh_3)_3$ [g]	5	DIPEA/toluene	110	16	0.10	61	8 equivalents of DIPEA
8	Bz	$RuCl_2(PPh_3)_3$ [g]	5	toluene	110	16	0.10	13	
9	H	Grubbs 2nd **1a**	10	MeOH	60	12	0.08	97[h]	81% yield
10	Bz	Grubbs 2nd **1a**	10	MeOH	60	12	0.08	96[h]	complete deprotection, 70% yield
11	Bz	Grubbs 2nd **1a**, VTMS[i]	5	toluene	110	15	0.02	86	10 equiv silane, quant. yield[j]
12	Bz	Grotjahn's catalyst **2**	10	acetone-d_6	70	13	0.20	86	79% yield

[a] X = solvent or substrate; procedure adapted from: Nelson, S. G.; Bungard, C. J.; Wang, K. *J. Am. Chem. Soc.* **2003**, *125*, 13000. [b] Full conversion was observed for the reference substrate *tert*-butyl(hept-6-en-1-yloxy)-dimethylsilane, which was run in parallel to ensure proper manipulation of the air sensitive iridium catalyst. [c] Procedure adapted from: Takemiya, A.; Liu, Z.; Hartwig, J. F. *U.S. Pat. Appl. Publ.* **2009**, US 20090156824. [d] Procedure adapted from: Hong, A. Y.; Krout, M. R.; Jensen, T.; Bennett, N. B.; Harned, A. M.; Stoltz, B. M. *Angew. Chem. Int. Ed.* **2011**, *50*, 2756. [e] Procedure adapted from: Thoma, G.; Curran, D. P.; Geib, S. V.; Giese, B.; Damm, W.; Wetterich, F. *J. Am. Chem. Soc.* **1993**, *115*, 8585. [f] The calculated conversion for isomerization for R = H is 64% conv. [g] Procedure adapted from: Warrington, J. M; Barriault L. Org. Lett 2005, 7, 4589. [h] Competing alkene reduction was observed. [i] Vinyloxytrimethylsilane. [j] Inseparable mixture of isomerized product and starting material. Thus, the calculated yield for the internal alkene is 86%.

Optimization of the catalyst loading for Grotjahn's catalyst 2:

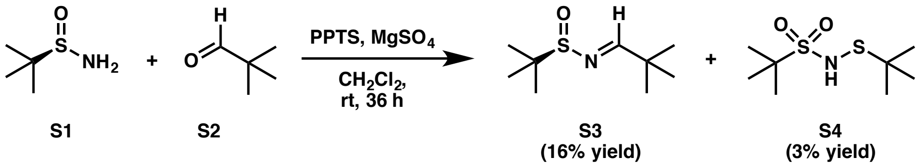


Entry[a]	Cat. 2 (mol%)	T (°C)	Conv.[b] t = 23 h	Conv.[b] t = 63 h
1	10	70	97%	95%
2	5	70	97%	95%
3	2	70	96%	95%
4	1	70	82%	89%
5	5	23	18%	37%

[a] 0.66 M in acetone-d_6. [b] Determined by ^{1}H-NMR.

Preparative Procedures

Synthesis of allyl sulfonamide 3:



Imine S3. To a solution of (*R*)-(+)-2-methyl-2-propanesulfinamide (**S1**) (1.02 g, 8.42 mmol, 1.0 equiv) in CH_2Cl_2 (14 mL) was added at rt pyridinium *p*-toluenesulfonate (106 mg, 0.42 mmol, 5 mol%), anhydrous magnesium sulfate (5.01 g, 42.1 mmol, 5.0 equiv) and pivalaldehyde (**S2**) (1.83 mL, 16.8 mmol, 2.0 equiv). After stirring for 2 d at rt, the suspension was filtered over Celite (the filter cake was washed thoroughly with CH_2Cl_2) and the solvent was removed under reduced pressure. Since a lot of unreacted starting material (sulfinamide) was observed by TLC, the crude product was resubmitted to the same reaction conditions (with 6 equivalents of pivalaldehyde) for 2 days. The reaction mixture was filtered over Celite and the solvent removed under reduced pressure. The residue was purified by column chromatography (hexane/Et_2O, 6:1 → 4:1 → 2:1) to afford imine **S3** (258 mg, 16%) as a colorless oil.[1] $R_f = 0.35$ (hexane/Et_2O, 4:1).[2]

Moreover, a mixed fraction was isolated as a suspension, which was diluted with an excess of hexanes. The precipitate was filtered off to give known sulfinylamide **S4** as a colorless solid (53.3 mg, 3%). X-ray quality crystals of sulfinylamide **S4** were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the side product in EtOAc.[3] $R_f = 0.24$ (hexane/Et_2O, 4:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.29 (s, 1H), 1.42 (s, 9H), 1.31 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 61.2, 48.6, 28.1, 24.7; IR (NaCl): 3233, 2960, 1456, 1363, 1297, 1180, 1123, 888, 810, 785, 659 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_8H_{19}NO_2S_2$ $[M]^{+\cdot}$: 225.0857, found 225.0850; mp 166-167 °C.[3]

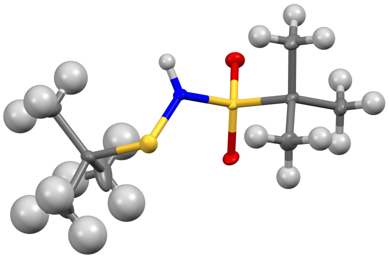
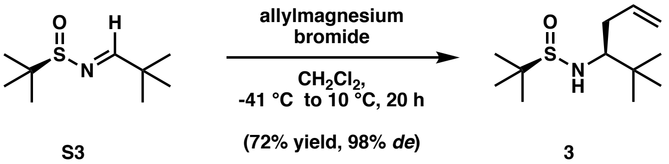


Figure 1: X-ray structure of side product **S4** (ellipsoids, 50% probability level).[3]



Sulfinamide 3. To a solution of **S3**[2] (250 mg, 1.32 mmol, 1.0 equiv) in CH_2Cl_2 (8.3 mL) was added dropwise at -41 °C (acetonitrile/CO_2 bath) allylmagnesium bromide (2.64 mL, 2.64 mmol, 2.0 equiv, 1.0 M solution in Et_2O). After stirring for 5 h at -41 °C, the reaction mixture was allowed to warm slowly to 10 °C in the cooling bath (Dewar) and was then quenched with sat. NH_4Cl (10 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2 x 25 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 4:1 → 2:1 → 1:1) to give **3** (221 mg, 72%, *dr* 99:1, 98% *de*, single diastereoisomer[4]) as a light yellow, crystalline solid. X-ray quality crystals sublimed at rt above a $CDCl_3$/CH_2Cl_2 solution of the product by slow evaporation of the solvents (colorless needles). R_f = 0.53 (hexane/EtOAc, 1:1); ^1H NMR (500 MHz, $CDCl_3$): δ 5.92 (dddd, *J* = 16.7, 10.1, 7.8, 6.4 Hz, 1H), 5.21-5.03 (m, 2H), 3.16 (d, *J* = 6.3 Hz, 1H), 3.02 (ddd, *J* = 9.2, 6.2, 4.0 Hz, 1H), 2.54 (m_c, 1H), 2.11 (m_c, 1H), 1.22 (s, 9H), 0.90 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 136.1, 118.0, 63.4, 56.3, 36.2, 35.6, 26.8, 22.9; IR (NaCl): 3226, 3077, 2952, 2908, 2868, 1639, 1471, 1390, 1365, 1284, 1241, 1179, 1139, 1076, 1047, 1022, 993, 904, 824, 755, 637 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for

$C_{12}H_{25}NOS$ [M+H]$^+$: 232.1730, found 232.1722; $[\alpha]^{25}_{D}$ −91.6° (*c* 1.03, $CHCl_3$); mp 78-80 °C. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525613.

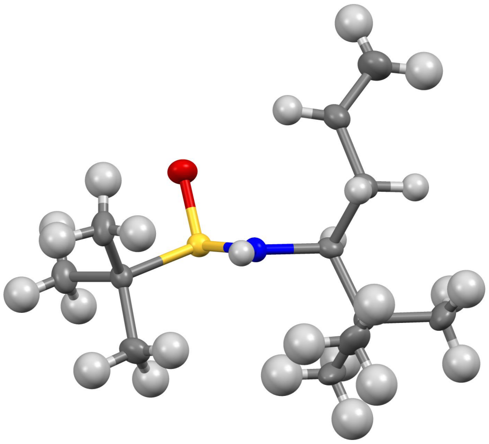


Figure 2: X-ray structure of **3** (ellipsoids, 50% probability level).

A few colorless crystals with different morphology were isolated at the bottom of the flask, which were identified as *tert*-butyl sulfonamide (**S5**) (impurity). The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525610.

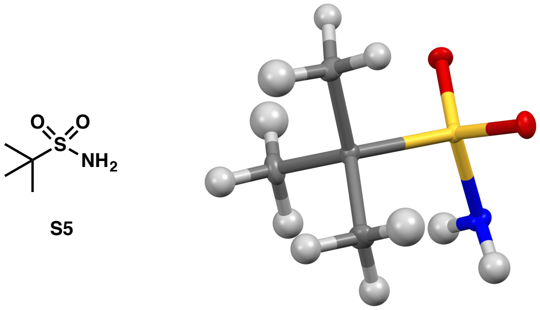
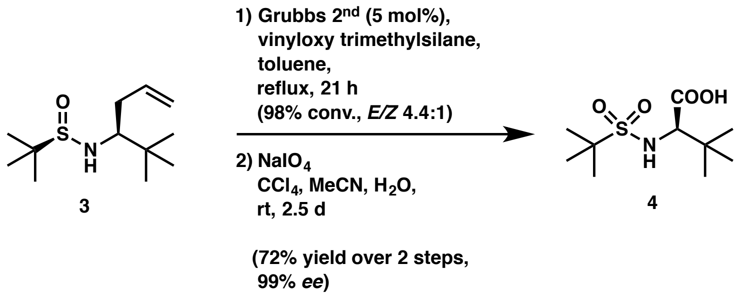


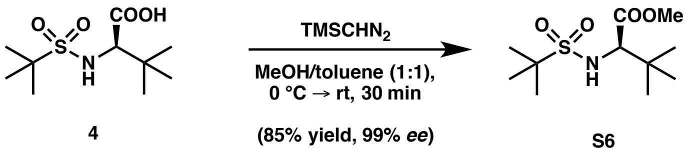
Figure 3: X-ray structure of **S5** (ellipsoids, 50% probability level).



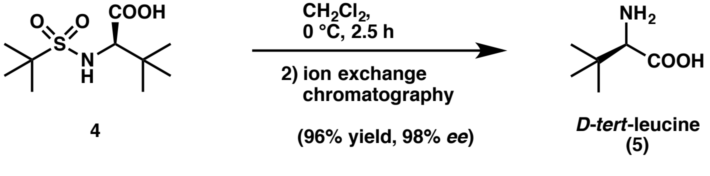
Carboxylic acid 4. To a solution of **3** (103 mg, 0.45 mmol, 1.0 equiv) and vinyloxytrimethylsilane (0.66 mL, 4.45 mmol, 10 equiv) in toluene (23.6 mL) was added at rt Grubbs 2nd generation catalyst **1a** (18.9 mg, 5 mol%). The purple reaction mixture was immersed in an oil bath (129 °C) (color changed to yellow) and refluxed for 21 h. The reaction mixture was then concentrated under reduced pressure to afford the disubstituted alkene[5] (126 mg, 98% conv., *E*/*Z* = 4.4:1) as a dark brown oil, which was used in the next step without further purification.

To a biphasic, brown solution of the crude alkene (126 mg, crude, calcd. 103 mg, 0.45 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (1.6 mL), acetonitrile (1.6 mL) and water (2.5 mL) was added at rt $NaIO_4$ (476 mg, 2.23 mmol, 5.0 equiv). After vigorous stirring for 2 days at rt, the olefin was fully cleaved, but the sulfinylamide was only partially oxidized according to LC-MS. For this reason, more $NaIO_4$ (286 mg, 1.34 mmol, 3.0 equiv) was added at rt and stirring was continued for 12 h. After oxidation was completed according to LC-MS, the reaction mixture was diluted with sat. NaH_2PO_4 (25 mL) and CH_2Cl_2 (30 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (4 x 30 mL). The combined organic extracts were washed with a 1:1 mixture of sat. $Na_2S_2O_3$ (10 mL)/sat. NaH_2PO_4 (10 mL) (some water was added to keep the aqueous layer on top of the organic). The aqueous layer was back extracted once with CH_2Cl_2 (30 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue (129 mg, dark brown oil, soluble in the eluent) was purified by column chromatography (CH_2Cl_2/MeOH/0.5% AcOH, 98:2 → 95:5) to afford carboxylic acid **4** (80.2 mg, 72% over 2 steps, 99% *ee*) as a light purple gummy solid. R_f = 0.30 (CH_2Cl_2/MeOH/0.5% AcOH, 95:5); ^{1}H NMR (500 MHz, CD_3OD): δ 3.70 (s, 1H), 1.35 (s, 9H), 1.04 (s, 9H); ^{13}C NMR (126 MHz, CD_3OD): δ 174.6, 67.3, 61.0, 35.5, 27.3, 24.6; IR (NaCl): 3271br, 2973, 2876, 1725, 1480, 1398, 1370, 1316, 1214, 1170, 1132, 1105, 1032, 918, 689 cm^{-1}; HRMS (MM: ESI-APCI–) m/z calc'd for $C_{10}H_{21}NO_4S$ $[M-H]^-$: 250.1119, found 250.1119; $[\alpha]^{25}_D$ −1.5° (*c* 1.542, MeOH).

HPLC derivatization of Bus protected *D*-tert-leucine 4:



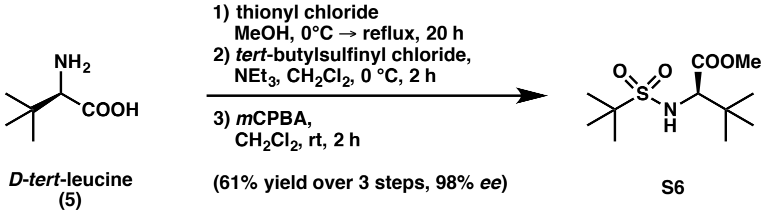
Ester S6. To a solution of **4** (5.0 mg, 19.9 μmol, 1.0 equiv) in a 1:1 mixture of toluene (0.1 mL) and MeOH (0.1 mL) was added at 0 °C TMS diazomethane (30 μL, 59.7 μmol, 3.0 equiv). After stirring 30 min at rt, the yellow reaction mixture was quenched with a few drops of a 10:1 mixture of MeOH/AcOH until the solution discolored. The reaction mixture was concentrated under reduced pressure and filtered over a plug of silica in a Pasteur pipette (eluting with hexane/EtOAc, 1:1) to afford **S6** (4.5 mg, 85%, 99% *ee*) as a colorless, crystalline solid. The analytical data were identical to those reported below (*vide infra*). R_f = 0.71 (hexane/EtOAc, 1:1).



***D-tert*-leucine (5).** To a solution of **4** (54.0 mg, 0.21 mmol, 1.0 equiv) in CH_2Cl_2 (6.0 mL) was added dropwise at 0 °C a solution of TfOH (0.19 mL, 2.15 mmol, 10 equiv). After stirring for

2.5 h at that temperature, the triflate salt of the amino acid had precipitated as an oil at the bottom of the solution. Water (3 mL) was then added and the organic solvent was removed under reduced pressure at rt. The crude aqueous amino acid solution was purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH, which was cooled to 0 °C in an ice bath prior to use; staining with ninhydrin or $KMnO_4$) to afford, after lyophilization and filtration over cotton, *D-tert*-leucine (**5**) (27.1 mg, 96%, 98% *ee*) as a colorless solid. $R_f = 0.58$ (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1); ^1H NMR (500 MHz, D_2O): δ 3.41 (s, 1H), 1.04 (s, 9H); ^{13}C NMR (126 MHz, D_2O): δ 173.5, 63.9, 31.8, 25.8; IR (KBr): 2966br, 2620, 2065, 1603br, 1533br, 1481, 1395, 1371, 1293, 1253, 1229, 1205, 1138, 1122, 1057, 1028, 1011, 939, 925, 881, 812, 727, 662 cm^{-1}; HRMS (MM: ESI-APCI–) m/z calc'd for $C_6H_{13}NO_2$ $[M-H]^-$: 130.0874, found 130.0873; $[\alpha]^{25}_D$ +5.7° (*c* 1.36, H_2O, 98% *ee*);[6] mp 254-255 °C (sublimation). Lit. $[\alpha]^{20}_D$ +8.9° (*c* 5.0, H_2O);[7] $[\alpha]^{21}_D$ +10.5° (*c* 1.0, H_2O);[8] $[\alpha]^{20}_D$ +9.2° (*c* 1.0, H_2O);[9] mp 250-252 °C (sublimation).[8]

HPLC derivatization of *D*-tert-leucine (5):



Ester S6. To a microwave vial charged with a solution of *D-tert*-leucine (**5**) (22.3 mg, 0.17 mmol, 1.0 equiv) in MeOH (0.70 mL) was added at 0 °C thionyl chloride (62 µL, 0.85 mmol, 5.0 equiv). After stirring for 20 h at 80 °C, the reaction mixture was concentrated under reduced pressure. EtOAc was added to the residue and the solvent was removed under reduced pressure to afford a mixture of *D*-*tert*-leucine methylester hydrochloride and *D*-*tert*-leucine hydrochloride (69% conv.) as colorless crystals.

To a suspension of the crude ester in CH_2Cl_2 (2.1 mL) was added at 0 °C triethylamine (0.24 mL, 1.75 mmol, 10 equiv) followed by *tert*-butylsulfinyl chloride (63 µL, 0.51 mmol, 3.0 equiv). After stirring for 2 h at 0 °C, the reaction mixture was quenched with sat. $NaHCO_3$ (3 mL) and extracted with CH_2Cl_2 (5 x 3 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was then purified by column chromatography (hexane/EtOAc, 2:1 → 1:1) to afford the sulfinyl amide (28.2 mg, 67% over 2 steps, *dr* 2.7:1) as a colorless oil. $R_f = 0.39$ (hexane/EtOAc, 1:1).

To a solution of the sulfinyl amide (28.2 mg, 113 µmol, 1.0 equiv) in CH_2Cl_2 (3.5 mL) was added at 0 °C *m*CPBA (41.6 mg, 245 µmol, 2.2 equiv, 1.5 equiv relative to amino acid, 77% wt/wt). After stirring for 2 h at 0 °C, the reaction mixture was quenched with sat. $NaHCO_3$ (4 mL) and sat. $Na_2S_2O_3$ (4 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 4:1 → 3:1) to afford (*R*)-**S6** (27.4 mg, 91%, 61% over 3 steps, 98% *ee*) as colorless crystals. X-ray quality crystals of the *L*-*tert*-leucine derivative[10] (*S*)-**S6** were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the product in EtOAc. $R_f = 0.71$ (hexane/EtOAc, 1:1); ^1H NMR (500 MHz, $CDCl_3$): δ 4.59 (d, J = 10.7 Hz, 1H), 3.77 (d, J = 10.8 Hz, 1H), 3.76 (s, 3H), 1.35 (s, 9H), 1.00 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 172.4, 65.5, 60.3, 52.0, 34.9, 26.5, 24.2; IR (KBr): 3276, 2986, 2950, 1743, 1465, 1370, 1321, 1305, 1217, 1158, 1131, 1110, 1037, 990, 949, 888, 808, 747, 694, 654 cm^{-1}; HRMS (ESI+) m/z calc'd for $C_{11}H_{23}NO_4S$ $[M+H]^+$: 283.1686, found 283.1672; $[\alpha]^{25}_D$ −5.0° (*c*

0.47, $CHCl_3$); mp 101-103 °C; SFC (Daicel Chiracel AD-H, 95:5 CO_2/*i*PrOH, 31 °C, 1.0 mL/min, 210 nm and 214 nm): t_R/min = 6.4 (*R*), 7.8 (*S*).

(*S*)-**S6**: $[\alpha]^{25}_D$ +4.8° (*c* 0.905, $CHCl_3$). The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525612.

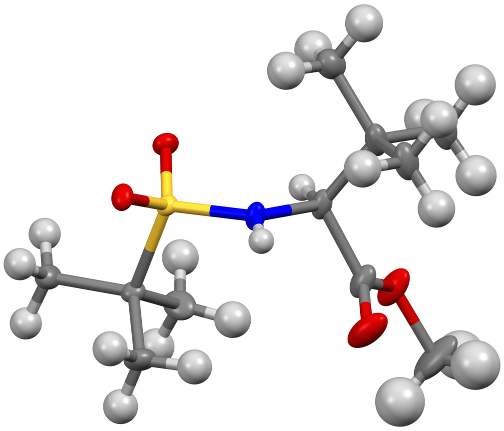
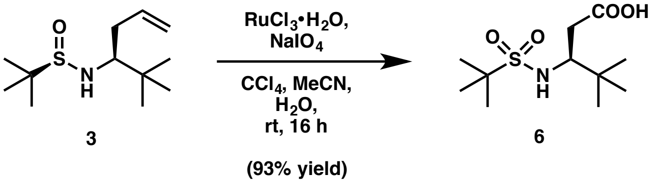


Figure 4: X-ray structure of (*S*)-**S6** (ellipsoids, 50% probability level).



Carboxylic acid 6. To a biphasic solution of **3** (80.9 mg, 0.35 mmol, 1.0 equiv) in a mixture carbon tetrachloride (1.3 mL), acetonitrile (1.3 mL) and water (1.9 mL) was added at rt $NaIO_4$ (538 mg, 2.52 mmol, 7.2 equiv). Once all of the $NaIO_4$ had been dissolved, $RuCl_3$ hydrate (3.6 mg, 5 mol%) was added. After vigorous stirring for 16 h at rt, the reaction mixture was diluted with sat. NaH_2PO_4 (25 mL) and CH_2Cl_2 (30 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (4 x 25 mL). The combined organic extracts were washed with a 1:1 mixture of sat. $Na_2S_2O_3$ (10 mL)/sat. NaH_2PO_4 (10 mL) (some water was added to keep the aqueous layer on top of the organic). The aqueous layer was back extracted once with CH_2Cl_2 (15 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue (97.7 mg) was purified by column chromatography (CH_2Cl_2/MeOH/0.5% AcOH, 98:2 → 95:5) to afford **6** (86.5 mg, 93%) as a white (slightly purple), crystalline solid. X-ray quality crystals were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the product in EtOAc. R_f = 0.34 (CH_2Cl_2/MeOH/0.5% AcOH, 95:5); ^{1}H NMR (500 MHz, CD_3OD): δ 3.74 (t, J = 5.7 Hz, 1H), 2.70 (dd, J = 16.2, 5.9 Hz, 1H), 2.43 (dd, J = 16.2, 5.6 Hz, 1H), 1.36 (s, 9H), 0.97 (s, 9H); ^{13}C NMR (126 MHz, CD_3OD): δ 175.9, 61.2, 60.9, 38.8, 36.8, 27.1, 24.9; IR (NaCl): 3489br, 3280br, 2971, 2876, 1716, 1479, 1428, 1399, 1370, 1299, 1203, 1170, 1127, 1089, 1017, 940, 865, 667 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_{11}H_{23}NO_4S$ $[M-H]^-$: 264.1275, found 264.1285; $[\alpha]^{25}_D$ −34.4° (c 0.635, MeOH); mp 155-157 °C. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525614.

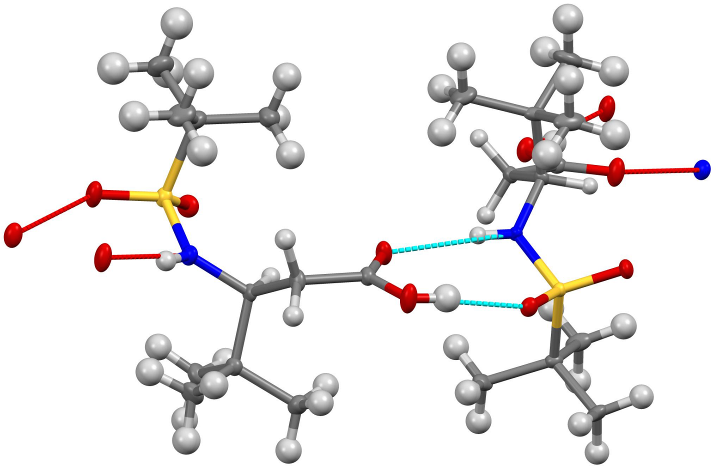
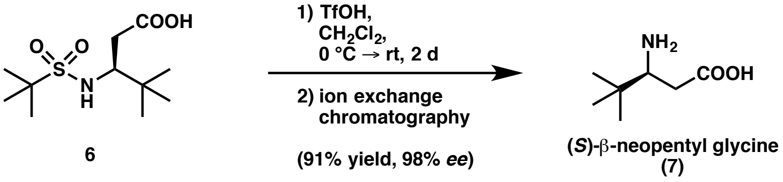
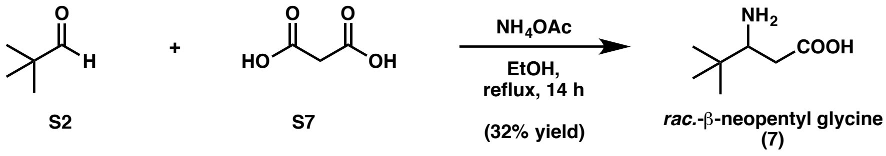


Figure 5: X-ray structure of **6** (ellipsoids, 50% probability level).

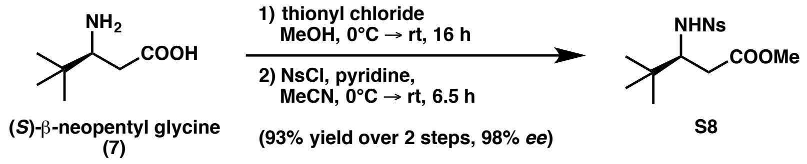


(*S*)-β-Neopentyl glycine (7). To a round-bottomed flask charged with **6** (41.2 mg, 0.16 mmol, 1.0 equiv) was added at 0 °C a solution of TfOH in CH_2Cl_2 (4.7 mL, 0.47 mmol, 3.0 equiv, 0.1 M). After stirring for 34 h at rt, the starting material was still not fully consumed according to LC-MS and TLC. Therefore, TfOH (0.13 mL, 1.47 mmol, 9.5 equiv) was added dropwise at 0 °C and stirring was continued for 12 h at rt (the amino acid salt precipitated from the solution). Water (2 mL) was added and the organic solvent was removed under reduced pressure at rt. The crude aqueous amino acid solution was purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH, staining with ninhydrin or $KMnO_4$) to afford, after filtration over cotton, (*S*)-β-neopentyl glycine (**7**) (20.5 mg, 91%, 98% *ee*) as a colorless solid. R_f = 0.56 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1);[11] ^{1}H NMR (500 MHz, D_2O): δ 3.28 (dd, *J* = 10.7, 3.3 Hz, 1H), 2.60 (dd, *J* = 17.0, 3.3 Hz, 1H), 2.34 (dd, *J* = 17.0, 10.6 Hz, 1H), 0.99 (s, 9H); ^{13}C NMR (126 MHz, D_2O): δ 178.7, 58.4, 34.4, 32.2, 24.9; IR (KBr): 3421br, 2967, 1624, 1577, 1476, 1388, 1146, 776, 645 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_7H_{15}NO_2$ $[M+H]^+$: 146.1176, found 146.1174; $[\alpha]^{25}_D$ −61.2° (*c* 0.97, H_2O, 98% *ee*); mp 230-231 °C (sublimation). Lit. for (*S*)-**7** $[\alpha]^{20}_D$ −67.7° (*c* 1.00, H_2O);[12] Lit. for (±)-**7** mp 229-230 °C.[13]

HPLC derivatization of (*S*)-β-neopentyl glycine (7) and preparation of racemic β-neopentyl glycine *via* Rodionov reaction:



***rac.*-β-Neopentyl glycine (7).** A suspension of pivalaldehyde (**S2**) (3.0 mL, 27.6 mmol, 1.0 equiv), malonic acid (**S7**) (2.87 g, 27.6 mmol, 1.0 equv) and ammonium acetate (4.26 g, 55.2 mmol, 2.0 equiv) in EtOH (55 mL) was refluxed for 14 h under air. Three-thirds of the solvent was evaporated off and acetone (60 mL) was added. The precipitated solids were filtered off and washed with acetone to afford malonic acid (1.22 g, with a little bit of the product) as a colorless solid. The mother liquor was stored in the freezer over night and the precipitated solids were filtered off to give *rac.*-β-neopentyl glycine (**7**) (886 mg, <22%, along with a minor amount of ammonium acetate) as a colorless, fluffy solid. This procedure was repeated once to give a second crop of *rac.*-β-neopentyl glycine (**7**) (389 mg, <10%, along with a minor amount of ammonium acetate).[13] The analytical data were identical to those reported above (*vide supra*). R_f = 0.56 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1).



Nosyl ester S8. To a solution of (*S*)-β-neopentyl glycine (**7**) (6.1 mg, 42.0 μmol, 1.0 equiv) in MeOH (0.30 mL) was added at 0 °C thionyl chloride (20 μL, 0.27 mmol, 6.5 equiv). After stirring for 16 h at rt, the reaction mixture was concentrated under reduced pressure. EtOAc was added to the residue and the solvent was removed under reduced pressure to afford neopentyl glycine methylester hydrochloride as colorless crystals.

To a solution of the crude ester in acetonitrile (0.31 mL) and pyridine (37 µL, 0.46 mmol, 11 equiv) was added at 0 °C 4-nitrobenzenesulfonyl chloride (14.0 mg, 63.0 µmol, 1.5 equiv). After stirring for 30 min at 0 °C and for 6 h at rt, the reaction mixture was concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 4:1) to afford **S8** (13.5 mg, 93% over 2 steps, 98% *ee*) as a colorless, crystalline solid.[14] X-ray quality crystals were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the product in EtOAc. R_f = 0.70 (hexane/EtOAc, 1:1); R_f = 0.11 (hexane/EtOAc, 4:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.38-8.31 (m, 2H), 8.11-8.04 (m, 2H), 5.47 (d, *J* = 9.9 Hz, 1H), 3.55 (s, 3H), 3.53 (dt, *J* = 9.8, 5.5 Hz, 1H), 2.37 (dd, *J* = 15.7, 5.7 Hz, 1H), 2.31 (dd, *J* = 15.7, 5.4 Hz, 1H), 0.86 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 172.3, 149.9, 147.0, 128.4, 124.2, 59.9, 52.0, 35.3, 35.2, 26.5; IR (KBr): 3284, 2967, 1745, 1706, 1518, 1357, 1313, 1291, 1207, 1165, 1064, 857, 742, 622 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_{14}H_{20}N_2O_6S$ $[M-H]^-$: 343.0969, found 343.0983; $[\alpha]^{25}_D$ +12.2° (*c* 0.61, $CHCl_3$); mp 128-129 °C; HPLC (Daicel Chiracel AD, 90:10 hexane/*i*PrOH, 25 °C, 1.0 mL/min, 254 nm): t_R/min = 19.6 (*S*), 22.3 (*R*). The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525616.

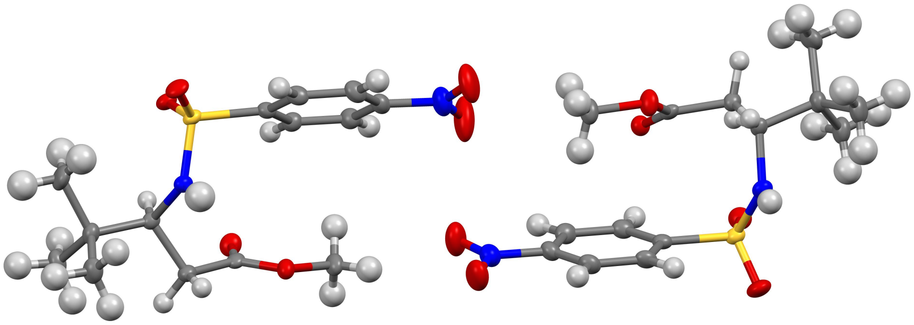
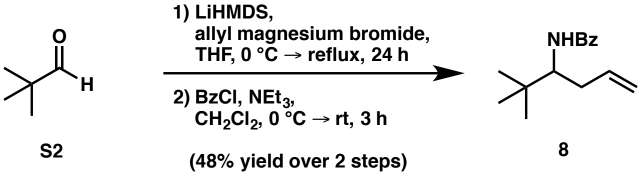
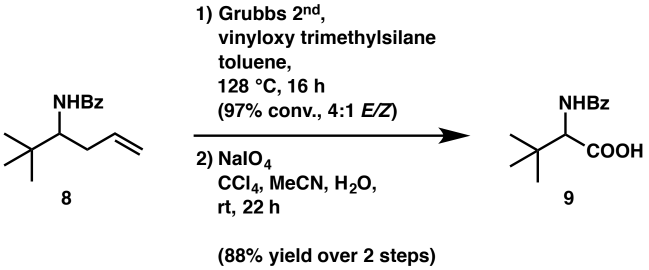


Figure 6: X-ray structure of **S8** (ellipsoids, 50% probability level).

Synthesis of allyl benzamide 8:



Allyl amide 8. To a solution of pivalaldehyde (**S2**) (2.0 mL, 18.4 mmol, 1.0 equiv) in THF (10 mL) was added dropwise at 0 °C a solution of LiHMDS (3.70 g, 22.1 mmol, 1.2 equiv) in THF (10 mL + 6 mL for washing). After stirring for 15 min at 0 °C, a solution of allyl magnesium bromide (22.1 mL, 22.1 mmol, 1.2 equiv, 1.0 M in Et_2O) was added dropwise at 0 °C to the reaction mixture. After stirring for 15 min at 0 °C, the reaction mixture was allowed to warm to rt over 20 min and was then refluxed for 23 h (oil bath 60 °C). After the reaction mixture had cooled to rt, it was poured into sat. $NaHCO_3$ (120 mL) and diluted with CH_2Cl_2 (40 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2 x 40 mL). The combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure (after most of the solvent had evaporated, the flask with the crude amine was taken out of the water bath and carefully concentrated under reduced pressure) to afford the amine (2.5 g, quant., crude product along with $(CH_3)_3SiOH$) as an orange oil.[15] To solution of the crude amine (1.68 g, 13.2 mmol, 1.0 equiv) in CH_2Cl_2 (50 mL) was added at 0 °C NEt_3 (2.2 mL, 15.8 mmol, 1.2 equiv) followed by the dropwise addition of BzCl (1.69 mL, 14.6 mmol, 1.1 equiv). After stirring for 15 min at 0 °C, the reaction mixture was allowed to warm to rt over 3 h and was quenched with sat. $NaHCO_3$ (30 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 30 mL). The combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 6:1 → 4:1 → 1:1) to afford amide **8** (2.16 g, 5% wt/wt benzoic acid, calcd. 2.04 g, 48% over 2 steps) as a bright yellow solid. The amide was then dissolved in a minimal amount of refluxing CH_2Cl_2 (ca. 8 mL) and the solids were precipitated by the addition of an excess of hexanes (200 mL). The flask was then stored in the freezer over night and the precipitate was filtered off and washed with hexanes (3 x 10 mL). After drying under high vacuum, amide **8** (1.68 g, 39% over 2 steps) was isolated as a colorless solid.[16] R_f = 0.23 (hexane/EtOAc, 6:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.77-7.70 (m, 2H), 7.52-7.46 (m, 1H), 7.46-7.40 (m, 2H), 5.82 (dddd, *J* = 17.3, 10.4, 8.3, 5.6 Hz, 1H), 5.76 (brs, 1H), 5.10-4.97 (m, 2H), 4.11 (ddd, *J* = 11.2, 10.2, 3.2 Hz, 1H), 2.56 (m_c, 1H), 2.02 (dddt, *J* = 14.6, 11.2, 8.3, 1.0 Hz, 1H), 0.99 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 167.5, 135.9, 135.3, 131.2, 128.6, 126.7, 116.9, 56.8, 35.2, 34.9, 26.5; IR (KBr): 3336, 3063, 2965, 1633, 1579, 1542, 1491, 1476, 1369, 1355, 1292, 1076, 1030, 990, 912, 852, 699 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{15}H_{21}NO$ $[M+H]^+$: 232.1696, found 232.1686; mp 164-165 °C.



Carboxylic acid 9. To a solution of **8** (210 mg, 0.91 mmol, 1.0 equiv) and vinyloxytrimethylsilane (1.35 mL, 9.08 mmol, 10 equiv) in toluene (48 mL) was added at rt Grubbs 2nd generation catalyst **1a** (38.5 mg, 5 mol%). The purple reaction mixture was immersed in an oil bath (128 °C) (color changed to yellow) and refluxed for 16 h. The reaction mixture was then concentrated under reduced pressure to afford the crude disubstituted alkene (260 mg, 97% conv., *E*/*Z* = 4:1) as a dark green, colorless solid, which was used in the next step without further purification.

To a biphasic, dark green solution of the crude product (260 mg, crude, calcd. 210 mg, 0.91 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (3.3 mL), acetonitrile (3.3 mL) and water (5.0 mL) was added at rt $NaIO_4$ (874 mg, 4.08 mmol, 4.5 equiv). After vigorous stirring for 22 h at rt, the reaction mixture was diluted with sat. NaH_2PO_4 (25 mL) and CH_2Cl_2 (30 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (4 x 30 mL). The combined organic extracts were washed with a 1:1 mixture of sat. $Na_2S_2O_3$ (10 mL)/sat. NaH_2PO_4 (10 mL), dried over $MgSO_4$ and the solvent was removed under reduced pressure. The crude acid **9** was dissolved in MeOH (10 mL) and 4 g of silica gel followed by DMSO (60 µL) were added. After stirring for 30 min at rt, the suspension was concentrated under reduced pressure. The crude acid, loaded on silica gel, was purified by column chromatography (CH_2Cl_2/MeOH/0.5% AcOH, 99.5:0.5 → 99:1 → 98:2) to afford **9** (188 mg, 88% over 2 steps) as a beige solid. X-ray quality crystals were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the mixture in EtOAc. $R_f = 0.40$ (CH_2Cl_2/MeOH/0.5% AcOH, 98:2); ^1H NMR (500 MHz, CD_3OD): δ 7.86-7.77 (m, 2H), 7.58-7.51 (m, 1H), 7.51-7.44 (m, 2H), 4.56 (s, 1H), 1.11 (s, 9H); ^{13}C NMR (126 MHz, CD_3OD): δ 174.3, 170.5, 135.6, 132.8, 129.6, 128.5, 62.4, 35.4, 27.3; IR (KBr): 3365, 3068, 2973, 2695, 2581, 2506, 1724, 1625, 1577, 1540, 1494, 1370, 1336, 1304, 1220, 1176, 1087, 706, 690 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_{13}H_{17}NO_3$ $[M-H]^-$: 234.1136, found 234.1145; mp 150-152 °C. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525611.

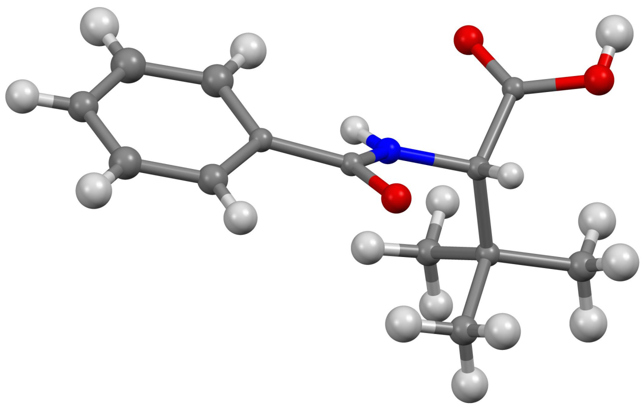
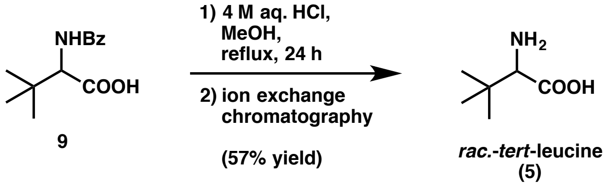
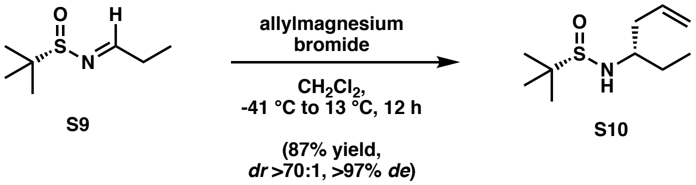


Figure 7: X-ray structure of **9** (ellipsoids, 50% probability level).

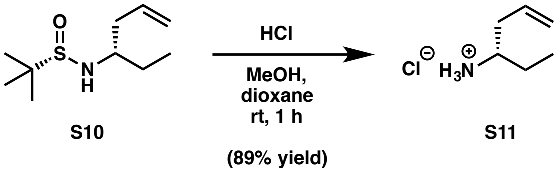


***rac.-tert*-leucine (5).** A microwave vial was charged with a solution of **9** (71.8 mg, 0.31 mmol, 1.0 equiv) in MeOH (2.0 ml). Then, 4 M aq. HCl (4.0 mL) was added dropwise at 90 °C to the suspension and the reaction mixture was refluxed at 120 °C for 24 h. The reaction mixture was allowed to cool to rt, was diluted with 1 M aq. HCl (10 mL) and washed with CH_2Cl_2 (3 x 25 mL). The organic layers were concentrated and discarded (27.0 mg). The aqueous layer was concentrated under reduced pressure (70 °C, water bath) and the residue was purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH, staining with ninhydrin) to afford **5** as a colorless solid. The residue was dissolved in MeOH (ultrasound bath, if the crystals don't dissolve) and filtered over cotton (in a Pasteur pipette) to furnish *rac.-tert*-leucine (**5**). (22.9 mg, 57%) as a colorless solid. The analytical data were identical to those reported above (*vide supra*). R_f = 0.58 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1).

Synthesis of allyl amide 10:



Sulfinamide S10. To a solution of (*R*)-2-methyl-*N*-propylidene-2-propanesulfinamide[17] (**S9**) (224 mg, 1.39 mmol, 1.0 equiv) in CH_2Cl_2 (8.7 mL) was added dropwise at -41 °C (acetonitrile/CO_2 bath) allylmagnesium bromide (2.80 mL, 2.80 mmol, 2.0 equiv, 1.0 M solution in Et_2O) over 15 min. After stirring for 5 h at -41 °C, the reaction mixture was allowed to warm slowly to 13 °C in the cooling bath (Dewar) and was then quenched with sat. NH_4Cl (15 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (5 x 20 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure to afford crude sulfinamide **S10** (292 mg, quant., *dr* = 15:1, 88% *de*) as a yellow liquid. The residue was purified by column chromatography (23 x 2.5 cm, hexane/EtOAc, 4:1) to afford pure (S_P,*S*)-**S10** (247 mg, 87%, *dr* > 70:1, >97% *de*) as a colorless liquid. All mixed fractions were discarded. (S_P,*R*)-**S10** R_f = 0.30 (hexane/EtOAc, 1:1). (S_P,*S*)-**S10:** R_f = 0.33 (hexane/EtOAc, 1:1); ^1H NMR (500 MHz, $CDCl_3$): δ 5.78 (m_c, 1H), 5.19-5.10 (m, 2H), 3.30-3.13 (m, 2H), 2.45-2.36 (m, 1H), 2.34-2.25 (m, 1H), 1.54 (m_c, 2H), 1.20 (s, 9H), 0.92 (t, J = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 134.3, 118.8, 55.9, 55.7, 39.9, 27.6, 22.7, 9.8; IR (NaCl): 3218, 3077, 2960, 2931, 2875, 1640, 1461, 1362, 1177, 1122, 1049, 992, 910 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{10}H_{21}NSO$ $[M+H]^+$: 204.1417, found 204.1408; $[\alpha]^{25}_D$ +73.2° (*c* 1.15, $CHCl_3$). Lit. for (S_P,*R*)-**S10** $[\alpha]^{26}_D$ –18.2° (*c* 0.45, $CHCl_3$).[18]



Amine hydrochloride S11. To a solution **S10** (312 mg, 1.53 mmol, 1.0 equiv) in MeOH (0.78 mL) was added at rt HCl (0.77 mL, 3.07 mmol, 2.0 equiv, 4 M solution in 1,4-dioxane). After stirring for 1 h at rt, the yellow reaction mixture was concentrated to near dryness and treated with an excess of Et_2O (stored in the freezer over night). The colorless precipitate was filtered off, washed with Et_2O (2 mL) and hexanes (2 x 4 mL) to give **S11** (185 mg, 89%) as a colorless solid. X-ray quality crystals were obtained at rt by slow diffusion of dioxane into a solution of the product in water over 5 months. ^{1}H NMR (500 MHz, CD_3OD): δ 5.82 (ddt, *J* = 17.2, 10.2, 7.2 Hz, 1H), 5.30-5.20 (m, 2H), 3.19 (m_c, 1H), 2.51-2.41 (m, 1H), 2.41-2.31 (m, 1H), 1.77-1.60 (m, 2H), 1.03 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, CD_3OD): δ 133.3, 120.5, 53.7, 37.5, 26.3, 9.8; IR (NaCl): 3418br, 2883br, 2025, 1601, 1515, 1463, 1441, 1385, 1191, 1020, 996, 924 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_6H_{13}N$ $[M+H]^+$: 100.1125, found 100.1122; $[\alpha]^{25}_D$ –0.8° (*c* 0.485, MeOH); mp 181-182 °C. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525617.

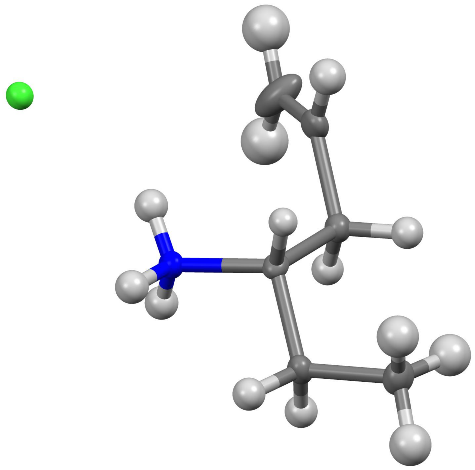
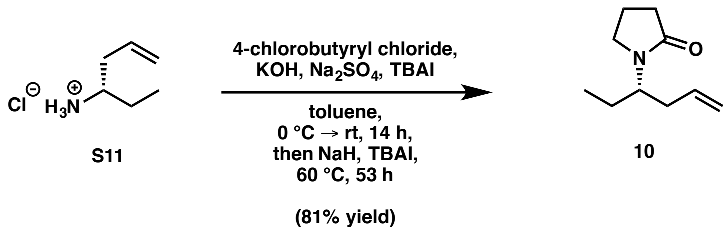
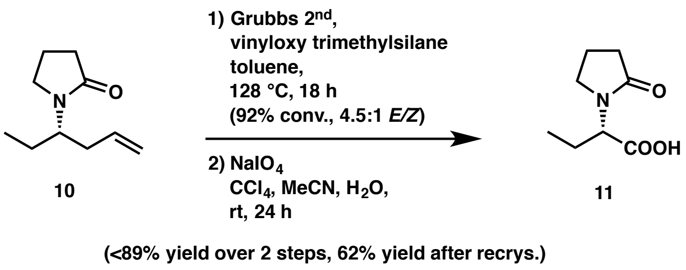


Figure 8: X-ray structure of **S11** (ellipsoids, 50% probability level).



Amide 10. To a suspension of **S11** (50.0 mg, 0.37 mmol, 1.0 equiv), TBAI (4.8 mg, 3.5 mol%) and anhydrous Na_2SO_4 (105 mg, 0.74 mmol, 2.0 equiv) in toluene (5.0 mL) was added at 0 °C powdered KOH (95.1 mg, 1.70 mmol, 4.6 equiv) followed by 4-chlorobutyryl chloride (0.05 mL, 0.44 mmol, 1.2 equiv). After stirring for 10 min at 0 °C, the reaction mixture was allowed to warm to rt over 14 h. NaH (17.7 mg, 0.44 mmol, 1.2 equiv) was added at 0 °C. The reaction mixture was then allowed to warm to rt and was heated to 60 °C for 48 h. Since the chloro amide intermediate was not fully consumed according to TLC, more NaH (12.2 mg, 0.31 mmol, 0.82 equiv) and TBAI (4.8 mg, 3.5 mol%) were added at rt and heating was continued for 5 h at 60 °C. The reaction mixture was quenched with sat. NH_4Cl (15 mL) and diluted with EtOAc (20 mL). The layers were separated and the aqueous layer was extracted with EtOAc (2 x 20 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 2:1 → 1:1) to afford **10** (49.9 mg, 81%) as a yellow liquid. $R_f = 0.21$ (hexane/EtOAc, 1:1); ^1H NMR (500 MHz, $CDCl_3$): δ 5.70 (m_c, 1H), 5.07-4.93 (m, 2H), 4.08 (m_c, 1H), 3.22 (m_c, 2H), 2.37 (m_c, 2H), 2.29-2.21 (m, 1H), 2.29-2.11 (m, 1H), 1.96 (m_c, 2H), 1.58-1.48 (m, 1H), 1.48-1.35 (m, 1H), 0.83 (t, J = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 175.4, 135.1, 116.7, 52.0, 41.9, 37.0, 31.5, 25.0, 18.2, 10.8; IR (NaCl): 3076, 2964, 1686, 1423, 1366, 1284, 1227, 996, 914, 847, 732, 646 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{10}H_{17}NO$ $[M+H]^+$: 168.1383, found 168.1388; $[\alpha]^{25}_D$ –60.2° (*c* 1.115, $CHCl_3$).



Carboxylic acid 11. To a solution of **10** (194 mg, 1.16 mmol, 1.0 equiv) and vinyloxytrimethylsilane (1.73 mL, 11.6 mmol, 10 equiv) in toluene (60 mL) was added at rt Grubbs 2nd generation catalyst **1a** (49.2 mg, 5 mol%). The purple reaction mixture was immersed in an oil bath (129 °C) (color changed to yellow) and refluxed for 18 h. The reaction mixture was concentrated under reduced pressure to afford the crude disubstituted alkene (253 mg, 92% conv., *E*/*Z* = 4.5:1) as a dark green liquid, which was used in the next step without further purification.

To a biphasic, dark green solution of the crude product (253 mg, calcd. 194 mg, 1.16 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (4.2 mL), acetonitrile (4.2 mL) and water (6.4 mL) was added at rt $NaIO_4$ (1.12 g, 5.22 mmol, 4.5 equiv). After vigorous stirring for 23 h at rt, the reaction mixture was diluted with sat. NaH_2PO_4 (25 mL), water (8 mL) and $CHCl_3$/*i*PrOH (5:1, 5 x 30 mL). Since there was still some product in the aqueous layer according to TLC, it was saturated with solid NaCl and extracted with $CHCl_3$/*i*PrOH (5:1, 3 x 30 mL). The combined organic extracts were washed with a 1:1 mixture of sat. $Na_2S_2O_3$ (10 mL)/sat. NaH_2PO_4 (10 mL). The aqueous layer was back extracted once with $CHCl_3$/*i*PrOH (5:1, 20 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. To a solution of the crude acid in CH_2Cl_2 (5 mL) were added 5 drops of DMSO and the solvent was removed under reduced pressure. The residue was then purified by column chromatography (EtOAc/MeOH/0.5% AcOH, 40:1 → 20:1 → 15:1) to afford **11** (177 mg, ca. 90% pure, <89%

over 2 steps) as a light brown, crystalline solid. An analytically pure sample was obtained by dissolving **11** in a minimal amount of CH_2Cl_2 (ca. 1.5 mL). The solution was then carefully overlayed with an excess of hexanes (8 mL) and stored in the freezer over night. The solvent was decanted off; the solids were washed twice with hexanes and dried under high vacuum to give **11** (123 mg, 62% after recrystallization) as beige crystals. X-ray quality crystals were obtained at rt by slow evaporation of a EtOAc solution. R_f = 0.15 (EtOAc/MeOH/0.5% AcOH, 20:1); ^{1}H NMR (500 MHz, CD_3OD): δ 4.53 (dd, *J* = 11.1, 4.7 Hz, 1H), 3.54 (ddd, *J* = 9.4, 8.1, 6.2 Hz, 1H), 3.44 (ddd, *J* = 9.5, 8.1, 5.7 Hz, 1H), 2.43 (m_c, 2H), 2.16-1.97 (m, 3H), 1.76 (m_c, 1H), 0.93 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, CD_3OD): δ 178.7, 173.8, 56.9, 45.1, 31.9, 23.0, 19.2, 11.2; IR (KBr): 3421br, 2970, 2881, 2568, 2371, 1720, 1638, 1460, 1312, 1293, 1229, 1206, 1167, 953, 820, 742 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_8H_{13}NO_3$ $[M-H]^-$: 170.0823, found 170.0823; $[\alpha]^{25}_D$ −31.5° (*c* 0.81, MeOH); $[\alpha]^{25}_D$ −25.9° (*c* 0.81, acetone);[19] mp 118-119 °C. Lit. $[\alpha]^{20}_D$ −27.3° (*c* 1.03, acetone).[20] The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525615.

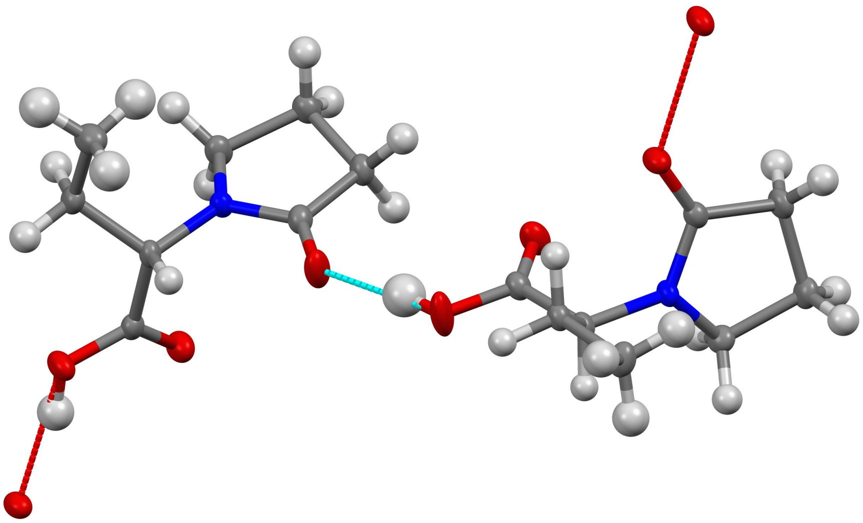
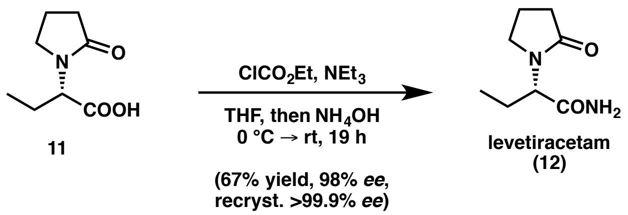


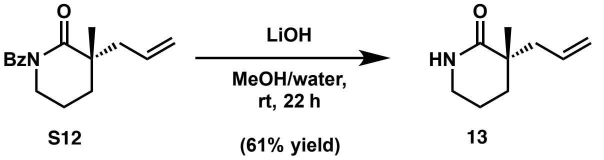
Figure 9: X-ray structure of **11** (ellipsoids, 50% probability level).



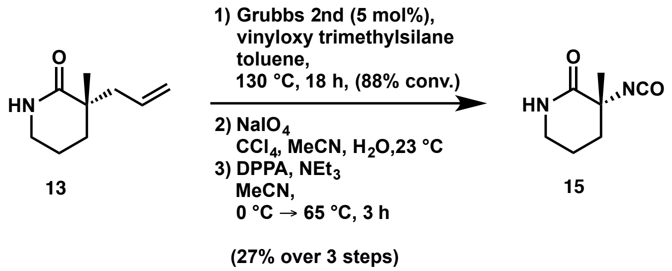
To a solution of **11** (99.0 mg, 0.58 mmol, 1.0 equiv) in THF (3.3 mL) was added at 0 °C triethylamine (88.7 µL, 0.64 mmol, 1.1 equiv) followed by ethyl chloroformate (60.6 µL, 0.64 mmol, 1.1 equiv). After stirring for 30 min at that temperature, a colorless precipitate (triethylammonium chloride) had been formed and aqueous NH_4OH (0.39 mL, 5.78 mmol, 10 equiv, 28-30% NH_3 in water) was added at 0 °C. After stirring for 18.5 h at rt, anhydrous K_2CO_3 (82 mg) was added and the reaction mixture was diluted with CH_2Cl_2. The reaction mixture was then dried over $MgSO_4$, filtered in a Pasteur pipette over Celite (washed thoroughly with 3 x CH_2Cl_2 and 3 x EtOAc, ca. 4 mL each) and the solvent was removed under reduced pressure to afford crude levetiracetam (**12**) (85.2 mg, 87%) as an orange oil, which crystallized upon storage in the freezer. The crude amide was then recrystallized from acetone to afford colorless crystals. The solvent was decanted off with a Pasteur pipette and the solids were washed three times with hexanes to give levetiracetam (**12**) (44.2 mg, 45%, >99.9% *ee*) as a colorless, crystalline solid. The decanted organic solvents were combined and concentrated under reduced pressure. The residue was purified by column chromatography (CH_2Cl_2/MeOH, 20:1 → 10:1) to afford a second crop of levetiracetam (**12**) (22.1 mg, 22%, 98.3% *ee*) as a colorless solid. $R_f = 0.33$ (CH_2Cl_2/MeOH, 10:1); ^1H NMR (500 MHz, $CDCl_3$): δ 6.34 (brs, 1H), 5.58 (brs, 1H), 4.45 (dd, $J = 8.9, 6.8$ Hz, 1H), 3.42 (m_c, 2H), 2.42 (m_c, 2H), 2.11-1.89 (m, 3H), 1.68 (m_c, 1H), 0.90 (t, $J = 7.4$ Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 176.0, 172.2, 56.1, 43.8, 31.1, 20.9, 18.1, 10.5; IR (KBr): 3362, 3192, 2992, 2940, 2912, 1676, 1654, 1430, 1381, 1296, 1276, 1214, 1083, 703, 637 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_8H_{14}N_2O_2$ $[M+H]^+$:

171.1128, found 171.1125; $[\alpha]^{25}_{D}$ –85.6° (*c* 0.97, acetone, >99.9% *ee*); mp 113-114 °C; HPLC (Daicel Chiracel OD-H, 98:2 hexane/*i*PrOH, 25 °C, 1.0 mL/min, 210 nm): t_R/min = 14.8 (*R*), 19.7 (*S*). Lit. $[\alpha]^{25}_{D}$ –91.5° (*c* 1.0, acetone); mp 116-117 °C.[21]

Synthesis of allyl amide 13:



Allyl amide 13: To a solution of **S12**[22] (290 mg, 1.12 mmol, 1.0 equiv, 97% *ee*) in MeOH (29 mL) was added at rt an aqueous solution of LiOH (40 mg, 1.68 mmol, 1.5 equiv) in water (11.5 mL). After stirring for 22 h at rt, the reaction mixture was concentrated under reduced pressure and diluted with sat. K_2CO_3 (10 mL) and EtOAc (20 mL). The layers were separated and the aqueous layer was extracted with EtOAc (3 x 25 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 2:1 → 1:1 → 1:2) to afford **13** (105 mg, 61%) as a yellow oil. R_f = 0.33 (hexane/EtOAc, 1:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.23 (brs, 1H), 5.75 (dq, *J* = 14.9, 8.1 Hz, 1H), 5.10–5.04 (m, 2H), 3.31–3.24 (m, 2H), 2.50 (dd, *J* = 12.9, 5.5 Hz, 1H), 2.23–2.17 (m, 1H), 1.85–1.76 (m, 3H), 1.55–1.49 (m, 1H), 1.21 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 177.6, 134.2, 118.2, 43.8, 42.8, 41.1, 32.2, 25.4, 19.2; IR (NaCl): 3290, 3205, 3074, 2939, 2867, 2360, 1659, 1490, 1415, 1372, 1351, 1329, 1308, 1279, 1209, 1106, 1019, 999, 912, 659 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_9H_{16}NO$ $[M+H]^+$: 154.1226, found 154.1219; $[\alpha]^{25}_{D}$ –58.4° (*c* 0.60, $CHCl_3$, 97% *ee*).

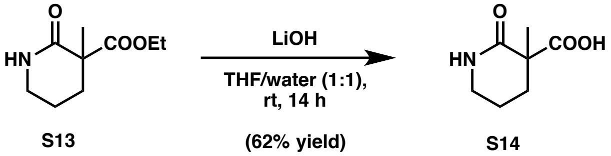


Isocyanate 15. To a solution of **13** (160 mg, 1.04 mmol, 1.0 equiv) and vinyloxytrimethylsilane (1.55 mL, 10.4 mmol, 10 equiv) in toluene (55 mL) was added at rt Grubbs 2nd generation catalyst **1a** (44 mg, 5 mol %). The purple reaction mixture was immersed in an oil bath (130 °C) (color changed red to orange to yellow) and refluxed for 18 h. The reaction mixture was then concentrated under reduced pressure to afford the crude disubstituted alkene (88% conversion) as a green oil, which was used in the next step without further purification.

To a biphasic solution of the crude product in a mixture of carbon tetrachloride (3.8 mL), acetonitrile (3.8 mL) and water (5.7 mL) was added at rt $NaIO_4$ (1.0 g, 4.68 mmol, 4.5 equiv). The color of the reaction mixture changed immediately to dark purple. After stirring vigorously for 24 h at rt, a black precipitate was formed above the suspension (probably RuO_2). The reaction mixture was then diluted with 3 M NaOH (8 mL), water (30 mL) and $CHCl_3$ (25 mL). The layers were separated and the aqueous layer was extracted with $CHCl_3$ (2 x 30 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl and extracted with $CHCl_3$/*i*PrOH (5:1, 10 x 30 mL). The extraction was continued until no product was left in the aqueous phase according to TLC (in case there was still product left after 10 extractions, the aqueous phase was saturated with solid NaCl and extracted further). The combined organic extracts were washed with a 1:1 mixture of sat. NaH_2PO_4/sat. $Na_2S_2O_3$ (20 mL). The aqueous layer was back extracted with $CHCl_3$/*i*PrOH (5:1, 2 x 10 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was dissolved in MeOH and filtered over cotton and concentrated *in vacuo*. The crude carboxylic acid (brown/orange) was then suspended in a mixture of aq. 1.0 M NaOH (10 mL), water (15 mL) and Et_2O (25 mL). The layers were separated and the aqueous layer (light yellow) was washed with Et_2O (30 mL) and EtOAc (15 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl, saturated with solid NaCl and extracted with $CHCl_3$/*i*PrOH (8 x 25 mL, checked by TLC). The combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. The residue was dissolved in MeOH and filtered over cotton in a Pasteur pipette to afford the crude carboxylic acid **S14**[23] as a yellow solid, which was used for the next step without further purification.

To a suspension of crude carboxylic acid **S14** (1.0 equiv) in acetonitrile (11 mL) was added at rt triethylamine (0.36 mL, 2.54 mmol, 2.0 equiv). After stirring for 5 min at rt and all solids had been dissolved, DPPA (0.30 mL, 1.41 mmol, 1.1 equiv) was added dropwise at 0 °C. After stirring for 5 min at 0 °C, the reaction mixture was allowed to warm to rt over 30 min and was heated at 65 °C for 3 h. The yellow reaction mixture was concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 1:1) to afford isocyanate **15** (43 mg, 27% over 3 steps) as a light brown oil. $R_f = 0.2$ (Hexanes/EtOAc 1:1); ^1H NMR (500 MHz, $CDCl_3$): δ 6.79 (brs, 1H), 3.42-3.24 (m, 2H), 2.06-1.94 (m, 1H), 1.94-1.76 (m, 3H), 1.58 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 172.5, 127.7, 59.6, 42.5, 35.8, 27.7, 19.4; IR (NaCl): 3255br, 2947, 2901, 2224, 1673, 1489, 1471, 1350, 1325, 1278, 1189, 1099, 1018, 840 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_7H_{11}N_2O_2$ $[M+H]^+$: 155.0815, found 155.0819; $[\alpha]^{25}_D$ +60.8° (*c* 0.20, $CHCl_3$).

Synthesis and Characterization of racemic carboxylic acid (±)-S14:



Carboxylic acid (±)-S14. To a solution of ethyl ester (±)-**S13**[24] (201 mg, 1.09 mmol, 1.0 equiv) in THF/water (1:1, 5.4 mL) was added at rt LiOH monohydrate (228 mg, 5.43 mmol, 5.0 equiv). After stirring for 14 h at rt, the reaction mixture was diluted with 20% aq. KOH (10 mL), water (7 mL) and washed with EtOAc (2 x 30 mL). The organic extracts were discarded. The aqueous layer was acidified with 4 M aq. HCl (to pH1), saturated with solid NaCl and extracted with $CHCl_3$/*i*PrOH (5:1, 4 x 15 mL). The combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure to afford crude (±)-**S14** (159 mg, impure) as a yellow solid (the viscous oil, which was first formed, was redissolved in CH_2Cl_2 and the solid precipitated with hexanes. The solvent was then removed under reduced pressure. This procedure was repeated 3 times). The crude carboxylic acid was triturated with a minimal amount of cold CH_2Cl_2 (2 x) and dried under high vacuum to afford (±)-**S14** (105 mg, 62%) as a light brown solid. The decanted organic solvents were combined and concentrated under reduced pressure (52.6 mg). X-ray quality crystals were formed in this residue after 2 weeks at rt. ^{1}H NMR (500 MHz, CD_3OD): δ 4.89 (brs, 1H), 3.37-3.26 (m, 2H), 2.23 (m_c, 1H), 1.95-1.72 (m, 3H), 1.43 (s, 3H); ^{13}C NMR (126 MHz, CD_3OD): δ 176.8, 174.8, 51.0, 43.2, 34.2, 23.0, 20.2; IR (NaCl): 3328, 2941, 2492, 1922, 1695, 1627, 1494, 1470, 1355, 1323, 1252, 1120, 1137, 1021, 928, 723 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_7H_{11}NO_3$ $[M-H]^-$: 156.0666, found 156.0661; mp 125-126 °C. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525608.

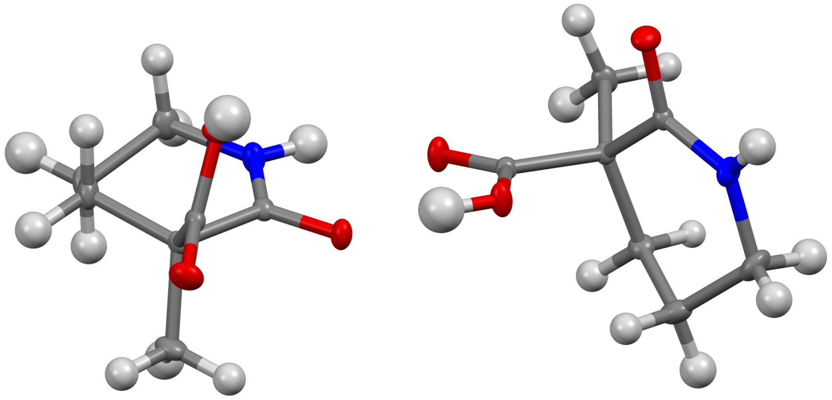
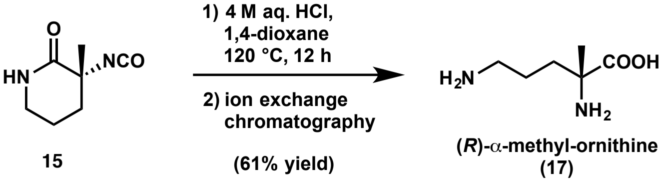
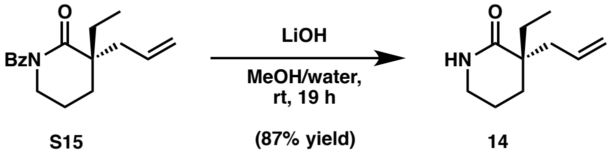


Figure 10: X-ray structure of (±)-**S14** (ellipsoids, 50% probability level).



(*R*)-α-methylornithine (17). A microwave vial was charged with a solution of **15** (38 mg, 0.25 mmol, 1.0 equiv) in 1,4-dioxane (2.2 ml). Then, 4 M aq. HCl (2.2 mL) was added dropwise at 90 °C to the suspension and the reaction mixture was refluxed at 125 °C for 24 h. The reaction mixture was allowed to cool to rt, was diluted with 1 M aq. HCl (20 mL) and washed with CH_2Cl_2 (3 x 25 mL). The organic layers were discarded and the aqueous layer was concentrated under reduced pressure (80 °C, water bath) to afford a yellow viscous oil. The crude HCl salt was purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH, staining with ninhydrin) to afford (*R*)-α-methylornithine **17** as a yellow viscous oil. The residue was dissolved in water,[25] filtered over cotton (in a Pasteur pipette) to remove insoluble material (from the resin) and concentrated to 0.5 mL. After adding an excess of acetonitrile, the amino acid precipitated to form a colorless suspension, which was concentrated under reduced pressure. Then, a similar procedure (dissolution/precipitation in MeOH, addition of acetonitrile and evaporation of the solvent) was repeated twice to afford (*R*)-α-methylornithine **17** (22 mg, 61%) as highly hygroscopic light tan solid. R$_f$ = 0.21 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1); ^{1}H NMR (500 MHz, D_2O): δ 3.01 (m$_c$, 2H), (ddd, *J* = 14.6, 12.9, 4.7 Hz, 1H), 1.86-1.73 (m, 2H), 1.67-1.55 (m, 1H), 1.49 (s, 3H); ^{13}C NMR (126 MHz, D_2O): δ 176.1, 61.2, 39.2, 34.1, 22.4, 21.9; IR (KBr):[26] 3431, 3367, 2931, 2601, 2521, 2105, 1590, 1534, 1462, 1405, 1374, 1323, 1281, 1255, 1194, 1152, 1090, 1033, 989, 968, 910, 797 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_6H_{15}N_2O_2$ $[M+H]^+$: 147.1133, found 147.1139; $[\alpha]^{25}_D$ −5.19 ° (*c* 0.95, 4N aq. HCl); mp 80–180 °C (highly hygroscopic solid). Lit. $[\alpha]^{26}_D$ −3.33° (*c* 1.05, 5N HCl)[27]

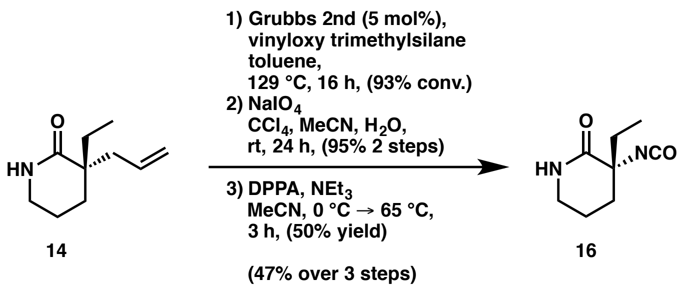
Synthesis of allyl amide 14:



S15

14

Amide 14. To a solution of **S15**[28] (848 mg, 3.13 mmol, 1.0 equiv, 99% *ee*) in MeOH (80 mL) was added at rt an aqueous solution of LiOH (112 mg, 4.69 mol, 1.5 equiv) in water (32 mL). After stirring for 19 h at rt, the reaction mixture was concentrated under reduced pressure and diluted with sat. K_2CO_3 (20 mL) and EtOAc (40 mL). The layers were separated and the aqueous layer was extracted with EtOAc (3 x 35 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 2:1 → 1:1 → 1:2) to afford **14** (456 mg, 87%) as a yellow oil.[29] R$_f$ = 0.20 (hexane/EtOAc, 1:1).

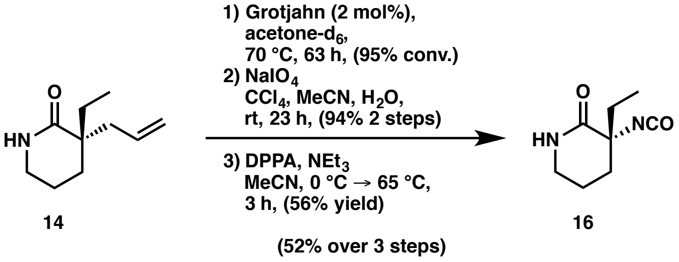


Isocyanate 16 with Grubbs catalyst 1a. To a solution of **14** (125 mg, 0.75 mmol, 1.0 equiv) and vinyloxytrimethylsilane (1.12 mL, 7.47 mmol, 10 equiv) in toluene (39 mL) was added at rt Grubbs 2nd generation catalyst **1a** (31.7 mg, 5 mol%). The purple reaction mixture was immersed in an oil bath (129 °C) (color changed to yellow/orange) and refluxed for 16 h. The reaction mixture was then concentrated under reduced pressure to afford the crude disubstituted alkene[30] (163 mg, 93% conversion) as a green oil, which was used in the next step without further purification. $R_f = 0.20$ (hexane/EtOAc, 1:1).

To a biphasic, brown solution of the crude alkene (163 mg, calcd. 125 mg, 0.75 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (2.8 mL), acetonitrile (2.8 mL) and water (4.1 mL) was added at rt $NaIO_4$ (719 mg, 3.36 mmol, 4.5 equiv). The color of the reaction mixture changed immediately to dark brown. After stirring vigorously for 24 h at rt, a black precipitate was formed above the suspension (probably RuO_2). The reaction mixture was then diluted with 3 M NaOH (8 mL), water (30 mL) and $CHCl_3$ (25 mL). The layers were separated and the aqueous layer was extracted with $CHCl_3$ (2 x 30 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl and extracted with $CHCl_3$/*i*PrOH (5:1, 10 x 30 mL). The extraction was continued until no product was left in the aqueous phase according to TLC (in case there was still product left after 10 extractions, the aqueous phase was saturated with solid NaCl and extracted further). The combined organic extracts were washed with a 1:1 mixture of sat. NaH_2PO_4/sat. $Na_2S_2O_3$ (20 mL). The aqueous layer was back extracted with

$CHCl_3$/*i*PrOH (5:1, 2 x 10 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was dissolved in MeOH and filtered over cotton and concentrated *in vacuo*. The crude carboxylic acid (brown/orange) was then suspended in a mixture of aq. 1.0 M NaOH (10 mL), water (15 mL) and Et_2O (25 mL). The layers were separated and the aqueous layer (light yellow) was washed with Et_2O (30 mL) and EtOAc (15 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl, saturated with solid NaCl and extracted with $CHCl_3$/*i*PrOH (8 x 25 mL, checked by TLC). The combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. The residue was dissolved in MeOH and filtered over cotton in a Pasteur pipette to afford the crude carboxylic acid **S17**[31] (121 mg, 95% over 2 steps, crude) as a yellow solid, which was used for the next step without further purification. R_f = 0.19 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot).

To a suspension of the crude acid **S17** (121 mg, 0.71 mmol, 1.0 equiv) in acetonitrile (6.1 mL) was added at rt triethylamine (0.21 mL, 1.48 mmol, 2.1 equiv). After stirring for 5 min at rt and all solids had been dissolved, DPPA (0.17 mL, 0.78 mmol, 1.1 equiv) was added dropwise at 0 °C. After stirring for 5 min at 0 °C, the reaction mixture was allowed to warm to rt over 30 min and was heated at 65 °C for 2.5 h. The yellow reaction mixture was concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 1:1 → 1:2 → 0:1) to afford **16** (59.7 mg, 50%, 47% over 3 steps) as a slightly yellow oil. R_f = 0.55 (EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.67 (brs, 1H), 3.49-3.15 (m, 2H), 2.07-1.74 (m, 6H), 0.99 (t, J = 7.4 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 172.4, 126.9, 63.2, 42.4, 32.5, 32.3, 19.1, 7.9; IR (NaCl): 3627br, 3287br, 2921br, 2228, 1680, 1680, 1538, 1348, 1214, 1179, 1135, 1102, 1049, 991, 972, 941, 896 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_8H_{12}N_2O_2$ $[M+H]^+$: 169.0972, found 169.0971; $[\alpha]^{25}_D$ +51.8° (*c* 0.64, $CHCl_3$).

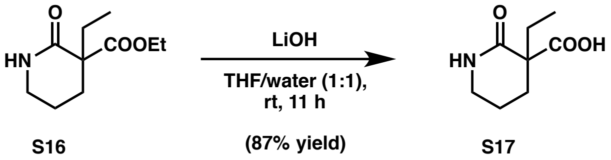


Isocyanate 16 with Grotjahn's catalyst 2. To a solution of **14** (100 mg, 0.60 mmol) in dry acetone-d_6 (0.9 mL) was added at rt Grotjahn's catalyst **2** (7.3 mg, 2.0 mol%) in a nitrogen-filled glovebox. The yellow reaction mixture was sealed and heated to 70 °C for 63 h and was concentrated under reduced pressure to give the crude disubstituted alkene[32] (136 mg, 95% conv.) as a dark brown oil. R_f = 0.20 (hexane/EtOAc, 1:1).

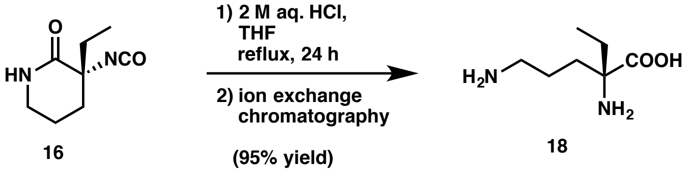
To a biphasic, brown solution of the crude alkene (136 mg, calcd. 100 mg, 0.60 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (2.2 mL), acetonitrile (2.2 mL) and water (3.3 mL) was added at rt $NaIO_4$ (575 mg, 2.69 mmol, 4.5 equiv). The color of the reaction mixture changed immediately to dark brown. After vigorous stirring for 23 h at rt, a black precipitate was formed above the suspension (probably RuO_2). The reaction mixture was then diluted with 3 M NaOH (8 mL), water (30 mL) and $CHCl_3$ (25 mL). The layers were separated and the aqueous layer was extracted with $CHCl_3$ (2 x 30 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl and extracted with $CHCl_3$/*i*PrOH (5:1, 9 x 30 mL). The combined organic extracts were washed with a 1:1 mixture of sat. NaH_2PO_4/sat. $Na_2S_2O_3$ (20 mL). The aqueous layer was back extracted with $CHCl_3$/*i*PrOH (5:1, 2 x 10 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was dissolved in MeOH and filtered over cotton and concentrated *in vacuo*. The crude carboxylic acid (brown/orange) was then suspended in a mixture of aq. 1.0 M NaOH (10 mL), water (15 mL) and Et_2O (25 mL). The layers were separated and the aqueous layer (light yellow) was washed with Et_2O (30 mL) and EtOAc (15 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl, saturated with solid NaCl and extracted with CH_2Cl_2 (2 x 25 mL) and $CHCl_3$/*i*PrOH (8 x 25 mL). The combined organic extracts were dried over $MgSO_4$ and concentrated under reduced pressure. The residue was dissolved in MeOH and filtered over cotton in a Pasteur pipette to afford the crude carboxylic acid **S17** (93.9 mg, 94% over 2 steps, crude) as a yellowish solid, which was thoroughly dried under high vacuum over night. R_f = 0.19 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot).

To a suspension of the crude acid **S17** (93.9 mg, 0.55 mmol, 1.0 equiv) in acetonitrile (4.7 mL) was added at rt triethylamine (0.16 mL, 1.15 mmol, 2.1 equiv). After stirring for 5 min at rt and all solids had been dissolved, DPPA (0.13 mL, 0.60 mmol, 1.1 equiv) was added dropwise at 0 °C. After stirring for 5 min at 0 °C, the reaction mixture was allowed to warm to rt over 25 min and was heated at 65 °C for 2 h. The yellow reaction mixture was concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 1:1 → 1:2 → 0:1) to afford **16** (52.0 mg, 56%, 52% over 3 steps) as a colorless oil. The analytical data were identical to those reported above (*vide supra*). R_f = 0.55 (EtOAc).

Synthesis and Characterization of racemic carboxylic acid (±)-S17:

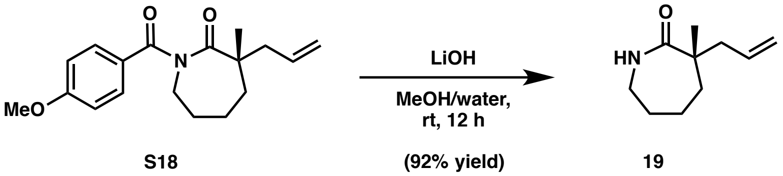


Carboxylic acid (±)-S17. To a solution of 3-ethyl-3-oxo-3-piperidinecarboxylic acid ethyl ester[33] (**16**) (1.02 g, 5.12 mmol, 1.0 equiv) in THF/water (1:1, 26 mL) was added at rt LiOH monohydrate (1.07 g, 25.6 mmol, 5.0 equiv). After stirring for 11 h at rt, the reaction mixture was diluted with 20% aq. KOH (30 mL) and washed with Et_2O (2 x 30 mL) and EtOAc (2 x 30 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M aq. HCl and extracted with $CHCl_3$/*i*PrOH (5:1, 10 x 40 mL). The combined organic extracts were dried over $MgSO_4$, dried and concentrated under reduced pressure to afford **S17** (764 mg, 87%) as a beige solid. An analytically pure sample of **S17** was obtained by triturating 50 mg of the crude acid with CH_2Cl_2 (2 x 5 mL) to furnish a colorless solid. R_f = 0.19 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot); ^{1}H NMR (500 MHz, CD_3OD): δ 4.93 (brs, 1H), 3.38-3.20 (m, 2H), 2.17-2.05 (m, 1H), 2.05-1.95 (m, 1H), 1.95-1.77 (m, 4H), 0.94 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, CD_3OD): δ 176.1, 174.1, 54.8, 43.0, 29.9, 29.8, 20.5, 9.2; IR (NaCl): 3266, 2941, 2497, 1682, 1621, 1492, 1446, 1357, 1326, 1258, 1202, 1100, 980, 740 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_8H_{13}NO_3$ $[M+H]^+$: 172.0968, found 172.0965; mp 117-119 °C.



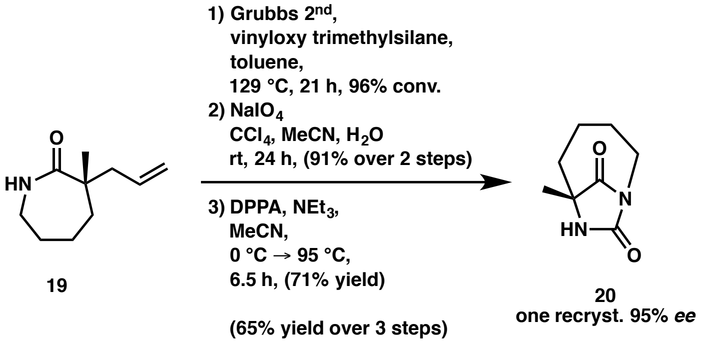
(*R*)-α-ethylornithine (18). A microwave vial was charged with a solution of **16** (63.5 mg, 0.38 mmol, 1.0 equiv) in THF (3.0 ml). Then, 2 M aq. HCl (6.0 mL) was added dropwise at 90 °C to the suspension and the reaction mixture was refluxed at 120 °C for 24 h. The reaction mixture was allowed to cool to rt, was diluted with 1 M aq. HCl (20 mL) and washed with CH_2Cl_2 (3 x 25 mL). The organic layers were discarded and the aqueous layer was concentrated under reduced pressure (80 °C, water bath) to afford a yellow viscous oil. The crude HCl salt was purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH, staining with ninhydrin) to afford (*R*)-α-ethylornithine **18** as a yellow viscous oil. The residue was dissolved in MeOH, filtered over cotton (in a Pasteur pipette) to remove insoluble material (from the resin) and concentrated to 0.5 mL. After adding an excess of acetonitrile, the amino acid precipitated to form a colorless suspension, which was concentrated under reduced pressure. The same procedure (dissolution in MeOH and addition of acetonitrile) was repeated twice to afford (*R*)-α-ethylornithine **18** (57.3 mg, 95%) as highly hygroscopic beige solid. R_f = 0.21 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1); ^{1}H NMR (500 MHz, D_2O): δ 2.88 (brs, 2H), 1.83-1.41 (m, 6H), 0.81 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (126 MHz, D_2O): δ 181.1, 63.0, 39.9, 35.6, 31.8, 23.1, 7.7; IR (KBr):[34] 2965br, 2162, 1569, 1448, 1399, 1320, 1194, 1021, 964, 874, 807 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_7H_{16}N_2O_2$ $[M+H]^+$: 161.1290, found 161.1295; $[\alpha]^{25}_D$ −3.9 ° (*c* 1.615, MeOH); mp 186-187 °C.

Synthesis of allyl amide 19:



Amide 19. To a solution of **S18**[35] (459 mg, 1.52 mmol, 1.0 equiv, 91% *ee*) in MeOH (40 mL) was added at rt an aqueous solution of LiOH (54.7 mg, 2.28 mol, 1.5 equiv) in water (15.9 mL). After stirring for 12 h at rt, MeOH was removed under reduced pressure and the aqueous solution was diluted with sat. $NaHCO_3$ (20 mL) and EtOAc (45 mL). The layers were separated and the aqueous layer was extracted with EtOAc (3 x 30 mL). The combined organic extracts

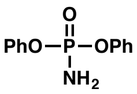
were dried over $MgSO_4$ combined with solid $NaHCO_3$ (in order to remove *p*-methoxy benzoic acid), filtered and the solvent was removed under reduced pressure. The residue was purified by column chromatography (22 x 3 cm, hexane/EtOAc, 2:1, then 1:1) to afford **19** (234 mg, 92%) as a bright yellow oil. R_f = 0.23 (hexane/EtOAc, 1:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.02 (brs, 1H), 5.81 (m_c, 1H), 5.12-4.99 (m, 2H), 3.28 (dddd, *J* = 14.2, 8.4, 5.5, 2.9 Hz, 1H), 3.19 (dtd, *J* = 14.7, 6.6, 3.1 Hz, 1H), 2.43-2.32 (m, 2H), 1.89-1.59 (m, 5H), 1.55 (ddd, *J* = 14.7, 8.9, 3.4 Hz, 1H), 1.19 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 180.6, 134.6, 117.7, 45.0, 42.4 (2C), 34.8, 29.2, 24.3, 24.1; IR (NaCl): 3285, 3218, 3074, 2928, 1645, 1480, 1435, 1416, 1378, 1361, 1336, 1284, 1117, 996, 974, 952, 912, 824 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{10}H_{17}NO$ $[M+H]^+$: 168.1383, found 168.1382; $[\alpha]^{25}_D$ −17.4° (*c* 0.595, $CHCl_3$).



Hydantoin 20. To a solution of **19** (234 mg, 1.40 mmol, 1.0 equiv) and vinyloxytrimethylsilane (2.1 mL, 14.0 mmol, 10 equiv) in toluene (72 mL) was added at rt Grubbs 2nd generation catalyst **1a** (59.4 mg, 5 mol%). The purple reaction mixture was immersed in an oil bath (129 °C) (color changed to yellow/orange) and refluxed for 21 h. The reaction mixture was then concentrated under reduced pressure to afford the crude disubstituted alkene (306 mg, 96% conv.) as a dark brown oil, which formed colorless crystals under high vacuum. The crude was used in the next step without further purification.

To a biphasic, brown solution of the crude product (306 mg, calcd. 234 mg, 1.40 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (5.2 mL), acetonitrile (5.2 mL) and water (7.8 mL) was added at rt $NaIO_4$ (1.35 g, 6.30 mmol, 4.5 equiv). The color of the reaction mixture changed immediately to dark brown. After stirring vigorously for 24 h at rt, the reaction mixture was diluted with 4 M NaOH (5 mL), water (35 mL) and $CHCl_3$ (30 mL). The layers were separated and the aqueous layer was extracted with $CHCl_3$ (2 x 35 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl (pH1) and extracted with $CHCl_3$/*i*PrOH (5:1, 10 x 40 mL). The extraction was continued until no product was left in the aqueous phase according to TLC (in case there was still product left after 10 extractions, the aqueous phase was saturated with solid NaCl and extracted further). The combined organic extracts were washed with a 1:1 mixture of sat. NaH_2PO_4/sat. $Na_2S_2O_3$ (20 mL). The aqueous layer was back extracted with $CHCl_3$/*i*PrOH (5:1, 2 x 20 mL). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was dissolved in MeOH and filtered over cotton and concentrated under reduced pressure to give crude carboxylic acid **S20**[36] (218 mg, 91% over 2 steps) as an orange/beige solid, which was used in the next steps without further purification. R_f = 0.22 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot).

To a suspension of the crude carboxylic acid **S20** (218 mg, 1.27 mmol, 1.0 equiv) in acetonitrile (10.9 mL) was added at rt triethylamine (0.37 mL, 2.67 mmol, 2.1 equiv). After stirring for 5 min, DPPA (0.30 mL, 1.40 mmol, 1.1 equiv) was added at 0 °C and the reaction mixture was allowed to warm to rt over 25 min. After stirring for 2.5 h at 65 °C and for 3.5 h at 94 °C, the yellow reaction mixture was concentrated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 2:1 → 1:1 → 1:2) to afford hydantoin **20**[37] (165 mg, 8% wt/wt diphenylphosphoramidate (**S19**), calcd. 152 mg, 71%, 65% over 3 steps, 91% *ee*) as a colorless crystalline solid. Hydantoin **20** was dissolved in a minimal amount of CH_2Cl_2, overlayed with an excess of hexanes and stored in the freezer to afford enantioenriched product (95% *ee*) as colorless crystals.[38] Analytically pure samples of the hydantoin and of the impurity[39] were obtained by two additional purifications by column chromatography. R_f = 0.56 (EtOAc); R_f = 0.30 (hexane/EtOAc, 1:2); ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.13 (brs, 1H), 3.61 (dd, J = 13.6, 6.9 Hz, 1H), 3.48 (ddd, J = 13.6, 11.5, 5.9 Hz, 1H), 1.97-1.83 (m, 2H), 1.83-1.68 (m, 2H), 1.63-1.53 (m, 1H), 1.49 (s, 3H), 1.47-1.34 (m, 1H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 182.5, 164.2, 65.6, 43.1, 42.3, 25.1, 21.4, 17.0; IR (KBr): 3309, 2940, 1781, 1705, 1458, 1379, 1319, 1293, 1233, 1197, 1176, 1139, 1029, 889, 834, 751 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_8H_{12}N_2O_2$ $[M+H]^+$: 169.0972, found 169.0967; $[\alpha]^{25}_D$ +82.4° (*c* 1.045, $CHCl_3$); mp 137-138 °C; SFC (Daicel Chiracel AD-H, 88:12 CO_2/*i*PrOH, 40 °C, 2.5 mL/min, 210 nm): t_R/min = 3.1 (*S*), 3.5 (*R*).

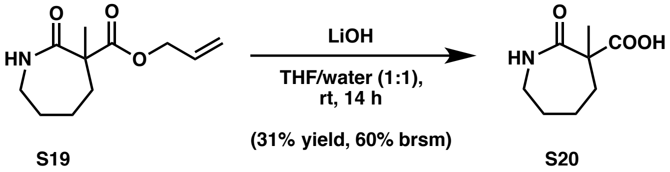


$$\mathrm{PhO{-}\overset{\displaystyle O}{\overset{\|}{\underset{\displaystyle NH_2}{\underset{|}{P}}}}{-}OPh}$$

S19

Diphenylphosphoramidate (**S19**): R_f = 0.30 (hexane/EtOAc, 1:2); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.38-7.31 (m, 4H), 7.29-7.23 (m, 4H), 7.22-7.16 (m, 2H), 3.28 (brs, 2H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 150.7, 129.7, 125.1, 120.3; ^{31}P NMR (121 MHz, $CDCl_3$): δ −0.64; IR (KBr): 3431, 3245, 1594, 1546, 1491, 1256, 1219, 1159, 956, 773 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{12}H_{12}NO_3P$ $[M+H]^+$: 250.0628, found 250.0625; mp 148-149 °C.

Synthesis and Characterization of racemic carboxylic acid (±)-S20:



Carboxylic acid (±)-S20. To a solution of (±)-**S19**[40] (200 mg, 0.95 mmol, 1.0 equiv) in THF/water (1:1, 4.8 mL) was added at rt LiOH monohydrate (199 mg, 4.73 mmol, 5.0 equiv). After stirring for 14 h at rt, the reaction mixture was diluted with 20% aq. KOH (10 mL), water (7 mL) and washed with EtOAc (2 x 30 mL). The organic extracts were concentrated to afford recovered starting material (±)-**S19** (96.2 mg, 48%) as a beige solid. The aqueous layer was acidified with 4 M aq. HCl (to pH1), saturated with solid NaCl and extracted with $CHCl_3$/*i*PrOH (5:1, 4 x 15 mL). The combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure to afford (±)-**S20** (115 mg) as a yellow solid (the viscous oil, which was first formed, was redissolved in CH_2Cl_2 and the solid precipitated with hexanes. The solvent was then removed under reduced pressure. This procedure was repeated 3 times). The impure carboxylic acid was triturated with a minimal amount of cold CH_2Cl_2 (2 x) and dried under high vacuum to afford (±)-**S20** (50.3 mg, 31%, 60% brsm) as a light brown solid. Slow diffusion of hexanes into a solution of the product in MeOH didn't lead to crystallization. X-ray quality crystals were finally obtained at rt by slow evaporation of the solvents. R_f = 0.39 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot); ^{1}H NMR (500 MHz, CD_3OD): δ 4.89 (brs, 1H), 3.18-3.04 (m, 2H), 2.05 (m_c, 1H), 1.97-1.80 (m, 2H), 1.79-1.71 (m, 1H), 1.55 (ddd, J = 14.4, 12.1, 3.6 Hz, 1H), 1.50-1.38 (m, 1H), 1.41 (s, 3H); ^{13}C NMR (126 MHz, CD_3OD): δ 178.5, 176.4, 54.4, 42.7, 35.7, 29.7, 27.1, 26.2; IR (NaCl): 3287br, 2936, 1694, 1632, 1454, 1335, 1282, 1252, 1194, 1132, 1049, 927, 718 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_8H_{13}NO_3$

[M−H]$^-$: 170.0823, found 170.0823; mp 132-133 °C. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525609.

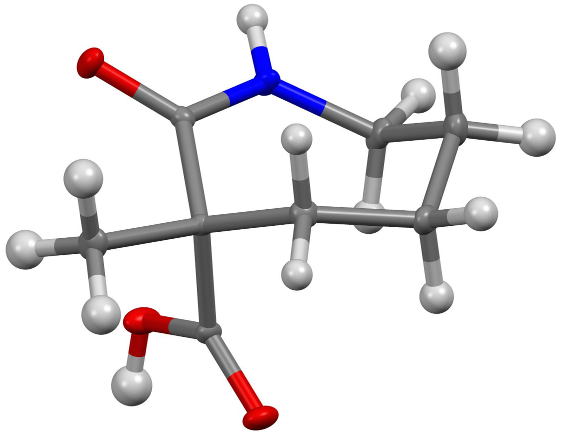
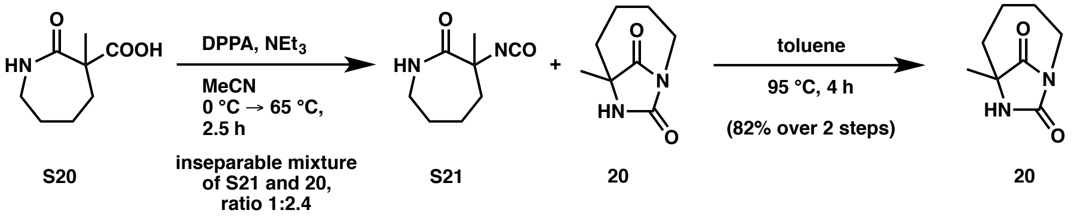


Figure 11: X-ray structure of (±)-**S20** (ellipsoids, 50% probability level).

Alternative procedure for the synthesis of hydantoin (±)-20 and its characterization by X-ray crystallography:



Hydantoin (±)-20. To a suspension of (±)-**S20** (97.7 mg, 0.57 mmol, 1.0 equiv) in acetonitrile (4.9 mL) was added at 0 °C triethylamine (0.17 mL, 1.20 mmol, 2.1 equiv). After stirring for 5 min, DPPA (0.14 mL, 0.63 mmol, 1.1 equiv) was added at 0 °C and the reaction mixture was allowed to warm to rt over 15 min. After stirring for 2 h at 65 °C, the yellow reaction mixture was concentrated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 1:1 → 1:2 → 1:3) to afford an inseparable mixture of the hydantoin (±)-**20** and the isocyanate (±)-**S21** (79.0 mg, 2.4:1, calcd. 58% hydantoin, 24% isocyanate,) as a colorless crystalline solid. $R_f = 0.56$ (EtOAc, one spot for hydantoin and isocyanate).

A solution of the crude product (79.0 mg, 0.47 mmol, 1.0 equiv, mixture, 2.4:1 mixture of hydantoin/isocyanate) in toluene (7.7 mL) was heated at 95 °C for 4 h under argon. The colorless solution was concentrated to afford hydantoin (±)-**20** (79.5 mg, quant., 82% over 2 steps) as a colorless, crystalline solid. X-ray quality crystals were grown by slow diffusion of heptane (with a few drops of benzene) into a solution of the mixture in EtOAc at rt. The analytical data were identical to those reported above (*vide supra*). $R_f = 0.56$ (EtOAc). The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525604.

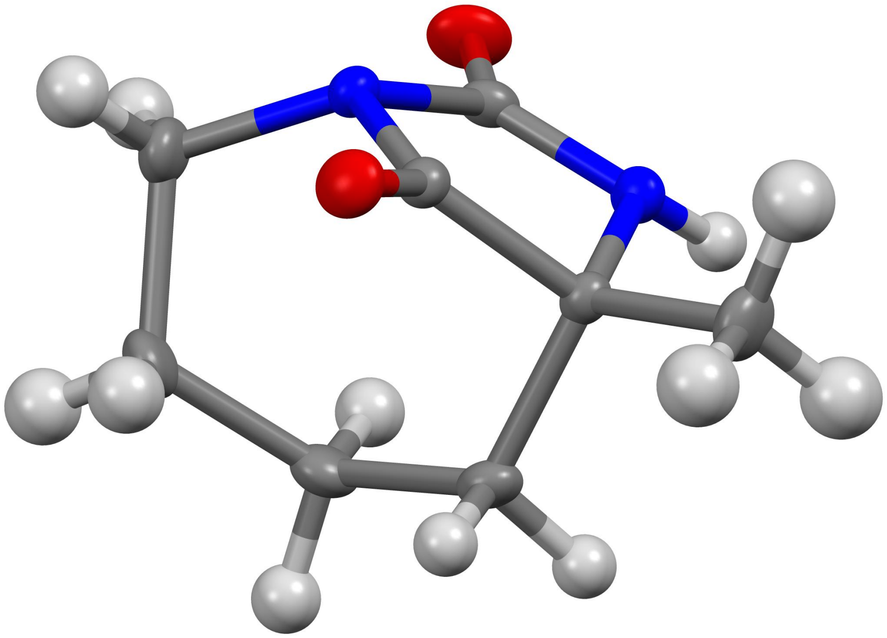
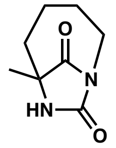


Figure 12: X-ray structure of (±)-**20** (ellipsoids, 50% probability level).

Dunitz-Winkler distortion parameters, selected bond length and angles of the *anti*-Bredt hydantoin X-ray structure (±)-20:

	C5C6N1C8	N1C8N2H2N	N2C8N1C1	formamide (planar)	formamide (perpendicular)
ω_1	–15.7°	161.7°	–129.6°	-	-
ω_2	–57.1°	–163.0°	–179.9°	-	-
ω_3	173.1°	–19.4°	51.4°	-	-
ω_4	114.1°	18.1°	–0.9°	-	-
X_C	–8.8°	1.1°	–1.0°	0.0°	0.0°
X_N	–50.2°	36.4°	–51.3°	0.0°	63.4°
τ	–36.4°	0.65°	25.2°	0.0°	90.0°
Σ angles at N	337.4°	348.1°	337.4°	360°	-
N-C(O) (Å)	1.4038	1.3490	1.4167	1.349	1.423
C=O (Å)	1.2098	1.2227	1.2227	1.193	1.179

Parameters for formamide adapted from: Tani, K.; Stoltz, B. M. *Nature* **2006**, *44*, 731-734.
For a definition of the distortion parameters see: Dunitz, J. D.; Winkler, F. K. *Acta Cryst.* **1975**, *B31*, 251.



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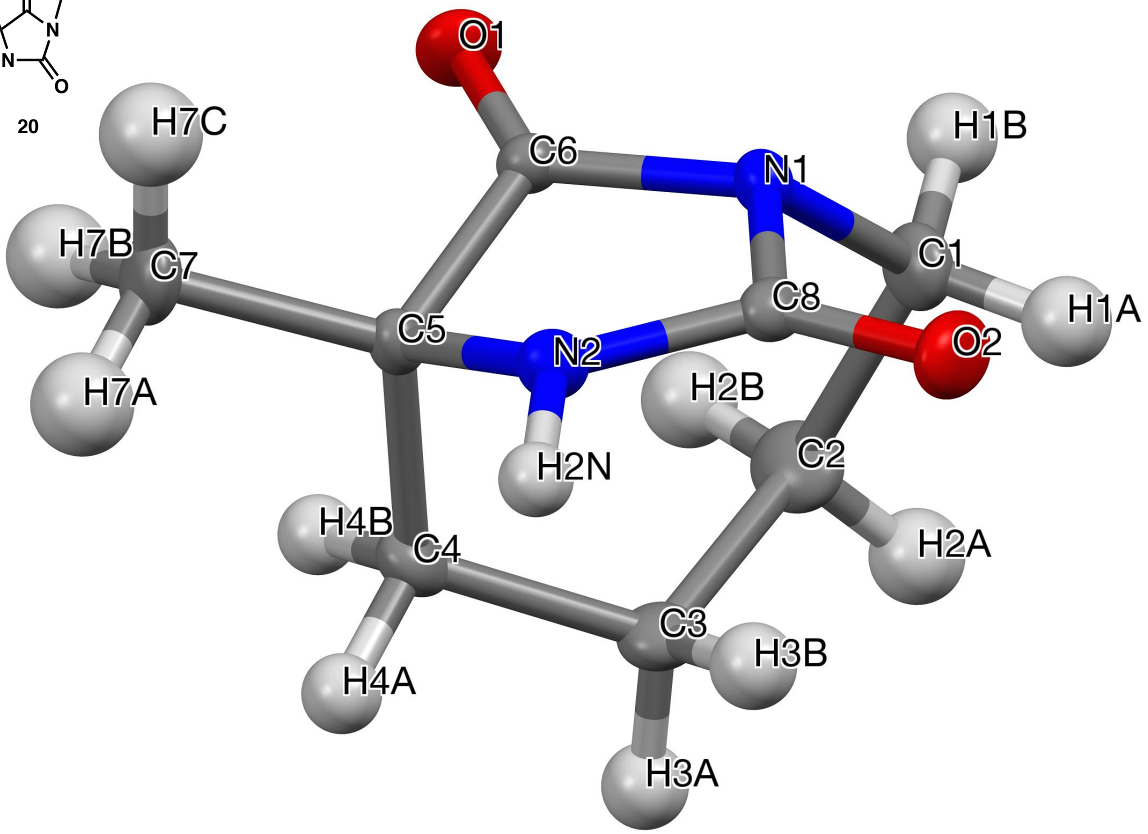
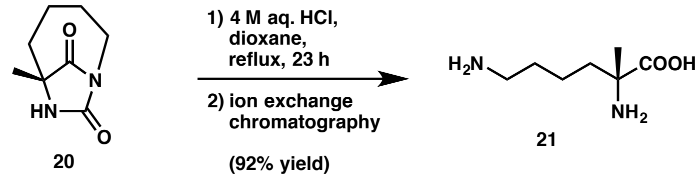
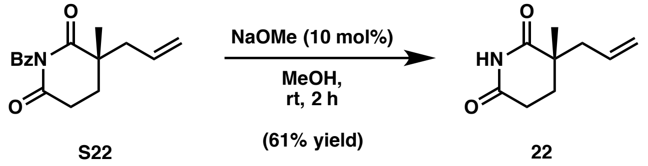


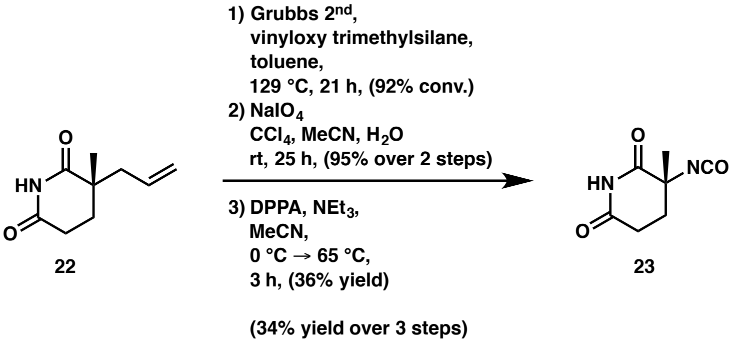


(*R*)-α-Methyl-lysine (21). To a microwave vial charged with a solution of **20** (57.1 mg, 0.34 mmol, 1.0 equiv) in dioxane (3.0 ml) was added at rt 4 M aq. HCl (3.0 mL). After refluxing for 23 h at 120 °C, the reaction mixture was allowed to cool to rt, was diluted with water (10 mL) and washed with CH_2Cl_2 (3 x 30 mL). The combined organic extracts were discarded. The aqueous layer was directly purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH, staining with ninhydrin) and lyophilized to give (*R*)-α-methyl-lysine (**21**) as a colorless solid. The residue was dissolved in MeOH, filtered over cotton (in a Pasteur pipette) and concentrated to ca. 0.2 mL. After adding an excess of acetonitrile, the amino acid precipitated to give a colorless suspension, which was concentrated under reduced pressure. The same procedure (dissolution in MeOH and addition of acetonitrile) was repeated twice to give (*R*)-α-methyl-lysine (**21**) (52.4 mg, 92%) as a colorless solid. R_f = 0.13 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1); ^{1}H NMR (500 MHz, D_2O): δ 3.00-2.84 (m, 2H), 1.80 (ddd, *J* = 14.2, 12.4, 4.6 Hz, 1H), 1.72-1.55 (m, 3H), 1.45-1.31 (m, 1H), 1.37 (s, 3H), 1.29-1.12 (m, 1H); ^{13}C NMR (126 MHz, D_2O): δ 184.0, 60.9, 41.2, 40.8, 29.8, 26.6, 22.6; IR (KBr): 3421, 3331, 3080, 2937, 2861, 2586, 1608, 1547, 1406, 1364, 1314, 1273, 1162, 951 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_7H_{16}N_2O_2$ $[M+H]^+$: 161.1285, found 161.1280; $[\alpha]^{25}_D$ −15.5° (*c* 0.85, 4M HCl); mp 192-202 °C (decomposition). Lit.[41] (*R*)-**21**: $[\alpha]_D$ −8.42° (*c* 0.8, 4N HCl), mp 134-137 °C (dec.); (*S*)-**21**: $[\alpha]_D$ +9.08° (*c* 0.98, 4N HCl), mp 123-125 °C (dec.).

Synthesis of allyl imide 22:



Imide 22. To a solution of **S22**[42] (2.24 g, 8.25 mmol, 1.0 equiv) in dry MeOH (98 mL) was added at rt a solution of NaOMe (44.6 mg, 10 mol%) in MeOH (5.0 mL). After stirring for 2 h at rt, the reaction mixture was concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 3:1 → 2:1 → 1:1) to afford **22** (845 mg, 61%) as a colorless crystalline solid. R_f = 0.14 (hexane/EtOAc, 4:1); R_f = 0.53 (hexane/EtOAc, 1:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.99 (brs, 1H), 5.73 (ddt, *J* = 17.3, 10.1, 7.2 Hz, 1H), 5.20-5.07 (m, 2H), 2.71-2.56 (m, 2H), 2.49 (dd, *J* = 14.0, 7.1 Hz, 1H), 2.32 (dd, *J* = 13.8, 7.7 Hz, 1H), 1.97 (m_c, 1H), 1.73 (m_c, 1H), 1.27 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 177.2, 172.4, 132.3, 119.6, 41.6, 41.0, 28.7 (2C), 22.6; IR (KBr): 3198, 3084, 2974, 2940, 2875, 1735, 1676, 1452, 1415, 1381, 1358, 1341, 1289, 1205, 995, 919, 867 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_9H_{13}NO_2$ $[M+H]^+$: 168.1024, found 168.1044; $[\alpha]^{25}_D$ −29.0° (*c* 1.04, $CHCl_3$); mp 110-112 °C.



Isocyanate 23. To a solution of **22** (502 mg, 3.00 mmol, 1.0 equiv) and vinyloxytrimethylsilane (4.5 mL, 30.0 mmol, 10 equiv) in toluene (153 mL) was added at rt Grubbs 2nd generation catalyst **1a** (127 mg, 5 mol%). The purple reaction mixture was immersed in an oil bath (129 °C)

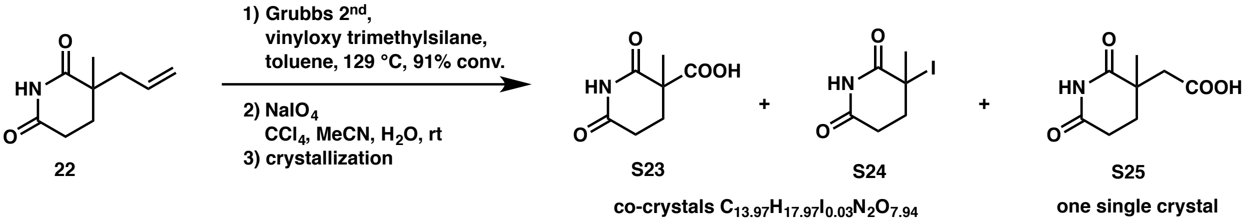
(color changed to yellow/orange) and refluxed for 21 h. The reaction mixture was then concentrated under reduced pressure to afford the crude disubstituted alkene (692 mg, 92% conversion) as a dark brown oil, which was used in the next step without further purification.

To a biphasic, brown solution of the crude alkene (692 mg, calcd. 502 mg, 3.00 mmol, 1.0 equiv) in a mixture of carbon tetrachloride (11 mL), acetonitrile (11 mL) and water (17 mL) was added at rt $NaIO_4$ (2.89 g, 13.5 mmol, 4.5 equiv). After stirring vigorously for 25 h at rt, the reaction mixture was diluted with sat. NaH_2PO_4 (30 mL), sat. $Na_2S_2O_3$ (30 mL), water (20 mL) and CH_2Cl_2 (60 mL). The layers were separated and the aqueous layer was washed with a mixture of CH_2Cl_2 (4 x 50 mL). The combined organic extracts were discarded. The aqueous layer was acidified with 4 M HCl (pH 1) and extracted with $CHCl_3$/*i*PrOH (5:1, 3 x 50 mL). The aqueous layer was then saturated with solid NaCl and extracted further with $CHCl_3$/*i*PrOH (5:1, >10 x 120 mL) until TLC indicated complete extraction of the product. (If too much NaCl was added, an emulsion was formed. In this case, additional water was added until the layers separated). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The crude was dissolved in MeOH (some insoluble sulfur precipitated), filtered over a plug of Celite in a Pasteur pipette and the filtrate was concentrated *in vacuo* to afford the crude carboxylic acid **S23** (600 mg, >>100%) as an orange sticky oil.

The crude carboxylic acid **S23** (600 mg) was dissolved in sat. NaH_2PO_4 (15 mL), sat. $Na_2S_2O_3$ (15 mL), water (7 mL) and extracted with $CHCl_3$/*i*PrOH (5:1, ca. 10 x 50 mL) until TLC indicated complete extraction of the product (after 5 extractions, solid NaCl was added to saturate the aqueous layer). The combined organic extracts were dried over $MgSO_4$ and the solvent was removed under reduced pressure. The crude acid was dissolved in MeOH (some insoluble sulfur precipitated), filtered over cotton in a Pasteur pipette and the filtrate was concentrated under reduced pressure. The oily residue was dissolved in a minimal amount of CH_2Cl_2 and the solids were precipitated by the addition of an excess of hexanes. The solvents were then removed under reduced pressure. The aforementioned procedure was then repeated three times. The solid residue was thoroughly dried under high vacuum over night to give the crude carboxylic acid **S23**[43] (489 mg, 95% over 2 steps, crude) as a beige solid, which was used for the next step without further purification. R_f = 0.20 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot).

To a suspension of the crude acid (489 mg, 2.86 mmol, 1.0 equiv) in acetonitrile (27 mL) was added at 0 °C triethylamine (0.42 mL, 3.00 mmol, 1.05 equiv). After stirring for 5 min at 0 °C, DPPA (0.65 mL, 3.00 mmol, 1.05 equiv) was added at 0 °C and the reaction mixture was allowed to warm to rt over 30 min. After stirring for 2.25 h at 65 °C, the yellow reaction mixture was concentrated under reduced pressure. The crude was purified by column chromatography (hexane/EtOAc, 4:1 → 3:1 → 2:1 → 1:1) to afford **23** (171 mg, 36%, 34% over 3 steps) as a colorless crystalline solid. R_f = 0.44 (hexane/EtOAc, 1:1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.24 (s, 1H), 2.80 (dt, J = 18.4, 5.7 Hz, 1H), 2.65 (ddd, J = 18.4, 9.9, 5.5 Hz, 1H), 2.17 (ddd, J = 14.0, 9.9, 5.5 Hz, 1H), 2.02 (dt, J = 14.0, 5.7 Hz, 1H), 1.66 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 171.9, 170.7, 127.6, 58.9, 32.0, 29.1, 25.5; IR (KBr): 3214, 3102, 2989, 2930, 2867, 2251, 1740, 1692, 1420, 1388, 1353, 1334, 1289, 1223, 1204, 1120, 900, 856 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_7H_8N_2O_3$ $[M+H]^+$: 169.0613, found 169.0589; $[\alpha]^{25}_D$ +75.8° (c 1.03, $CHCl_3$); mp 113-114 °C.

Characterization of the racemic carboxylic acid (±)-S23:



Carboxylic acid (±)-S23 was prepared according to the sequential ruthenium catalysis procedure described above. Analytical data for (±)-**S23**: R$_f$ = 0.20 (EtOAc/MeOH/0.5% AcOH, 20:1, broad spot); ^{1}H NMR (500 MHz, CD$_3$OD): δ 2.66-2.54 (m, 2H), 2.31 (dt, *J* = 13.9, 4.9 Hz, 1H), 1.99 (ddd, *J* = 13.9, 10.2, 6.8 Hz, 1H), 1.48 (s, 3H); ^{13}C NMR (126 MHz, CD$_3$OD): δ 175.0, 174.8, 174.6, 51.3, 30.6, 30.4, 21.3; IR (KBr): 3245br, 3085br, 2942, 2573, 1718, 1454, 1663, 1454, 1378, 1349, 1300, 1262, 1200, 1124, 935, 894, 803, 715, 617 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_7H_9NO_4$ [M+H]$^+$: 172.0610, found 172.0604; mp 121-123 °C. X-ray quality crystals were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the crude product in EtOAc. The desired carboxylic acid (±)-**S23** co-crystallized with a minor amount (1.5%) of an alkyliodide side product (±)-**S24**. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525607.

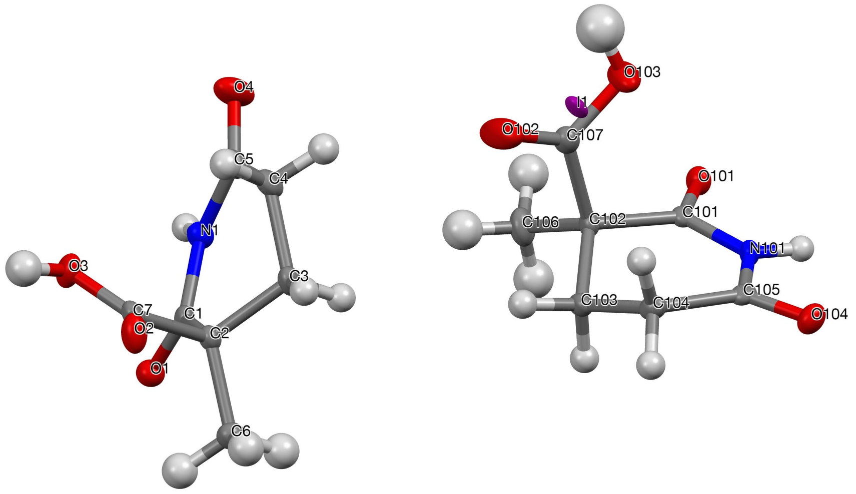


Figure 13: X-ray co-crystal structure of (±)-**S23** and (±)-**S24** (ellipsoids, 50% probability level).

Moreover, a single crystal was isolated, which was identified as the CH_2 elongated minor carboxylic acid (±)-**S25** (derived from oxidative cleavage of remaining (±)-**22**). The X-ray structure was not refined due to impurities.

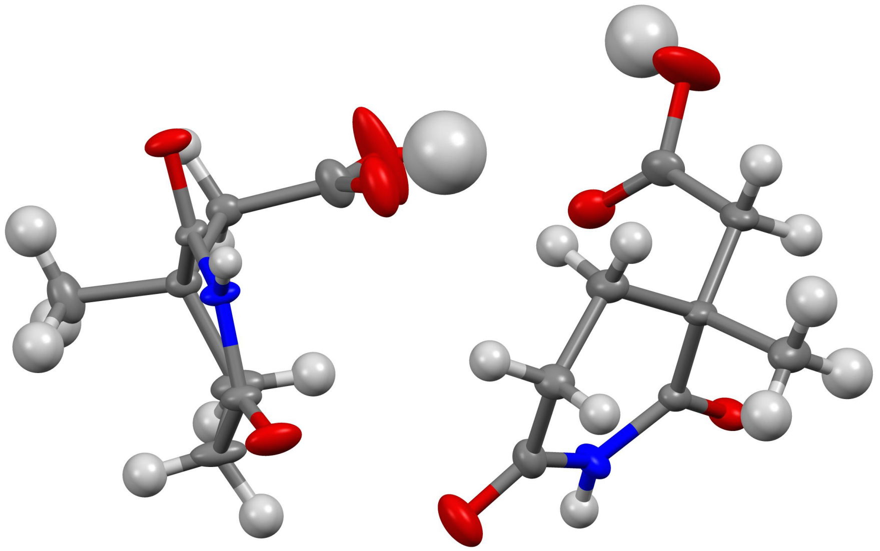
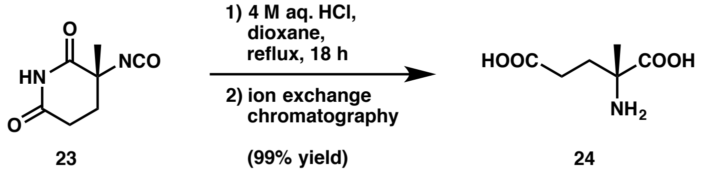
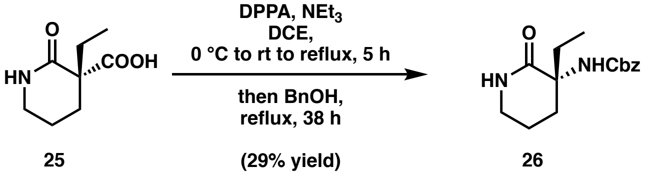


Figure 14: X-ray structure of (±)-**25** (ellipsoids, 50% probability level).



(*R*)-α-Methylglutamic acid (24). To a microwave vial charged with a solution of **23** (61.0 mg, 0.36 mmol, 1.0 equiv) in dioxane (3.2 mL) was added at rt 4 M aq. HCl (3.2 mL). After refluxing for 18 h at 120 °C, the reaction mixture was allowed to cool to rt, was diluted with water (10 mL) and washed with Et_2O (3 x 25 mL). The combined organic extracts were discarded. The aqueous layer was directly purified by ion exchange chromatography (Dowex 50WX8-200, 200 mesh, Aldrich, 217506-500 g, hydrogen form, 20 g, elution with ca. 2 M NH_4OH)[44] and lyophilized to give (*R*)-α-methylglutamic acid (**24**) as a colorless solid. The residue was dissolved in MeOH, filtered over cotton (in a Pasteur pipette) and concentrated to ca. 0.2 mL.

After adding an excess of acetonitrile, the amino acid precipitated to give a colorless suspension, which was concentrated under reduced pressure. The same procedure (dissolution in MeOH and addition of acetonitrile) was repeated twice to give (*R*)-α-methylglutamic acid (**24**) (58.1 mg, 99%) as a colorless solid. R_f = 0.48 (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1, very faint orange spot with ninhydrin); ^{1}H NMR (400 MHz, D_2O): δ 2.40-2.17 (m, 2H), 2.15-1.92 (m, 2H), 1.49 (s, 3H); ^{13}C NMR (101 MHz, D_2O): δ 181.3, 176.6, 61.0, 33.4, 32.4, 22.4; IR (KBr): 3421br, 3040br, 1579br, 1458, 1340, 1309, 1264, 1130, 897, 826, 791 cm^{-1}; HRMS (MM: ESI-APCI−) m/z calc'd for $C_6H_{11}NO_4$ [M-H]$^-$: 160.0615, found 160.0616; $[\alpha]^{25}_D$ −8.1° (*c* 1.155, 4M HCl); mp 155-165 °C. Lit. $[\alpha]^{21}_D$ −11.5° (*c* 4, 6N HCl),[45] mp 183-184 °C;[27] $[\alpha]^{rt}_D$ −12.1° (*c* 3.24, 5N HCl);[46] mp 169-172 °C.[47]



Carboxybenzylamine 26. To a suspension of the crude carboxylic acid **25**[48] (192 mg, 1.12 mmol, 1.0 equiv, crude) in 1,2-dichloroethane (10 mL) was added at rt triethylamine (0.33 mL, 2.36 mmol, 2.1 equiv). Once all solids had been dissolved, DPPA (0.27 mL, 1.23 mmol, 1.1 equiv) was added dropwise at 0 °C. After stirring for 5 min at 0 °C, the reaction mixture was allowed to warm to rt over 2.5 h and was refluxed (85 °C oil bath) for 2.25 h. After the yellow reaction mixture had cooled to rt, benzyl alcohol (0.16 mL, 1.57 mmol, 1.4 equiv) was added. After refluxing for 38 h, the reaction mixture concentrated under reduced pressure. The residue was purified by column chromatography (hexane/EtOAc, 1:1 → 1:2 → EtOAc) to afford **26** (91.2 mg, 29%, 27% over 3 steps including the sequential ruthenium catalysis, 98% *ee*) as an orange solid. R_f = 0.54 (EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.38-7.26 (m, 5H), 6.33

(brs, 1H), 5.70 (brs, 1H), 5.12-4.99 (m, 2H), 3.38 (brs, 1H), 3.31-3.17 (m, 1H), 2.27 (brs, 2H), 2.06-1.76 (m, 4H), 0.92 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 173.9, 155.3, 136.5, 128.4, 127.9 (2C), 66.4, 58.5, 42.1, 30.4, 29.9, 19.8, 7.9; IR (KBr): 3331, 3232, 3067, 3032, 2969, 2868, 1723, 1664, 1529, 1454, 1328, 1281, 1255, 1211, 1096, 1009, 911, 782, 740 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{15}H_{20}N_2O_3$ $[M+H]^+$: 277.1547, found 277.1538; $[\alpha]^{25}_D$ +0.2° (*c* 1.05, $CHCl_3$); mp 105-106 °C; SFC (Daicel Chiracel AD-H, 80:20 CO_2/*i*PrOH, 40 °C, 2.5 mL/min, 210 nm): t_R/min = 5.6 (*R*), 6.9 (*S*). During the racemic synthesis, X-ray quality crystals of (±)-**26** were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the product in EtOAc. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525606.

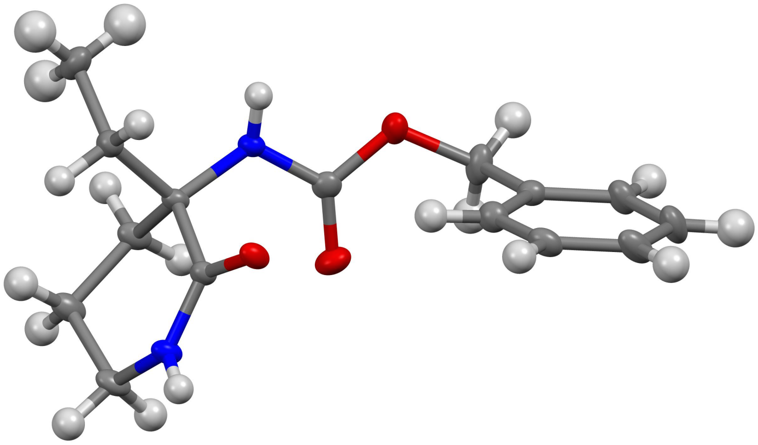
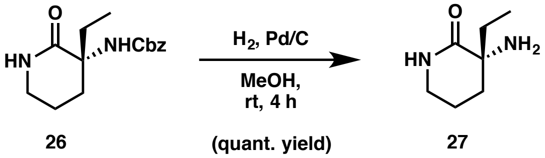


Figure 15: X-ray structure of (±)-**26** (ellipsoids, 50% probability level).



Amine 27. To a solution of **26** (101 mg, 0.37 mmol, 1.0 equiv) in MeOH (3.0 mL) was added at rt Pd/C (8.9 mg, 10% wt/wt Pd, 2 mol%). The heterogeneous, black suspension was vigorously

stirred under a hydrogen atmosphere (balloon) for 4 h, filtered over Celite and concentrated under reduced pressure to afford **27** (52.8 mg, quant.) as a colorless, crystalline solid. $R_f = 0.41$ (n-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1, ninhydrin); ^1H NMR (500 MHz, $CDCl_3$): δ 5.90 (brs, 1H), 3.30 (m_c, 2H), 1.97-1.89 (m, 1H), 1.84 (m_c, 2H), 1.77-1.57 (m, 5H), 0.92 (t, J = 7.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$): δ 177.6, 42.7, 42.7, 32.5, 32.2, 19.5, 7.7; IR (KBr): 3372, 3274, 3190, 3057, 2957, 2873, 1653, 1491, 1412, 1350, 1282, 1203, 1104, 989, 902, 855, 819 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_7H_{14}N_2O$ $[M+H]^+$: 143.1179, found 143.1178; $[\alpha]^{25}_D$ +43.9° (c 0.806, $CHCl_3$); mp 86-87 °C. During the racemic synthesis, X-ray quality crystals of (±)-**27** were obtained at rt by slow diffusion of heptane (with a few drops of benzene) into a solution of the product in EtOAc. The X-ray structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC) under the deposition number 1525605.

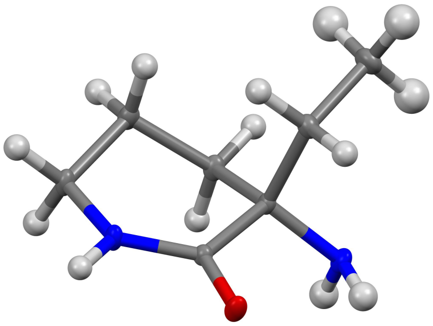
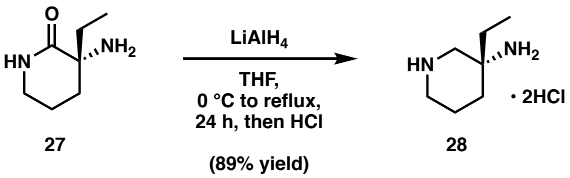
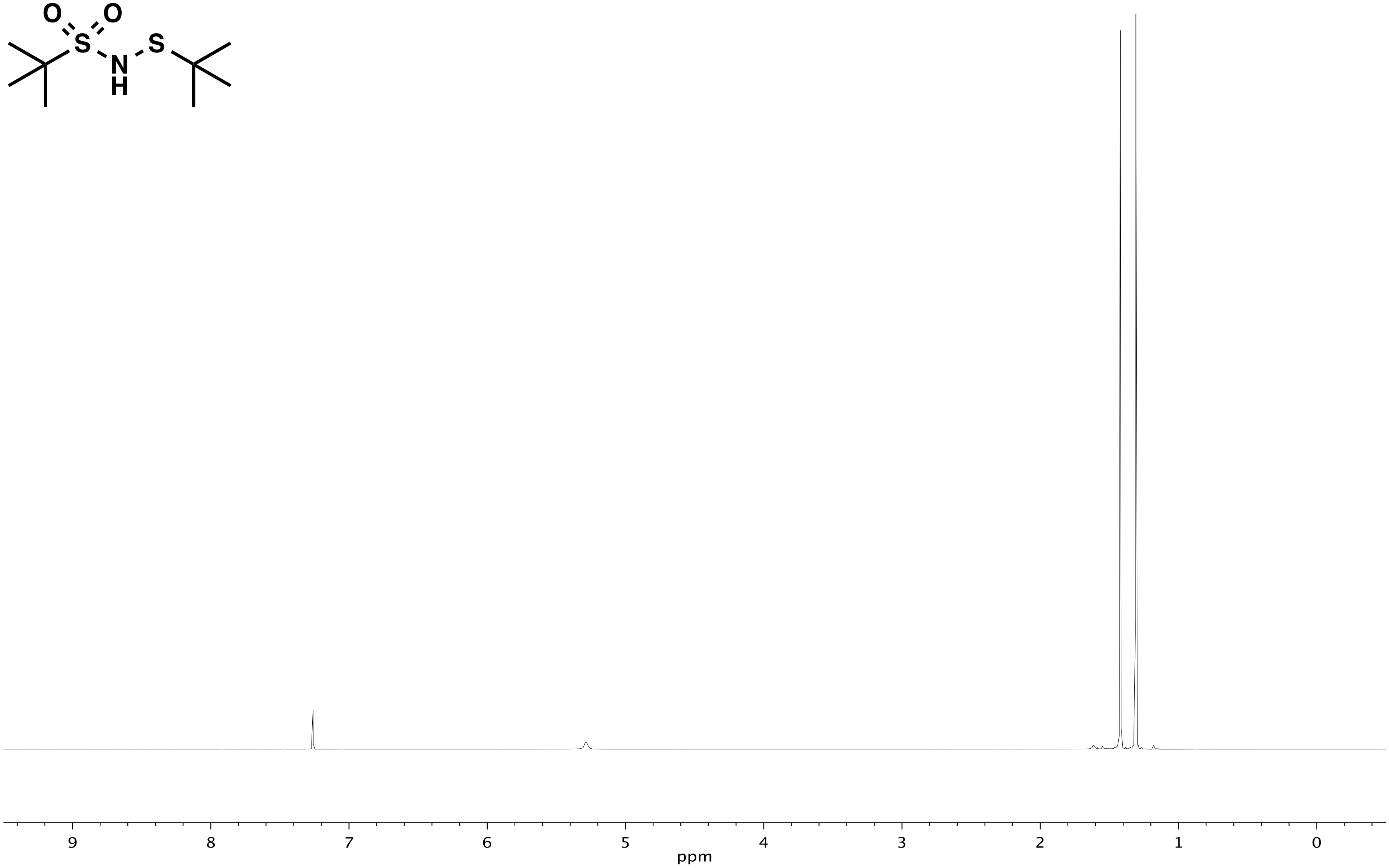


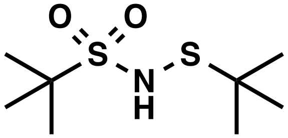
Figure 16: X-ray structure of (±)-**27** (ellipsoids, 50% probability level).

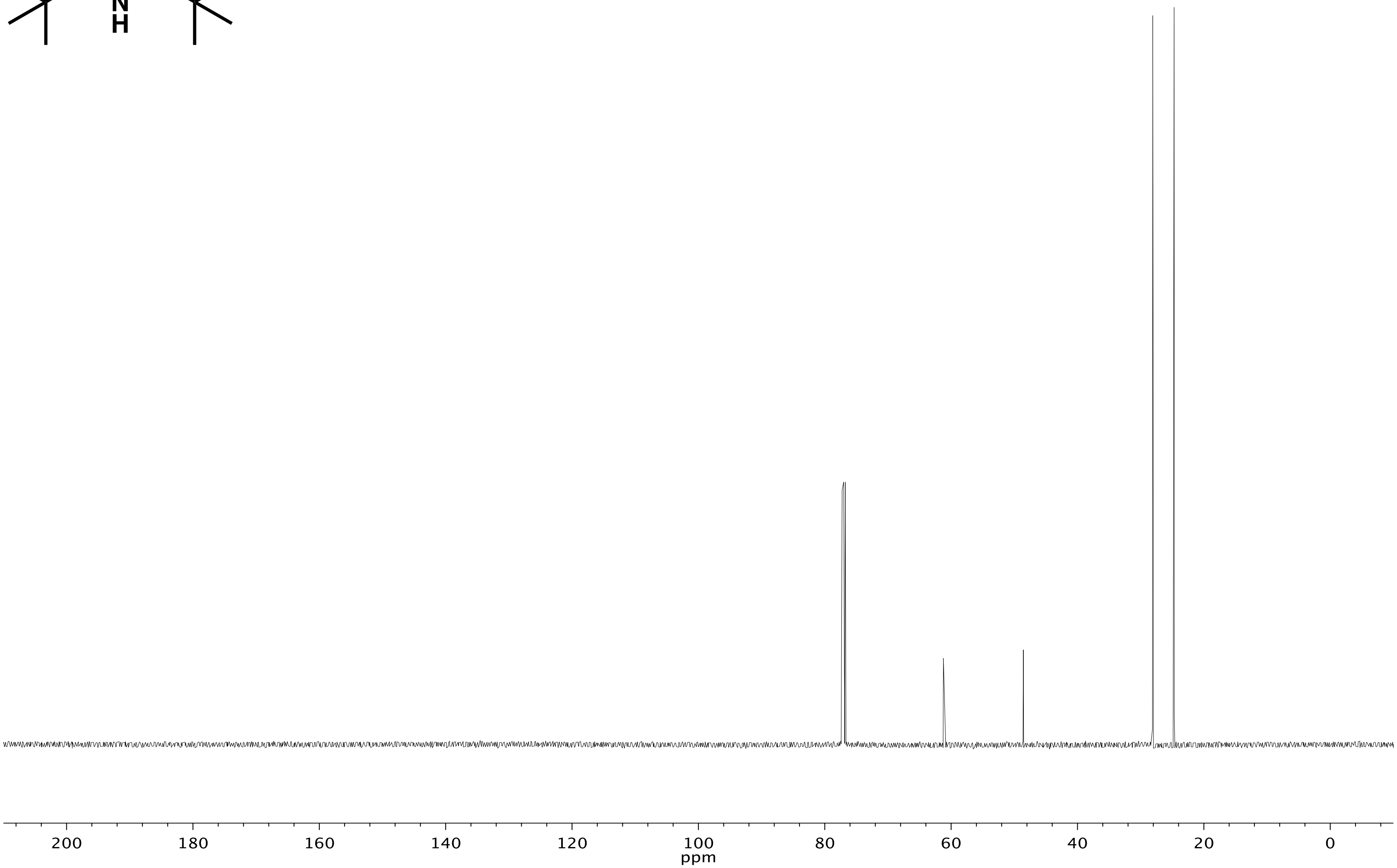


Diamine dihydrochloride 28. To a solution of **27** (41.6 mg, 0.29 mmol, 1.0 equiv) in THF (4.2 mL) was added cautiously at 0 °C $LiAlH_4$ (55.5 mg, 1.46 mmol, 5.0 equiv). After refluxing for 24 h, the heterogeneous reaction mixture was allowed to cool to rt, quenched cautiously at 0 °C with sat. K_2CO_3 (15 mL), 6 M NaOH (ca. 3 mL) and diluted with CH_2Cl_2 (15 mL). The suspension was allowed to warm to rt (in case it would be still an emulsion, more 6 M NaOH was added) and the formed biphasic solution was extracted with $CHCl_3$/*i*PrOH (5:1, 6 x 20 mL). The combined organic extracts were washed with sat. K_2CO_3 (15 mL) and the aqueous layer was back extracted once with $CHCl_3$/*i*PrOH (5:1, 20 mL). The combined organic extracts were dried over $MgSO_4$ and concentrated to ca. 0.7 mL (mainly *i*PrOH). To this yellow solution was added dropwise at rt HCl (0.4 mL, ca. 5.5 equiv, 4.0 M solution in dioxane). After stirring for 5 min at rt, the solution was concentrated to near dryness and treated under vigorous stirring with 2 mL of MeCN (the solution didn't turn turbid) and then with an excess of Et_2O (stored in the freezer over night). The colorless solution was decanted off with a Pasteur pipette. The gummy yellow residue was then washed with Et_2O (2 x 3 mL), concentrated under reduced pressure (50 °C) and dried under high vacuum to give **28** (52.0 mg, 89%) as a bright yellow, highly hygroscopic solid. $R_f = 0.11$ (*n*-BuOH/H_2O/EtOAc/AcOH, 1:1:1:1, ninhydrin, orange spot); ^1H NMR (500 MHz, CD_3OD): δ 3.46 (d, $J = 13.4$ Hz, 1H), 3.30 (d, $J = 13.6$ Hz, 1H), 3.30-3.15 (m, 2H), 2.15-1.84 (m, 4H), 1.90 (q, $J = 7.5$ Hz, 2H), 1.05 (t, $J = 7.6$ Hz, 3H); ^{13}C NMR (126 MHz, CD_3OD): δ 55.0, 49.0, 44.5, 30.6, 28.8, 19.0, 6.8; IR (KBr):[49] 3403br, 2944br, 2832br, 2595br, 2054br, 1596, 1528, 1458, 1309, 1074, 1041, 1021, 952, 872 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_7H_{16}N_2$ $[M+H]^+$: 129.1391, found 129.1388; $[\alpha]^{25}_D$ −11.4° (*c* 2.45, MeOH); mp 120-168 °C.[50]

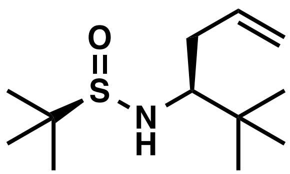
NMR Spectra

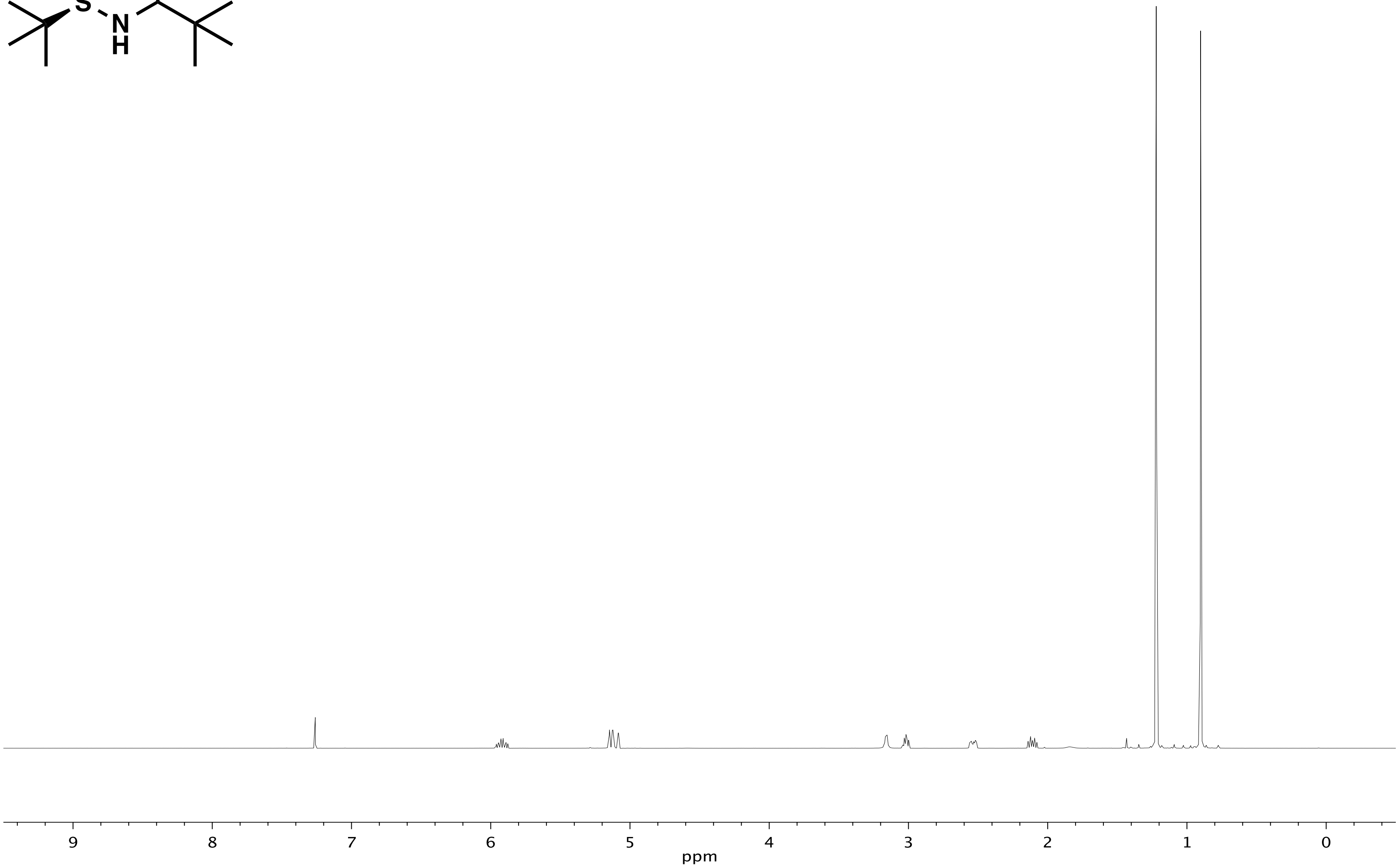




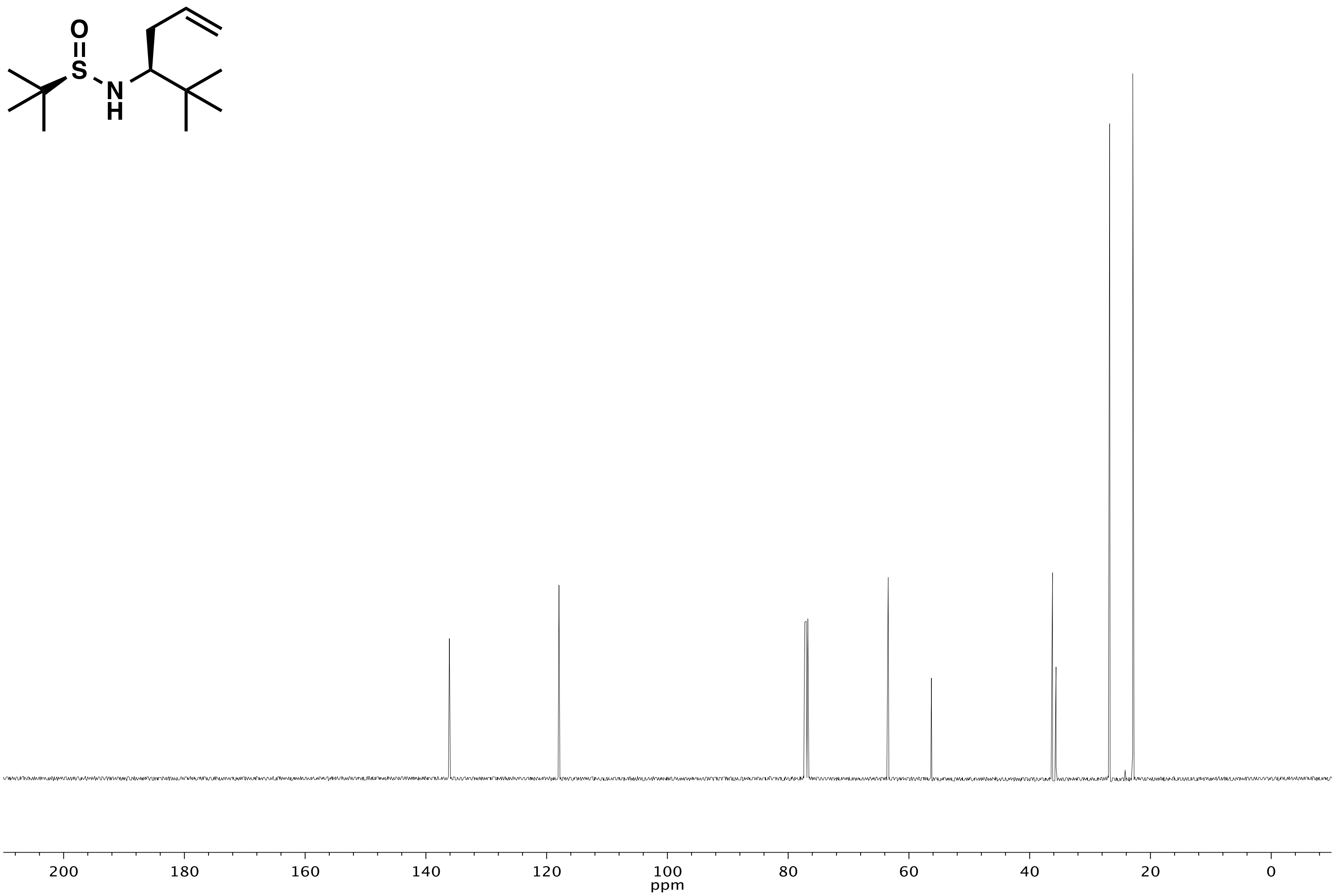


^{13}C NMR (126 MHz, CDCl$_3$) of compound **S4.**

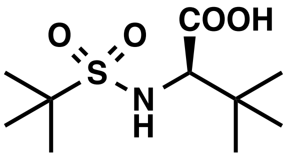


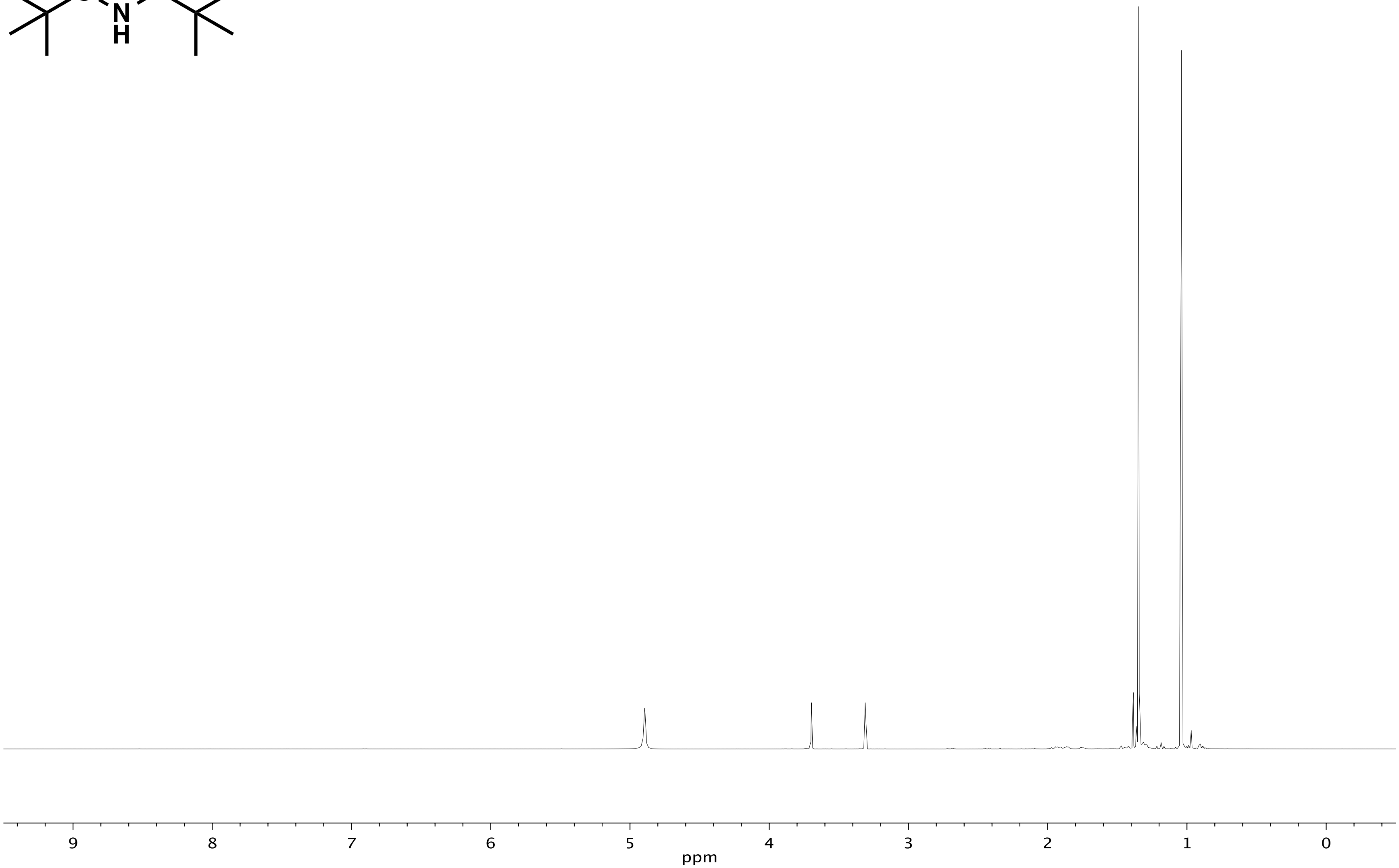


^{1}H NMR (500 MHz, CDCl$_3$) of compound **3**.

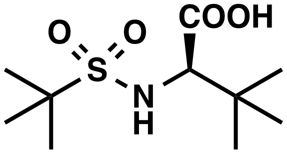


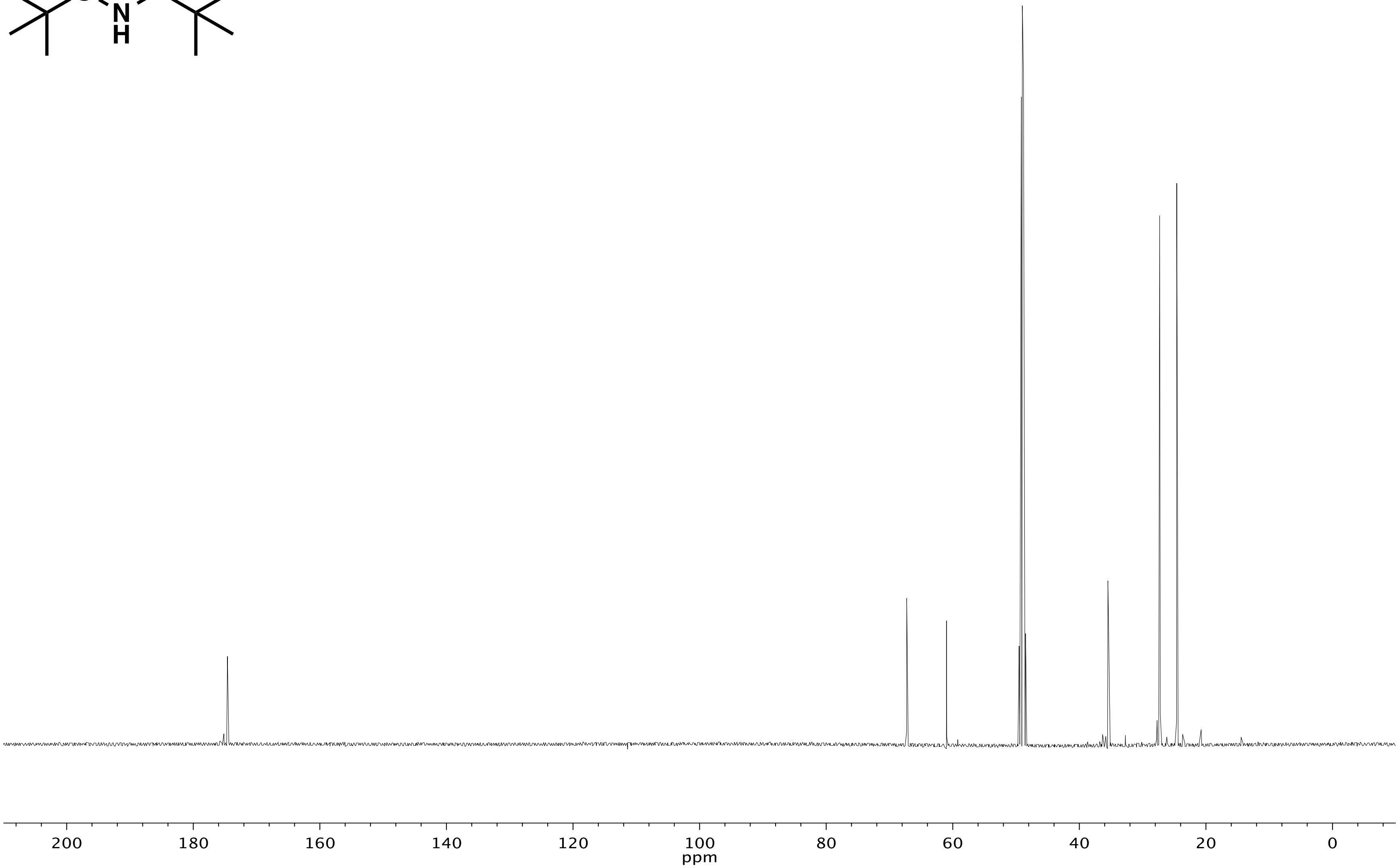
^{13}C NMR (126 MHz, CDCl$_3$) of compound **3.**



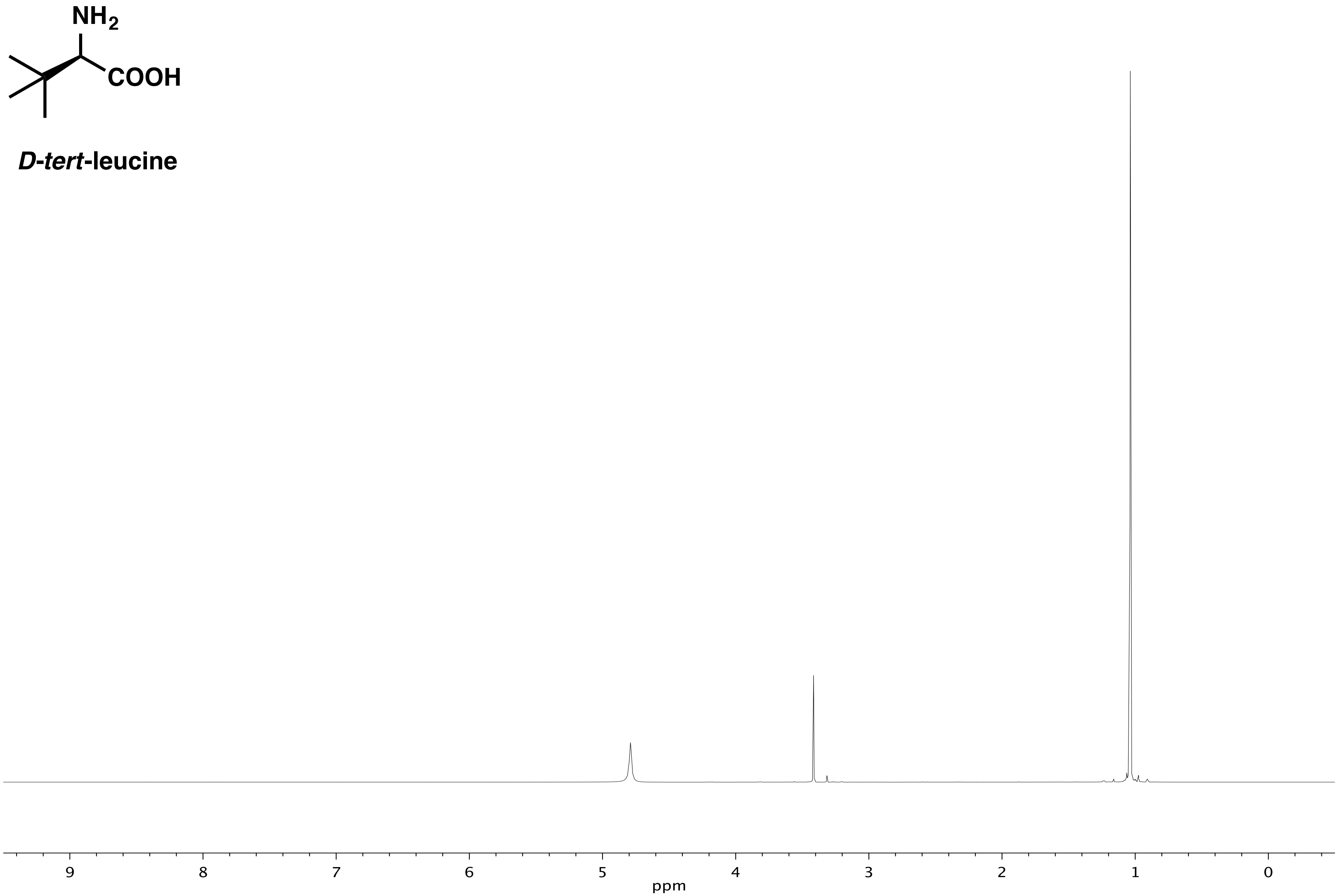


^{1}H NMR (500 MHz, CD$_3$OD) of compound **4**.



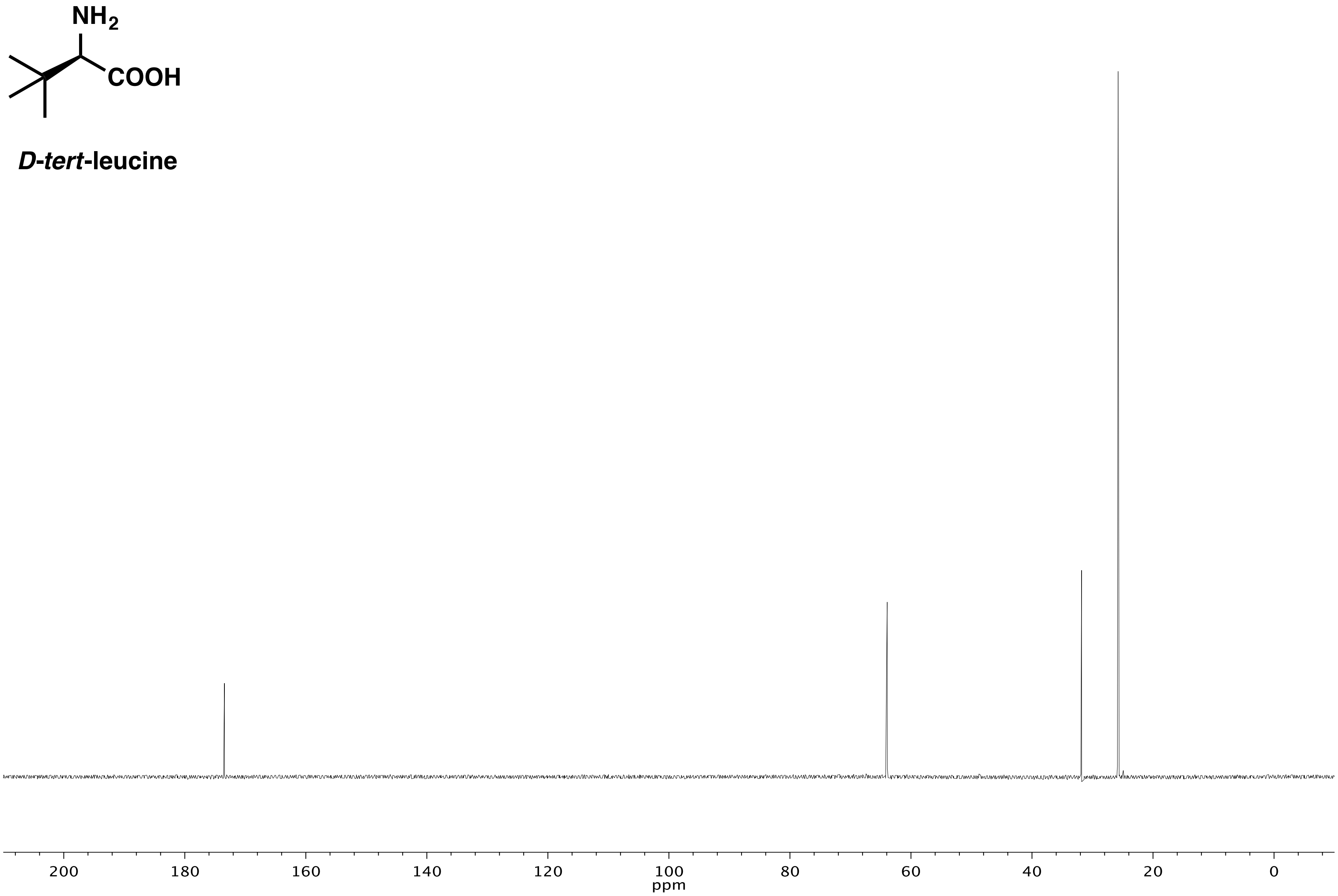


^{13}C NMR (126 MHz, CD$_3$OD) of compound **4.**

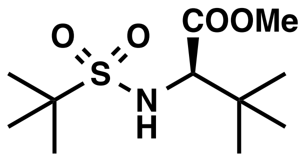


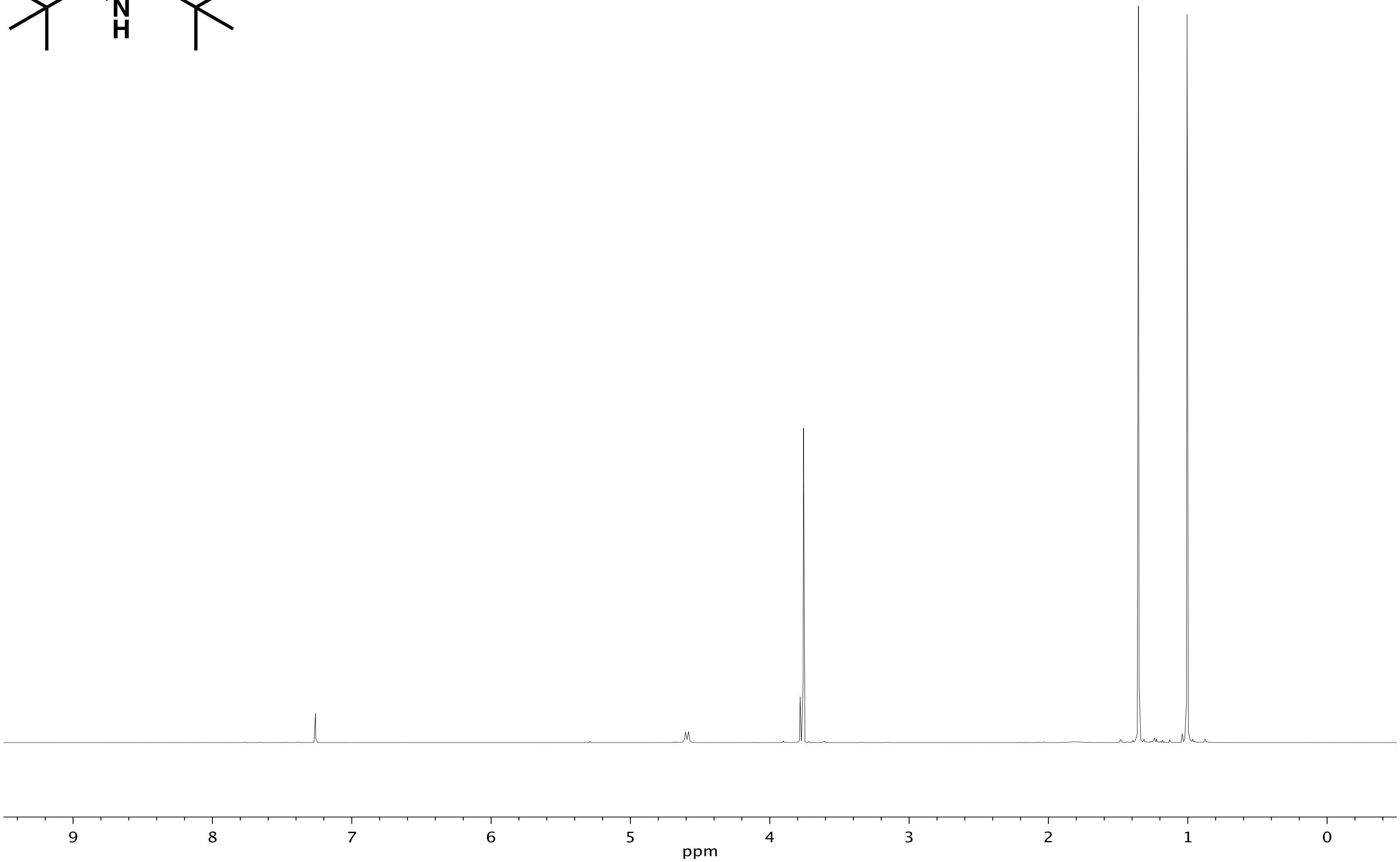
***D-tert*-leucine**

^{1}H NMR (500 MHz, D$_2$O) of compound **5**.

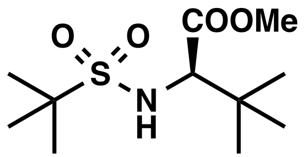


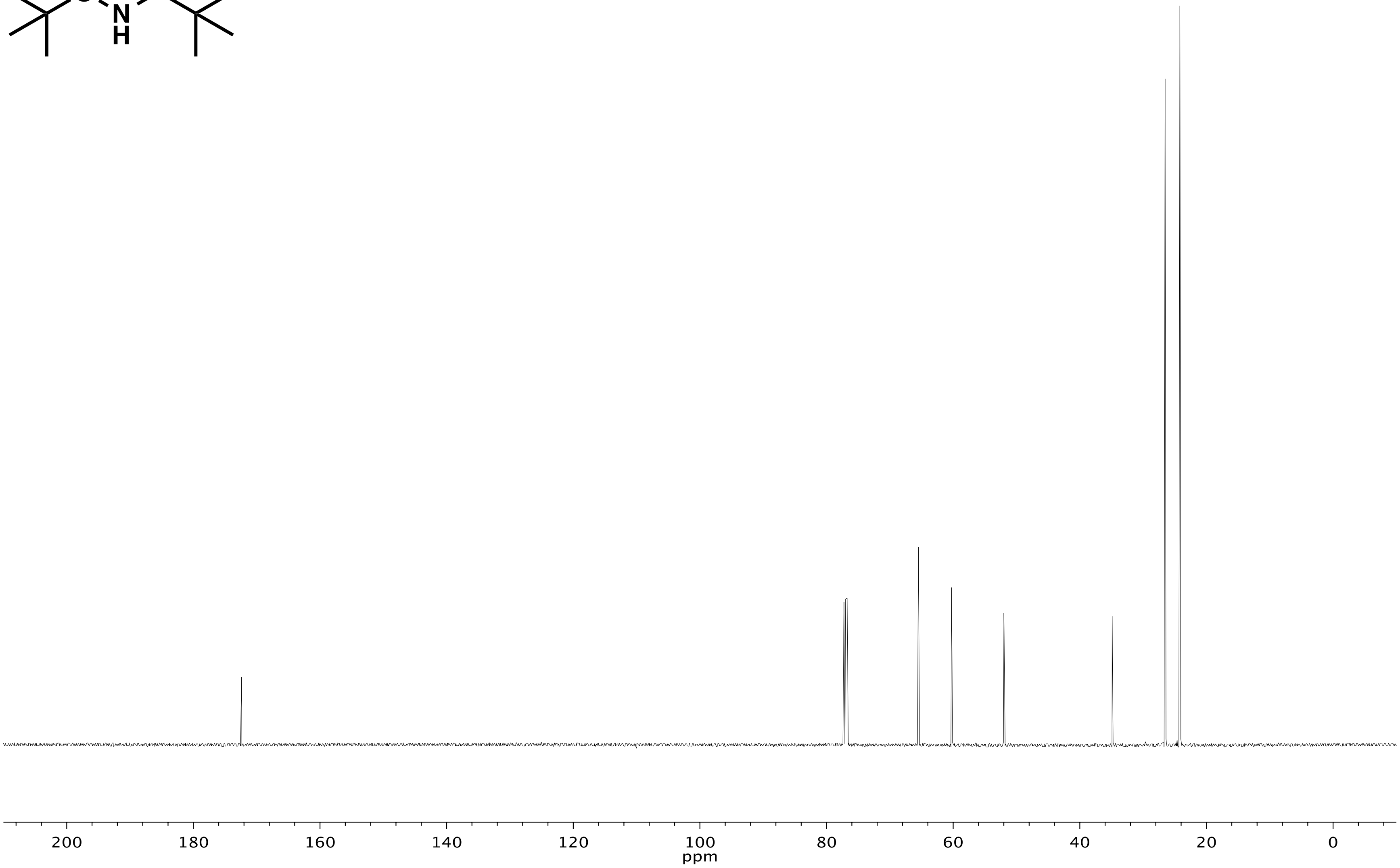
^{13}C NMR (101 MHz, D_2O) of compound **5.**



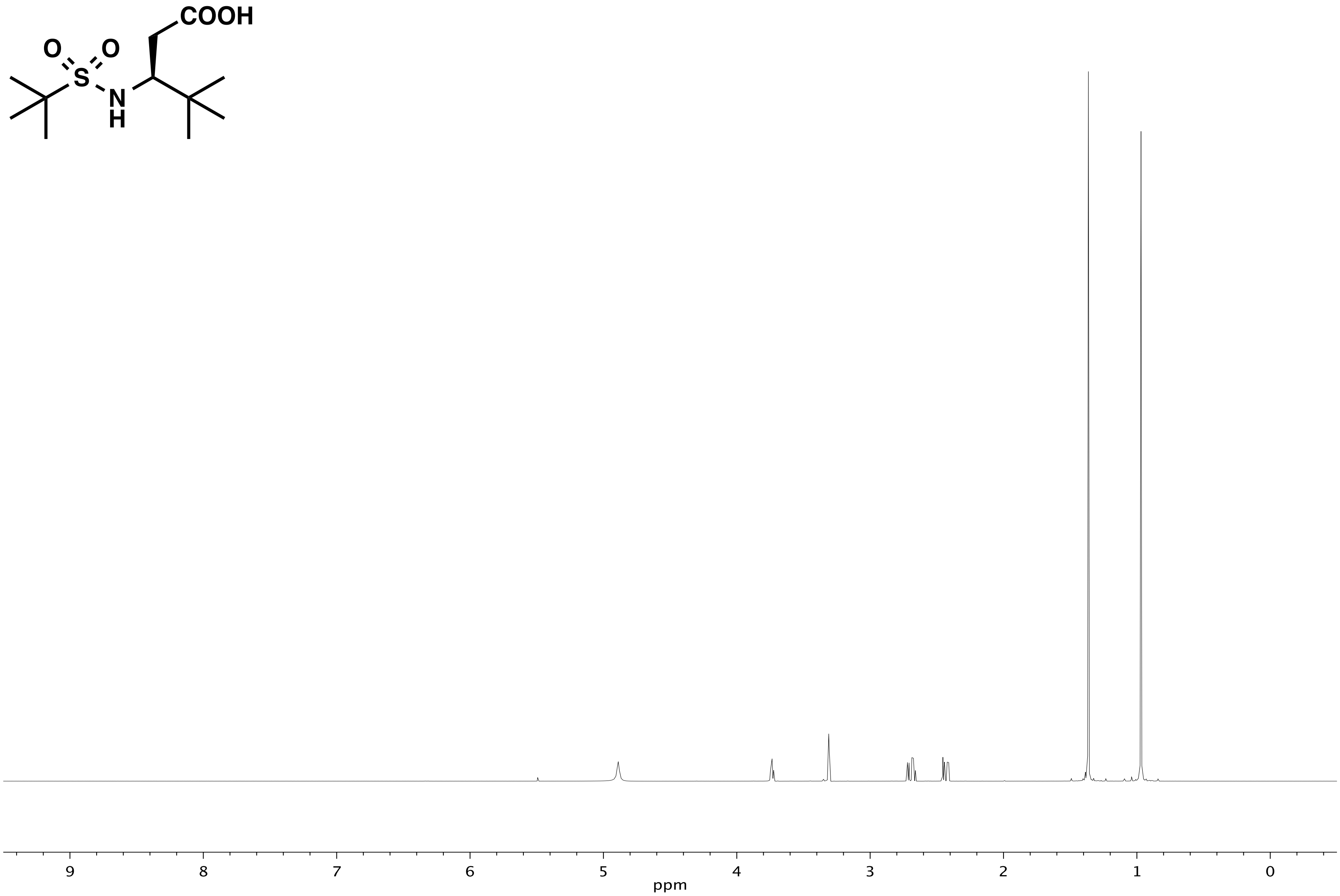


^{1}H NMR (500 MHz, CDCl$_3$) of compound **S6**.

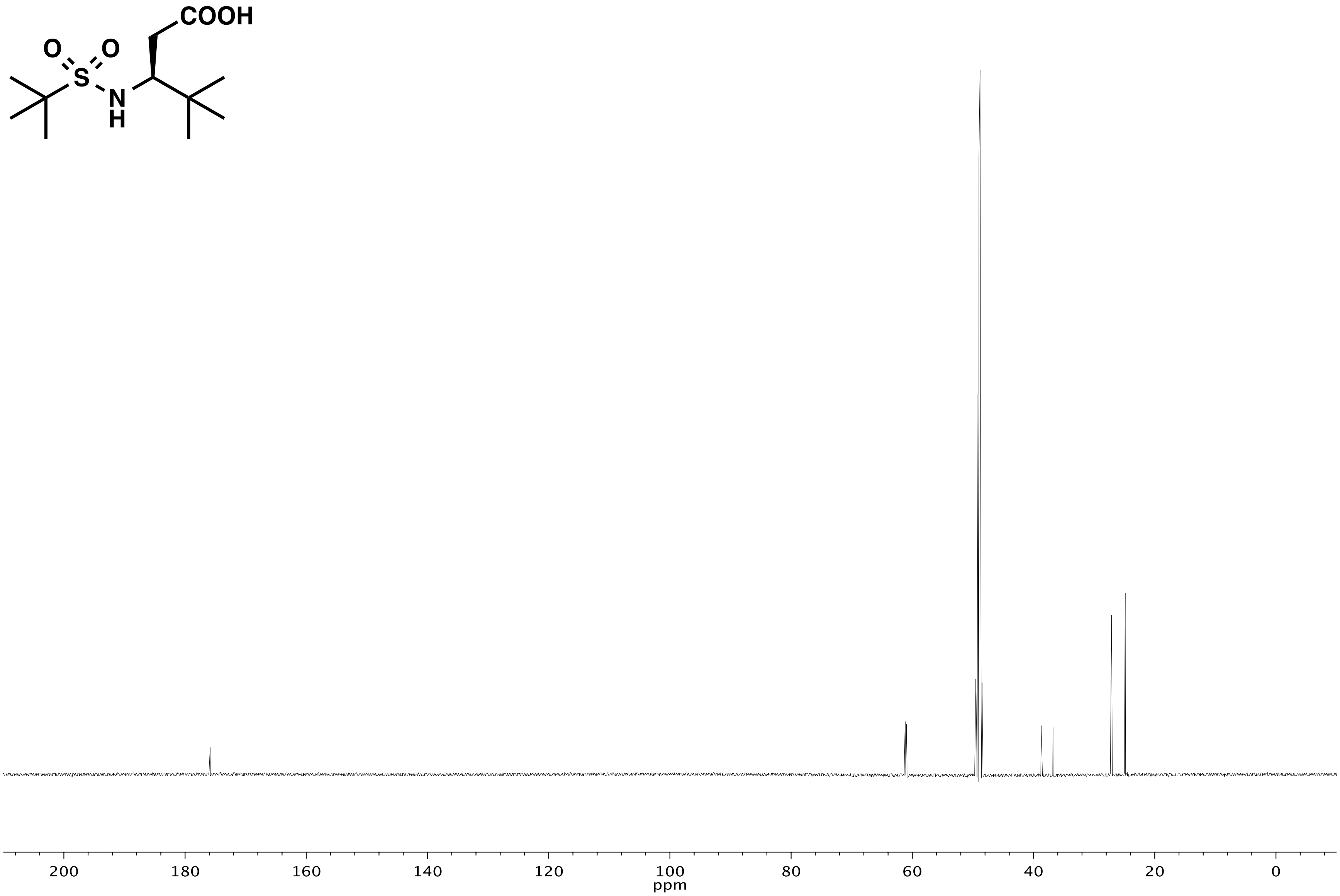




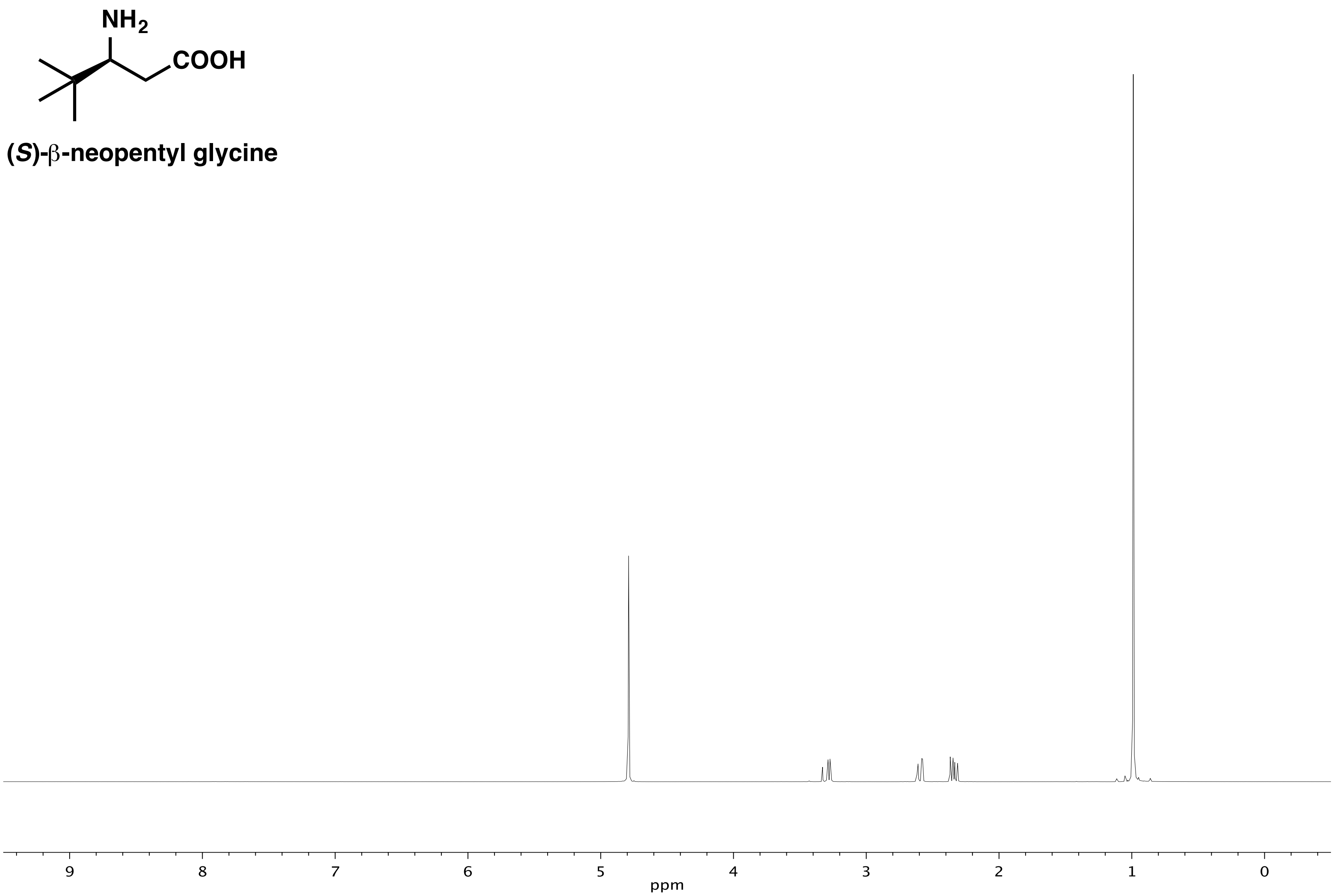
^{13}C NMR (126 MHz, CDCl$_3$) of compound **S6.**



^{1}H NMR (500 MHz, CD_3OD) of compound **6**.

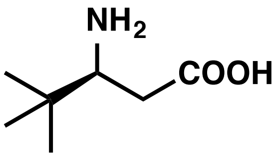


^{13}C NMR (126 MHz, CD$_3$OD) of compound **6.**

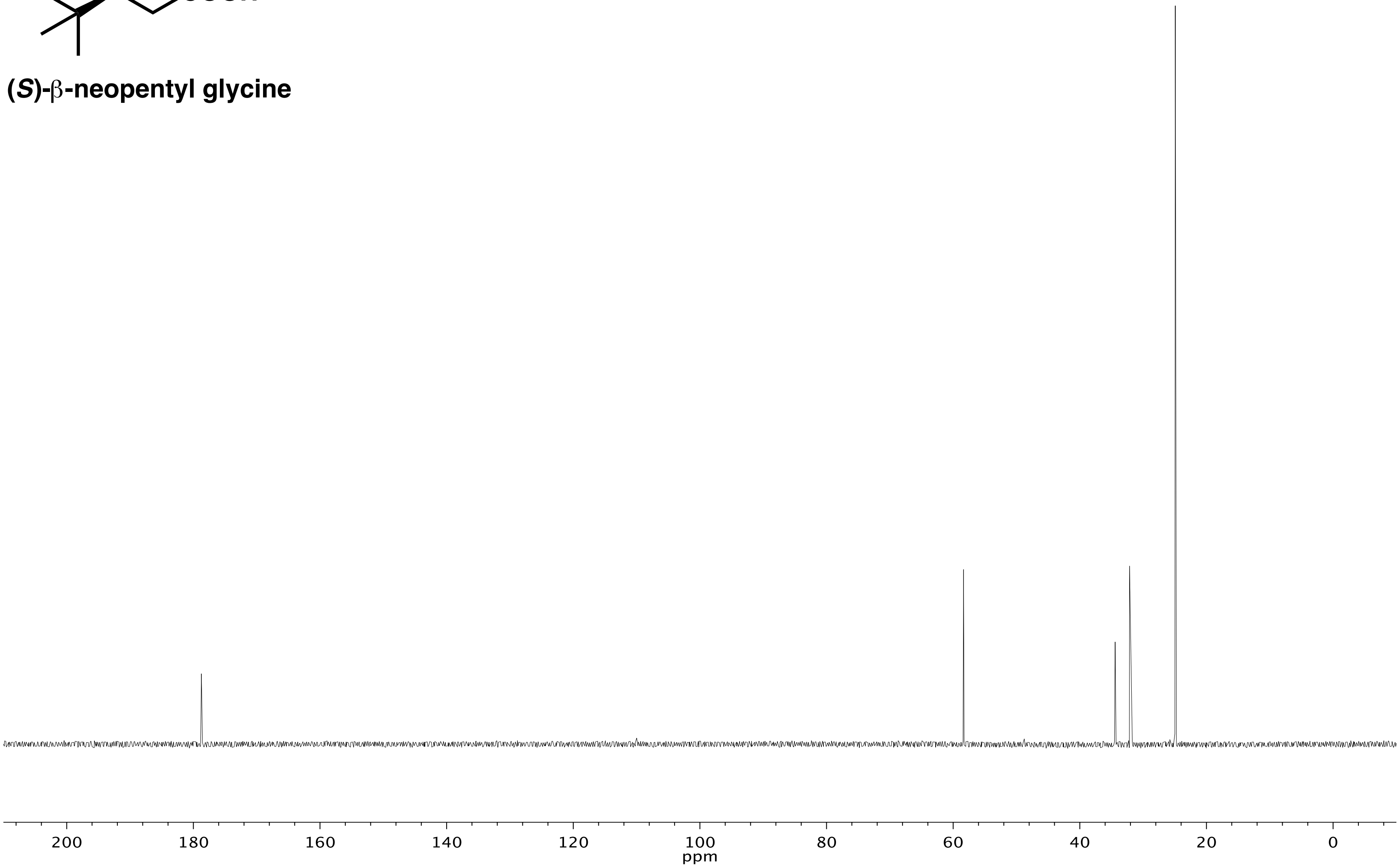


(*S*)-β-neopentyl glycine

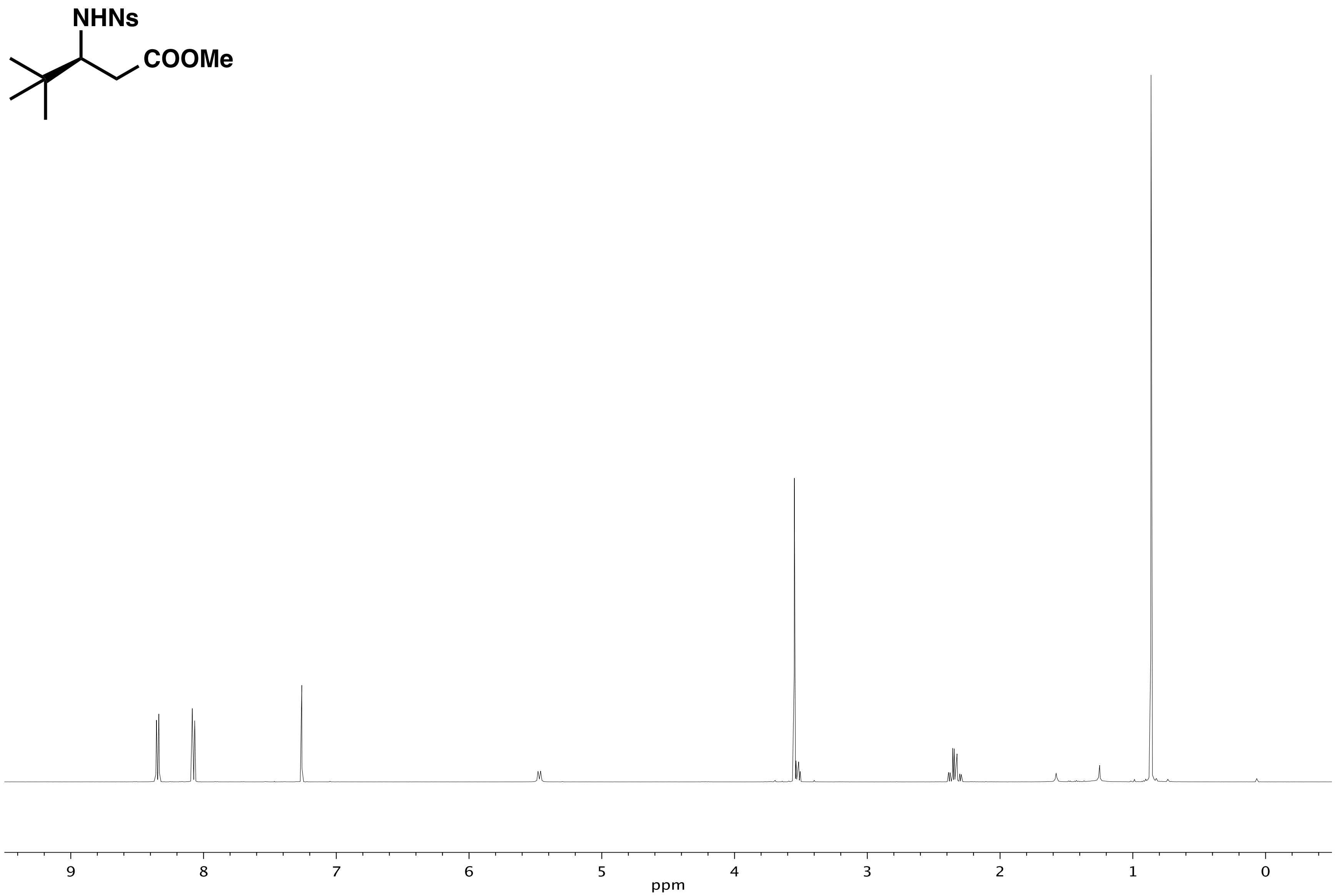
^{1}H NMR (500 MHz, D_2O) of compound **7**.



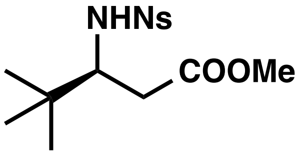
(*S*)-β-neopentyl glycine

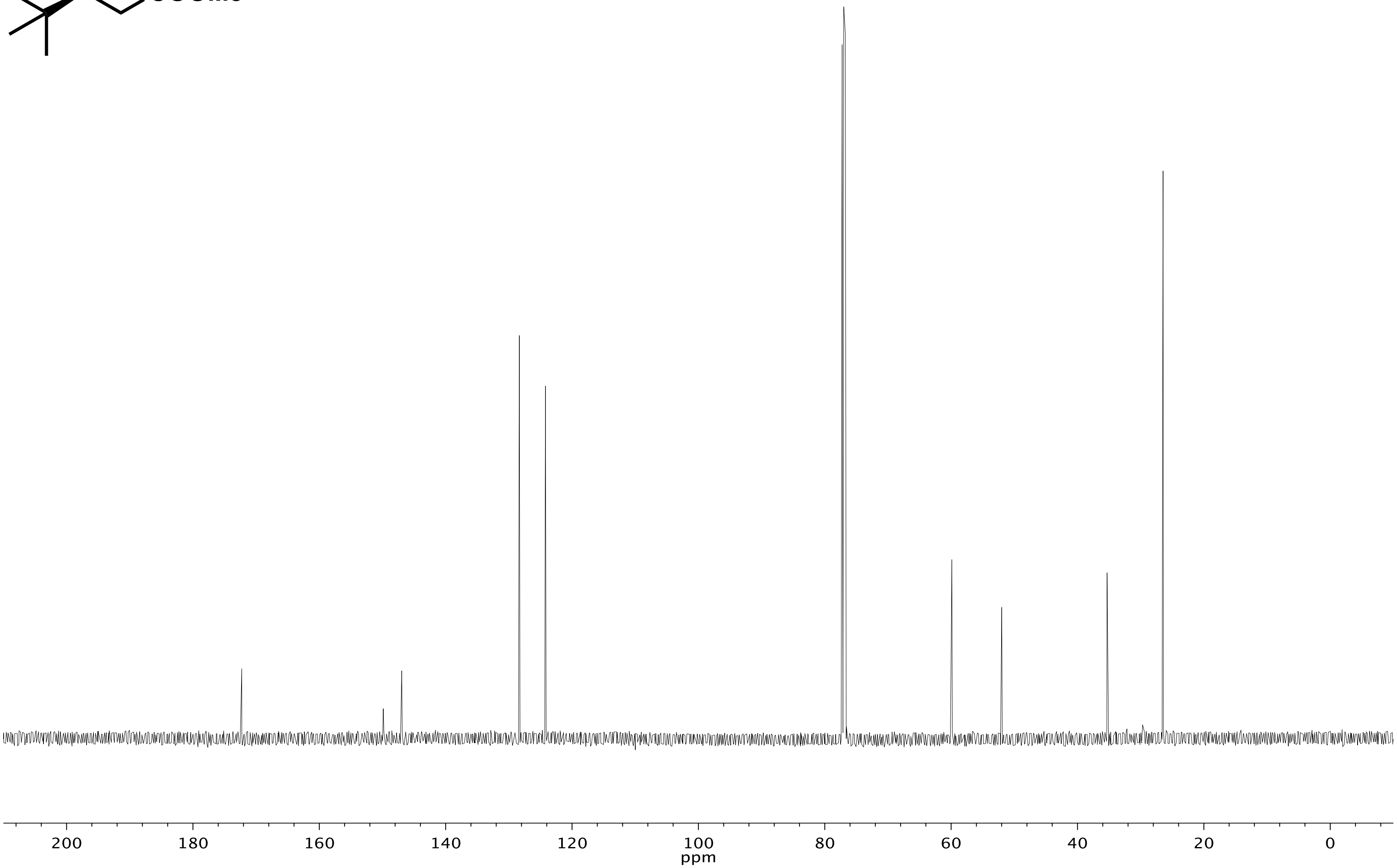


^{13}C NMR (126 MHz, D_2O) of compound **7.**

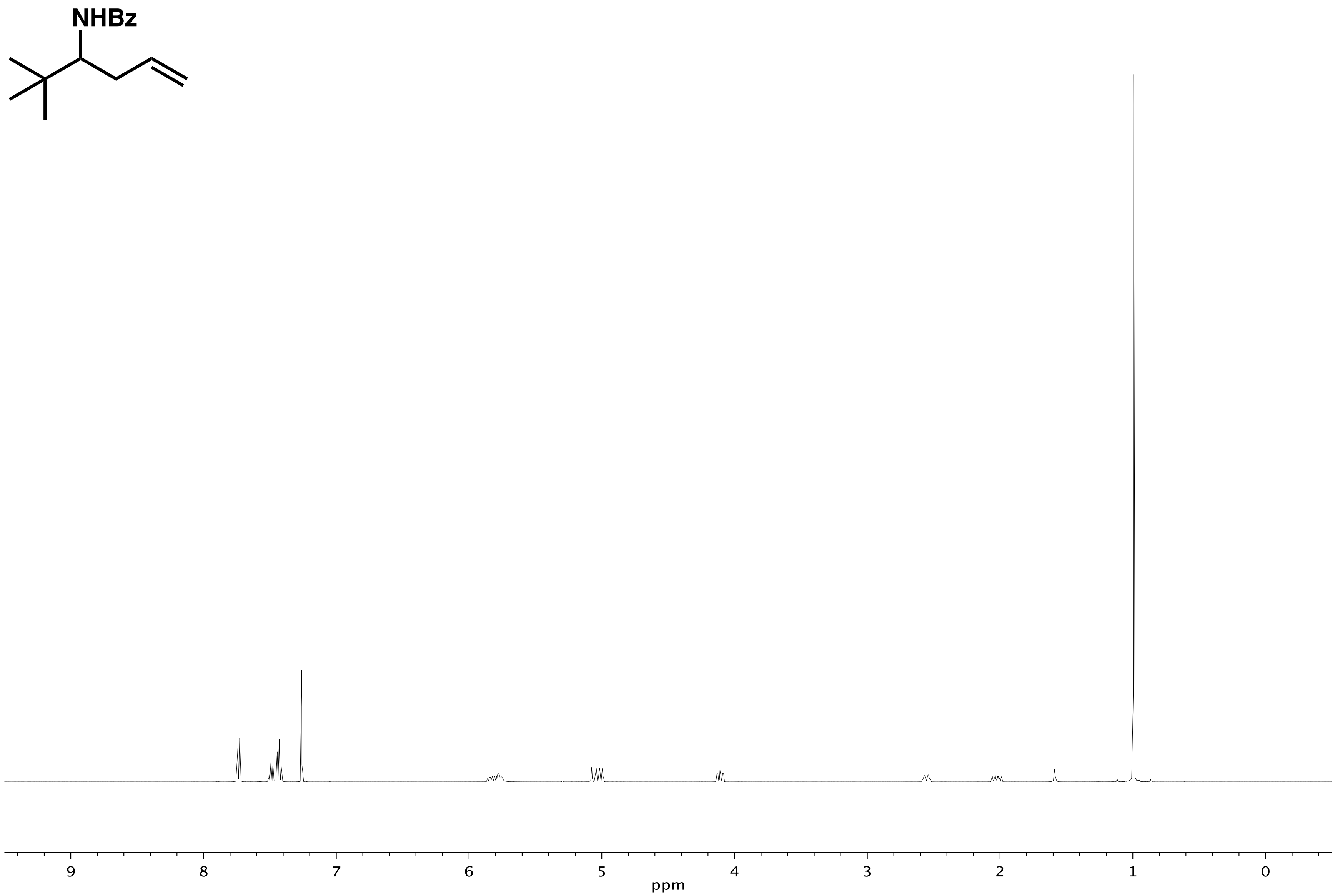


^{1}H NMR (500 MHz, $CDCl_3$) of compound **S8**.

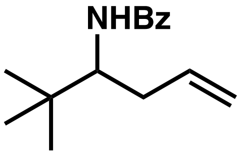


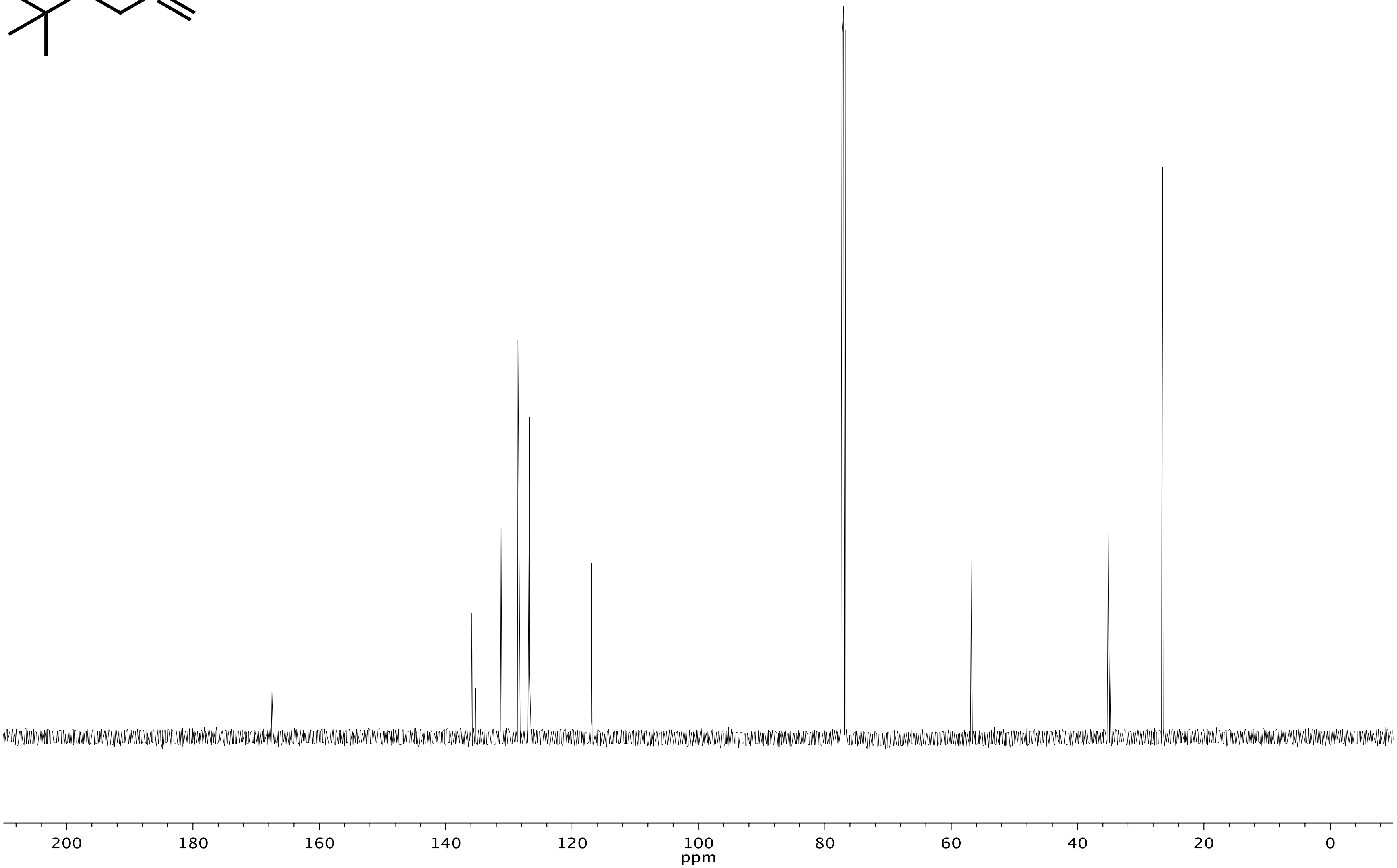


^{13}C NMR (126 MHz, CDCl$_3$) of compound **S8.**

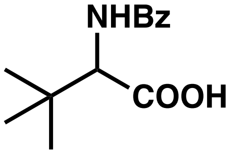


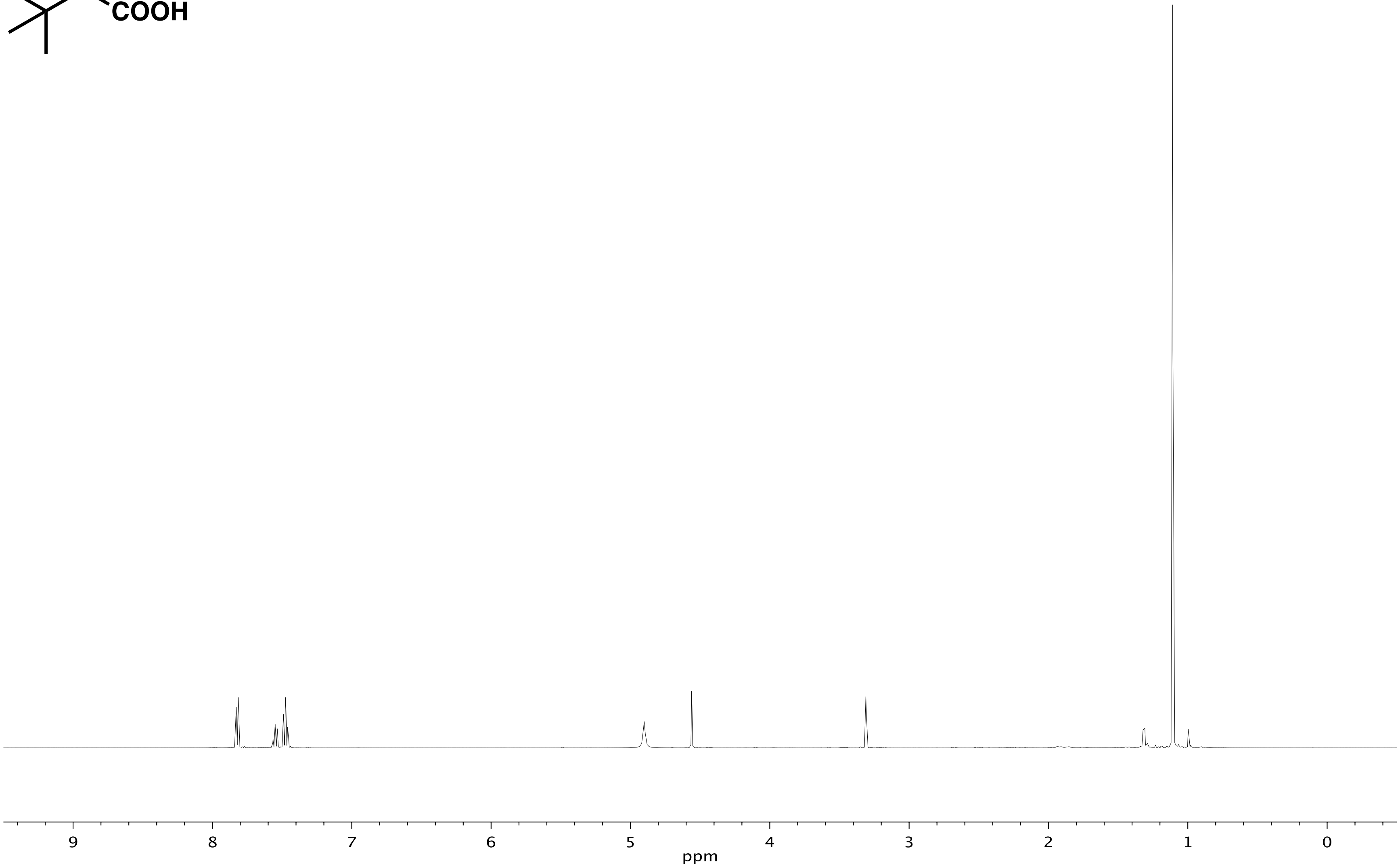
^{1}H NMR (500 MHz, CDCl$_3$) of compound **8**.



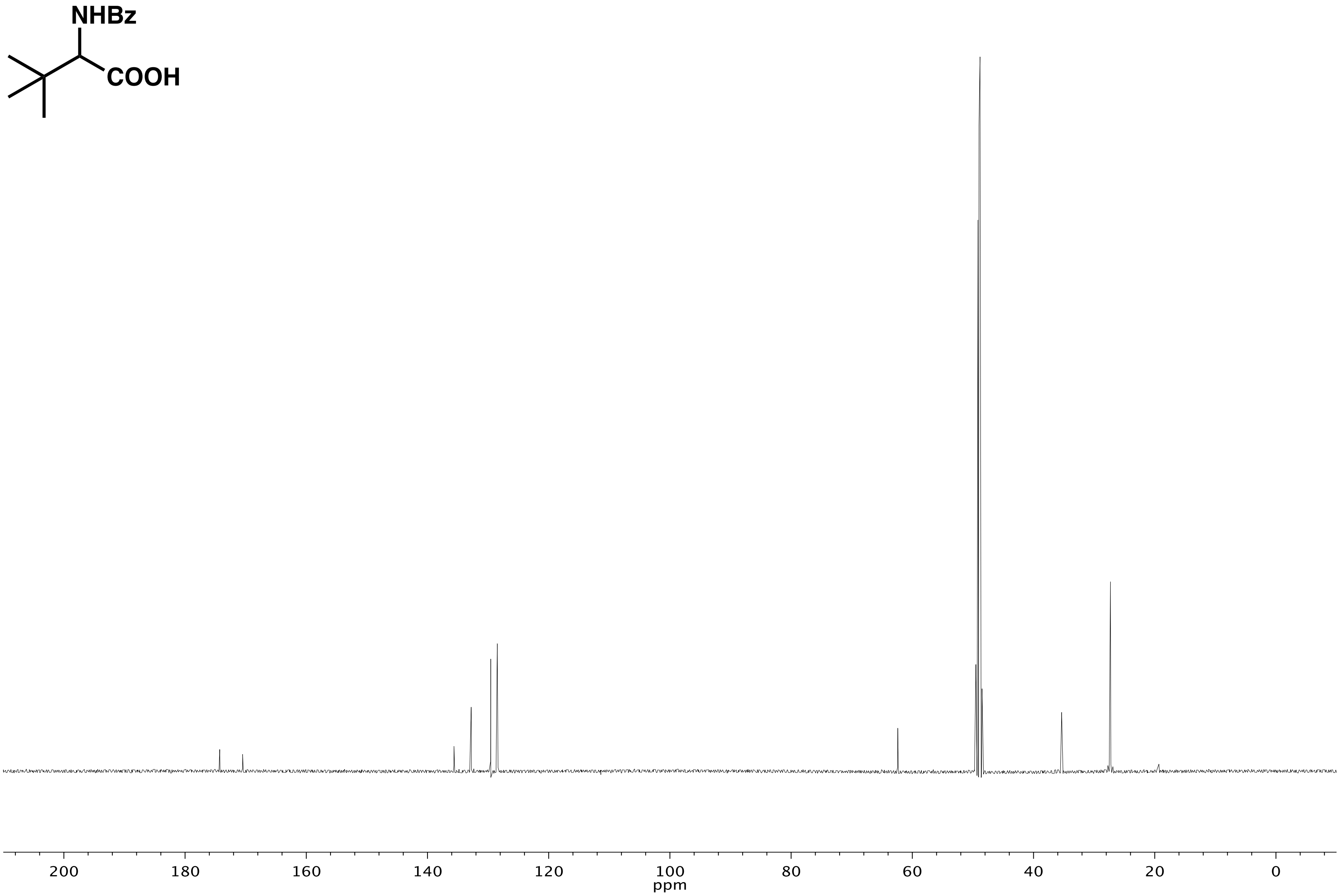


^{13}C NMR (126 MHz, CDCl$_3$) of compound **8.**

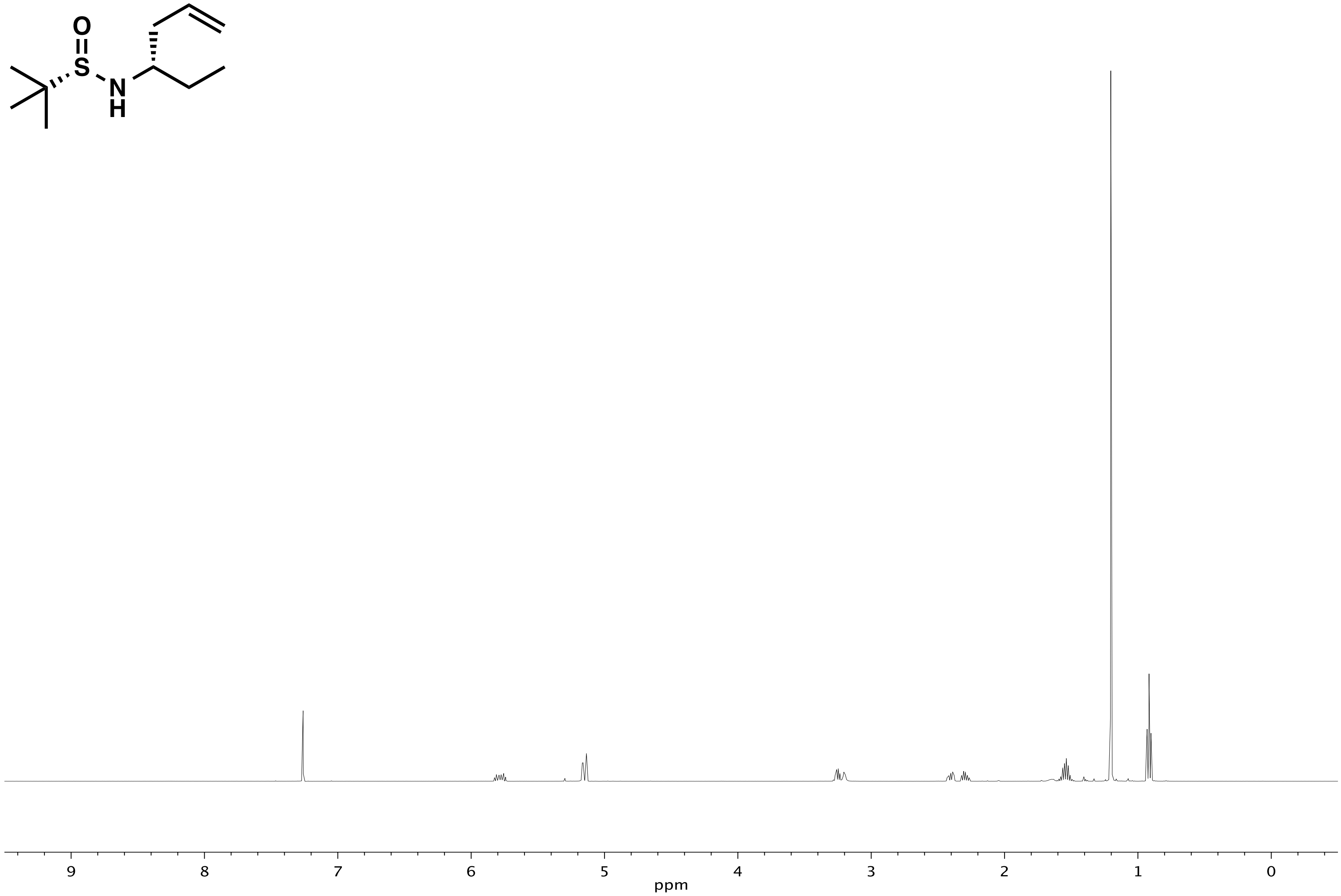




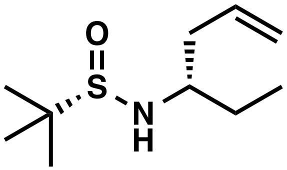
^{1}H NMR (500 MHz, CD_3OD) of compound **9**.

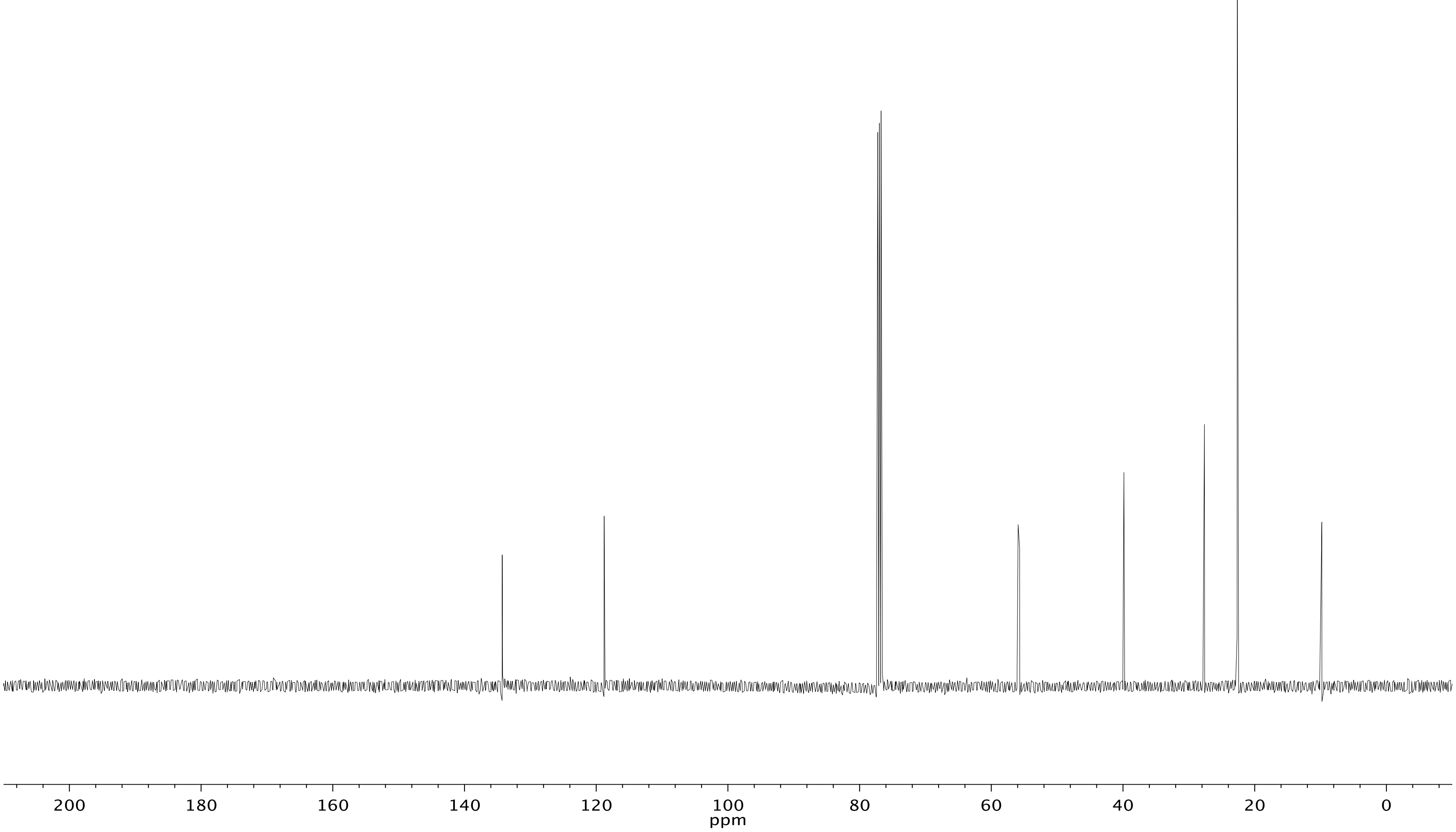


^{13}C NMR (126 MHz, CD_3OD) of compound **9.**

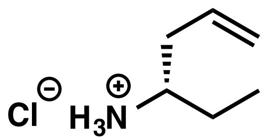


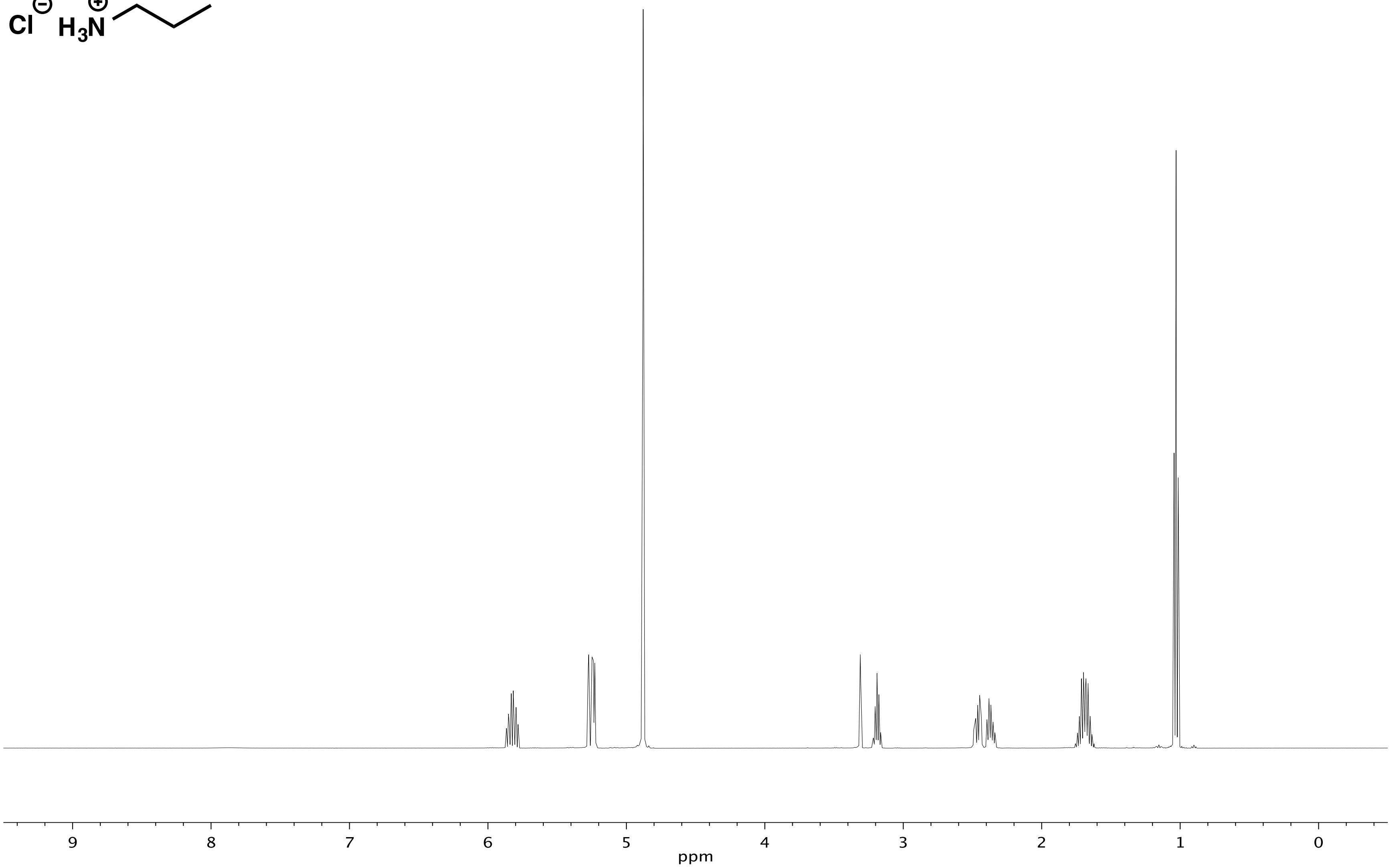
[1]H NMR (500 MHz, $CDCl_3$) of compound **S10**.



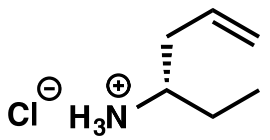


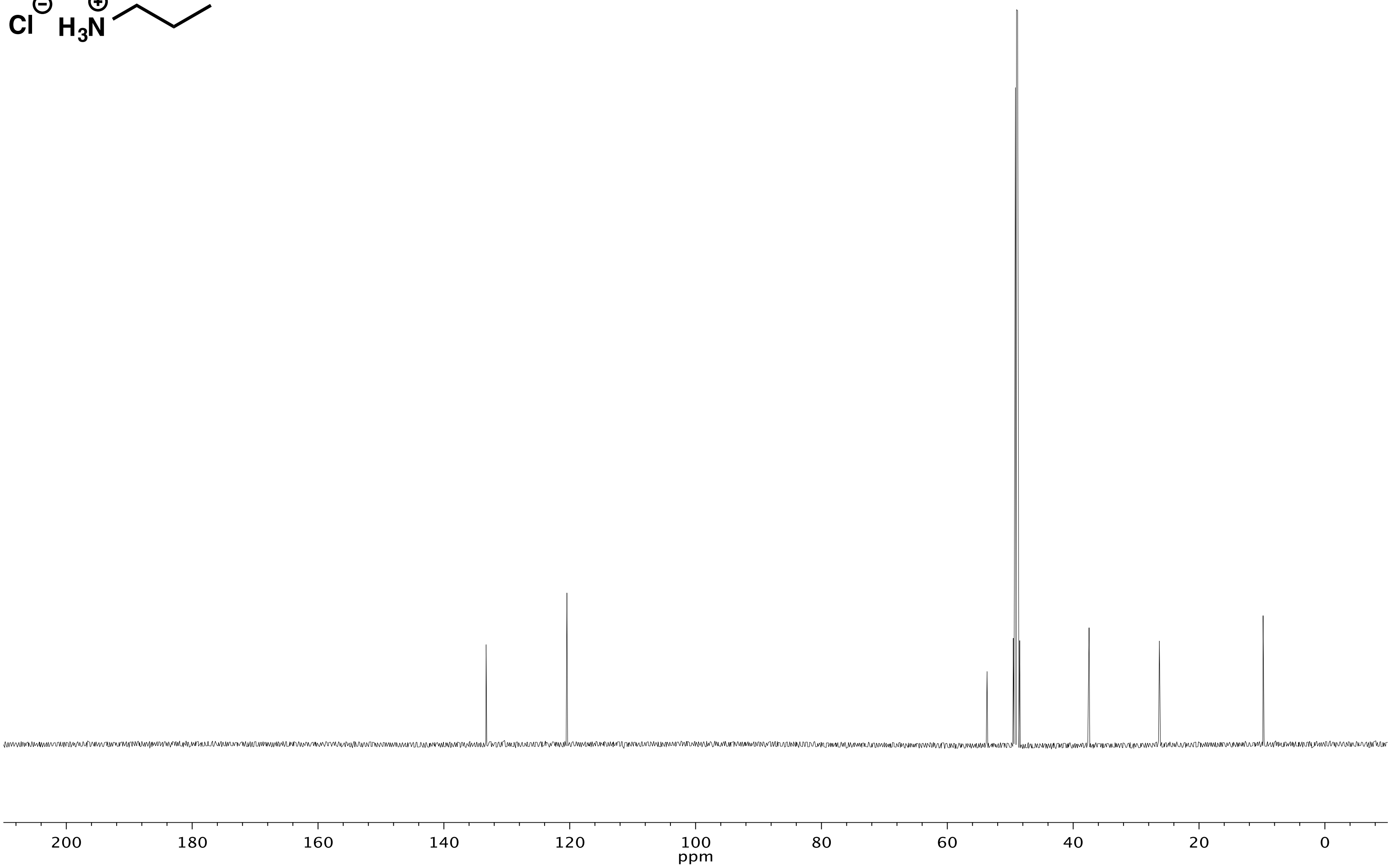
^{13}C NMR (126 MHz, CDCl$_3$) of compound **S10.**



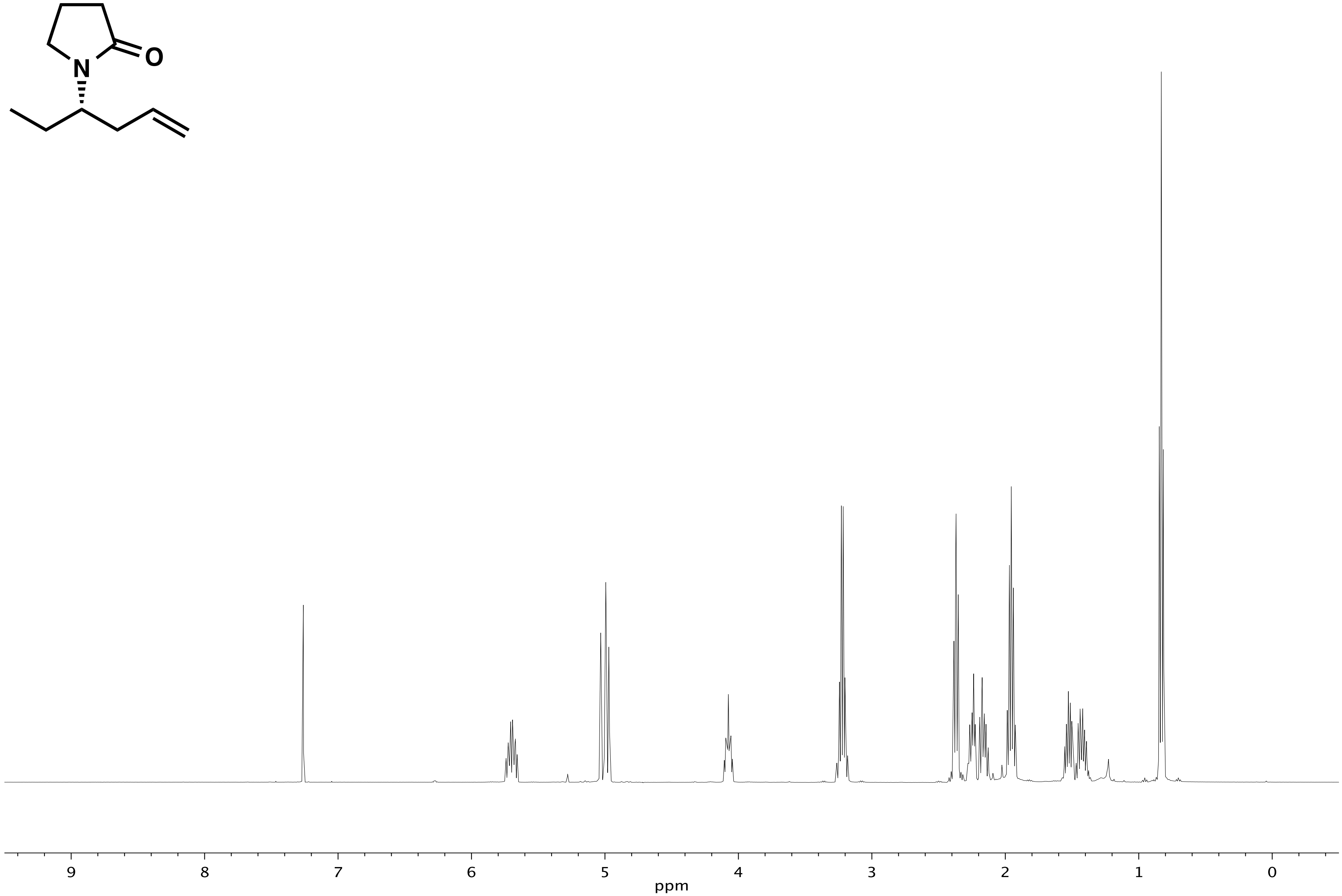


^{1}H NMR (500 MHz, CD_3OD) of compound **S11**.

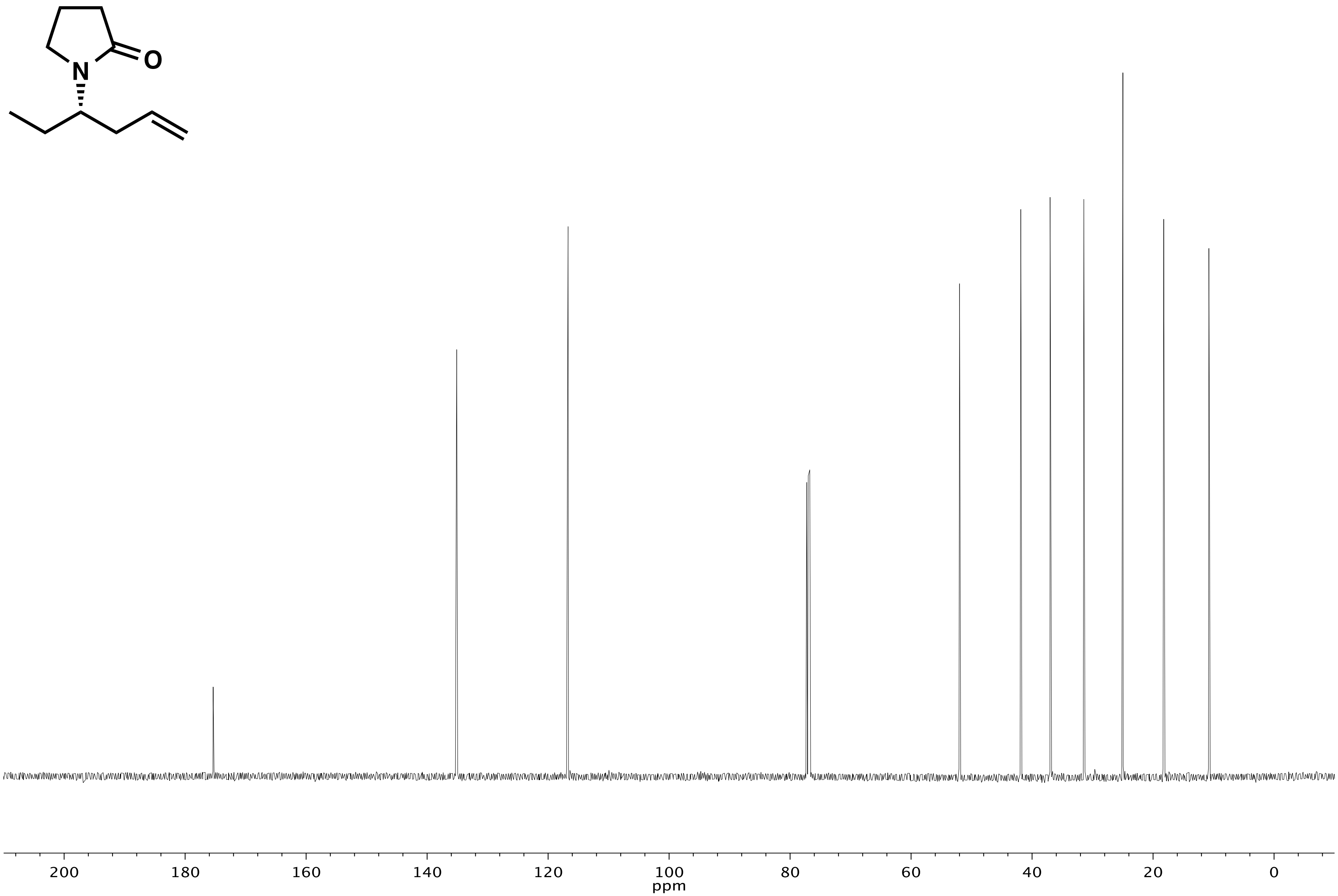




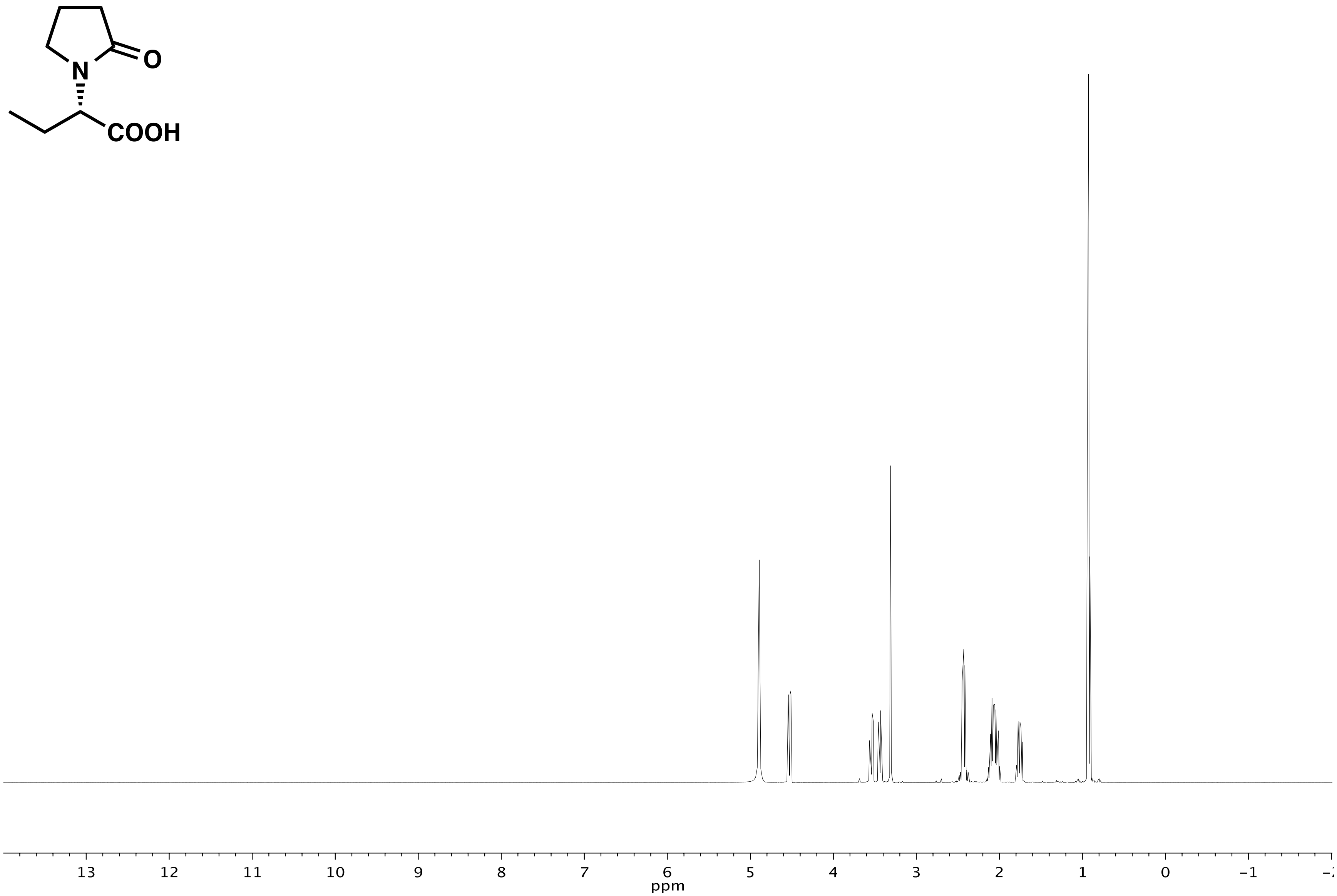
^{13}C NMR (126 MHz, CD$_3$OD) of compound **S11.**



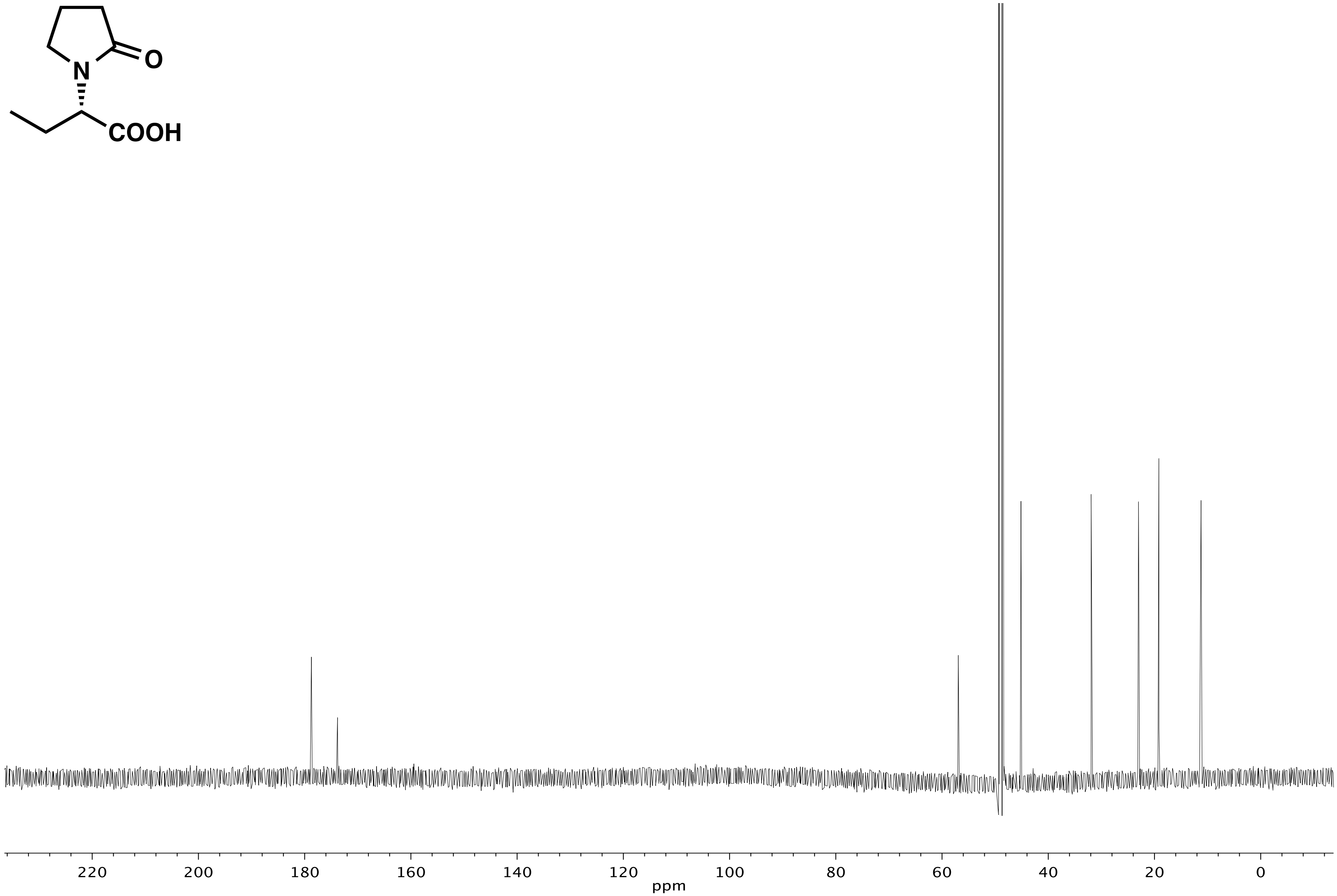
^{1}H NMR (500 MHz, CDCl$_3$) of compound **10**.



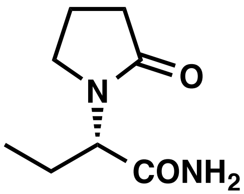
^{13}C NMR (126 MHz, CDCl$_3$) of compound **10.**



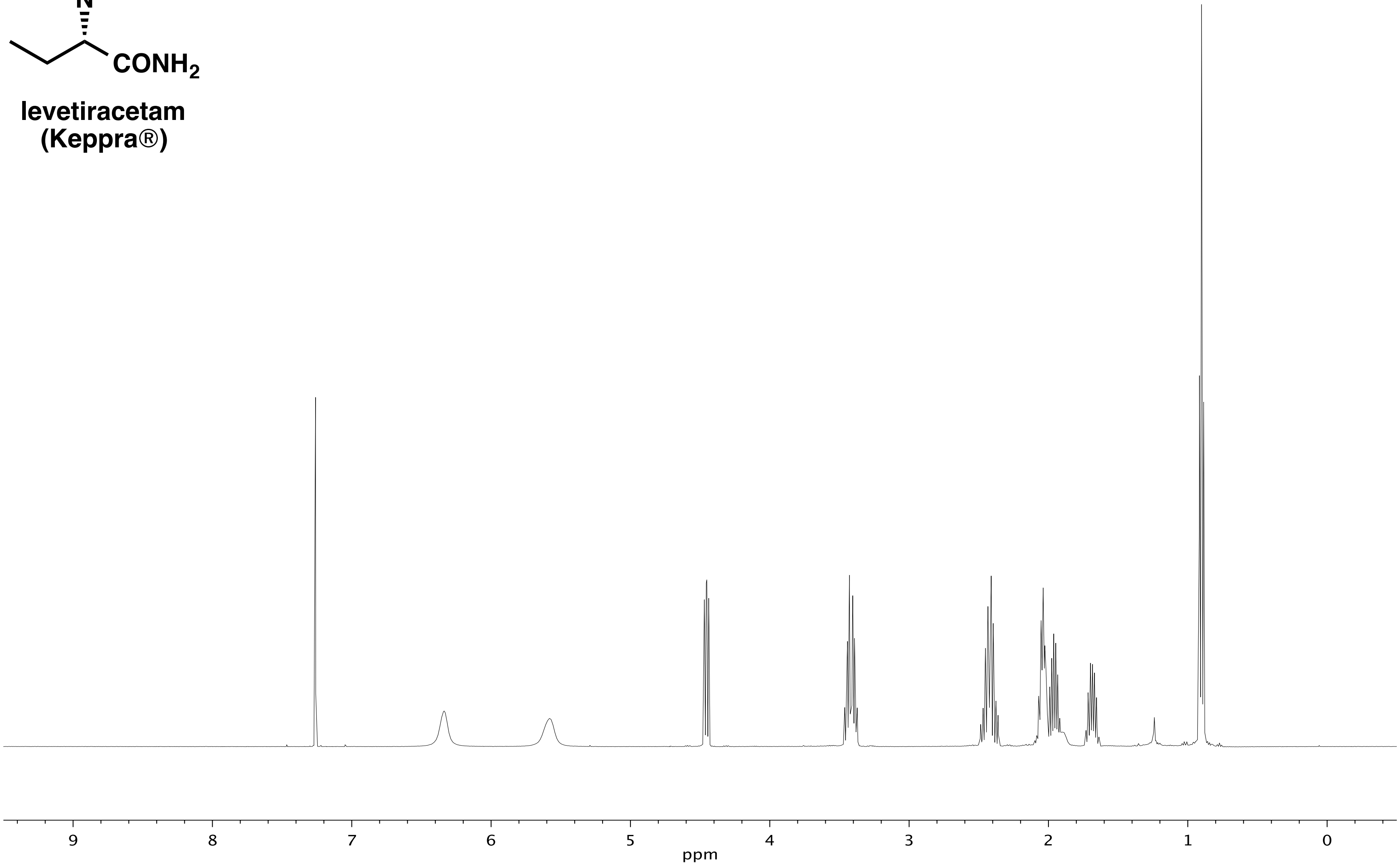
^{1}H NMR (500 MHz, CD_3OD) of compound **11**.



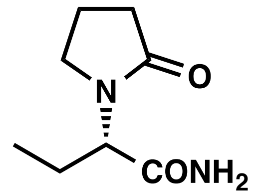
^{13}C NMR (126 MHz, CD$_3$OD) of compound **11.**



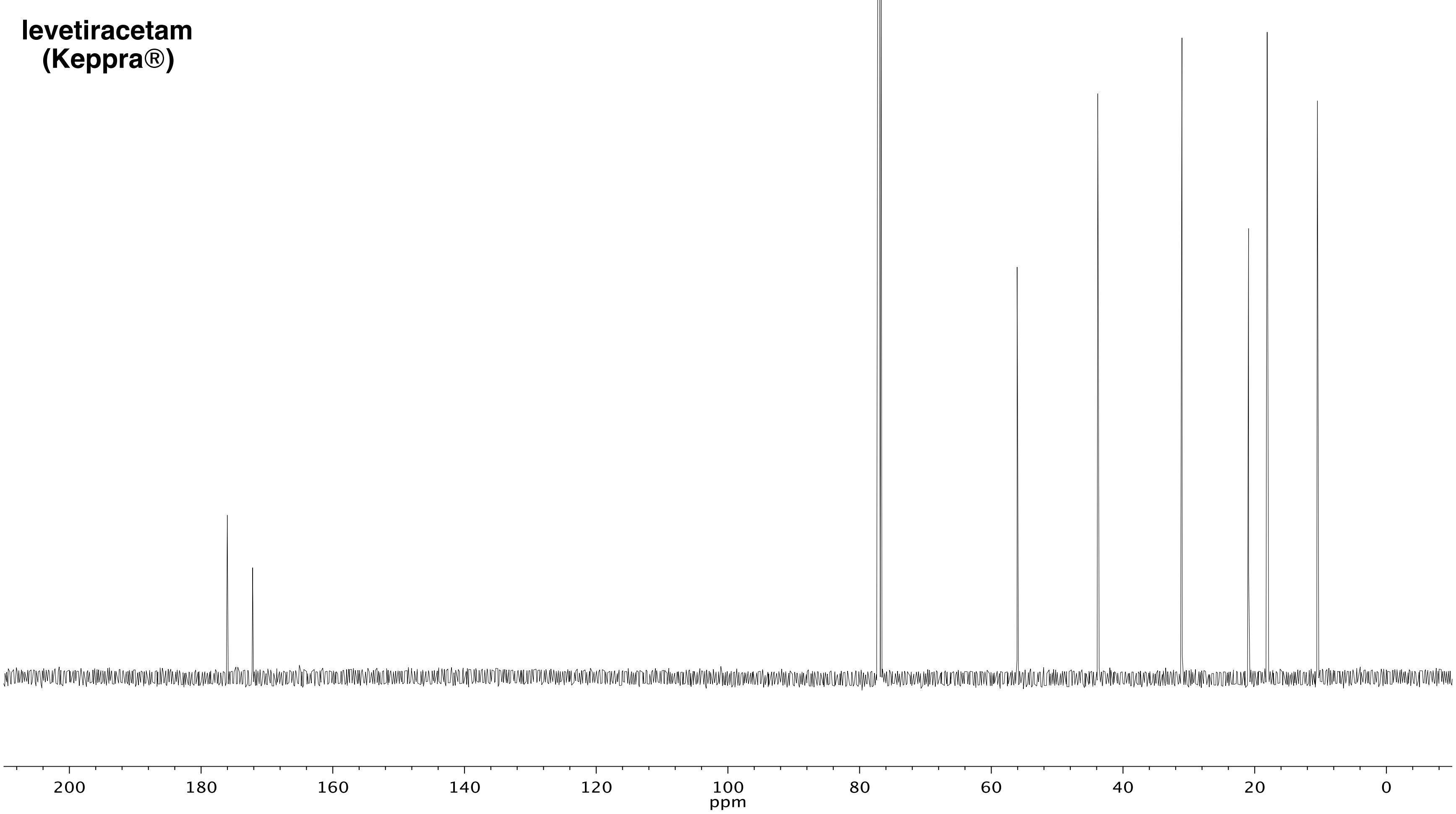
levetiracetam
(Keppra®)



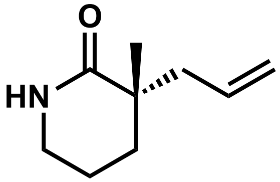
^{1}H NMR (500 MHz, CDCl$_3$) of compound **12**.

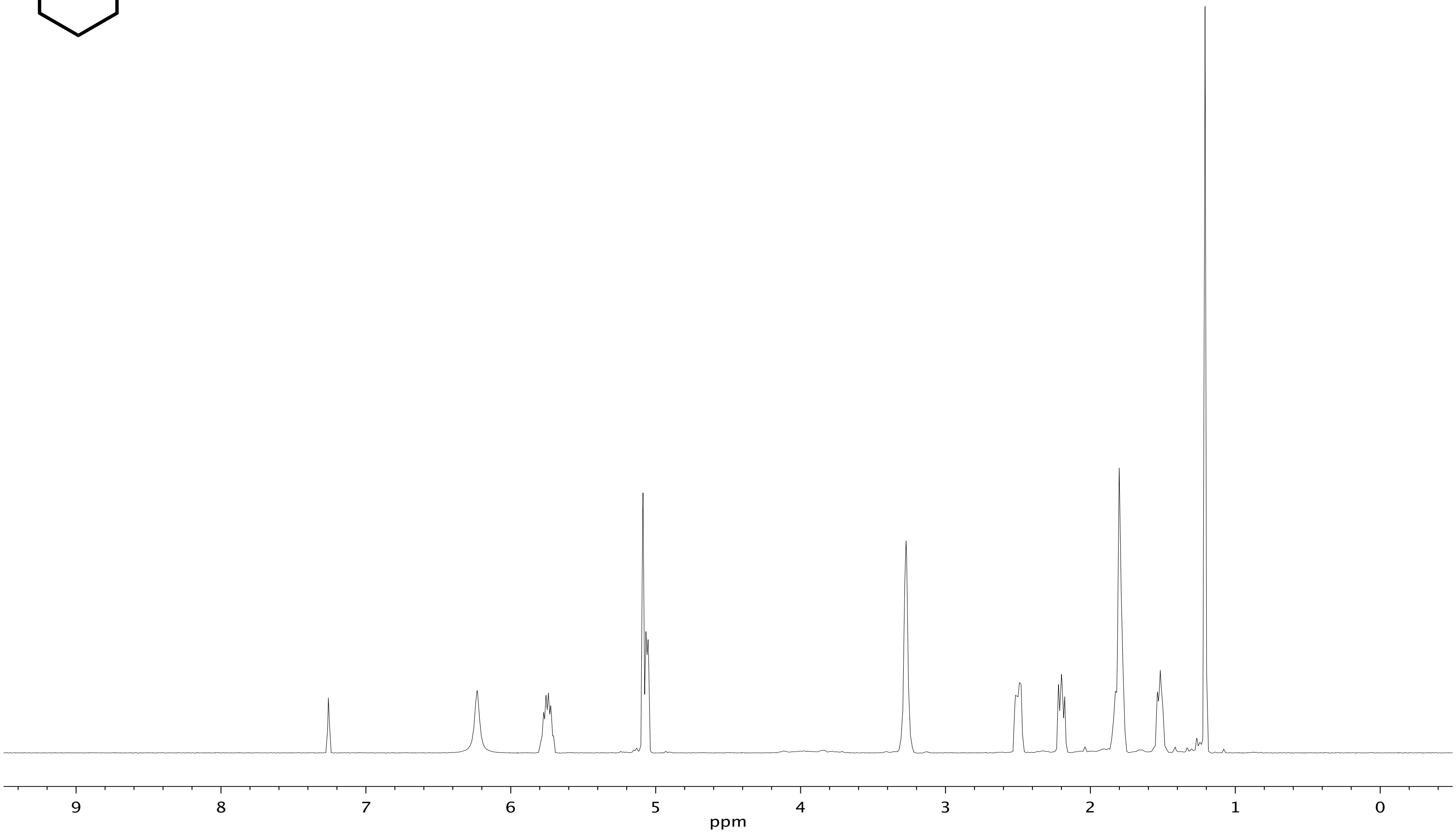


levetiracetam
(Keppra®)

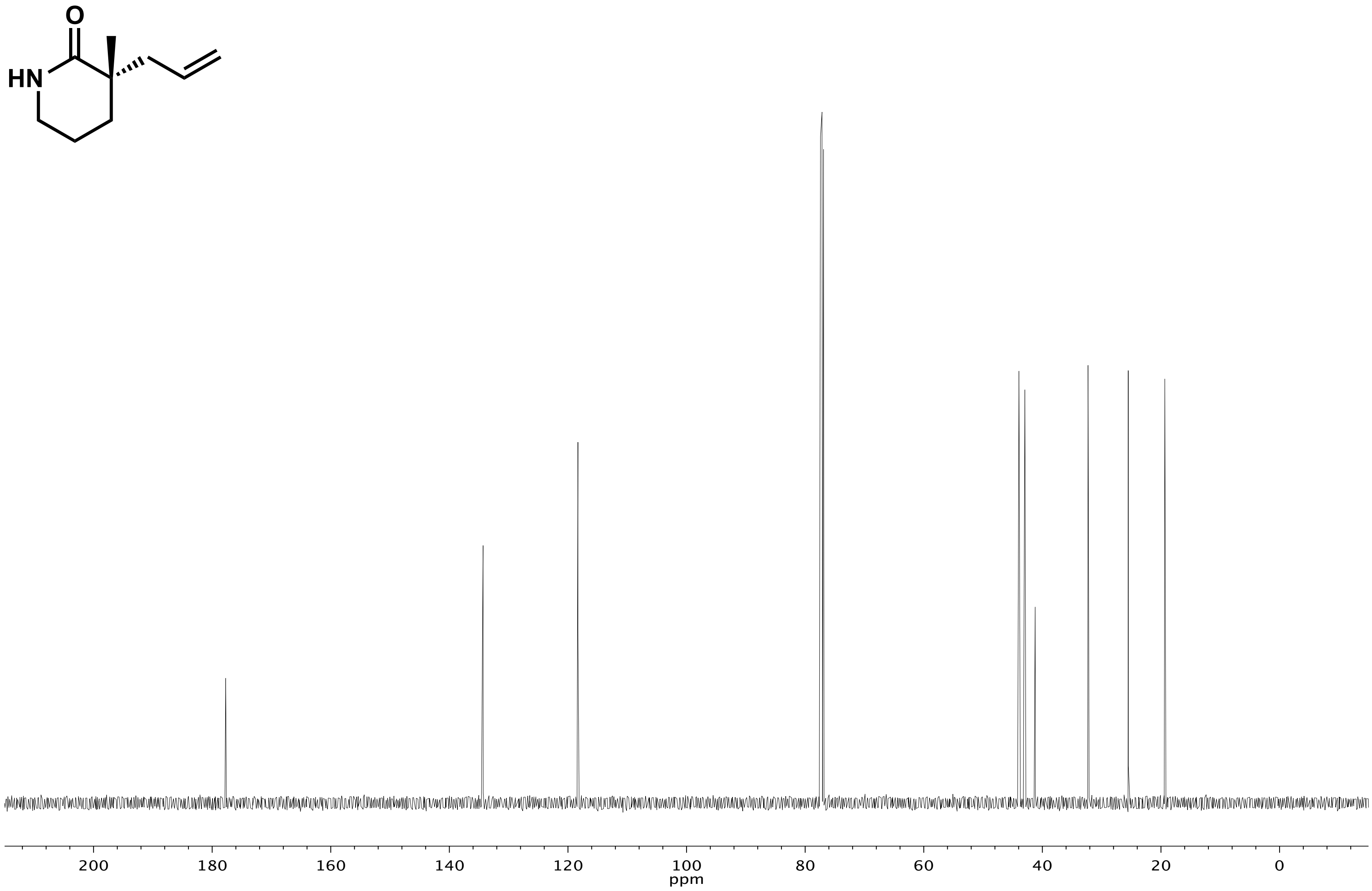


^{13}C NMR (126 MHz, CDCl$_3$) of compound **12**.

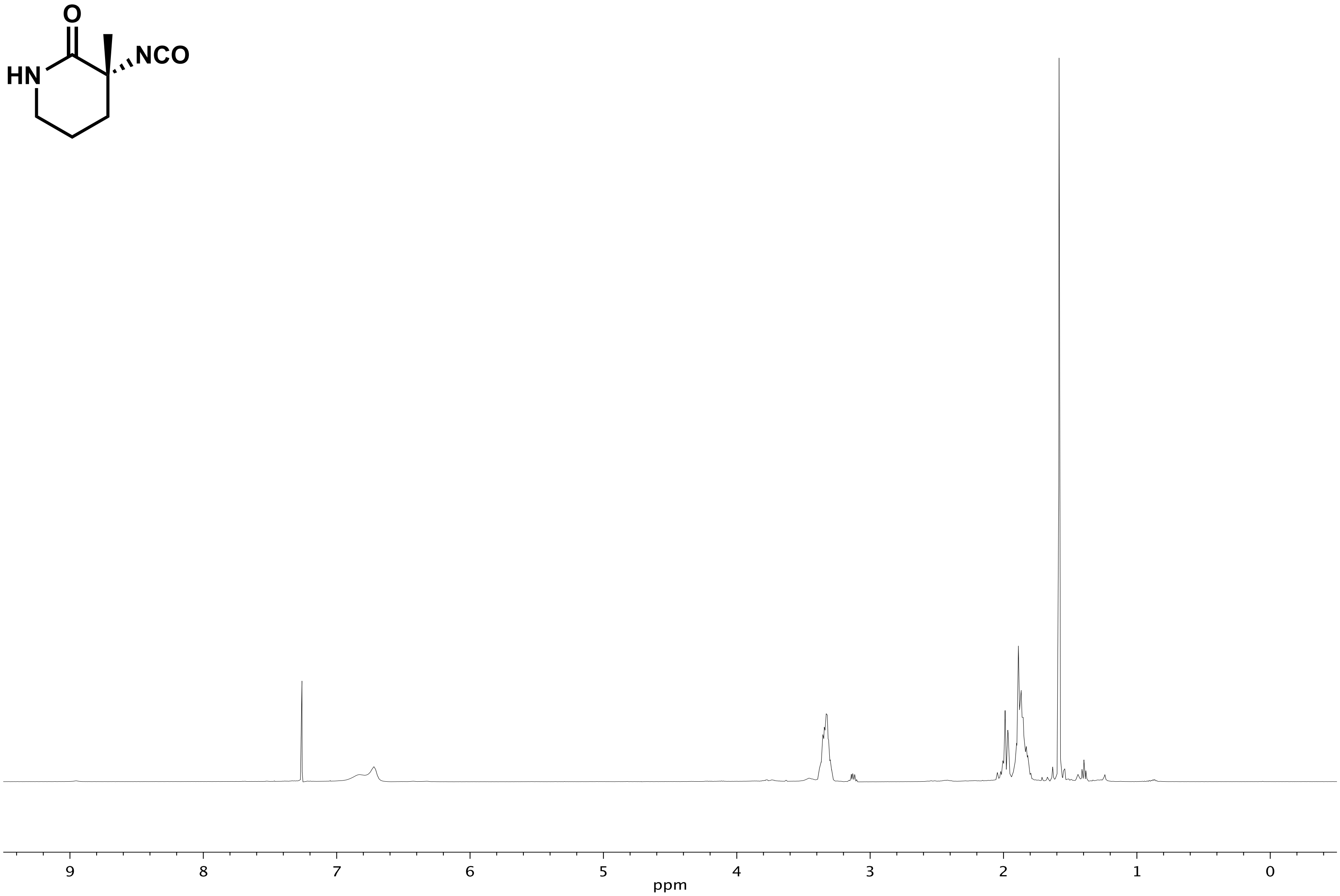




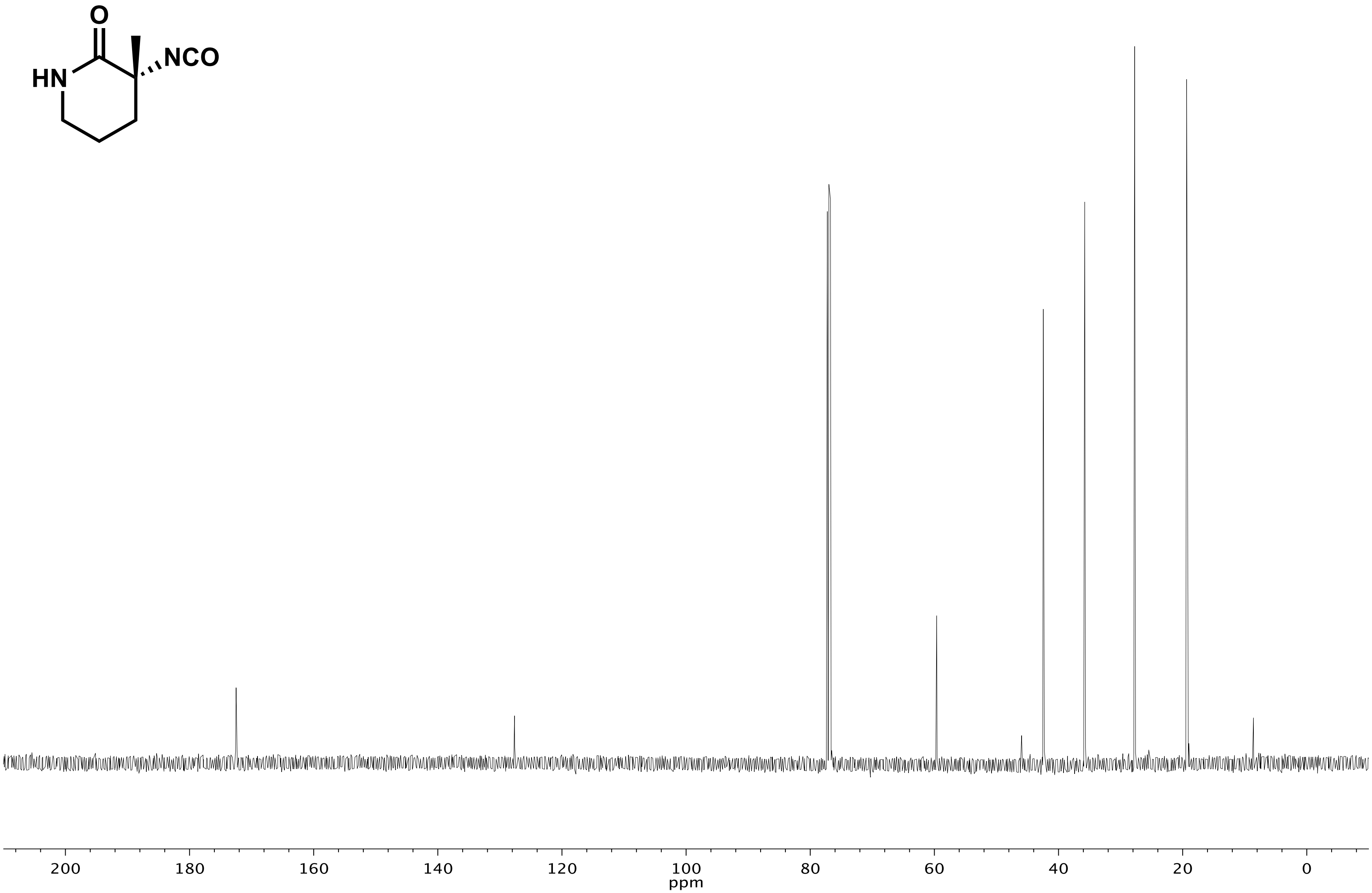
^{1}H NMR (500 MHz, CDCl$_3$) of compound **13**.



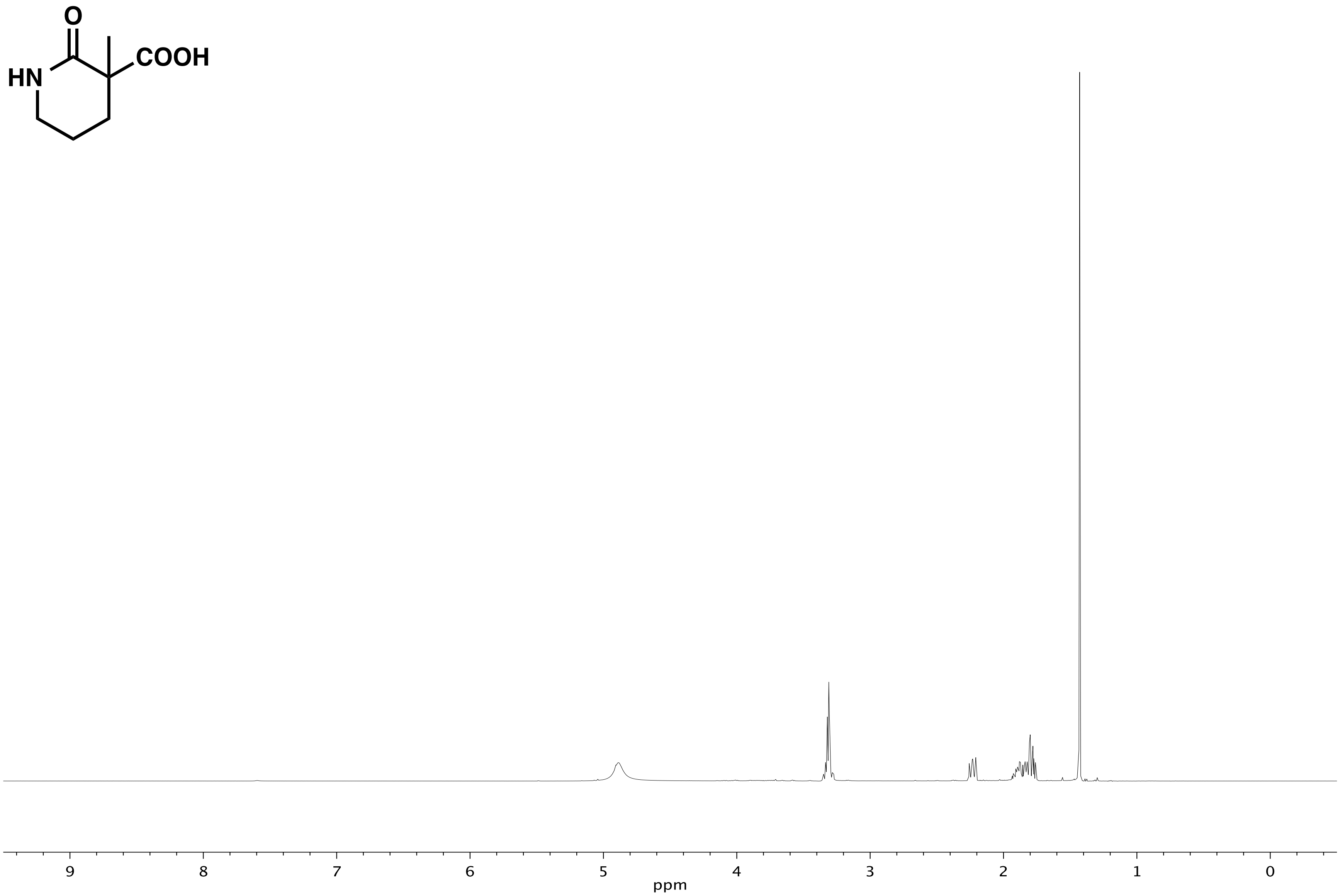
^{13}C NMR (126 MHz, CDCl$_3$) of compound **13**.



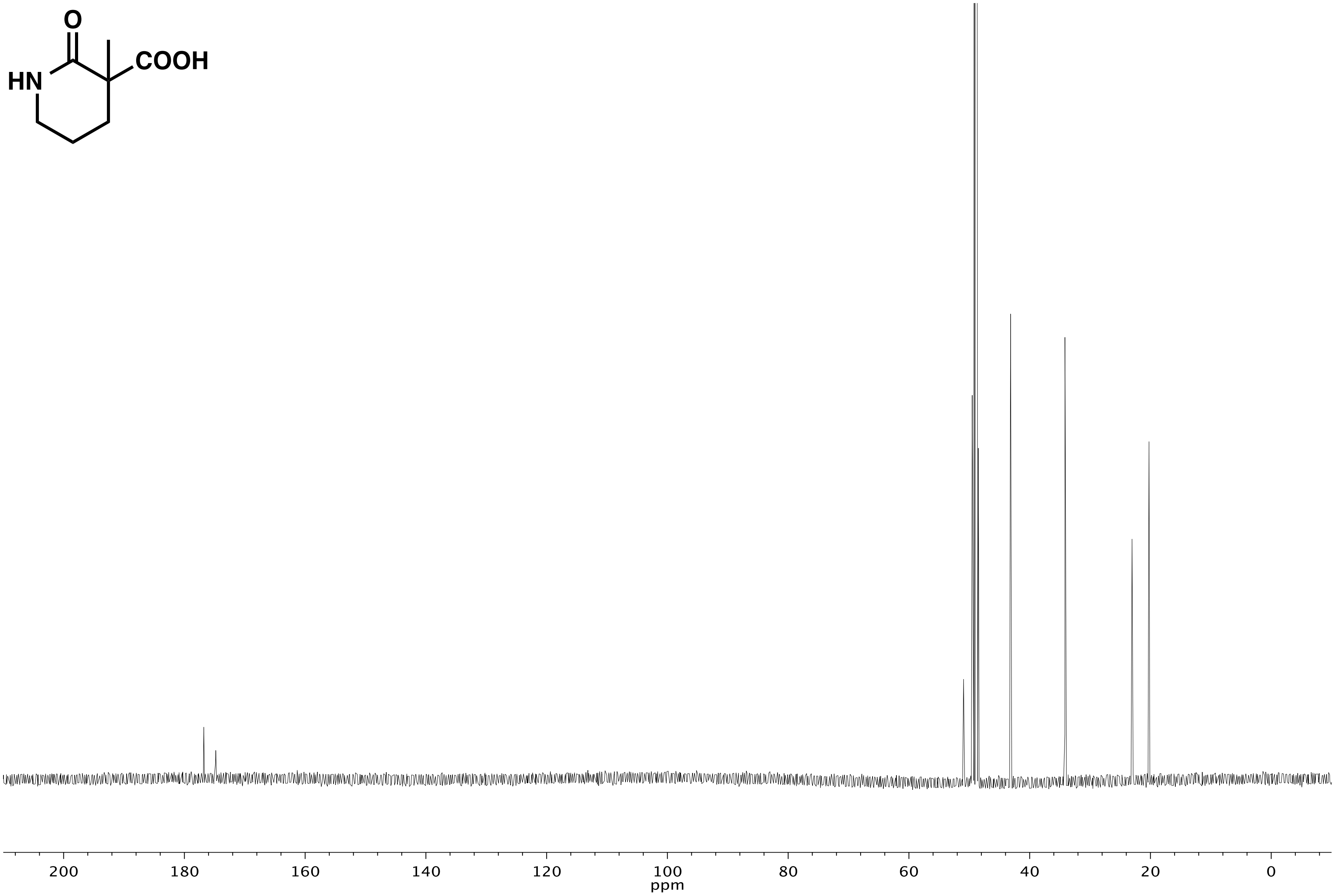
^{1}H NMR (500 MHz, CDCl$_3$) of compound **15**.



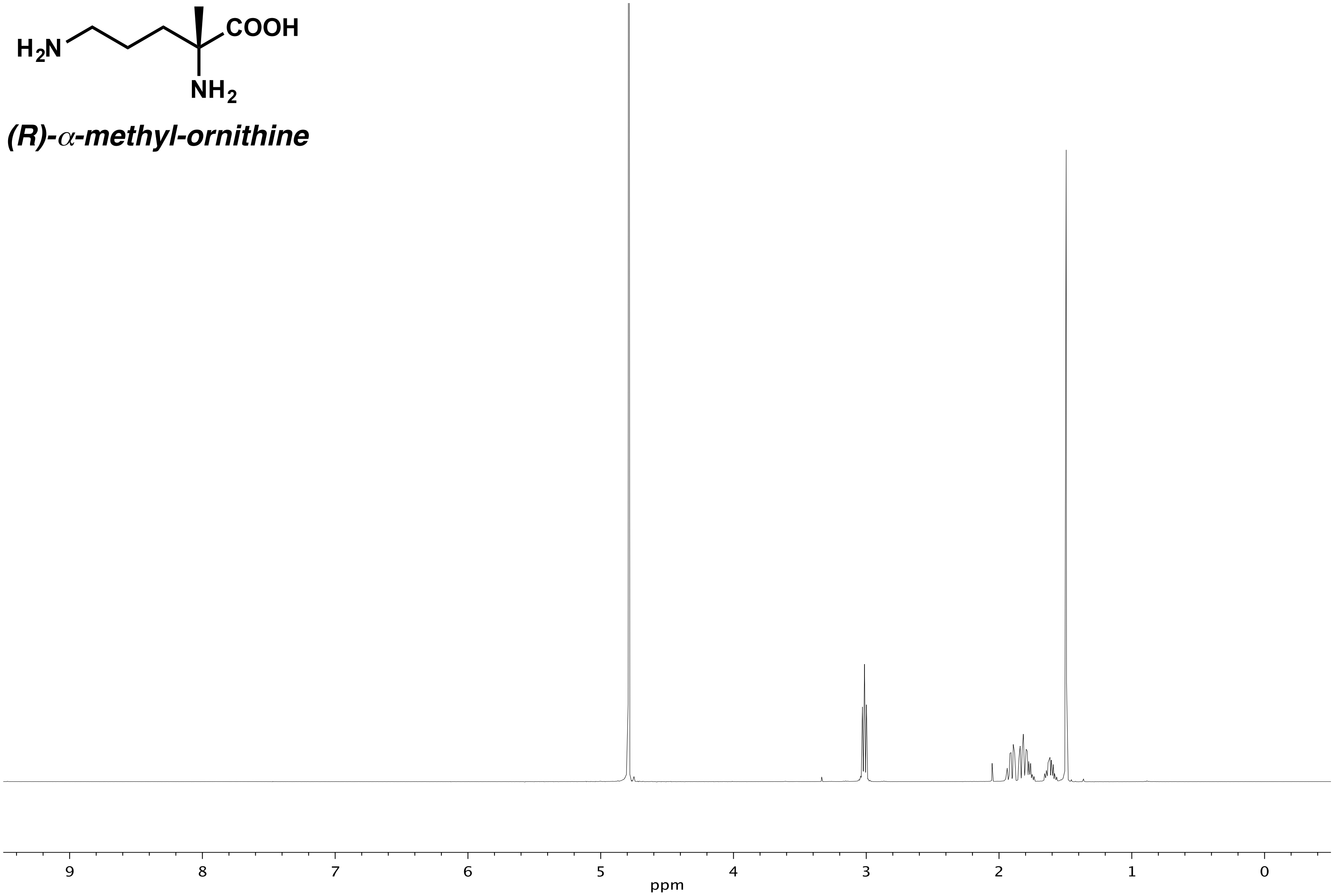
^{13}C NMR (126 MHz, CDCl$_3$) of compound **15.**



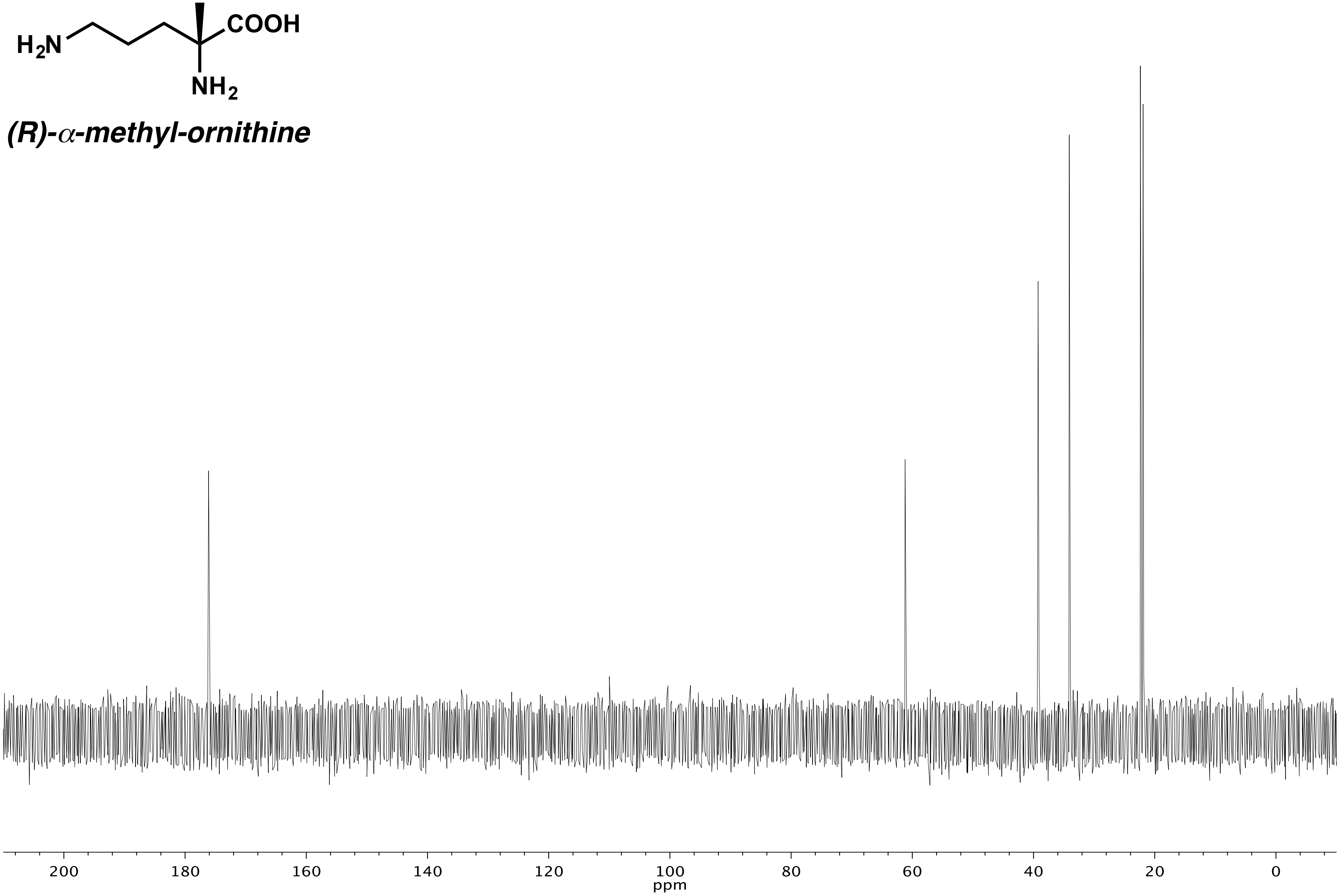
^{1}H NMR (500 MHz, CD$_3$OD) of compound **S14**.



^{13}C NMR (126 MHz, CD$_3$OD) of compound **S14.**

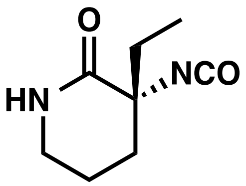


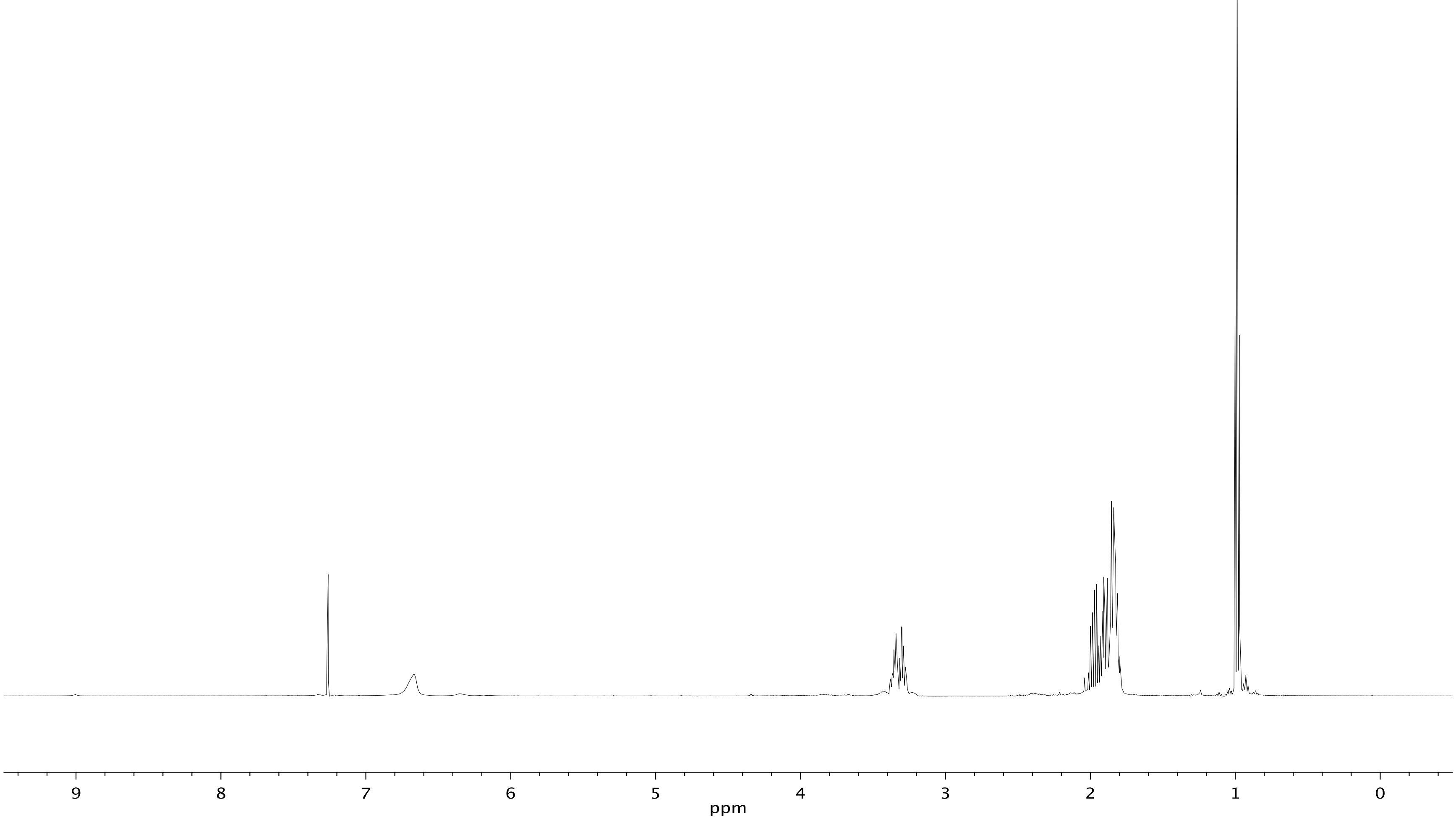
^{1}H NMR (500 MHz, D$_2$O) of compound **17**.



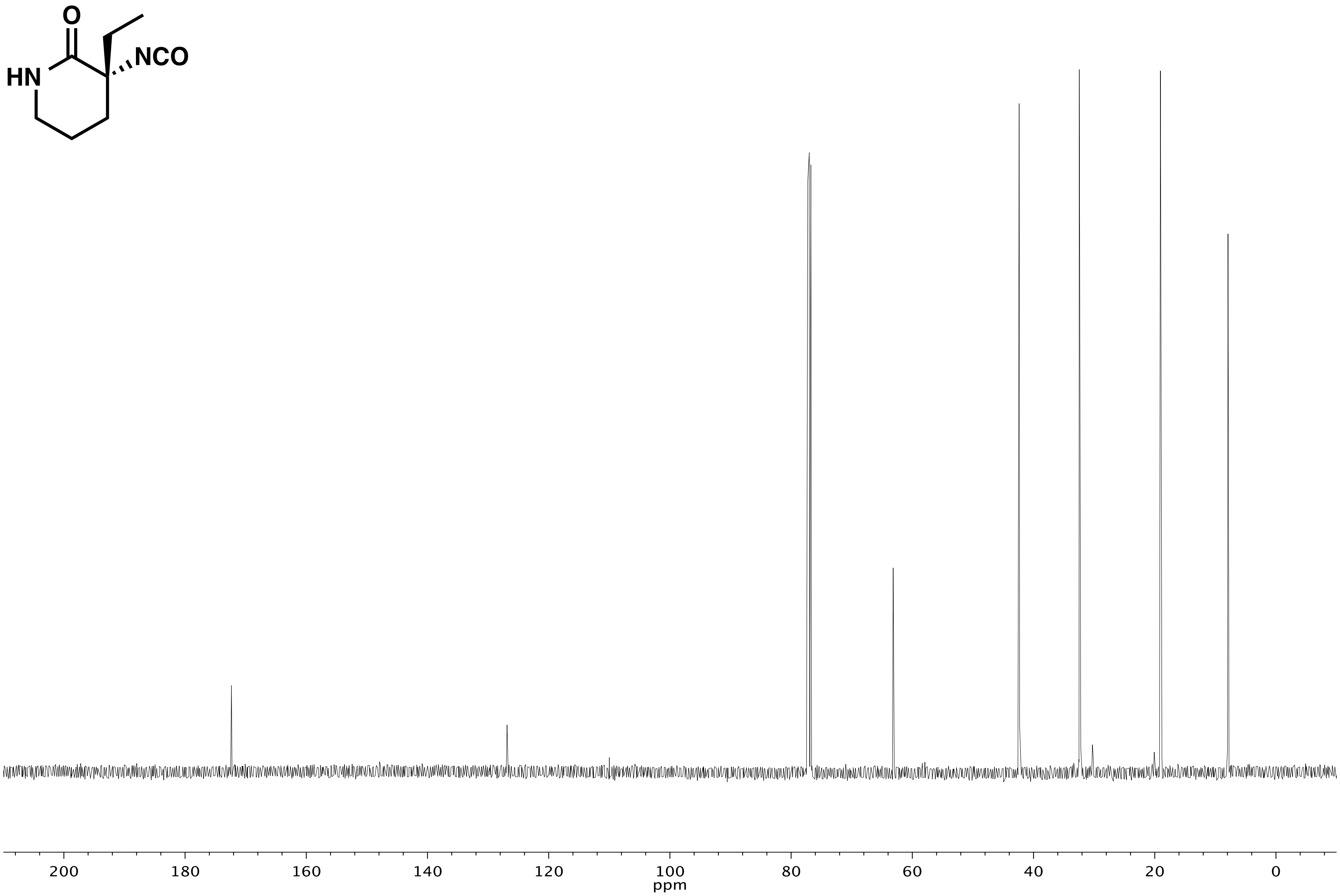
(R)-α-methyl-ornithine

^{13}C NMR (126 MHz, D_2O) of compound **17.**

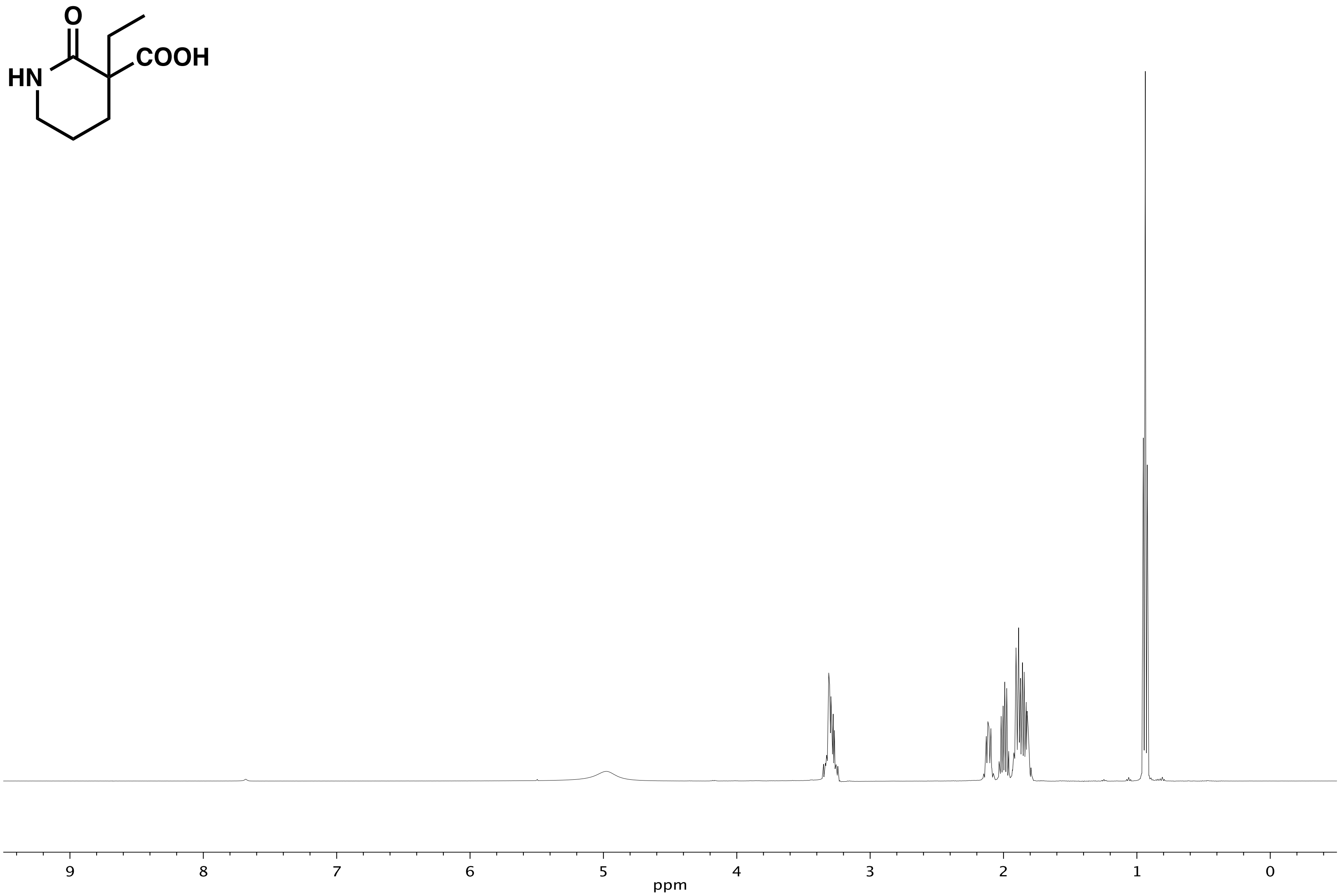




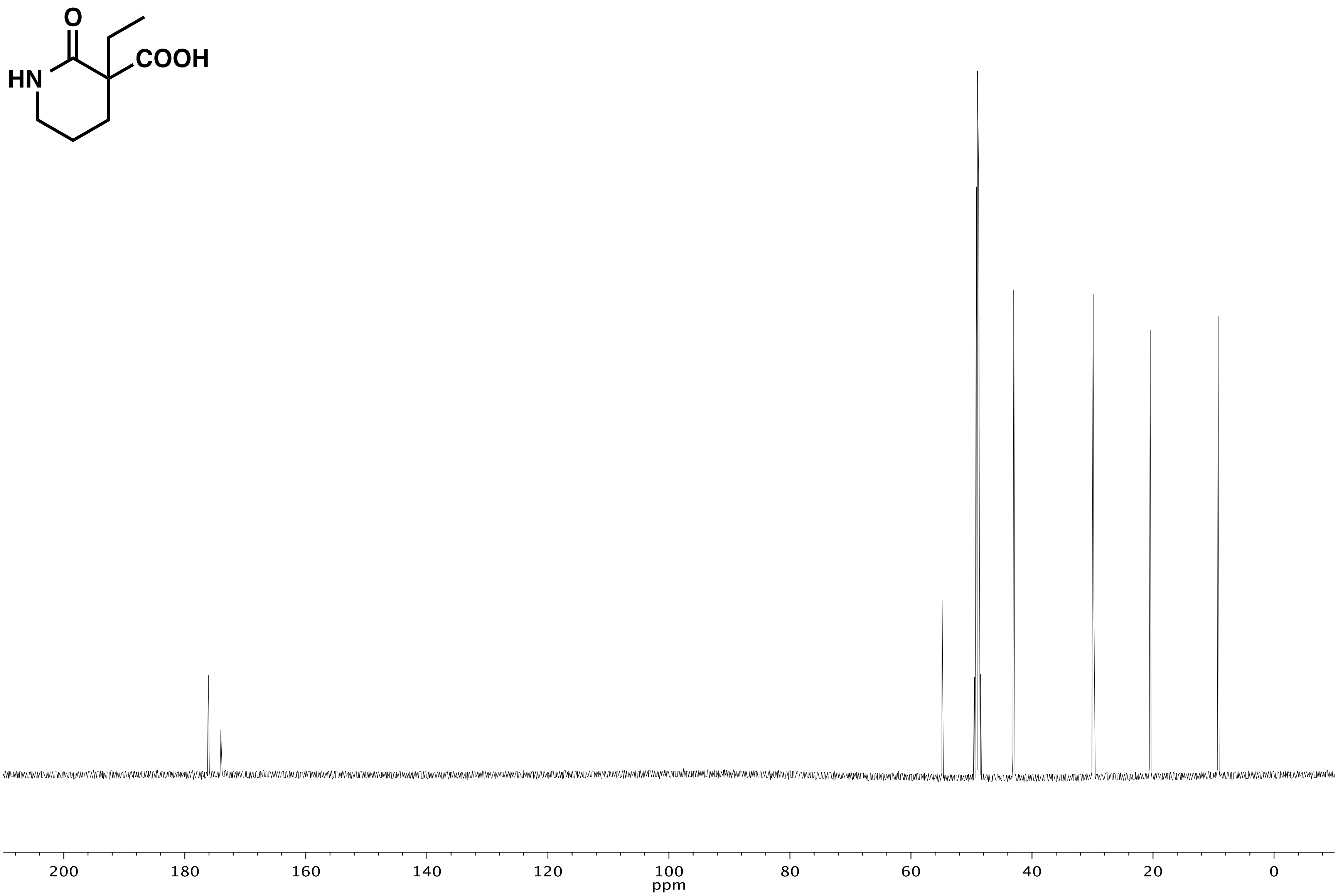
^{1}H NMR (500 MHz, CDCl$_3$) of compound **16**.



^{13}C NMR (126 MHz, CDCl$_3$) of compound **16**.

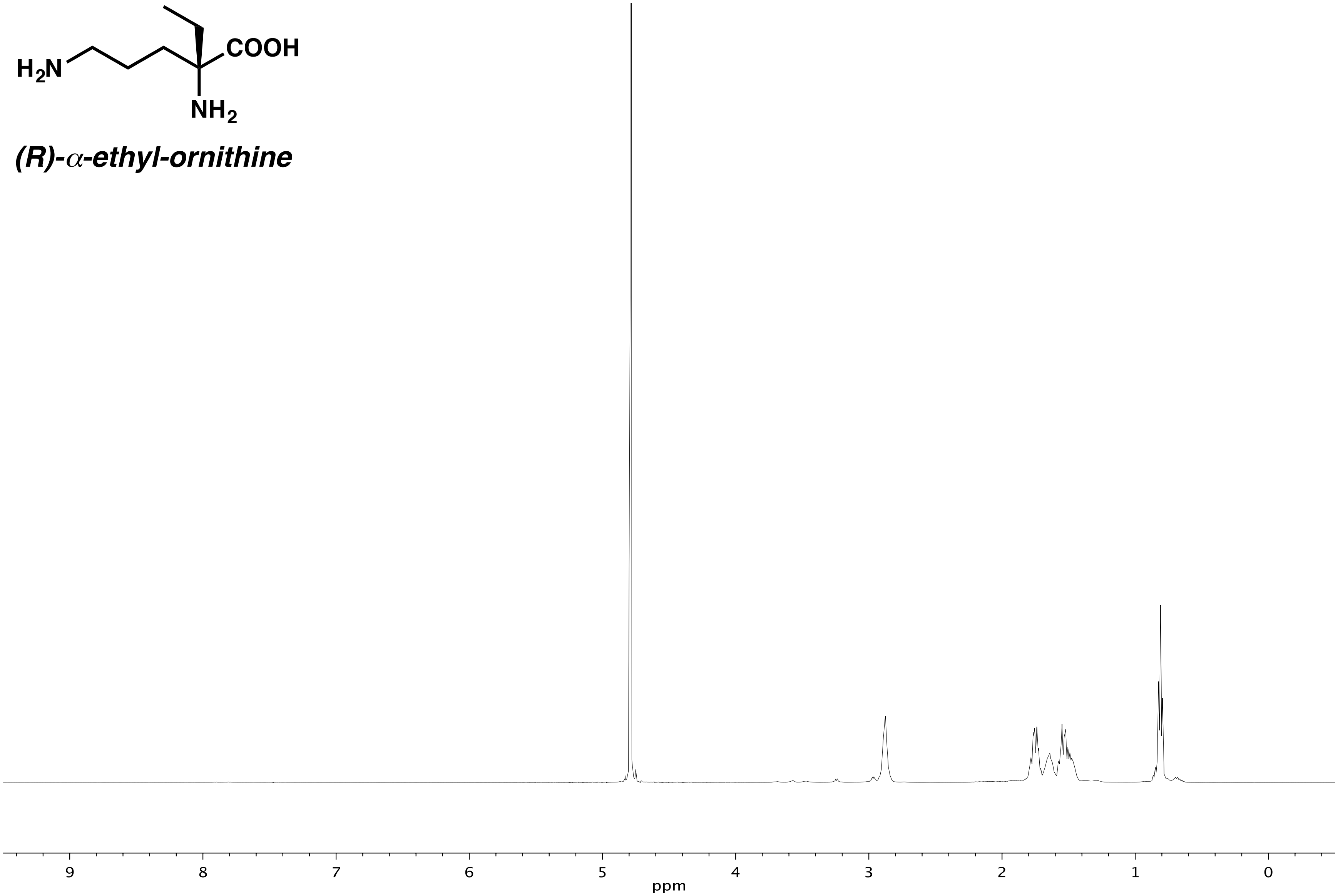


^{1}H NMR (500 MHz, CD$_3$OD) of compound **S17**.

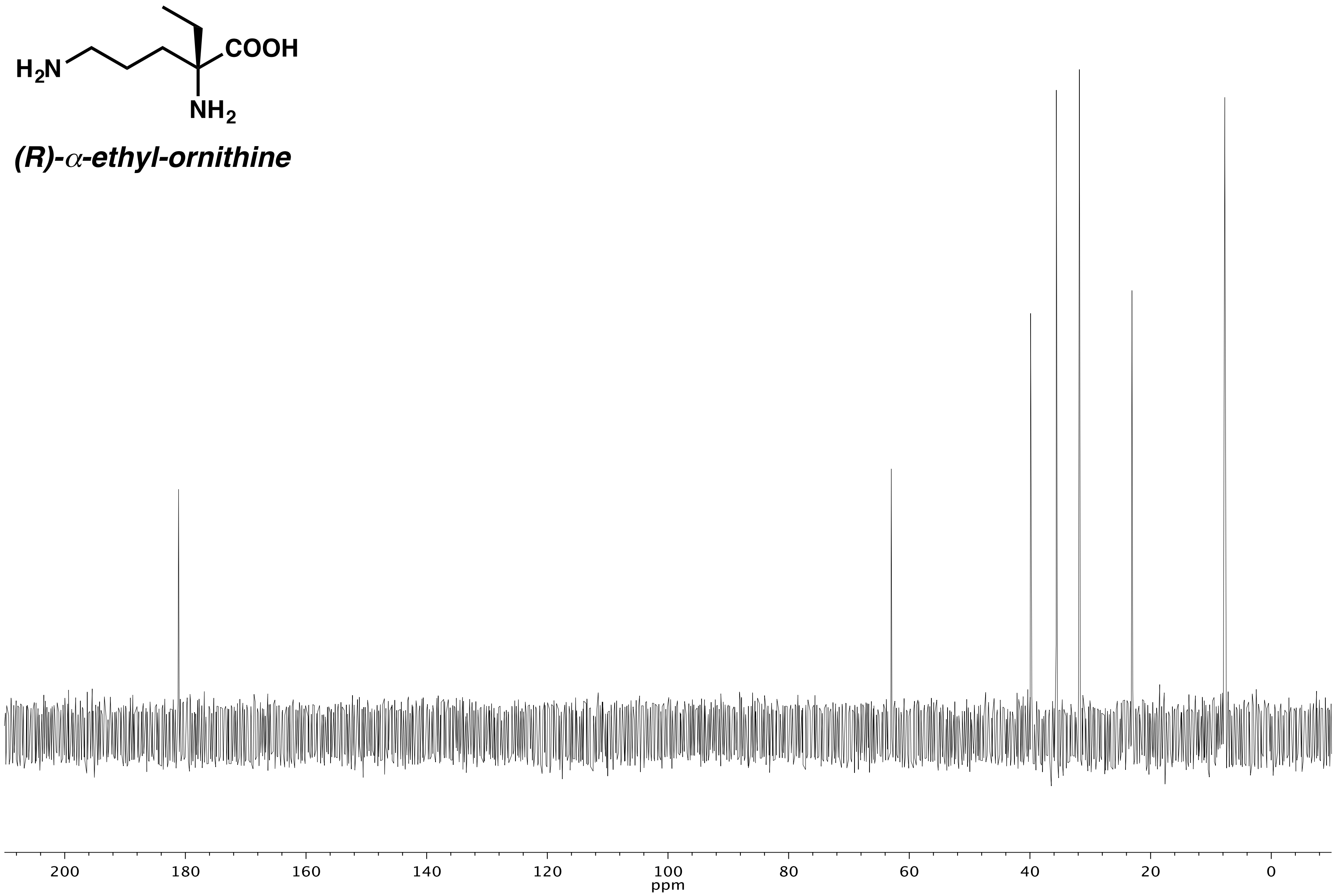


^{13}C NMR (126 MHz, CD_3OD) of compound **S17.**

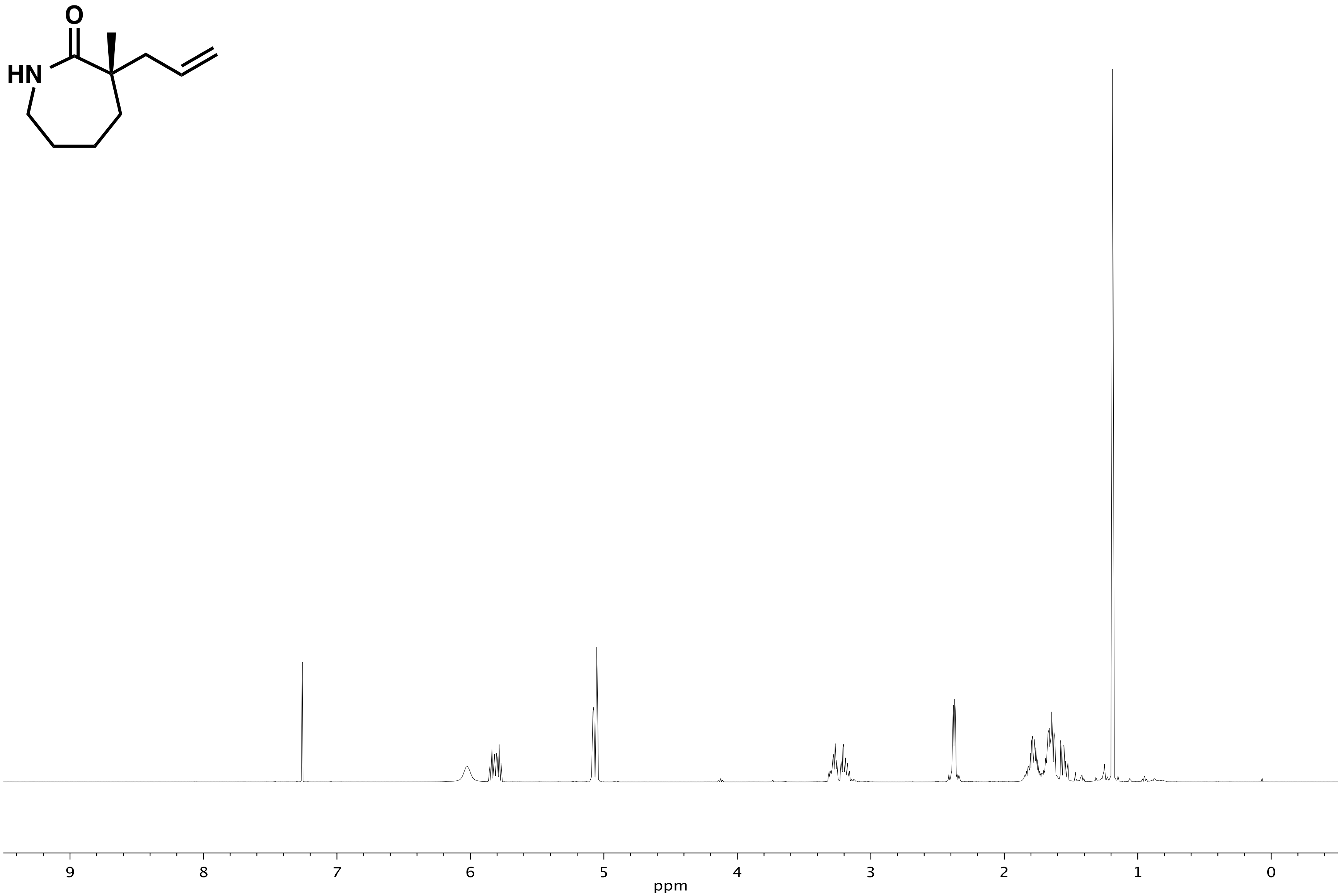
(R)-α-ethyl-ornithine



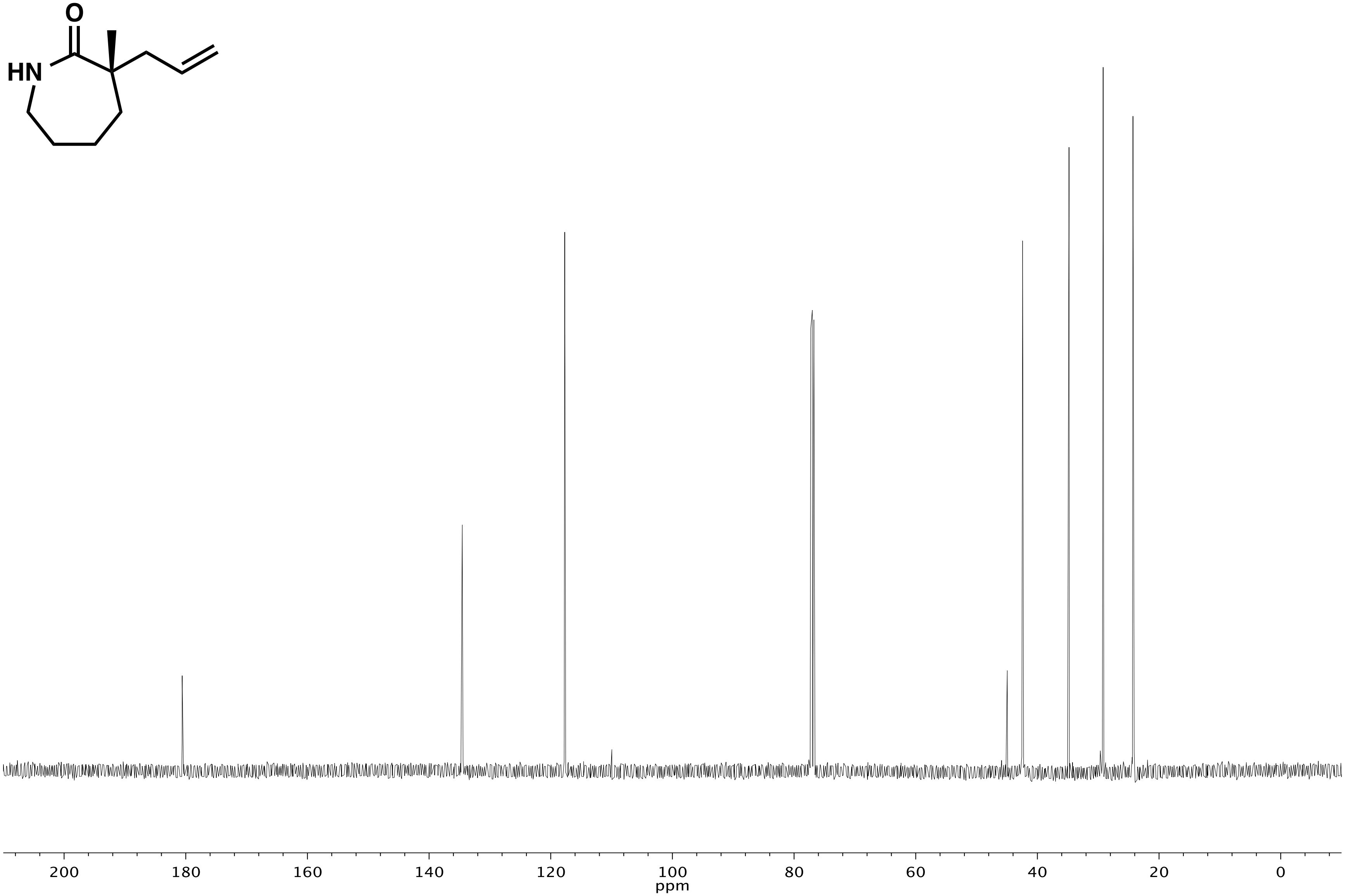
^{1}H NMR (500 MHz, D_2O) of compound **18**.



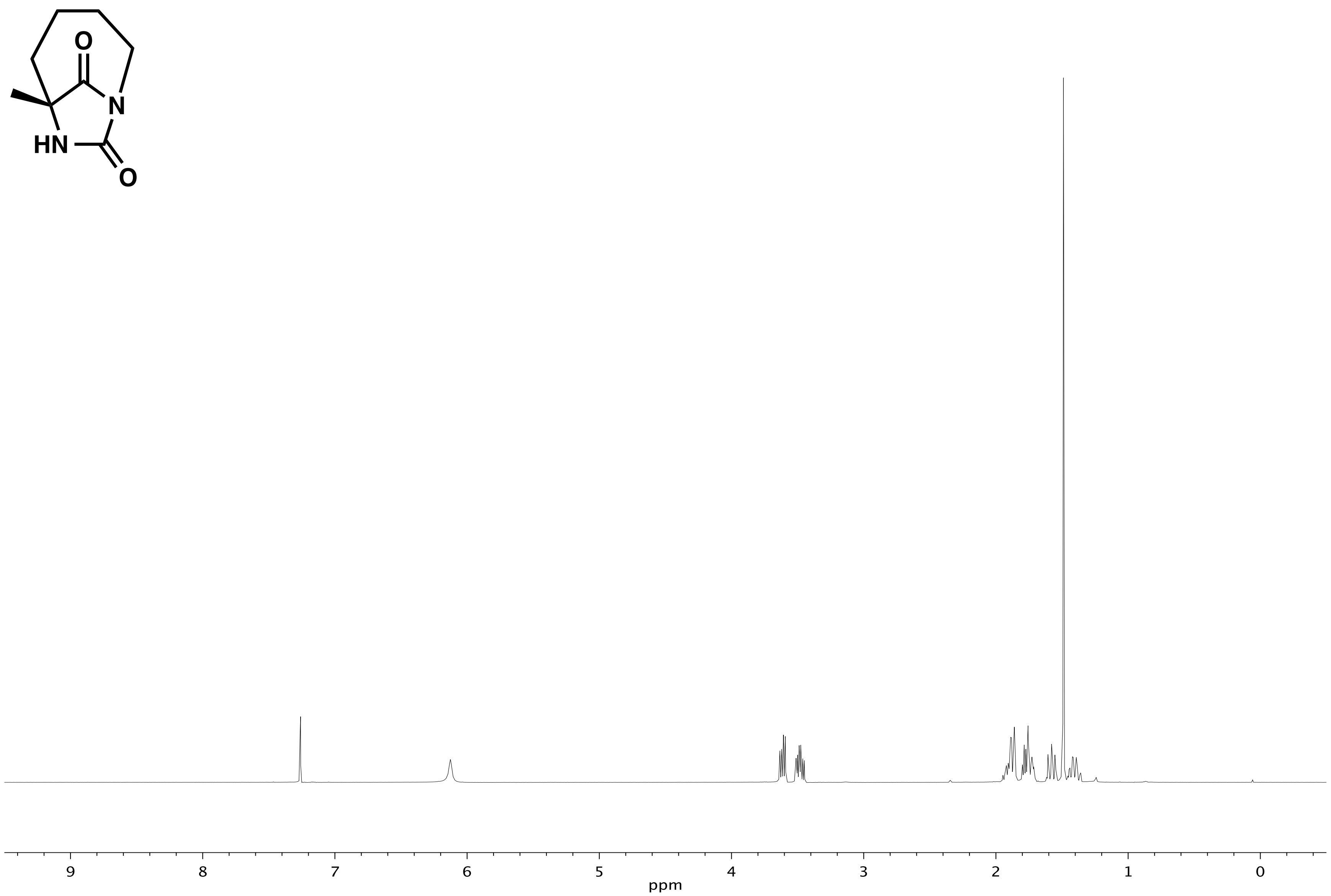
^{13}C NMR (126 MHz, D_2O) of compound **18.**



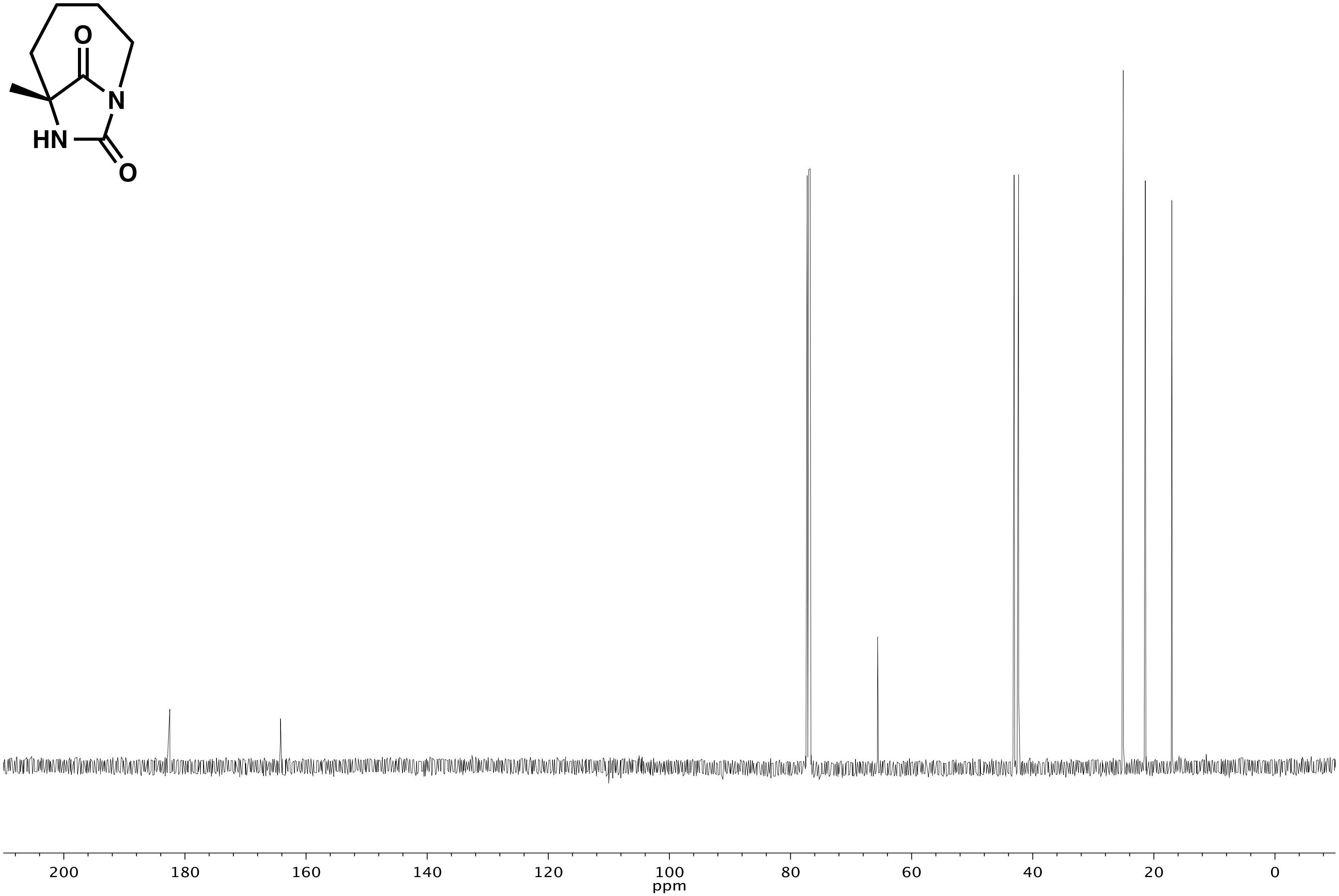
^{1}H NMR (500 MHz, CDCl$_3$) of compound **19**.



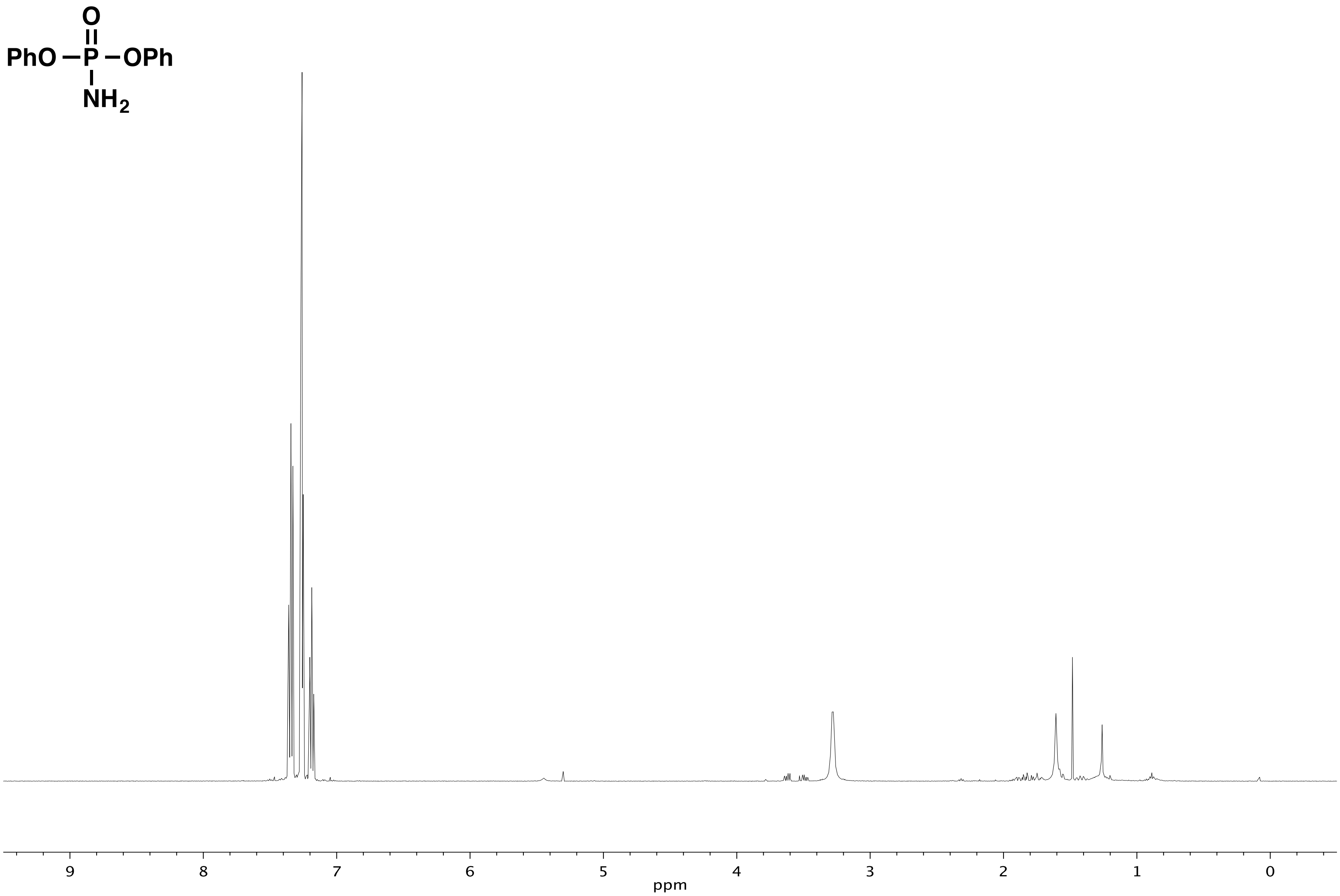
^{13}C NMR (126 MHz, CDCl$_3$) of compound **19**.



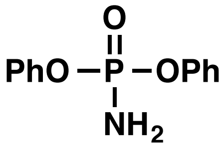
^{1}H NMR (500 MHz, $CDCl_3$) of compound **20.**

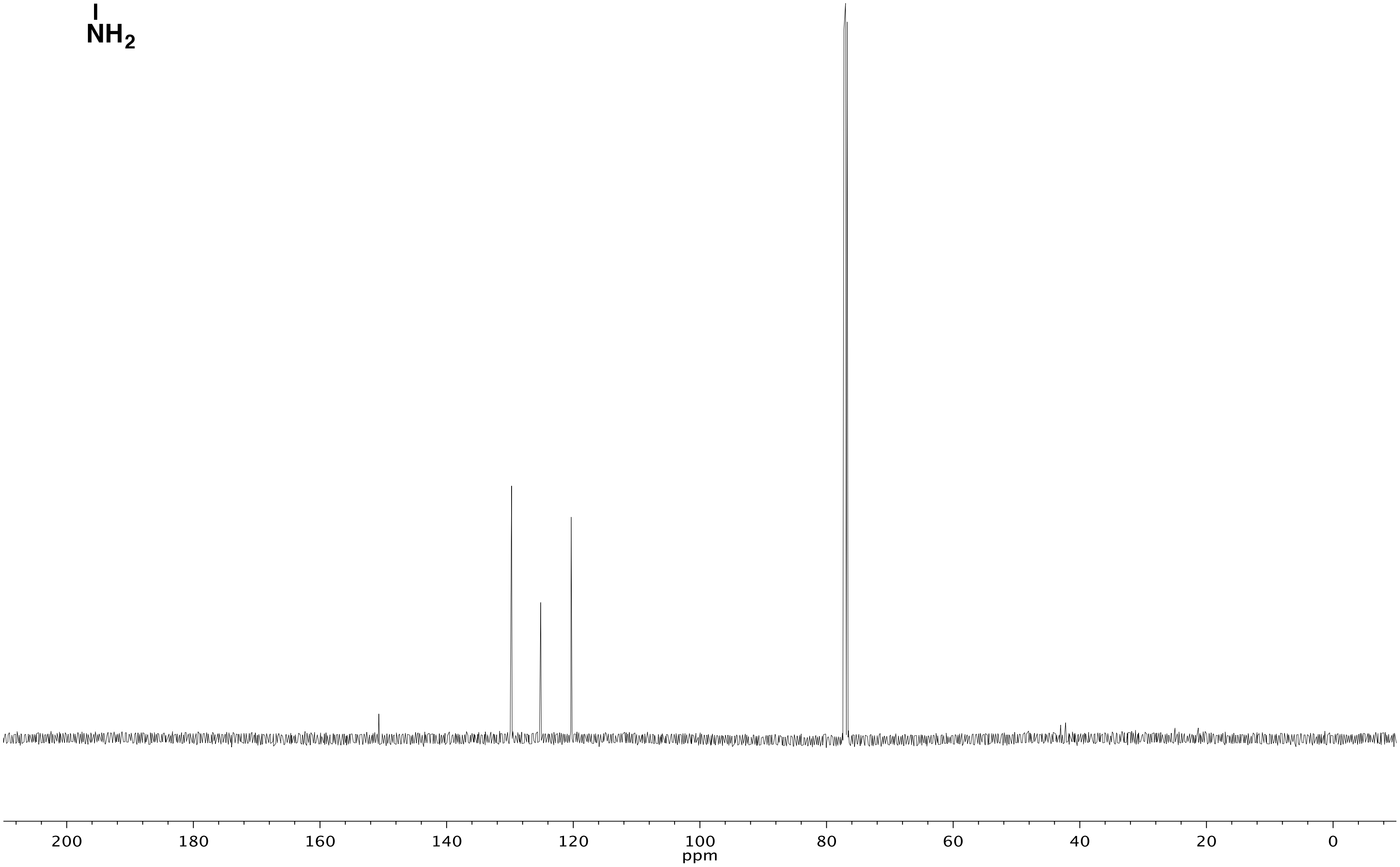


^{13}C NMR (126 MHz, CDCl$_3$) of compound **20.**

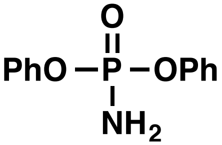


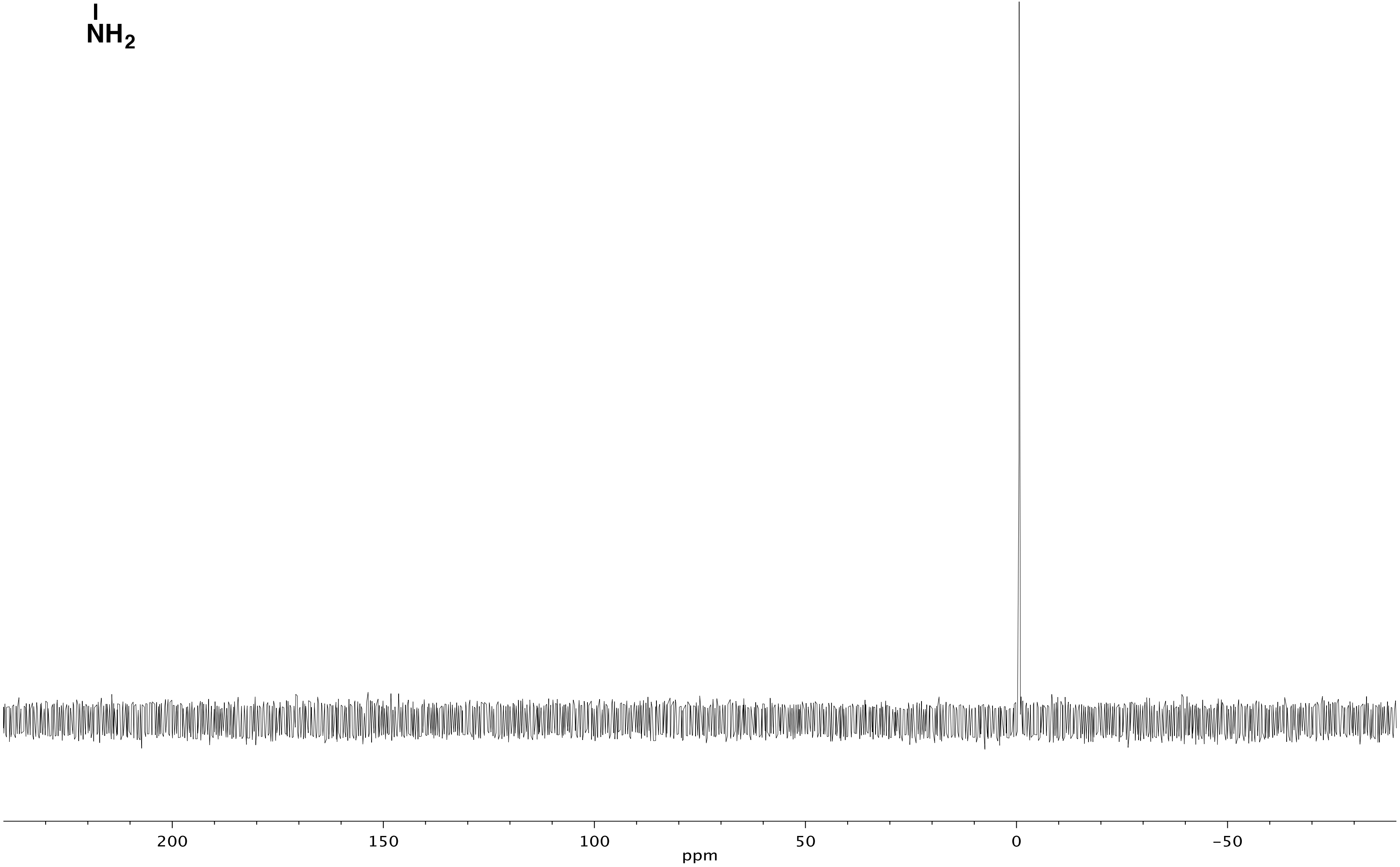
^{1}H NMR (500 MHz, CDCl$_3$) of compound **S19.**



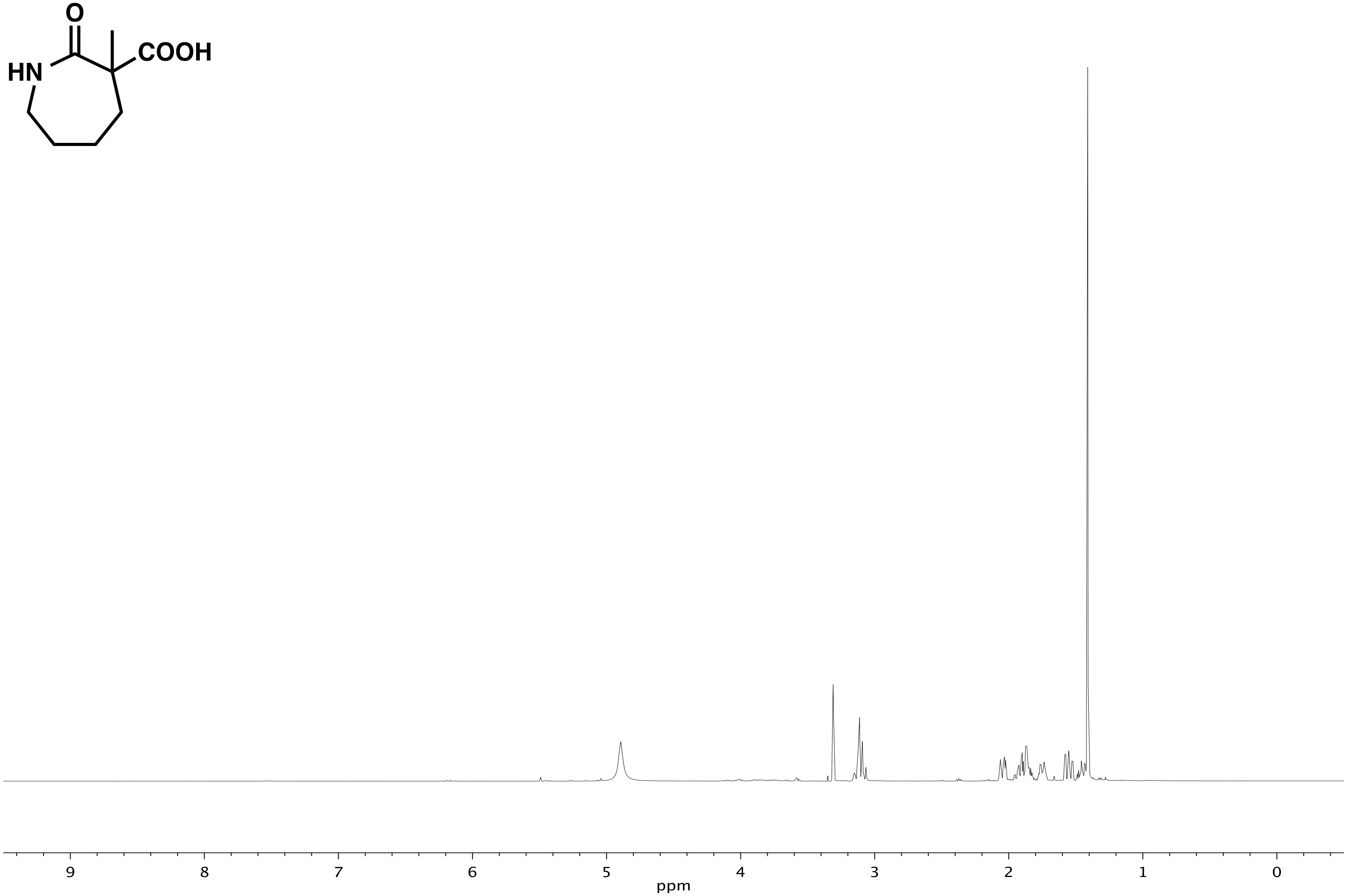


^{13}C NMR (126 MHz, CDCl$_3$) of compound **S19.**

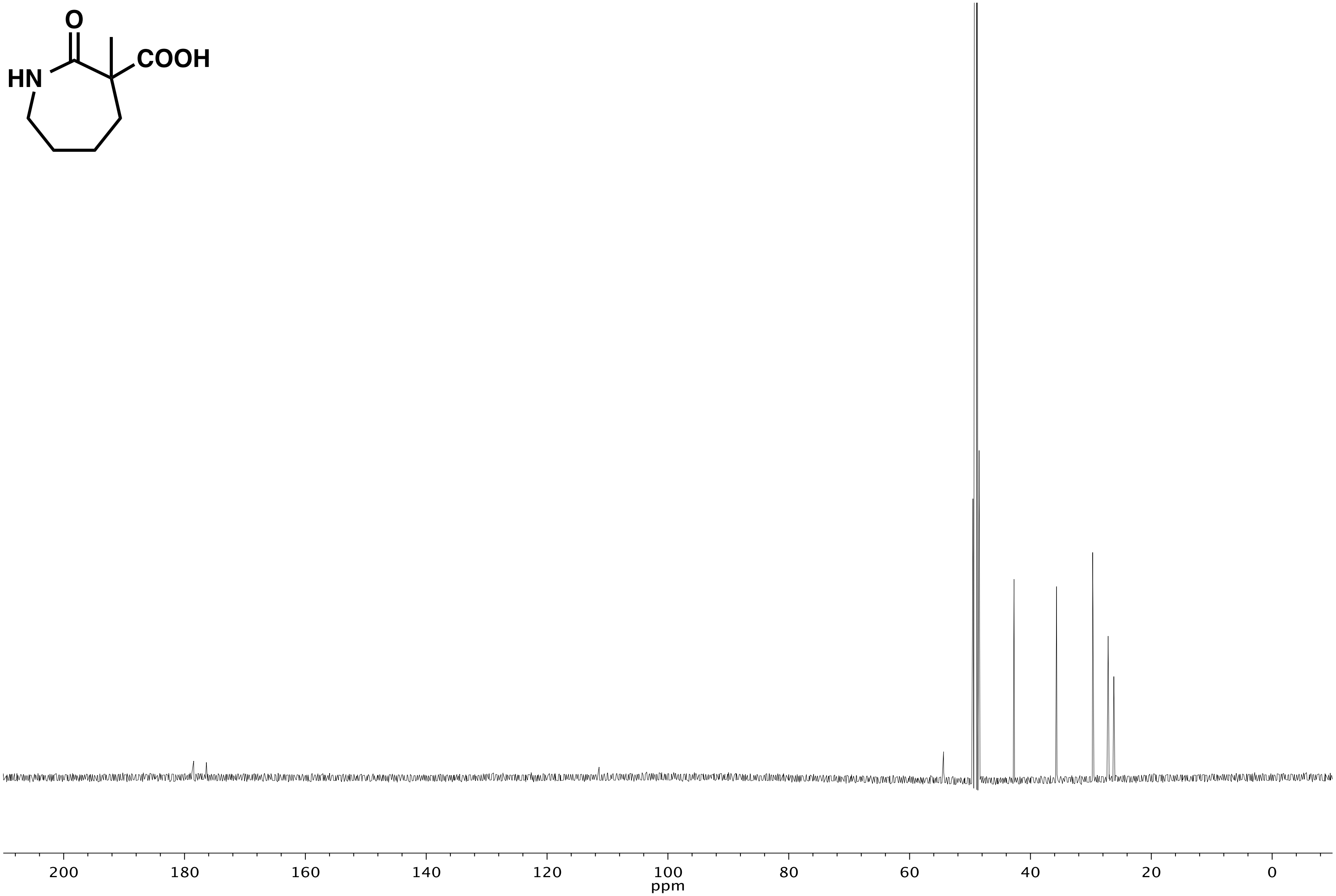




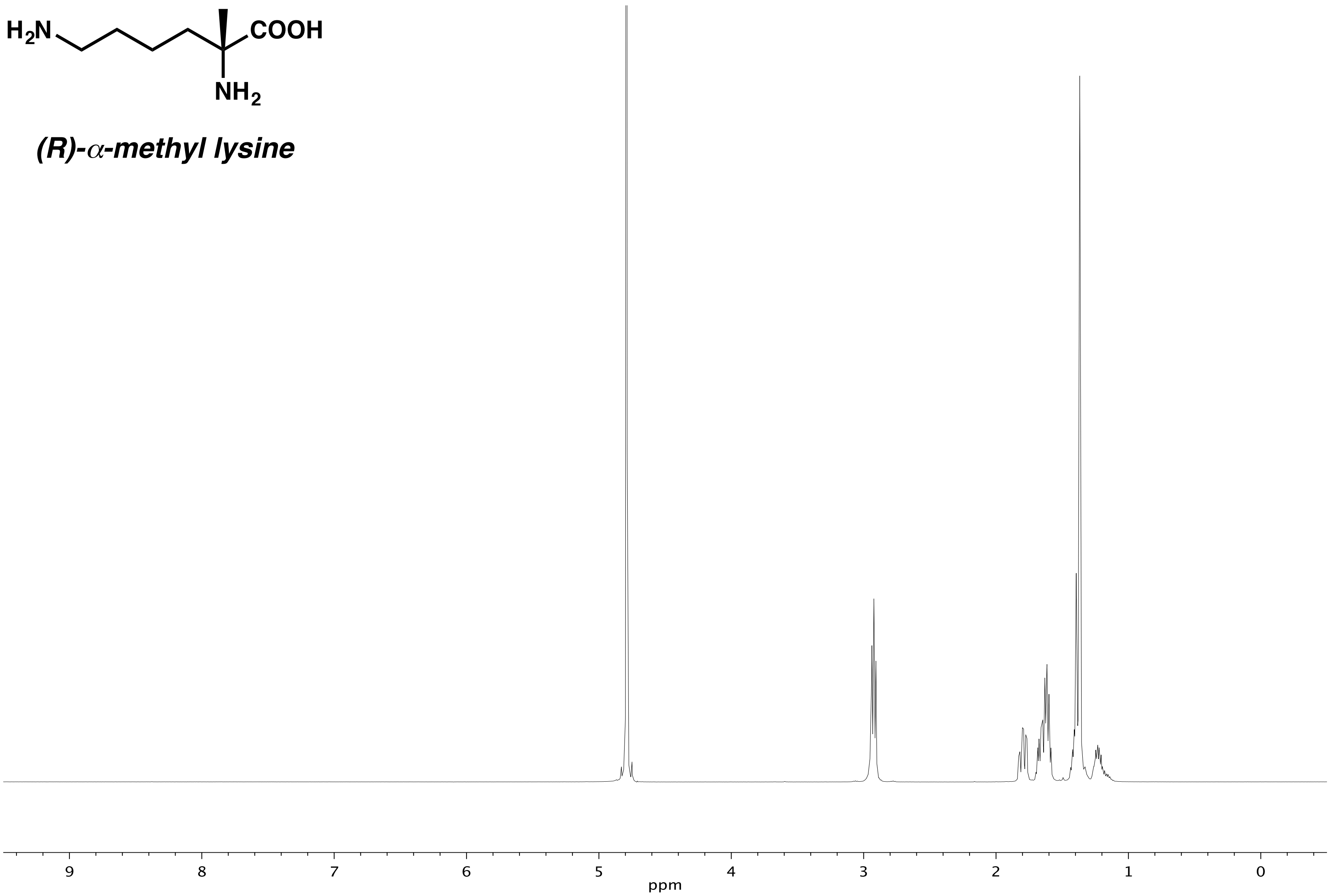
^{31}P NMR (121 MHz, CDCl$_3$) of compound **S19.**



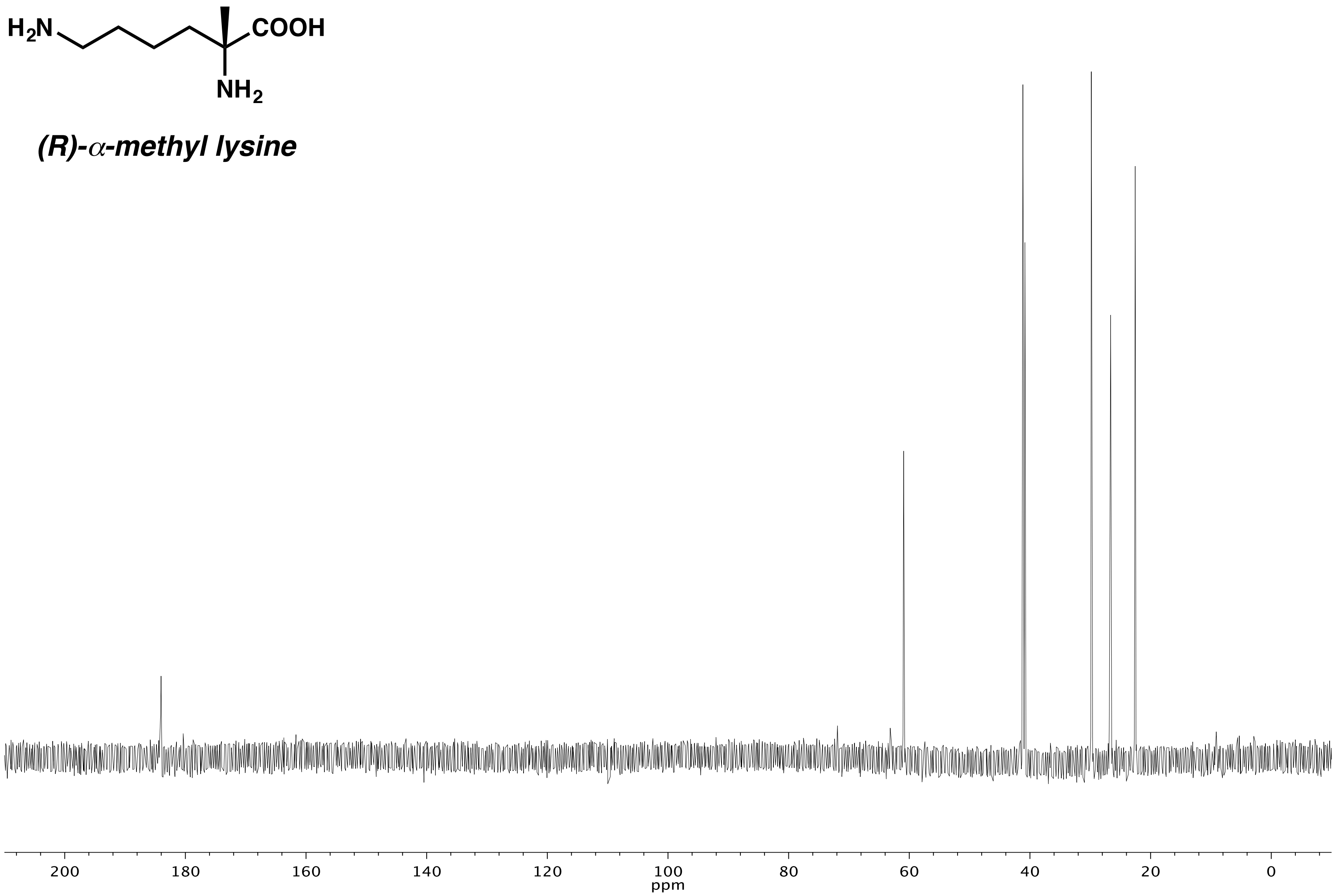
^{1}H NMR (500 MHz, CD$_3$OD) of compound **S20**.



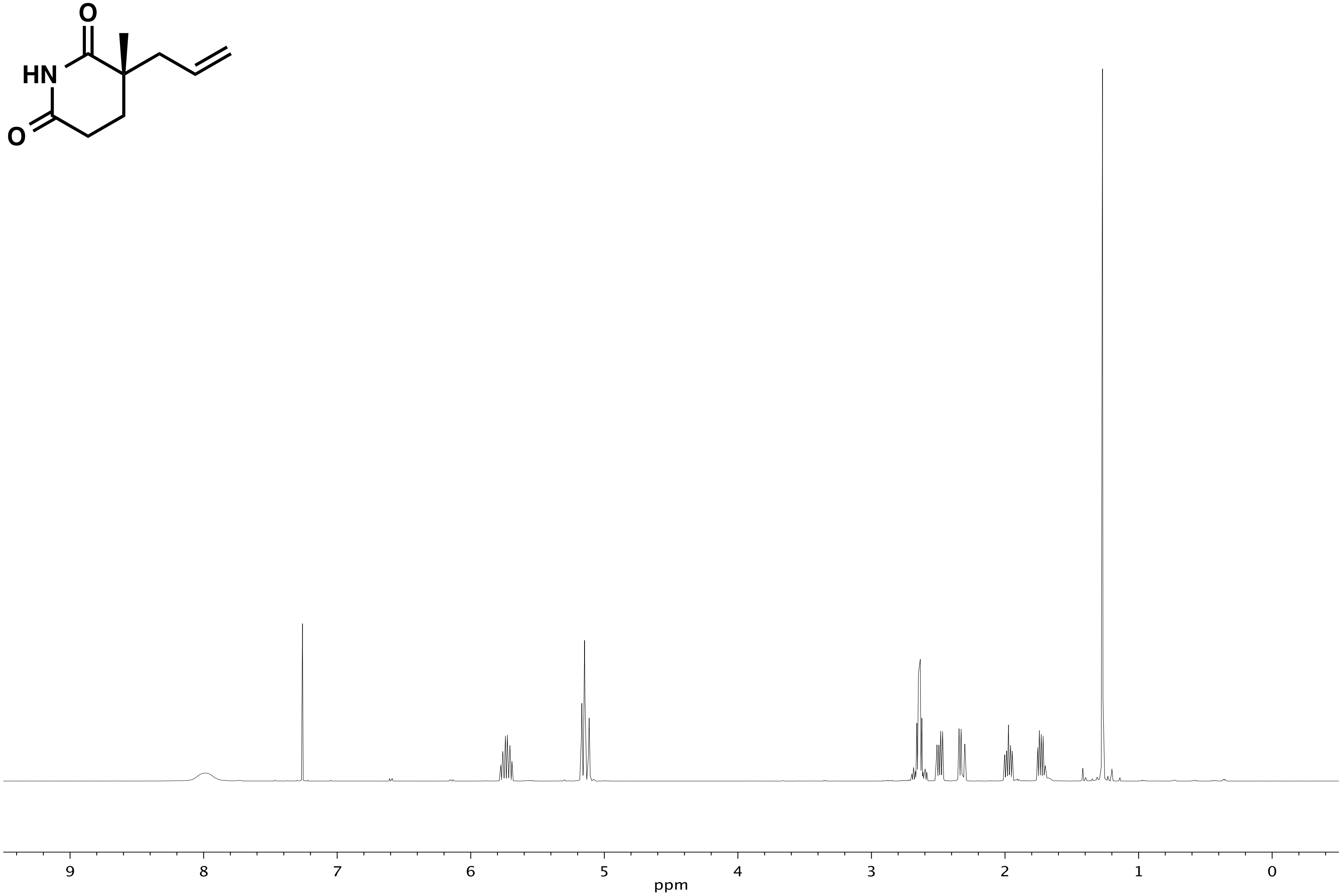
^{13}C NMR (126 MHz, CD$_3$OD) of compound **S20.**



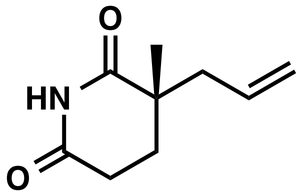
^{1}H NMR (500 MHz, D_2O) of compound **21.**

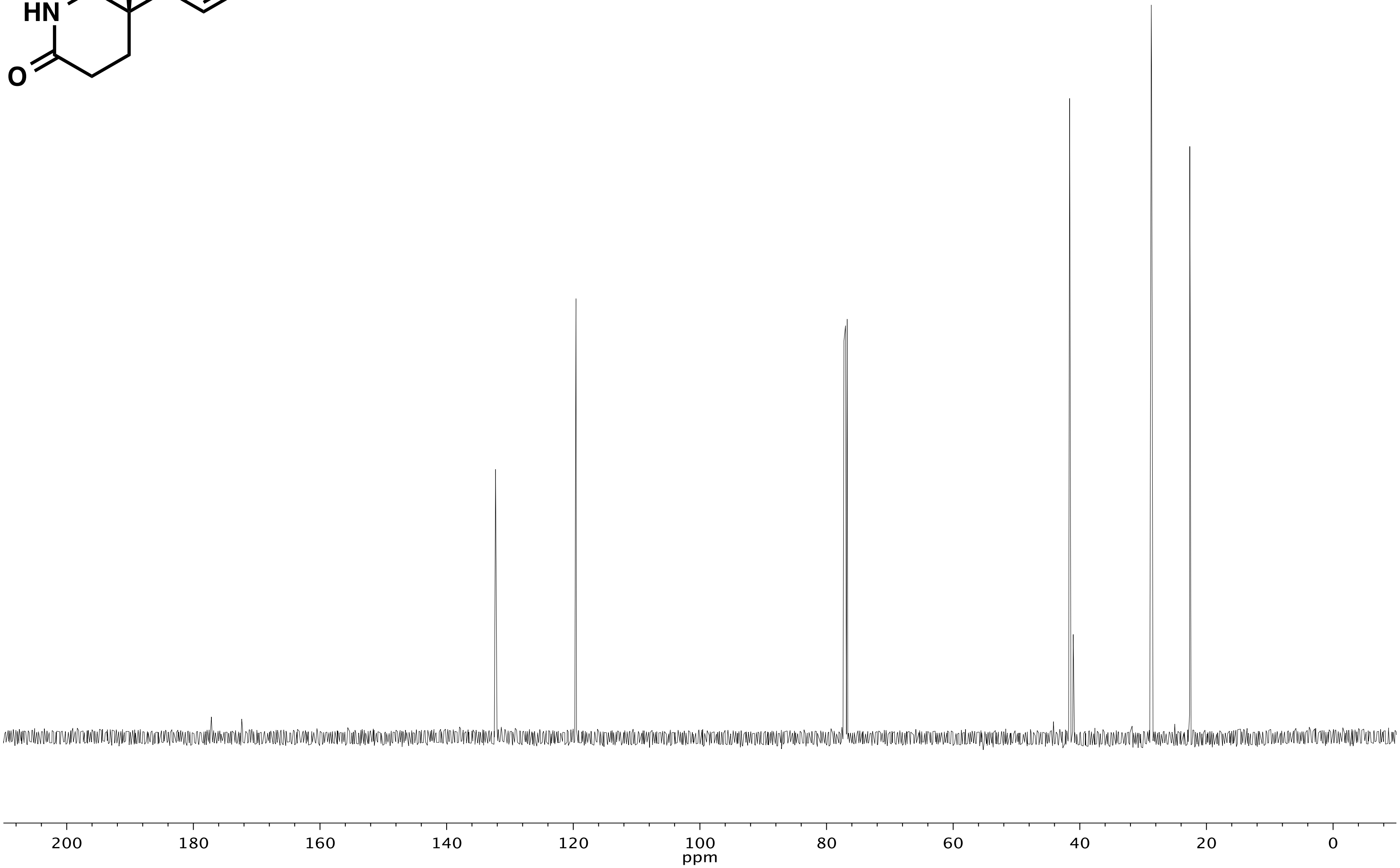


^{13}C NMR (126 MHz, D_2O) of compound **21.**

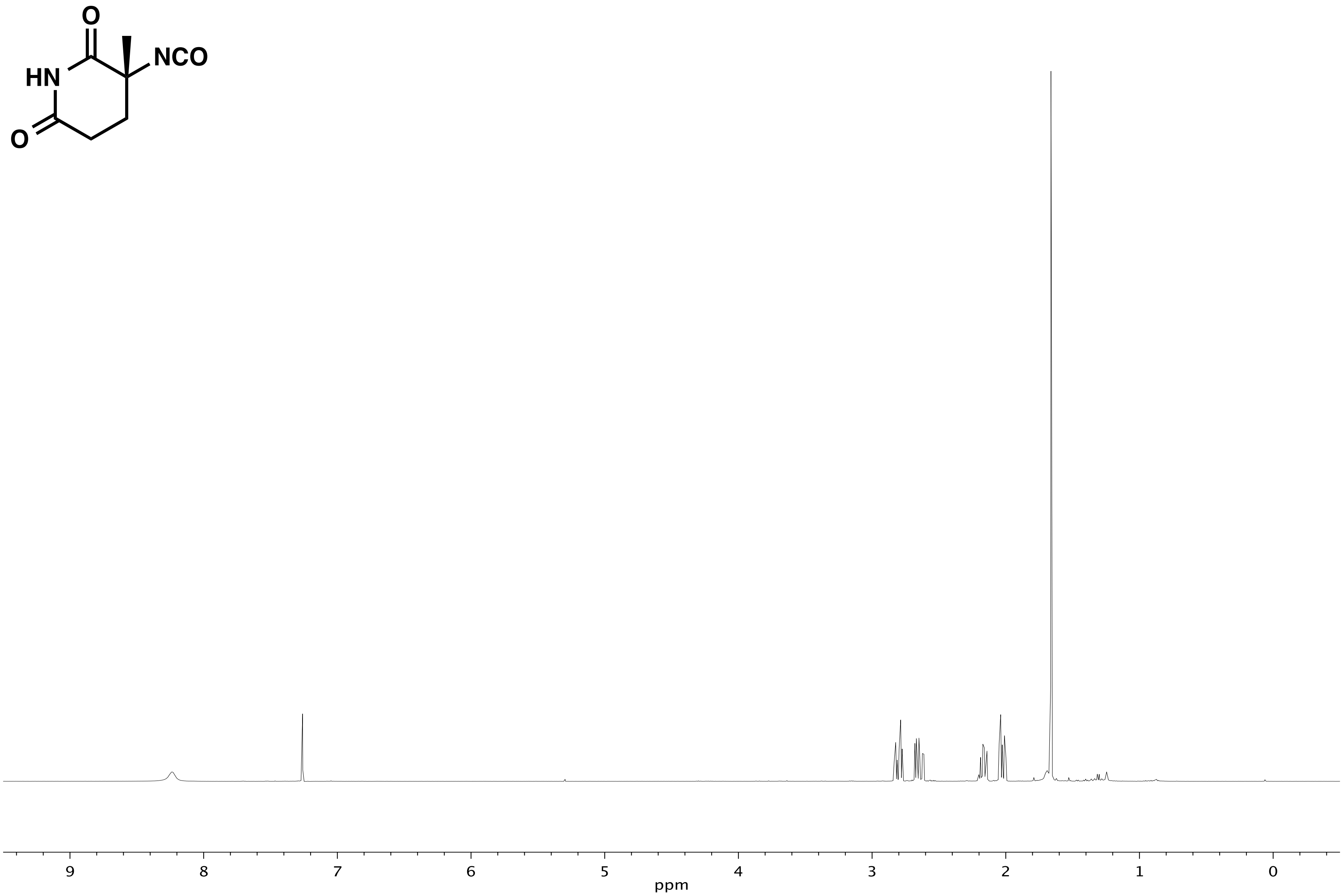


^{1}H NMR (500 MHz, CDCl$_3$) of compound **22**.

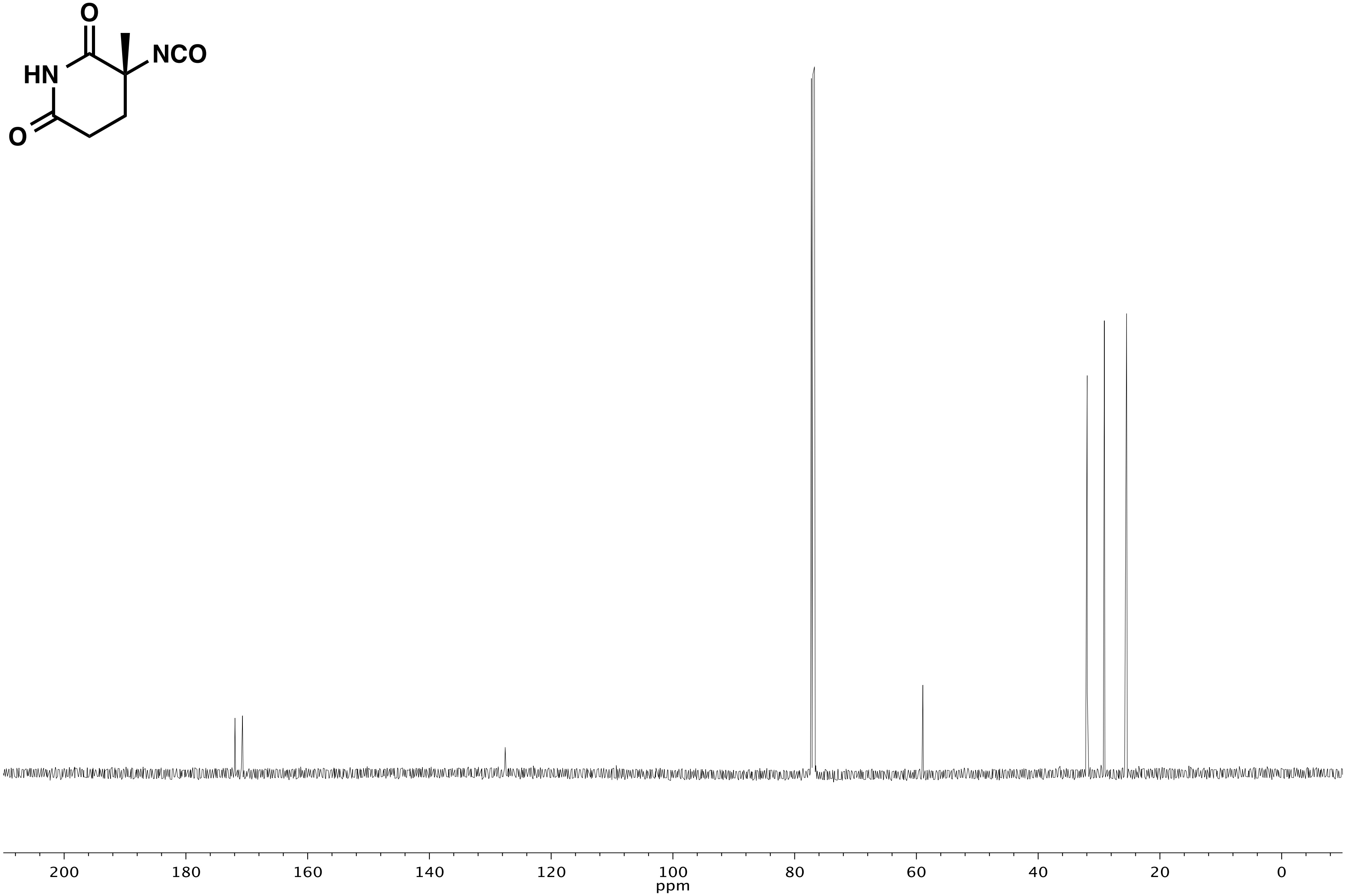




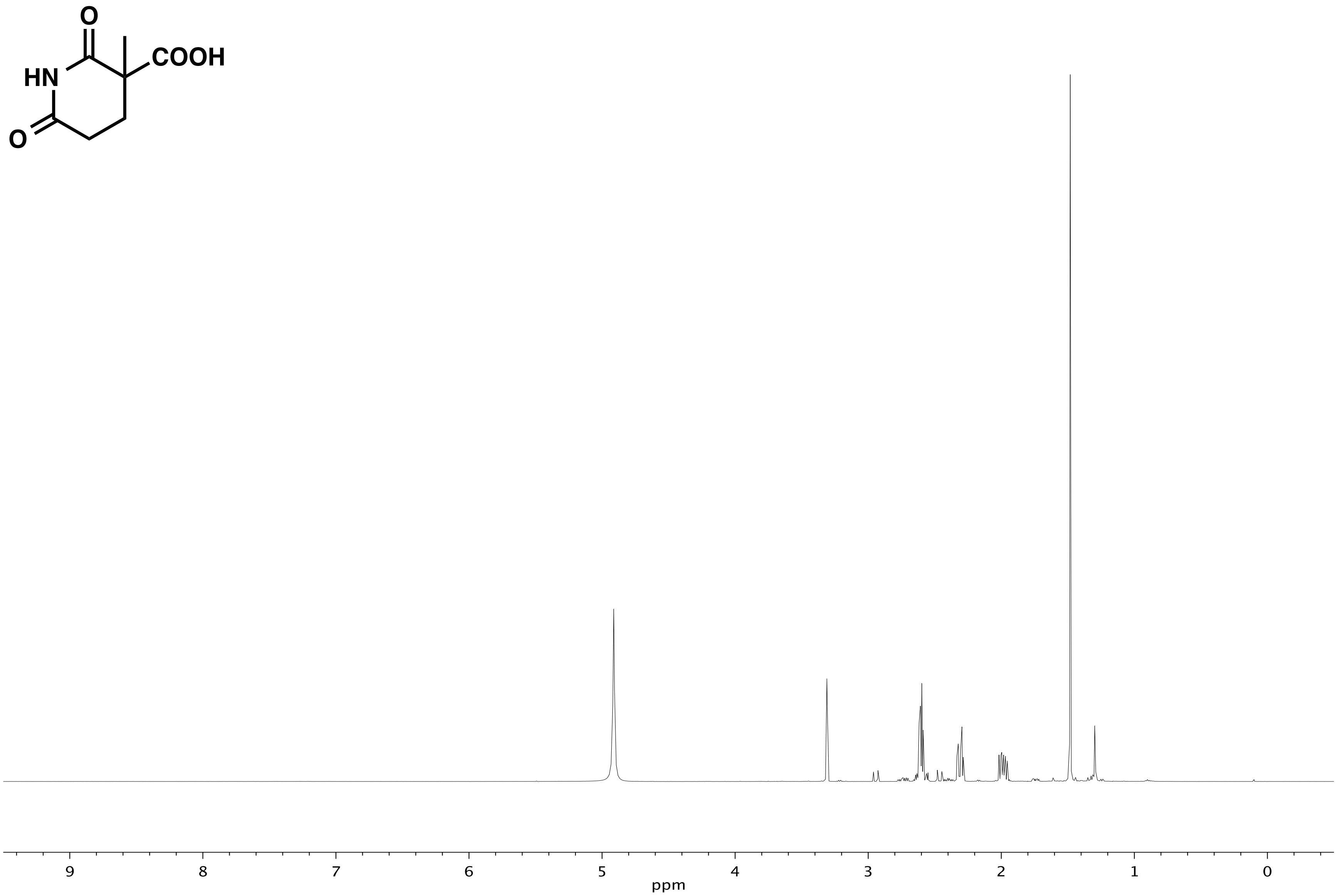
^{13}C NMR (126 MHz, CDCl$_3$) of compound **22.**



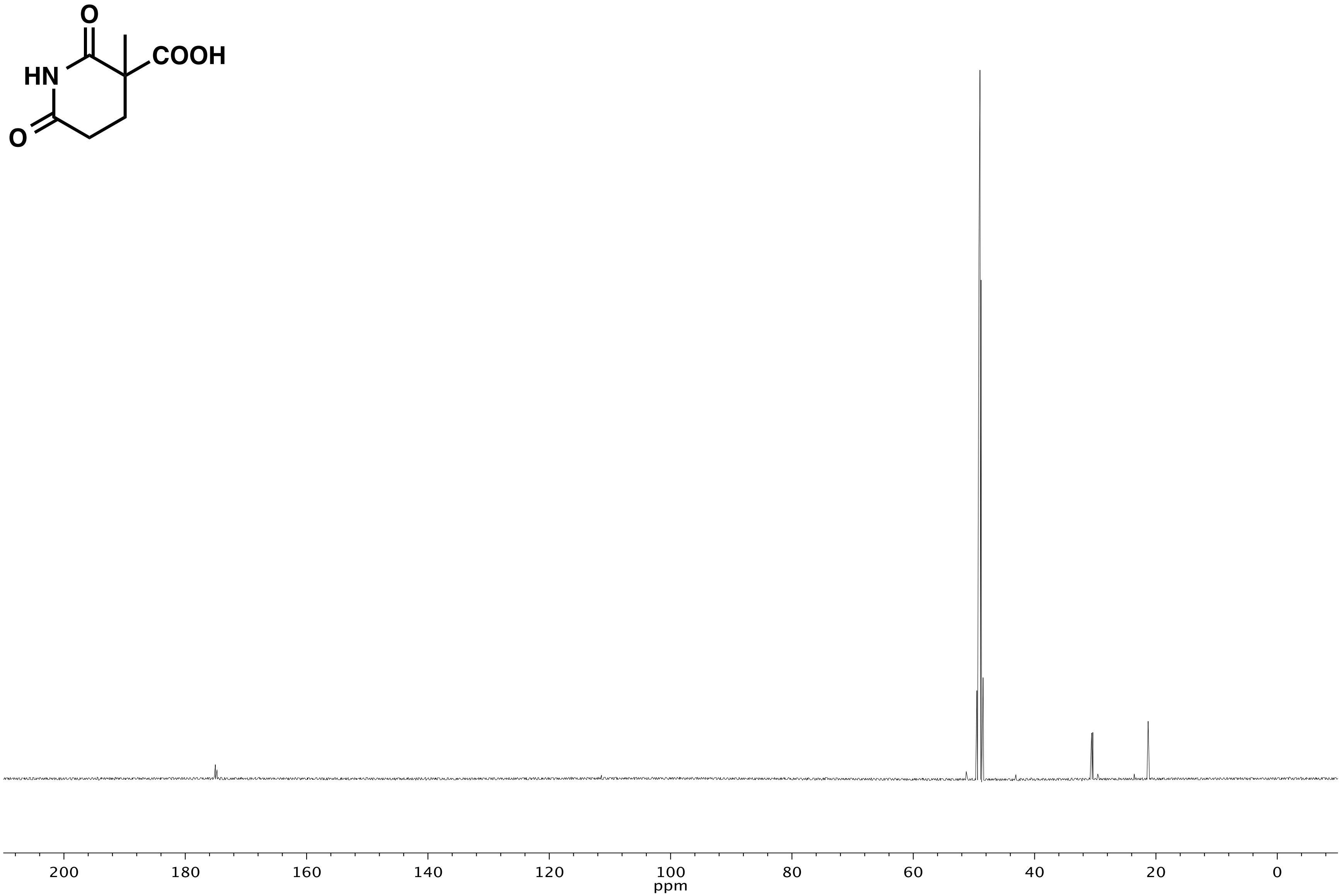
^{1}H NMR (500 MHz, CDCl$_3$) of compound **23**.



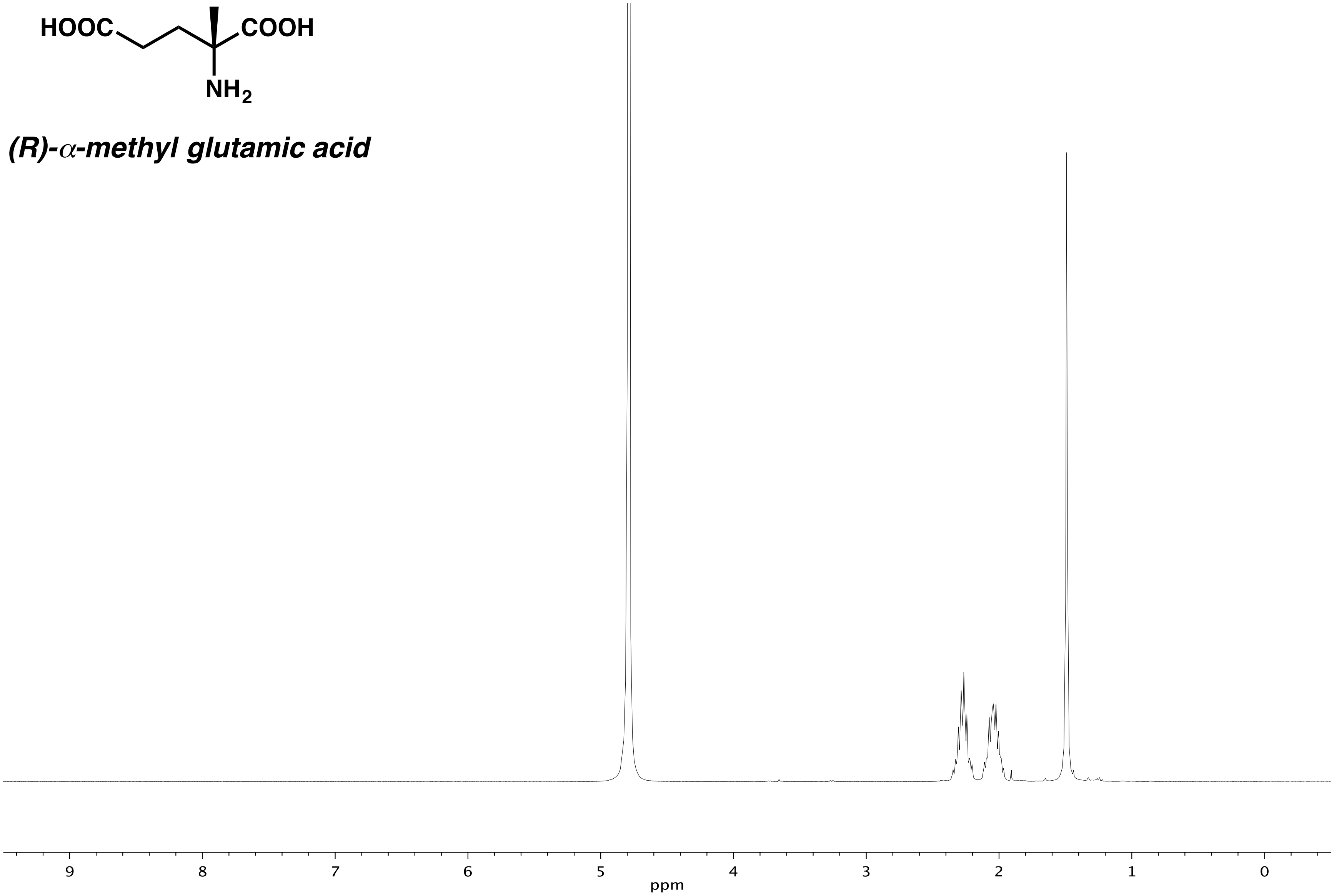
^{13}C NMR (126 MHz, CDCl$_3$) of compound **23.**



^{1}H NMR (500 MHz, CD_3OD) of compound **S23.**

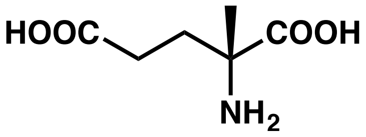


^{13}C NMR (126 MHz, CD$_3$OD) of compound **S23.**

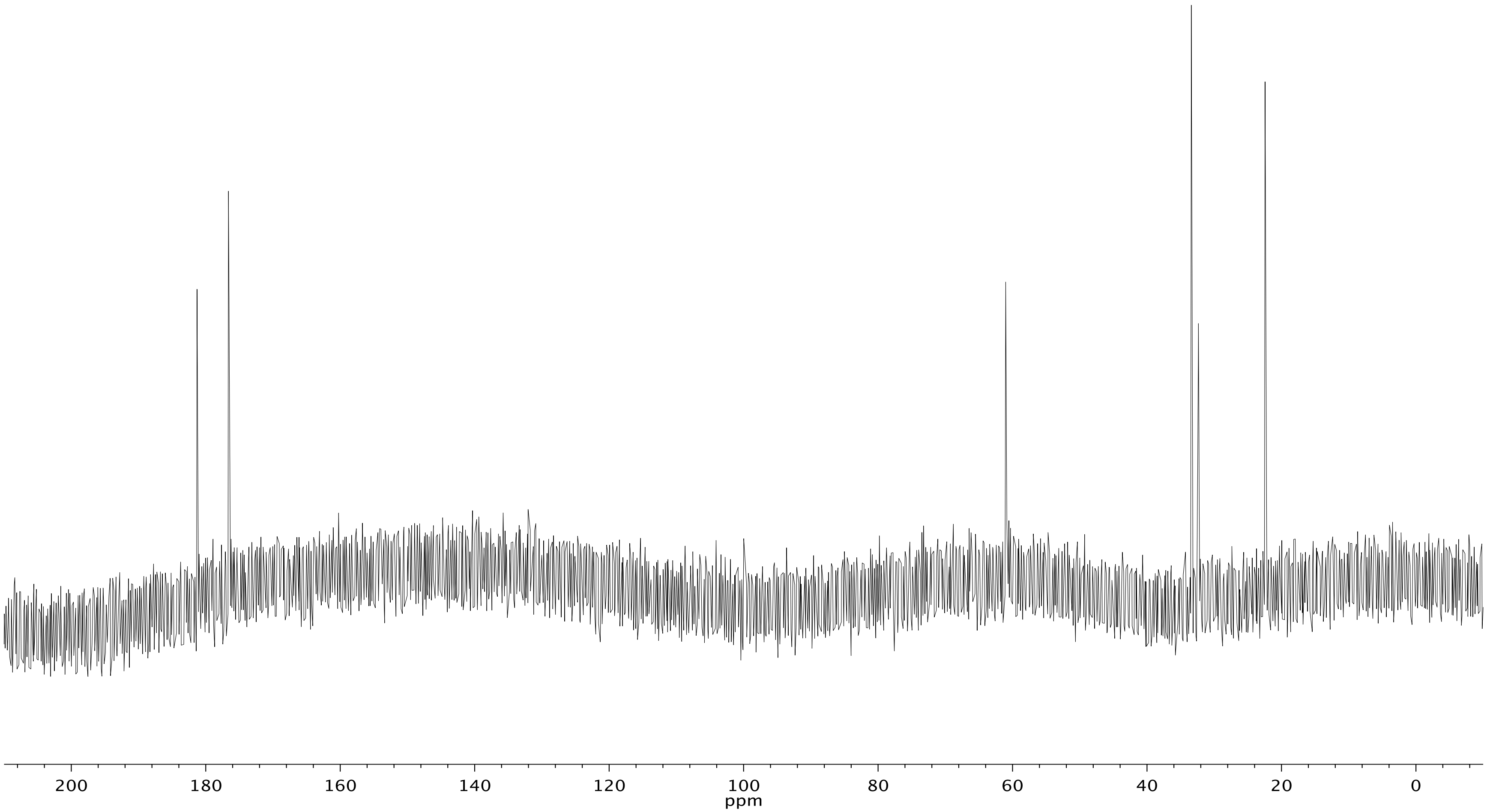


(R)-α-methyl glutamic acid

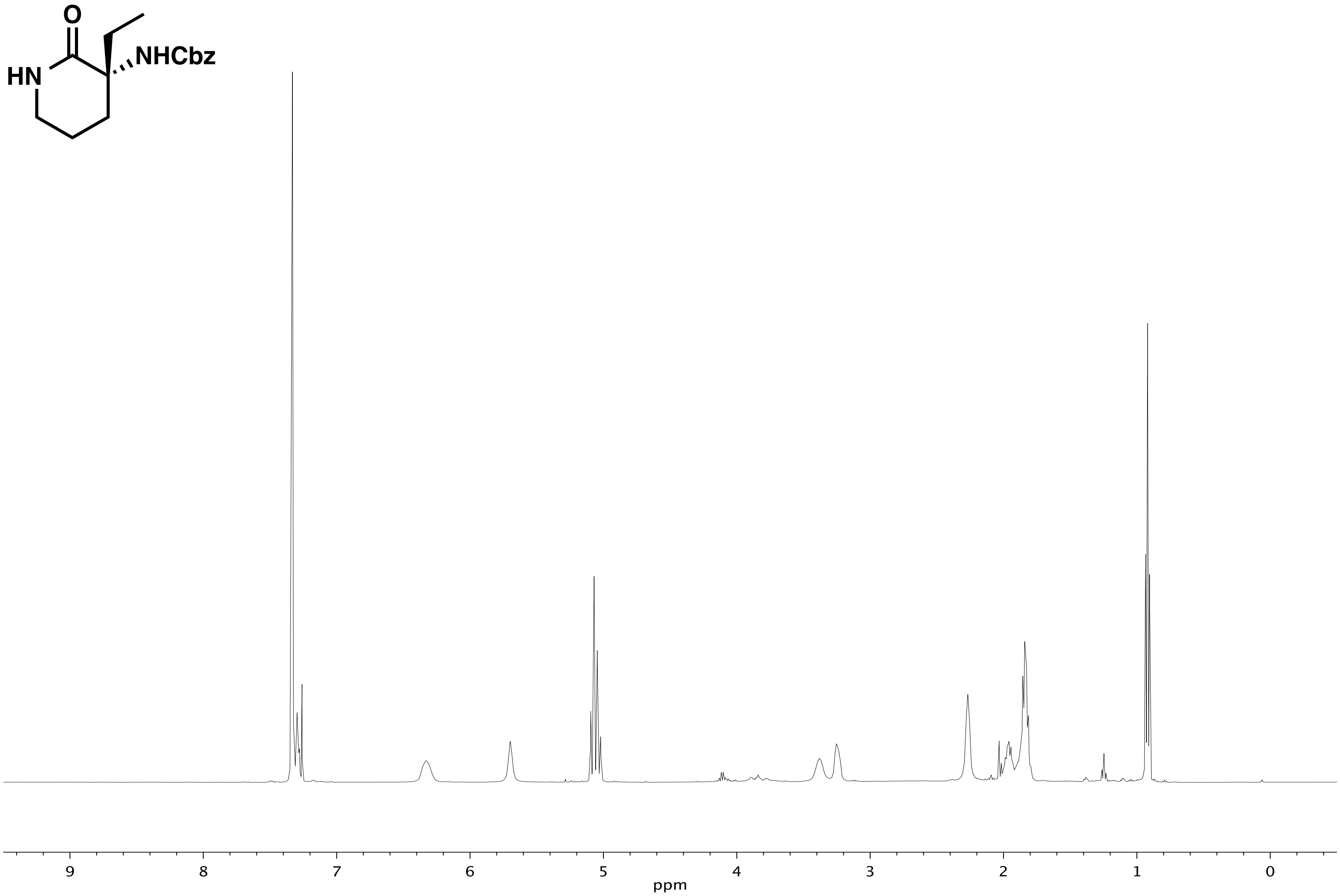
^{1}H NMR (400 MHz, D_2O) of compound **24.**



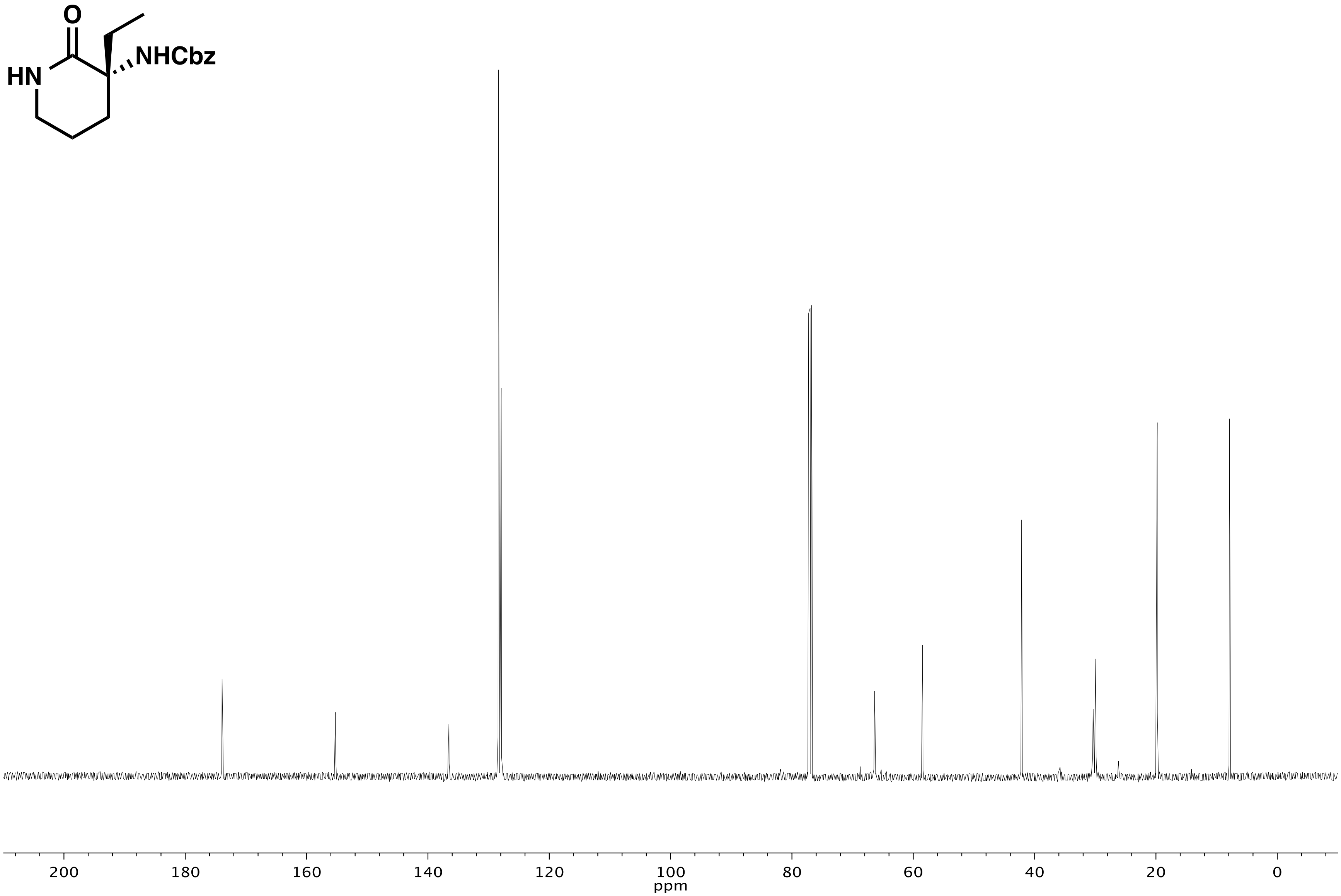
(R)-α-methyl glutamic acid



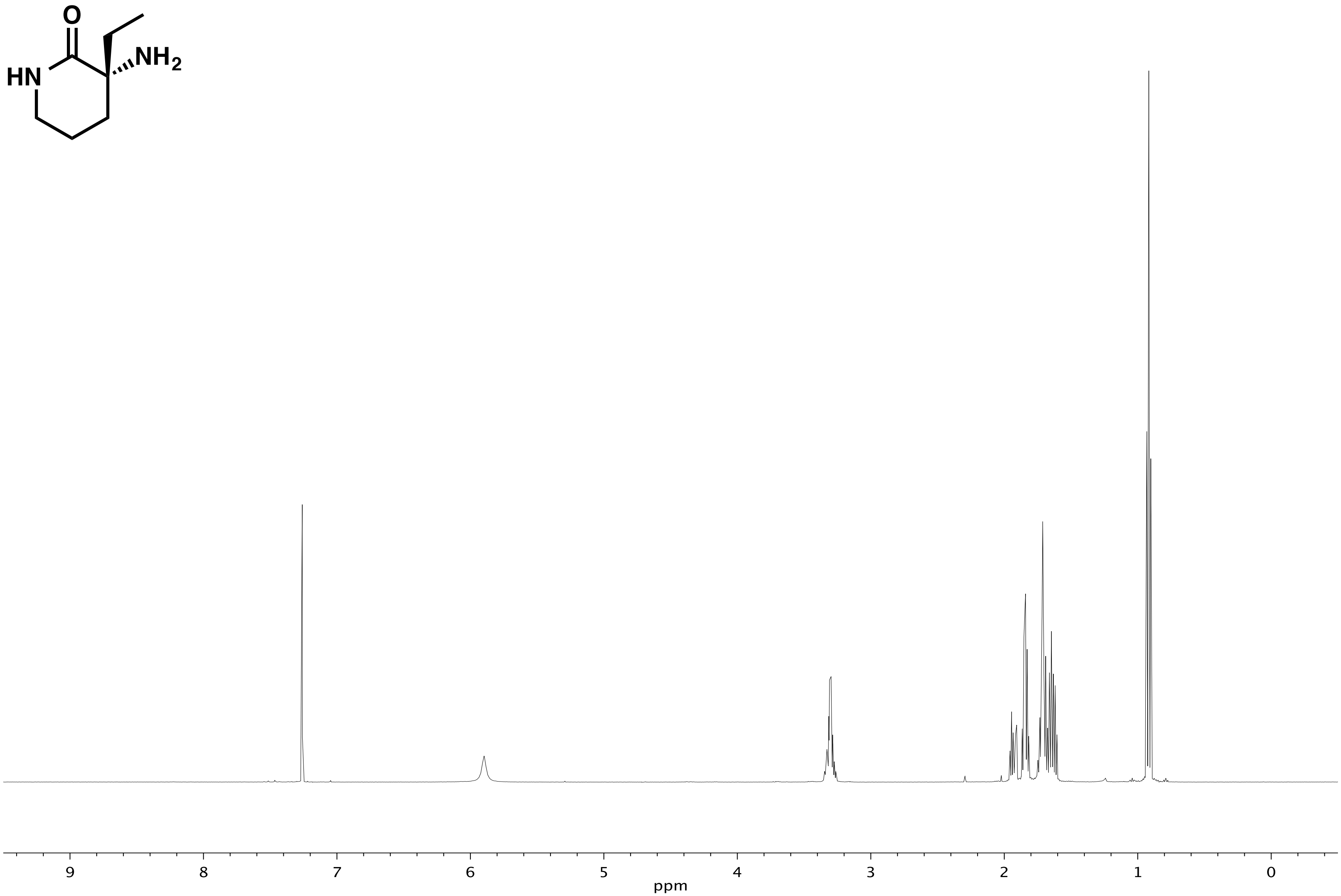
^{13}C NMR (101 MHz, D_2O) of compound **24.**



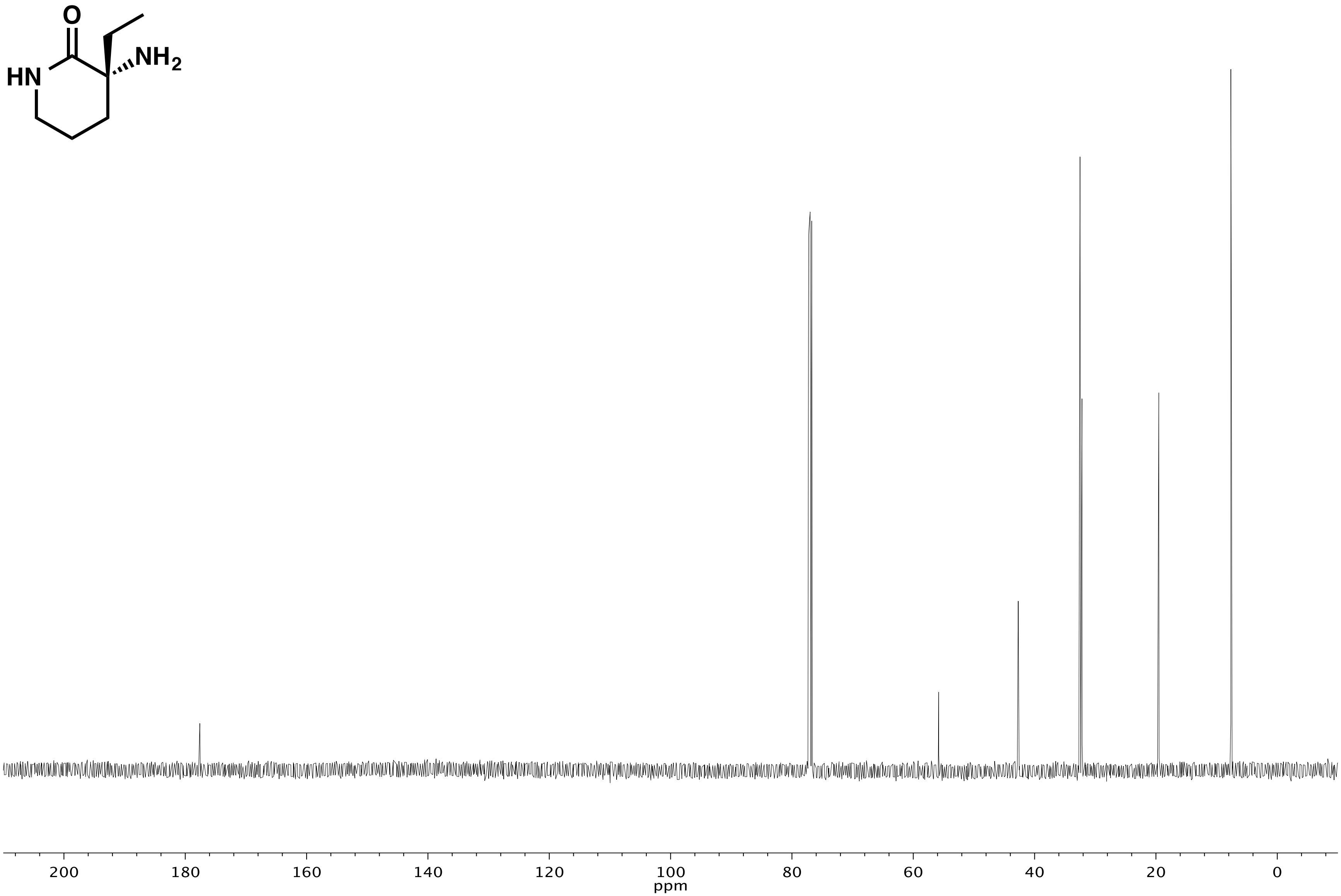
^{1}H NMR (500 MHz, CDCl$_3$) of compound **26**.



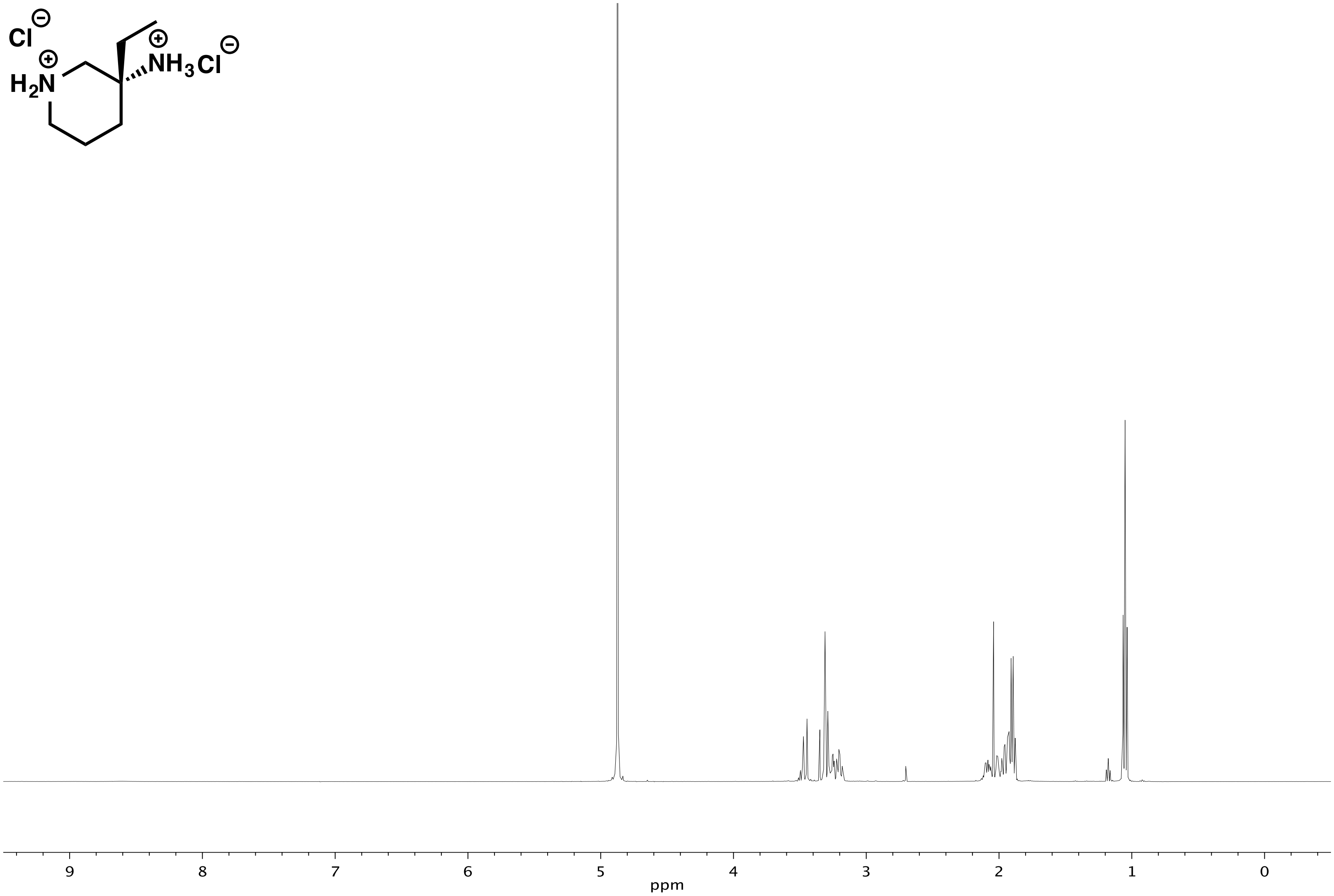
^{13}C NMR (126 MHz, CDCl$_3$) of compound **26**.



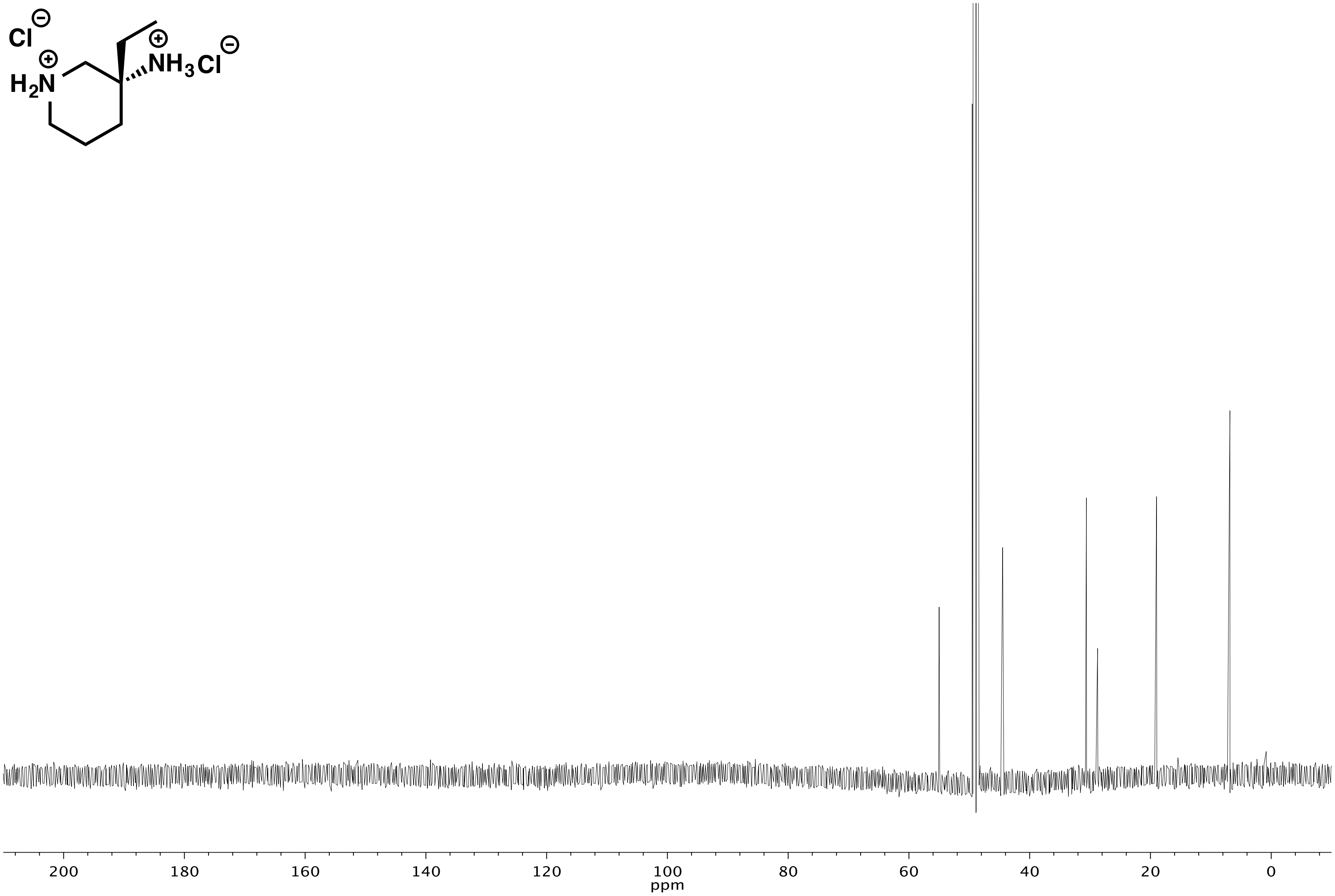
^{1}H NMR (500 MHz, CDCl$_3$) of compound **27**.



^{13}C NMR (126 MHz, CDCl$_3$) of compound **27.**



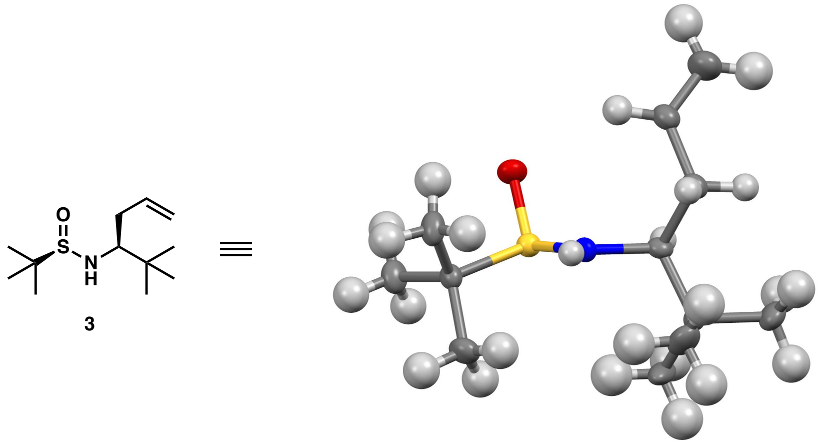
^{1}H NMR (500 MHz, CD$_3$OD) of compound **28**.



^{13}C NMR (126 MHz, CD$_3$OD) of compound **28.**

X-ray Structure Determination

Low-temperature diffraction data (ϕ-and ω-scans) were collected on a Bruker Kappa diffractometer coupled to an Apex II CCD detector with graphite monochromated Mo Kα radiation (λ = 0.71073 Å) and on a Bruker AXS D8 VENTURE KAPPA diffractometer coupled to a PHOTON 100 CMOS detector with Mo Kα radiation (λ = 0.71073 Å) or Cu Kα radiation (l = 1.54178 Å) from an IμS micro-source. The structure was solved by direct methods using SHELXS[51] and refined against F^2 on all data by full-matrix least squares with SHELXL-2013[52] using established refinement techniques.[53] All non-hydrogen atoms were refined anisotropically. Unless otherwise noted, all hydrogen atoms were included into the model at geometrically calculated positions and refined using a riding model. The isotropic displacement parameters of all hydrogen atoms were fixed to 1.2 times the *U* value of the atoms they are linked to (1.5 times for methyl groups).



3

Compound **3** crystallizes in the tetragonal space group $P4_1$ with one molecule in the asymmetric unit.

Table 1. Crystal data and structure refinement for **3**.

Identification code	p14097	
CCDC Deposition Number	1525613	
Empirical formula	C12 H25 N O S	
Formula weight	231.39	
Temperature	100 K	
Wavelength	1.54178 Å	
Crystal system	Tetragonal	
Space group	P 41	
Unit cell dimensions	a = 10.1168(3) Å	$\alpha = 90°$
	b = 10.1168(3) Å	$\beta = 90°$
	c = 14.1197(7) Å	$\gamma = 90°$
Volume	1445.15(11) $Å^3$	
Z	4	
Density (calculated)	1.064 Mg/m^3	
Absorption coefficient	1.811 mm^{-1}	
F(000)	512	
Crystal size	0.14 x 0.04 x 0.02 mm^3	
Theta range for data collection	4.370 to 79.571°.	
Index ranges	-10<=h<=10, -12<=k<=12, -17<=l<=17	
Reflections collected	9579	
Independent reflections	2910 [R(int) = 0.1295]	
Completeness to theta = 66.500°	99.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7924 and 0.6454	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2910 / 1 / 211	
Goodness-of-fit on F^2	1.133	
Final R indices [I>2sigma(I)]	R1 = 0.0587, wR2 = 0.1100	
R indices (all data)	R1 = 0.0914, wR2 = 0.1233	
Absolute structure parameter	0.14(3)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.283 and -0.302 e.$Å^{-3}$	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for **3**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	3371(1)	2507(1)	4573(1)	19(1)
O(1)	3028(4)	3926(3)	4416(3)	27(1)
N(1)	4886(4)	2297(4)	4968(3)	18(1)
C(1)	2462(5)	2014(5)	5650(3)	22(1)
C(2)	2803(8)	595(6)	5881(5)	35(1)
C(3)	1022(6)	2125(7)	5365(4)	29(1)
C(4)	2783(6)	2948(7)	6468(4)	31(1)
C(5)	5962(5)	2234(5)	4254(3)	19(1)
C(6)	6573(5)	830(5)	4233(4)	28(1)
C(7)	7715(7)	750(7)	3537(5)	37(2)
C(8)	7052(8)	426(8)	5219(5)	42(2)
C(9)	5508(7)	-146(7)	3900(6)	45(2)
C(10)	6958(5)	3338(5)	4435(3)	21(1)
C(11)	6387(6)	4698(5)	4318(4)	27(1)
C(12)	6902(8)	5616(8)	3771(5)	42(2)

Table 3. Bond lengths [Å] and angles [°] for **3**.

S(1)-O(1)	1.494(4)
S(1)-N(1)	1.644(4)
S(1)-C(1)	1.845(5)
N(1)-H(1)	0.89(7)
N(1)-C(5)	1.486(6)
C(1)-C(2)	1.511(8)
C(1)-C(3)	1.515(8)
C(1)-C(4)	1.527(7)
C(2)-H(2A)	1.11(8)
C(2)-H(2B)	0.85(9)
C(2)-H(2C)	0.91(9)
C(3)-H(3A)	1.01(7)

C(3)-H(3B)	0.95(8)
C(3)-H(3C)	0.95(7)
C(4)-H(4A)	0.93(8)
C(4)-H(4B)	0.99(8)
C(4)-H(4C)	1.02(8)
C(5)-H(5)	1.03(6)
C(5)-C(6)	1.549(7)
C(5)-C(10)	1.526(7)
C(6)-C(7)	1.519(9)
C(6)-C(8)	1.530(9)
C(6)-C(9)	1.536(9)
C(7)-H(7A)	0.95(9)
C(7)-H(7B)	1.00(9)
C(7)-H(7C)	0.90(8)
C(8)-H(8A)	0.95(10)
C(8)-H(8B)	1.05(9)
C(8)-H(8C)	0.99(9)
C(9)-H(9A)	0.97(9)
C(9)-H(9B)	0.94(10)
C(9)-H(9C)	0.97(10)
C(10)-H(10A)	0.89(7)
C(10)-H(10B)	1.08(6)
C(10)-C(11)	1.501(8)
C(11)-H(11)	0.96(7)
C(11)-C(12)	1.315(9)
C(12)-H(12A)	0.95(8)
C(12)-H(12B)	0.93(8)

O(1)-S(1)-N(1)	113.0(2)
O(1)-S(1)-C(1)	105.5(2)
N(1)-S(1)-C(1)	98.7(2)
S(1)-N(1)-H(1)	119(4)
C(5)-N(1)-S(1)	117.3(3)
C(5)-N(1)-H(1)	112(4)
C(2)-C(1)-S(1)	108.7(4)
C(2)-C(1)-C(3)	110.4(5)

C(2)-C(1)-C(4)	112.1(5)
C(3)-C(1)-S(1)	103.9(4)
C(3)-C(1)-C(4)	111.0(5)
C(4)-C(1)-S(1)	110.4(4)
C(1)-C(2)-H(2A)	110(4)
C(1)-C(2)-H(2B)	112(5)
C(1)-C(2)-H(2C)	111(5)
H(2A)-C(2)-H(2B)	104(7)
H(2A)-C(2)-H(2C)	108(6)
H(2B)-C(2)-H(2C)	111(7)
C(1)-C(3)-H(3A)	109(4)
C(1)-C(3)-H(3B)	110(5)
C(1)-C(3)-H(3C)	107(4)
H(3A)-C(3)-H(3B)	110(6)
H(3A)-C(3)-H(3C)	114(6)
H(3B)-C(3)-H(3C)	106(6)
C(1)-C(4)-H(4A)	116(5)
C(1)-C(4)-H(4B)	105(4)
C(1)-C(4)-H(4C)	111(4)
H(4A)-C(4)-H(4B)	110(6)
H(4A)-C(4)-H(4C)	106(6)
H(4B)-C(4)-H(4C)	109(6)
N(1)-C(5)-H(5)	108(3)
N(1)-C(5)-C(6)	110.2(4)
N(1)-C(5)-C(10)	109.8(4)
C(6)-C(5)-H(5)	106(3)
C(10)-C(5)-H(5)	109(3)
C(10)-C(5)-C(6)	114.3(4)
C(7)-C(6)-C(5)	111.4(5)
C(7)-C(6)-C(8)	109.5(5)
C(7)-C(6)-C(9)	107.5(5)
C(8)-C(6)-C(5)	110.8(5)
C(8)-C(6)-C(9)	109.2(6)
C(9)-C(6)-C(5)	108.4(5)
C(6)-C(7)-H(7A)	111(5)
C(6)-C(7)-H(7B)	112(5)

C(6)-C(7)-H(7C)	110(6)
H(7A)-C(7)-H(7B)	105(7)
H(7A)-C(7)-H(7C)	110(8)
H(7B)-C(7)-H(7C)	109(7)
C(6)-C(8)-H(8A)	111(5)
C(6)-C(8)-H(8B)	109(5)
C(6)-C(8)-H(8C)	116(5)
H(8A)-C(8)-H(8B)	105(7)
H(8A)-C(8)-H(8C)	106(8)
H(8B)-C(8)-H(8C)	109(7)
C(6)-C(9)-H(9A)	108(5)
C(6)-C(9)-H(9B)	108(5)
C(6)-C(9)-H(9C)	112(6)
H(9A)-C(9)-H(9B)	113(7)
H(9A)-C(9)-H(9C)	116(7)
H(9B)-C(9)-H(9C)	99(8)
C(5)-C(10)-H(10A)	110(4)
C(5)-C(10)-H(10B)	109(3)
H(10A)-C(10)-H(10B)	105(5)
C(11)-C(10)-C(5)	113.5(4)
C(11)-C(10)-H(10A)	108(4)
C(11)-C(10)-H(10B)	110(3)
C(10)-C(11)-H(11)	117(4)
C(12)-C(11)-C(10)	124.0(6)
C(12)-C(11)-H(11)	119(4)
C(11)-C(12)-H(12A)	123(5)
C(11)-C(12)-H(12B)	123(5)
H(12A)-C(12)-H(12B)	113(7)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2$x 10^3) for **3**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}

S(1)	21(1)	21(1)	16(1)	1(1)	-2(1)	1(1)
O(1)	33(2)	18(2)	30(2)	7(2)	-6(2)	6(1)
N(1)	16(2)	23(2)	16(2)	1(2)	2(2)	0(2)
C(1)	26(3)	24(3)	16(2)	-3(2)	3(2)	-1(2)
C(2)	43(4)	32(3)	29(3)	10(3)	11(3)	-5(3)
C(3)	18(3)	42(4)	28(3)	-9(3)	1(2)	-5(2)
C(4)	25(3)	47(4)	21(3)	-11(3)	2(2)	0(3)
C(5)	23(3)	18(3)	16(2)	0(2)	2(2)	1(2)
C(6)	24(3)	23(3)	37(3)	-1(2)	9(2)	2(2)
C(7)	34(4)	32(4)	44(4)	-14(3)	11(3)	2(3)
C(8)	46(4)	37(4)	44(4)	15(3)	7(3)	15(3)
C(9)	38(4)	21(3)	76(5)	-19(3)	17(4)	-3(3)
C(10)	24(3)	26(3)	14(2)	1(2)	-2(2)	-6(2)
C(11)	29(3)	24(3)	28(3)	-3(2)	3(2)	-4(2)
C(12)	47(4)	34(4)	45(4)	9(3)	8(3)	-2(3)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10 ^{3}) for **3**.

	x	y	z	U(eq)
H(1)	5130(60)	2730(60)	5490(50)	22
H(2A)	2670(80)	-40(80)	5250(60)	52
H(2B)	2270(80)	270(80)	6290(60)	52
H(2C)	3660(90)	520(80)	6080(60)	52
H(3A)	830(70)	3070(80)	5190(50)	44
H(3B)	470(70)	1860(70)	5880(60)	44
H(3C)	880(70)	1510(70)	4870(50)	44
H(4A)	3630(80)	2880(70)	6720(50)	46
H(4B)	2120(70)	2750(60)	6970(60)	46
H(4C)	2670(70)	3910(80)	6260(50)	46
H(5)	5540(60)	2370(60)	3600(40)	23
H(7A)	7480(80)	1110(80)	2940(70)	55
H(7B)	7980(80)	-180(90)	3400(60)	55
H(7C)	8420(80)	1190(80)	3770(60)	55

H(8A)	7750(100)	980(90)	5420(60)	63
H(8B)	7460(90)	-530(90)	5180(60)	63
H(8C)	6380(90)	440(80)	5730(70)	63
H(9A)	4790(90)	-130(90)	4350(70)	68
H(9B)	5900(90)	-990(100)	3840(70)	68
H(9C)	5260(90)	-10(90)	3240(80)	68
H(10A)	7290(60)	3270(60)	5020(50)	26
H(10B)	7800(60)	3210(60)	3970(40)	26
H(11)	5580(60)	4890(60)	4650(50)	33
H(12A)	7670(80)	5480(80)	3400(60)	50
H(12B)	6470(80)	6400(80)	3630(60)	50

Table 6. Torsion angles [°] for **3**.

S(1)-N(1)-C(5)-C(6)	-113.0(4)
S(1)-N(1)-C(5)-C(10)	120.3(4)
O(1)-S(1)-N(1)-C(5)	-85.2(4)
O(1)-S(1)-C(1)-C(2)	-177.7(4)
O(1)-S(1)-C(1)-C(3)	64.8(4)
O(1)-S(1)-C(1)-C(4)	-54.4(4)
N(1)-S(1)-C(1)-C(2)	-60.8(4)
N(1)-S(1)-C(1)-C(3)	-178.3(4)
N(1)-S(1)-C(1)-C(4)	62.5(4)
N(1)-C(5)-C(6)-C(7)	-177.7(5)
N(1)-C(5)-C(6)-C(8)	-55.6(6)
N(1)-C(5)-C(6)-C(9)	64.2(6)
N(1)-C(5)-C(10)-C(11)	-63.8(5)
C(1)-S(1)-N(1)-C(5)	163.8(4)
C(5)-C(10)-C(11)-C(12)	-127.0(6)
C(6)-C(5)-C(10)-C(11)	171.9(4)
C(10)-C(5)-C(6)-C(7)	-53.5(6)
C(10)-C(5)-C(6)-C(8)	68.6(6)
C(10)-C(5)-C(6)-C(9)	-171.6(5)

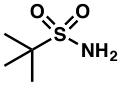
Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for **3** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1)...O(1)#1	0.89(7)	2.25(7)	3.091(5)	158(5)

Symmetry transformations used to generate equivalent atoms:

#1 -y+1,x,z+1/4



S5

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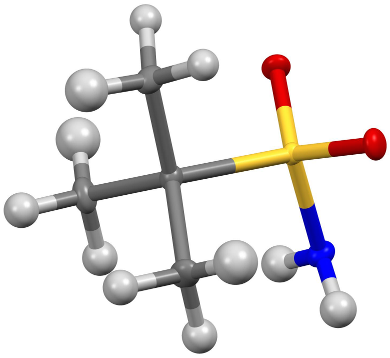


Compound **S5** crystallizes in the orthorhombic space group *Pmn*2_1 with half a molecule in the asymmetric unit.

Table 1. Crystal data and structure refinement for **S5**.

Identification code	a14358	
CCDC Deposition Number	1525610	
Empirical formula	C4 H11 N O2 S	
Formula weight	137.20	
Temperature	100 K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	P m n 21	
Unit cell dimensions	a = 7.733(3) Å	α = 90°
	b = 6.629(3) Å	β = 90°
	c = 6.587(3) Å	γ = 90°
Volume	337.6(2) Å^3	

Z	2
Density (calculated)	1.350 Mg/m^3
Absorption coefficient	0.397 mm^{-1}
F(000)	148
Crystal size	0.29 x 0.19 x 0.02 mm^3
Theta range for data collection	3.073 to 39.756°.
Index ranges	-13<=h<=13, -9<=k<=11, -11<=l<=11
Reflections collected	7315
Independent reflections	2075 [R(int) = 0.0420]
Completeness to theta = 25.000°	100.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	1.0000 and 0.8998
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2075 / 1 / 66
Goodness-of-fit on F^2	1.020
Final R indices [I>2sigma(I)]	R1 = 0.0347, wR2 = 0.0660
R indices (all data)	R1 = 0.0477, wR2 = 0.0696
Absolute structure parameter	0.07(4)
Extinction coefficient	n/a
Largest diff. peak and hole	0.490 and -0.375 e.Å^{-3}

Table 2. Atomic coordinates (x 10^5) and equivalent isotropic displacement parameters (Å^{2}x 10^4) for **S5**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	50000	49246(7)	52063(10)	86(1)
O(1)	66013(13)	57604(17)	44384(17)	134(2)
N(1)	50000	52940(30)	76270(30)	128(3)
C(1)	50000	22400(30)	46850(30)	108(3)
C(2)	50000	20170(40)	23700(30)	142(4)
C(3)	33690(20)	13110(20)	56120(20)	169(3)

Table 3. Bond lengths [Å] and angles [°] for **S5**.

S(1)-O(1)	1.4478(11)
S(1)-O(1)#1	1.4478(11)
S(1)-N(1)	1.6134(19)
S(1)-C(1)	1.812(2)
N(1)-H(1)	0.87(2)
C(1)-C(2)	1.532(3)
C(1)-C(3)#1	1.531(2)
C(1)-C(3)	1.531(2)
C(2)-H(2A)	0.92(2)
C(2)-H(2B)	0.95(4)
C(3)-H(3A)	0.89(3)
C(3)-H(3B)	0.99(2)
C(3)-H(3C)	0.95(2)

O(1)-S(1)-O(1)#1	117.58(10)
O(1)#1-S(1)-N(1)	106.69(6)
O(1)-S(1)-N(1)	106.69(6)
O(1)-S(1)-C(1)	108.03(6)
O(1)#1-S(1)-C(1)	108.03(6)
N(1)-S(1)-C(1)	109.65(9)
S(1)-N(1)-H(1)	114.8(19)
C(2)-C(1)-S(1)	106.47(14)
C(3)-C(1)-S(1)	108.62(11)
C(3)#1-C(1)-S(1)	108.62(11)
C(3)-C(1)-C(2)	111.00(12)
C(3)#1-C(1)-C(2)	111.00(12)
C(3)#1-C(1)-C(3)	110.98(18)
C(1)-C(2)-H(2A)	112.4(13)
C(1)-C(2)-H(2B)	108(2)
H(2A)-C(2)-H(2B)	110.6(19)
C(1)-C(3)-H(3A)	109.8(16)
C(1)-C(3)-H(3B)	110.1(16)
C(1)-C(3)-H(3C)	108.4(16)
H(3A)-C(3)-H(3B)	111(2)
H(3A)-C(3)-H(3C)	112(2)
H(3B)-C(3)-H(3C)	106(2)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,y,z

Table 4. Anisotropic displacement parameters ($Å^2$x 10^4) for **S5**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	67(1)	86(2)	107(1)	3(2)	0	0
O(1)	101(4)	130(5)	171(5)	6(4)	35(4)	-32(4)
N(1)	116(7)	160(9)	108(7)	-21(6)	0	0
C(1)	102(7)	101(8)	121(8)	-9(6)	0	0
C(2)	132(8)	167(10)	128(8)	-26(7)	0	0
C(3)	171(6)	128(6)	209(8)	-2(5)	51(5)	-40(5)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **S5**.

	x	y	z	U(eq)
H(1)	4050(30)	4960(30)	8240(50)	24(6)
H(2A)	5930(30)	2640(30)	1770(30)	18(6)
H(2B)	5000	620(60)	2060(60)	33(10)
H(3A)	2440(30)	1870(30)	5070(50)	35(6)
H(3B)	3380(40)	1480(40)	7100(40)	22(6)
H(3C)	3390(30)	-110(30)	5380(50)	22(6)

Table 6. Torsion angles [°] for **S5**.

O(1)#1-S(1)-C(1)-C(2)	64.09(6)
O(1)-S(1)-C(1)-C(2)	-64.09(6)
O(1)-S(1)-C(1)-C(3)#1	55.51(14)
O(1)#1-S(1)-C(1)-C(3)#1	-176.31(11)

O(1)-S(1)-C(1)-C(3)	176.31(11)
O(1)#1-S(1)-C(1)-C(3)	-55.51(14)
N(1)-S(1)-C(1)-C(2)	180.000(1)
N(1)-S(1)-C(1)-C(3)	60.40(11)
N(1)-S(1)-C(1)-C(3)#1	-60.40(11)

Symmetry transformations used to generate equivalent atoms:

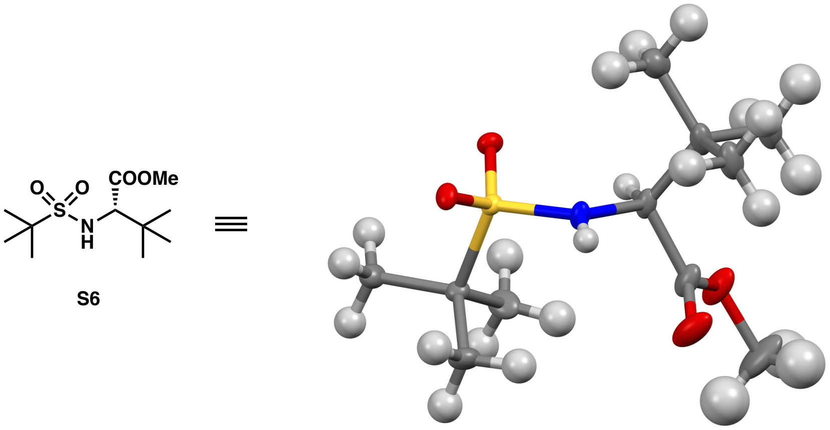
#1 -x+1,y,z

Table 7. Hydrogen bonds for **S5** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1)...O(1)#2	0.87(2)	2.10(2)	2.9696(17)	174(3)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,y,z #2 x-1/2,-y+1,z+1/2



S6

Compound (*S*)-**S6** crystallizes in the tetragonal space group $P4_32_12$ with one molecule in the asymmetric unit. The coordinates for the hydrogen atom bound to N1 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H distance (0.88(4) Å). The ellipsoids for the methyl ester group are elongated, indicating disorder. However, refinement of a second component did not improve the structure.

Table 1. Crystal data and structure refinement for (*S*)-**S6**.

Identification code	A14430	
CCDC Deposition Number	1525612	
Empirical formula	C11 H23 N O4 S	
Formula weight	265.36	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Tetragonal	
Space group	$P4_32_12$	
Unit cell dimensions	a = 9.7978(3) Å	α = 90°.
	b = 9.7978(3) Å	β = 90°.
	c = 30.8360(9) Å	γ = 90°.
Volume	2960.2(2) Å^3	
Z	8	
Density (calculated)	1.191 Mg/m^3	
Absorption coefficient	0.222 mm^{-1}	
F(000)	1152	
Crystal size	0.400 x 0.300 x 0.200 mm^3	
Theta range for data collection	2.181 to 30.577°.	
Index ranges	-13<=h<=14, -13<=k<=13, -44<=l<=44	
Reflections collected	33003	
Independent reflections	4535 [R(int) = 0.0361]	
Completeness to theta = 25.242°	99.9 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7461 and 0.6881	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	4535 / 1 / 164	
Goodness-of-fit on F^2	1.069	
Final R indices [I>2sigma(I)]	R1 = 0.0279, wR2 = 0.0702	
R indices (all data)	R1 = 0.0304, wR2 = 0.0718	
Absolute structure parameter	-0.03(2)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.292 and -0.184 e.Å^{-3}	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for (*S*)-**S6**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	3891(1)	3417(1)	4261(1)	14(1)
O(1)	2859(1)	4078(1)	4521(1)	18(1)
O(2)	4458(1)	4136(1)	3896(1)	19(1)
N(1)	5130(1)	3072(1)	4588(1)	17(1)
C(1)	6516(1)	2769(2)	4446(1)	19(1)
C(2)	6847(2)	1296(2)	4566(1)	25(1)
O(3)	6429(2)	725(1)	4885(1)	38(1)
O(4)	7667(1)	716(1)	4271(1)	33(1)
C(3)	8066(3)	-681(2)	4364(1)	53(1)
C(4)	7568(2)	3807(2)	4635(1)	24(1)
C(5)	8999(2)	3456(2)	4474(1)	36(1)
C(6)	7195(2)	5242(2)	4477(1)	31(1)
C(7)	7543(2)	3773(2)	5133(1)	30(1)
C(8)	3141(1)	1855(1)	4055(1)	16(1)
C(9)	4199(2)	1086(2)	3786(1)	29(1)
C(10)	1942(2)	2299(2)	3767(1)	22(1)
C(11)	2633(2)	1008(2)	4437(1)	26(1)

Table 3. Bond lengths [Å] and angles [°] for (*S*)-**S6**.

S(1)-O(2)	1.4398(10)
S(1)-O(1)	1.4434(10)
S(1)-N(1)	1.6137(12)
S(1)-C(8)	1.8129(14)
N(1)-C(1)	1.4579(18)
N(1)-H(1N)	0.849(15)
C(1)-C(2)	1.525(2)
C(1)-C(4)	1.561(2)
C(1)-H(1)	1.0000
C(2)-O(3)	1.2044(19)

C(2)-O(4)	1.3394(18)
O(4)-C(3)	1.452(2)
C(3)-H(3A)	0.9800
C(3)-H(3B)	0.9800
C(3)-H(3C)	0.9800
C(4)-C(5)	1.527(2)
C(4)-C(6)	1.533(2)
C(4)-C(7)	1.537(2)
C(5)-H(5A)	0.9800
C(5)-H(5B)	0.9800
C(5)-H(5C)	0.9800
C(6)-H(6A)	0.9800
C(6)-H(6B)	0.9800
C(6)-H(6C)	0.9800
C(7)-H(7A)	0.9800
C(7)-H(7B)	0.9800
C(7)-H(7C)	0.9800
C(8)-C(11)	1.526(2)
C(8)-C(9)	1.527(2)
C(8)-C(10)	1.535(2)
C(9)-H(9A)	0.9800
C(9)-H(9B)	0.9800
C(9)-H(9C)	0.9800
C(10)-H(10A)	0.9800
C(10)-H(10B)	0.9800
C(10)-H(10C)	0.9800
C(11)-H(11A)	0.9800
C(11)-H(11B)	0.9800
C(11)-H(11C)	0.9800

O(2)-S(1)-O(1)	118.98(6)
O(2)-S(1)-N(1)	107.49(6)
O(1)-S(1)-N(1)	105.88(6)
O(2)-S(1)-C(8)	107.16(6)
O(1)-S(1)-C(8)	106.88(6)
N(1)-S(1)-C(8)	110.36(7)

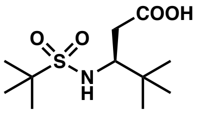
C(1)-N(1)-S(1)	123.69(9)
C(1)-N(1)-H(1N)	119.3(13)
S(1)-N(1)-H(1N)	115.0(13)
N(1)-C(1)-C(2)	108.53(12)
N(1)-C(1)-C(4)	111.71(12)
C(2)-C(1)-C(4)	112.63(12)
N(1)-C(1)-H(1)	107.9
C(2)-C(1)-H(1)	107.9
C(4)-C(1)-H(1)	107.9
O(3)-C(2)-O(4)	124.14(15)
O(3)-C(2)-C(1)	124.47(14)
O(4)-C(2)-C(1)	111.39(12)
C(2)-O(4)-C(3)	115.29(13)
O(4)-C(3)-H(3A)	109.5
O(4)-C(3)-H(3B)	109.5
H(3A)-C(3)-H(3B)	109.5
O(4)-C(3)-H(3C)	109.5
H(3A)-C(3)-H(3C)	109.5
H(3B)-C(3)-H(3C)	109.5
C(5)-C(4)-C(6)	108.75(14)
C(5)-C(4)-C(7)	109.64(13)
C(6)-C(4)-C(7)	109.55(15)
C(5)-C(4)-C(1)	109.76(14)
C(6)-C(4)-C(1)	108.68(12)
C(7)-C(4)-C(1)	110.42(13)
C(4)-C(5)-H(5A)	109.5
C(4)-C(5)-H(5B)	109.5
H(5A)-C(5)-H(5B)	109.5
C(4)-C(5)-H(5C)	109.5
H(5A)-C(5)-H(5C)	109.5
H(5B)-C(5)-H(5C)	109.5
C(4)-C(6)-H(6A)	109.5
C(4)-C(6)-H(6B)	109.5
H(6A)-C(6)-H(6B)	109.5
C(4)-C(6)-H(6C)	109.5
H(6A)-C(6)-H(6C)	109.5

H(6B)-C(6)-H(6C)	109.5
C(4)-C(7)-H(7A)	109.5
C(4)-C(7)-H(7B)	109.5
H(7A)-C(7)-H(7B)	109.5
C(4)-C(7)-H(7C)	109.5
H(7A)-C(7)-H(7C)	109.5
H(7B)-C(7)-H(7C)	109.5
C(11)-C(8)-C(9)	111.93(13)
C(11)-C(8)-C(10)	110.53(12)
C(9)-C(8)-C(10)	110.24(12)
C(11)-C(8)-S(1)	108.61(9)
C(9)-C(8)-S(1)	109.44(10)
C(10)-C(8)-S(1)	105.90(9)
C(8)-C(9)-H(9A)	109.5
C(8)-C(9)-H(9B)	109.5
H(9A)-C(9)-H(9B)	109.5
C(8)-C(9)-H(9C)	109.5
H(9A)-C(9)-H(9C)	109.5
H(9B)-C(9)-H(9C)	109.5
C(8)-C(10)-H(10A)	109.5
C(8)-C(10)-H(10B)	109.5
H(10A)-C(10)-H(10B)	109.5
C(8)-C(10)-H(10C)	109.5
H(10A)-C(10)-H(10C)	109.5
H(10B)-C(10)-H(10C)	109.5
C(8)-C(11)-H(11A)	109.5
C(8)-C(11)-H(11B)	109.5
H(11A)-C(11)-H(11B)	109.5
C(8)-C(11)-H(11C)	109.5
H(11A)-C(11)-H(11C)	109.5
H(11B)-C(11)-H(11C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for (*S*)-**S6**.

	x	y	z	U(eq)
H(1N)	4889(19)	2861(19)	4844(5)	21
H(1)	6540	2846	4122	23
H(3A)	8476	-727	4654	79
H(3B)	8730	-988	4148	79
H(3C)	7259	-1271	4354	79
H(5A)	8996	3409	4156	54
H(5B)	9279	2572	4593	54
H(5C)	9641	4163	4568	54
H(6A)	7835	5906	4599	46
H(6B)	6265	5466	4570	46
H(6C)	7245	5272	4159	46
H(7A)	7805	2861	5234	45
H(7B)	6620	3986	5236	45
H(7C)	8186	4449	5247	45
H(9A)	3756	325	3635	43
H(9B)	4915	732	3977	43
H(9C)	4604	1707	3572	43
H(10A)	2286	2831	3522	33
H(10B)	1310	2860	3938	33
H(10C)	1462	1489	3660	33
H(11A)	2201	172	4330	39
H(11B)	1967	1540	4604	39
H(11C)	3406	769	4625	39



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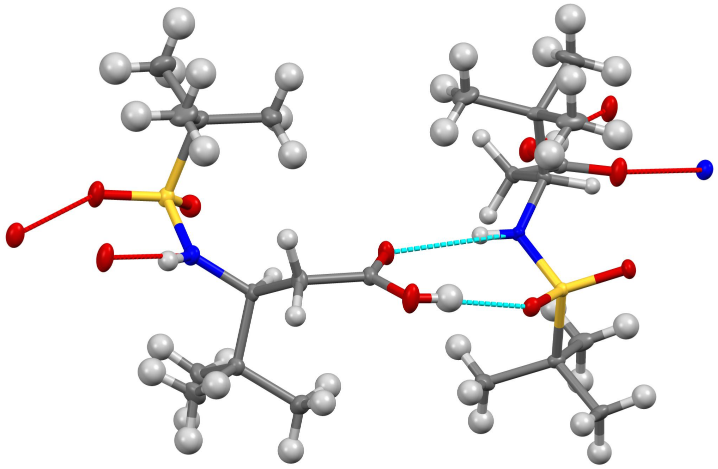


Compound **6** crystallizes in the monoclinic space group *P*2_1 with two molecules in the asymmetric unit. The coordinates for the hydrogen atoms bound to N1, O4, N101, and O104 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H (0.88(4) Å) or O-H (0.84(4) Å)distance.

Table 1. Crystal data and structure refinement for **6**.

Identification code	P14108	
CCDC Deposition Number	1525614	
Empirical formula	C11 H23 N O4 S	
Formula weight	265.36	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2_1	
Unit cell dimensions	a = 10.4844(3) Å	α = 90°.
	b = 11.3186(3) Å	β = 110.2168(10)°.
	c = 12.8247(3) Å	γ = 90°.
Volume	1428.13(7) Å^3	
Z	4	
Density (calculated)	1.234 Mg/m^3	
Absorption coefficient	0.230 mm^{-1}	
F(000)	576	
Crystal size	0.150 x 0.150 x 0.150 mm^3	

Theta range for data collection	2.470 to 36.320°.
Index ranges	-17<=h<=17, -18<=k<=18, -21<=l<=21
Reflections collected	65630
Independent reflections	13734 [R(int) = 0.0726]
Completeness to theta = 25.242°	99.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7471 and 0.7089
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	13734 / 5 / 331
Goodness-of-fit on F^2	1.029
Final R indices [I>2sigma(I)]	R1 = 0.0360, wR2 = 0.0752
R indices (all data)	R1 = 0.0547, wR2 = 0.0793
Absolute structure parameter	0.003(13)
Extinction coefficient	n/a
Largest diff. peak and hole	0.335 and -0.372 e.Å^{-3}

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **6**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	1772(1)	7586(1)	-1345(1)	22(1)
O(2)	2361(1)	7753(1)	694(1)	20(1)
S(1)	2009(1)	7021(1)	-278(1)	15(1)
N(1)	3198(1)	6076(1)	-138(1)	16(1)
C(1)	439(2)	6254(2)	-401(1)	20(1)
C(2)	-697(2)	7188(2)	-735(2)	31(1)
C(3)	573(2)	5717(2)	729(1)	25(1)
C(4)	174(2)	5304(2)	-1298(1)	29(1)
C(5)	4131(1)	5605(1)	926(1)	13(1)
C(6)	3890(2)	4275(1)	1012(1)	17(1)
C(7)	4000(2)	3891(1)	2170(1)	15(1)
O(3)	3644(1)	4504(1)	2793(1)	20(1)
O(4)	4480(1)	2805(1)	2405(1)	24(1)
C(8)	5634(2)	5906(1)	1069(1)	15(1)
C(9)	6584(2)	5314(2)	2130(1)	21(1)

C(10)	5820(2)	7247(2)	1190(1)	21(1)
C(11)	5999(2)	5484(2)	66(1)	24(1)
O(101)	4560(1)	2233(1)	6315(1)	16(1)
O(102)	5019(1)	2311(1)	4554(1)	15(1)
S(101)	4838(1)	2934(1)	5485(1)	10(1)
N(101)	3628(1)	3867(1)	4977(1)	12(1)
C(101)	6382(1)	3760(1)	6146(1)	13(1)
C(102)	7513(1)	2848(2)	6643(1)	18(1)
C(103)	6663(2)	4512(2)	5262(1)	20(1)
C(104)	6170(2)	4526(2)	7058(1)	21(1)
C(105)	2598(1)	4160(1)	5480(1)	11(1)
C(106)	2572(1)	5497(1)	5666(1)	13(1)
C(107)	2583(1)	5858(1)	6800(1)	13(1)
O(103)	2850(1)	5212(1)	7601(1)	23(1)
O(104)	2276(1)	6994(1)	6815(1)	19(1)
C(108)	1193(2)	3641(1)	4785(1)	17(1)
C(109)	1321(2)	2302(2)	4673(2)	28(1)
C(110)	641(2)	4190(2)	3619(1)	24(1)
C(111)	198(2)	3878(2)	5400(2)	28(1)

Table 3. Bond lengths [Å] and angles [°] for **6**.

O(1)-S(1)	1.4519(11)
O(2)-S(1)	1.4352(11)
S(1)-N(1)	1.6047(14)
S(1)-C(1)	1.8189(17)
N(1)-C(5)	1.4770(18)
N(1)-H(1N)	0.868(16)
C(1)-C(4)	1.528(2)
C(1)-C(3)	1.532(2)
C(1)-C(2)	1.539(3)
C(2)-H(2A)	0.9800
C(2)-H(2B)	0.9800
C(2)-H(2C)	0.9800
C(3)-H(3A)	0.9800

C(3)-H(3B)	0.9800
C(3)-H(3C)	0.9800
C(4)-H(4A)	0.9800
C(4)-H(4B)	0.9800
C(4)-H(4C)	0.9800
C(5)-C(6)	1.537(2)
C(5)-C(8)	1.559(2)
C(5)-H(5)	1.0000
C(6)-C(7)	1.5126(18)
C(6)-H(6A)	0.9900
C(6)-H(6B)	0.9900
C(7)-O(3)	1.2107(17)
C(7)-O(4)	1.323(2)
O(4)-H(4O)	0.844(18)
C(8)-C(10)	1.531(2)
C(8)-C(9)	1.535(2)
C(8)-C(11)	1.5396(19)
C(9)-H(9A)	0.9800
C(9)-H(9B)	0.9800
C(9)-H(9C)	0.9800
C(10)-H(10A)	0.9800
C(10)-H(10B)	0.9800
C(10)-H(10C)	0.9800
C(11)-H(11A)	0.9800
C(11)-H(11B)	0.9800
C(11)-H(11C)	0.9800
O(101)-S(101)	1.4355(10)
O(102)-S(101)	1.4544(10)
S(101)-N(101)	1.6050(12)
S(101)-C(101)	1.8067(14)
N(101)-C(105)	1.4747(16)
N(101)-H(01N)	0.785(15)
C(101)-C(103)	1.525(2)
C(101)-C(104)	1.533(2)
C(101)-C(102)	1.535(2)
C(102)-H(10D)	0.9800

C(102)-H(10E)	0.9800
C(102)-H(10F)	0.9800
C(103)-H(10G)	0.9800
C(103)-H(10H)	0.9800
C(103)-H(10I)	0.9800
C(104)-H(10J)	0.9800
C(104)-H(10K)	0.9800
C(104)-H(10L)	0.9800
C(105)-C(106)	1.534(2)
C(105)-C(108)	1.550(2)
C(105)-H(105)	1.0000
C(106)-C(107)	1.5066(18)
C(106)-H(10M)	0.9900
C(106)-H(10N)	0.9900
C(107)-O(103)	1.2115(18)
C(107)-O(104)	1.3284(19)
O(104)-H(04O)	0.813(17)
C(108)-C(109)	1.533(2)
C(108)-C(111)	1.533(2)
C(108)-C(110)	1.536(2)
C(109)-H(10O)	0.9800
C(109)-H(10P)	0.9800
C(109)-H(10Q)	0.9800
C(110)-H(11D)	0.9800
C(110)-H(11E)	0.9800
C(110)-H(11F)	0.9800
C(111)-H(11G)	0.9800
C(111)-H(11H)	0.9800
C(111)-H(11I)	0.9800

O(2)-S(1)-O(1)	118.27(7)
O(2)-S(1)-N(1)	109.35(7)
O(1)-S(1)-N(1)	105.79(6)
O(2)-S(1)-C(1)	107.68(7)
O(1)-S(1)-C(1)	105.88(7)
N(1)-S(1)-C(1)	109.65(8)

C(5)-N(1)-S(1)	125.77(9)
C(5)-N(1)-H(1N)	120.5(14)
S(1)-N(1)-H(1N)	113.4(14)
C(4)-C(1)-C(3)	111.49(15)
C(4)-C(1)-C(2)	110.60(14)
C(3)-C(1)-C(2)	110.22(13)
C(4)-C(1)-S(1)	108.92(11)
C(3)-C(1)-S(1)	108.83(11)
C(2)-C(1)-S(1)	106.65(13)
C(1)-C(2)-H(2A)	109.5
C(1)-C(2)-H(2B)	109.5
H(2A)-C(2)-H(2B)	109.5
C(1)-C(2)-H(2C)	109.5
H(2A)-C(2)-H(2C)	109.5
H(2B)-C(2)-H(2C)	109.5
C(1)-C(3)-H(3A)	109.5
C(1)-C(3)-H(3B)	109.5
H(3A)-C(3)-H(3B)	109.5
C(1)-C(3)-H(3C)	109.5
H(3A)-C(3)-H(3C)	109.5
H(3B)-C(3)-H(3C)	109.5
C(1)-C(4)-H(4A)	109.5
C(1)-C(4)-H(4B)	109.5
H(4A)-C(4)-H(4B)	109.5
C(1)-C(4)-H(4C)	109.5
H(4A)-C(4)-H(4C)	109.5
H(4B)-C(4)-H(4C)	109.5
N(1)-C(5)-C(6)	110.28(12)
N(1)-C(5)-C(8)	110.49(11)
C(6)-C(5)-C(8)	112.93(12)
N(1)-C(5)-H(5)	107.6
C(6)-C(5)-H(5)	107.6
C(8)-C(5)-H(5)	107.6
C(7)-C(6)-C(5)	113.18(12)
C(7)-C(6)-H(6A)	108.9
C(5)-C(6)-H(6A)	108.9

C(7)-C(6)-H(6B)	108.9
C(5)-C(6)-H(6B)	108.9
H(6A)-C(6)-H(6B)	107.8
O(3)-C(7)-O(4)	124.23(13)
O(3)-C(7)-C(6)	123.14(14)
O(4)-C(7)-C(6)	112.60(12)
C(7)-O(4)-H(4O)	108.5(17)
C(10)-C(8)-C(9)	108.75(13)
C(10)-C(8)-C(11)	109.42(13)
C(9)-C(8)-C(11)	109.46(13)
C(10)-C(8)-C(5)	108.43(12)
C(9)-C(8)-C(5)	109.20(12)
C(11)-C(8)-C(5)	111.53(12)
C(8)-C(9)-H(9A)	109.5
C(8)-C(9)-H(9B)	109.5
H(9A)-C(9)-H(9B)	109.5
C(8)-C(9)-H(9C)	109.5
H(9A)-C(9)-H(9C)	109.5
H(9B)-C(9)-H(9C)	109.5
C(8)-C(10)-H(10A)	109.5
C(8)-C(10)-H(10B)	109.5
H(10A)-C(10)-H(10B)	109.5
C(8)-C(10)-H(10C)	109.5
H(10A)-C(10)-H(10C)	109.5
H(10B)-C(10)-H(10C)	109.5
C(8)-C(11)-H(11A)	109.5
C(8)-C(11)-H(11B)	109.5
H(11A)-C(11)-H(11B)	109.5
C(8)-C(11)-H(11C)	109.5
H(11A)-C(11)-H(11C)	109.5
H(11B)-C(11)-H(11C)	109.5
O(101)-S(101)-O(102)	117.27(7)
O(101)-S(101)-N(101)	109.30(6)
O(102)-S(101)-N(101)	107.13(6)
O(101)-S(101)-C(101)	108.47(6)
O(102)-S(101)-C(101)	106.57(6)

N(101)-S(101)-C(101)	107.71(7)
C(105)-N(101)-S(101)	124.44(9)
C(105)-N(101)-H(01N)	118.6(14)
S(101)-N(101)-H(01N)	116.9(14)
C(103)-C(101)-C(104)	111.53(13)
C(103)-C(101)-C(102)	111.39(12)
C(104)-C(101)-C(102)	110.98(11)
C(103)-C(101)-S(101)	108.22(10)
C(104)-C(101)-S(101)	107.91(10)
C(102)-C(101)-S(101)	106.59(11)
C(101)-C(102)-H(10D)	109.5
C(101)-C(102)-H(10E)	109.5
H(10D)-C(102)-H(10E)	109.5
C(101)-C(102)-H(10F)	109.5
H(10D)-C(102)-H(10F)	109.5
H(10E)-C(102)-H(10F)	109.5
C(101)-C(103)-H(10G)	109.5
C(101)-C(103)-H(10H)	109.5
H(10G)-C(103)-H(10H)	109.5
C(101)-C(103)-H(10I)	109.5
H(10G)-C(103)-H(10I)	109.5
H(10H)-C(103)-H(10I)	109.5
C(101)-C(104)-H(10J)	109.5
C(101)-C(104)-H(10K)	109.5
H(10J)-C(104)-H(10K)	109.5
C(101)-C(104)-H(10L)	109.5
H(10J)-C(104)-H(10L)	109.5
H(10K)-C(104)-H(10L)	109.5
N(101)-C(105)-C(106)	110.22(11)
N(101)-C(105)-C(108)	110.93(11)
C(106)-C(105)-C(108)	113.48(12)
N(101)-C(105)-H(105)	107.3
C(106)-C(105)-H(105)	107.3
C(108)-C(105)-H(105)	107.3
C(107)-C(106)-C(105)	114.97(11)
C(107)-C(106)-H(10M)	108.5

C(105)-C(106)-H(10M)	108.5
C(107)-C(106)-H(10N)	108.5
C(105)-C(106)-H(10N)	108.5
H(10M)-C(106)-H(10N)	107.5
O(103)-C(107)-O(104)	123.86(13)
O(103)-C(107)-C(106)	125.29(13)
O(104)-C(107)-C(106)	110.84(12)
C(107)-O(104)-H(04O)	105.9(18)
C(109)-C(108)-C(111)	108.56(14)
C(109)-C(108)-C(110)	108.94(14)
C(111)-C(108)-C(110)	109.60(14)
C(109)-C(108)-C(105)	109.41(13)
C(111)-C(108)-C(105)	108.56(13)
C(110)-C(108)-C(105)	111.72(13)
C(108)-C(109)-H(10O)	109.5
C(108)-C(109)-H(10P)	109.5
H(10O)-C(109)-H(10P)	109.5
C(108)-C(109)-H(10Q)	109.5
H(10O)-C(109)-H(10Q)	109.5
H(10P)-C(109)-H(10Q)	109.5
C(108)-C(110)-H(11D)	109.5
C(108)-C(110)-H(11E)	109.5
H(11D)-C(110)-H(11E)	109.5
C(108)-C(110)-H(11F)	109.5
H(11D)-C(110)-H(11F)	109.5
H(11E)-C(110)-H(11F)	109.5
C(108)-C(111)-H(11G)	109.5
C(108)-C(111)-H(11H)	109.5
H(11G)-C(111)-H(11H)	109.5
C(108)-C(111)-H(11I)	109.5
H(11G)-C(111)-H(11I)	109.5
H(11H)-C(111)-H(11I)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (Å^{2}x 10^3) for **6**. The anisotropic displacement factor exponent takes the form: -2p^2[h^2 a*^{2}U^{11} + ... + 2 h k a* b* U^{12}]

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	32(1)	21(1)	14(1)	4(1)	9(1)	8(1)
O(2)	24(1)	21(1)	15(1)	-5(1)	7(1)	-1(1)
S(1)	18(1)	16(1)	11(1)	-1(1)	5(1)	2(1)
N(1)	18(1)	21(1)	9(1)	0(1)	5(1)	3(1)
C(1)	15(1)	23(1)	18(1)	-1(1)	2(1)	1(1)
C(2)	22(1)	35(1)	35(1)	3(1)	8(1)	9(1)
C(3)	20(1)	30(1)	25(1)	4(1)	7(1)	-3(1)
C(4)	23(1)	32(1)	25(1)	-10(1)	1(1)	-3(1)
C(5)	16(1)	16(1)	8(1)	1(1)	5(1)	1(1)
C(6)	24(1)	17(1)	10(1)	-1(1)	6(1)	-1(1)
C(7)	16(1)	17(1)	12(1)	2(1)	5(1)	0(1)
O(3)	27(1)	20(1)	15(1)	4(1)	12(1)	6(1)
O(4)	40(1)	18(1)	16(1)	4(1)	12(1)	9(1)
C(8)	16(1)	17(1)	13(1)	0(1)	7(1)	1(1)
C(9)	18(1)	24(1)	19(1)	2(1)	6(1)	5(1)
C(10)	24(1)	19(1)	22(1)	2(1)	11(1)	-4(1)
C(11)	25(1)	31(1)	21(1)	-2(1)	16(1)	0(1)
O(101)	18(1)	17(1)	15(1)	6(1)	7(1)	0(1)
O(102)	17(1)	14(1)	13(1)	-1(1)	5(1)	3(1)
S(101)	10(1)	10(1)	10(1)	1(1)	4(1)	1(1)
N(101)	10(1)	16(1)	9(1)	3(1)	5(1)	3(1)
C(101)	10(1)	14(1)	15(1)	-1(1)	3(1)	1(1)
C(102)	12(1)	21(1)	17(1)	0(1)	1(1)	5(1)
C(103)	14(1)	19(1)	29(1)	6(1)	9(1)	-2(1)
C(104)	16(1)	22(1)	21(1)	-9(1)	1(1)	2(1)
C(105)	11(1)	12(1)	13(1)	-1(1)	7(1)	1(1)
C(106)	14(1)	12(1)	12(1)	1(1)	6(1)	0(1)
C(107)	12(1)	14(1)	13(1)	-2(1)	4(1)	0(1)
O(103)	37(1)	18(1)	13(1)	1(1)	9(1)	7(1)
O(104)	28(1)	14(1)	15(1)	-1(1)	8(1)	5(1)
C(108)	10(1)	15(1)	25(1)	-4(1)	6(1)	-1(1)

C(109)	16(1)	17(1)	48(1)	-9(1)	7(1)	-4(1)
C(110)	16(1)	30(1)	22(1)	-6(1)	-2(1)	0(1)
C(111)	18(1)	27(1)	45(1)	-3(1)	19(1)	-3(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **6**.

	x	y	z	U(eq)
H(1N)	3200(20)	5790(19)	-765(14)	19
H(2A)	-1562	6817	-789	47
H(2B)	-770	7528	-1457	47
H(2C)	-483	7815	-174	47
H(3A)	-247	5263	662	37
H(3B)	686	6351	1274	37
H(3C)	1367	5195	975	37
H(4A)	935	4745	-1093	43
H(4B)	85	5676	-2009	43
H(4C)	-667	4882	-1365	43
H(5)	3914	6009	1538	16
H(6A)	2974	4071	489	20
H(6B)	4564	3831	784	20
H(4O)	4590(20)	2660(20)	3075(16)	36
H(9A)	7521	5567	2265	31
H(9B)	6521	4454	2041	31
H(9C)	6316	5545	2761	31
H(10A)	6743	7455	1232	32
H(10B)	5674	7506	1869	32
H(10C)	5161	7637	546	32
H(11A)	5454	5919	-600	36
H(11B)	5808	4637	-50	36
H(11C)	6966	5627	208	36
H(01N)	3568(19)	4157(17)	4406(13)	14
H(10D)	7629	2369	6045	27
H(10E)	7267	2335	7159	27

H(10F)	8366	3258	7043	27
H(10G)	7500	4966	5604	30
H(10H)	5902	5056	4933	30
H(10I)	6767	3999	4682	30
H(10J)	7009	4958	7450	31
H(10K)	5933	4020	7584	31
H(10L)	5432	5089	6722	31
H(105)	2886	3775	6227	13
H(10M)	3369	5856	5542	15
H(10N)	1746	5828	5101	15
H(04O)	2240(20)	7120(20)	7429(15)	28
H(10O)	420	1964	4290	42
H(10P)	1711	1949	5413	42
H(10Q)	1914	2138	4244	42
H(11D)	500	5040	3682	37
H(11E)	-225	3816	3192	37
H(11F)	1296	4067	3239	37
H(11G)	61	4732	5435	42
H(11H)	572	3559	6155	42
H(11I)	-674	3496	5003	42

Table 6. Torsion angles [°] for **6**.

O(2)-S(1)-N(1)-C(5)	27.67(15)
O(1)-S(1)-N(1)-C(5)	156.06(13)
C(1)-S(1)-N(1)-C(5)	-90.18(13)
O(2)-S(1)-C(1)-C(4)	-169.76(12)
O(1)-S(1)-C(1)-C(4)	62.82(13)
N(1)-S(1)-C(1)-C(4)	-50.88(13)
O(2)-S(1)-C(1)-C(3)	-48.03(14)
O(1)-S(1)-C(1)-C(3)	-175.44(12)
N(1)-S(1)-C(1)-C(3)	70.85(13)
O(2)-S(1)-C(1)-C(2)	70.85(12)
O(1)-S(1)-C(1)-C(2)	-56.56(12)
N(1)-S(1)-C(1)-C(2)	-170.26(10)

S(1)-N(1)-C(5)-C(6)	114.69(13)
S(1)-N(1)-C(5)-C(8)	-119.76(13)
N(1)-C(5)-C(6)-C(7)	-141.56(12)
C(8)-C(5)-C(6)-C(7)	94.28(14)
C(5)-C(6)-C(7)-O(3)	34.6(2)
C(5)-C(6)-C(7)-O(4)	-147.55(14)
N(1)-C(5)-C(8)-C(10)	66.55(14)
C(6)-C(5)-C(8)-C(10)	-169.40(11)
N(1)-C(5)-C(8)-C(9)	-175.10(12)
C(6)-C(5)-C(8)-C(9)	-51.05(15)
N(1)-C(5)-C(8)-C(11)	-53.99(17)
C(6)-C(5)-C(8)-C(11)	70.06(15)
O(101)-S(101)-N(101)-C(105)	14.47(13)
O(102)-S(101)-N(101)-C(105)	142.50(11)
C(101)-S(101)-N(101)-C(105)	-103.19(12)
O(101)-S(101)-C(101)-C(103)	-179.39(10)
O(102)-S(101)-C(101)-C(103)	53.50(11)
N(101)-S(101)-C(101)-C(103)	-61.19(11)
O(101)-S(101)-C(101)-C(104)	-58.56(12)
O(102)-S(101)-C(101)-C(104)	174.33(10)
N(101)-S(101)-C(101)-C(104)	59.64(11)
O(101)-S(101)-C(101)-C(102)	60.71(10)
O(102)-S(101)-C(101)-C(102)	-66.41(10)
N(101)-S(101)-C(101)-C(102)	178.91(9)
S(101)-N(101)-C(105)-C(106)	125.08(12)
S(101)-N(101)-C(105)-C(108)	-108.37(13)
N(101)-C(105)-C(106)-C(107)	-132.51(12)
C(108)-C(105)-C(106)-C(107)	102.39(14)
C(105)-C(106)-C(107)-O(103)	13.8(2)
C(105)-C(106)-C(107)-O(104)	-167.01(12)
N(101)-C(105)-C(108)-C(109)	56.71(16)
C(106)-C(105)-C(108)-C(109)	-178.56(12)
N(101)-C(105)-C(108)-C(111)	175.03(13)
C(106)-C(105)-C(108)-C(111)	-60.25(16)
N(101)-C(105)-C(108)-C(110)	-64.00(16)
C(106)-C(105)-C(108)-C(110)	60.72(15)

Symmetry transformations used to generate equivalent atoms:

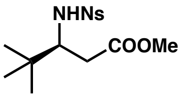
Table 7. Hydrogen bonds for **6** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(102)-H(10E)...O(2)#1	0.98	2.69	3.3728(17)	127.5
C(106)-H(10M)...O(102)#2	0.99	2.39	3.3416(17)	160.2
O(104)-H(04O)...O(1)#3	0.813(17)	1.878(17)	2.6745(14)	166(2)
N(1)-H(1N)...O(103)#4	0.868(16)	2.103(16)	2.9608(15)	169.6(18)
N(101)-H(01N)...O(3)	0.785(15)	2.134(16)	2.8980(14)	164.4(19)
O(4)-H(4O)...O(102)	0.844(18)	1.835(19)	2.6752(14)	174(2)
O(4)-H(4O)...S(101)	0.844(18)	3.026(19)	3.8403(11)	163(2)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,y-1/2,-z+1 #2 -x+1,y+1/2,-z+1 #3 x,y,z+1

#4 x,y,z-1



S8

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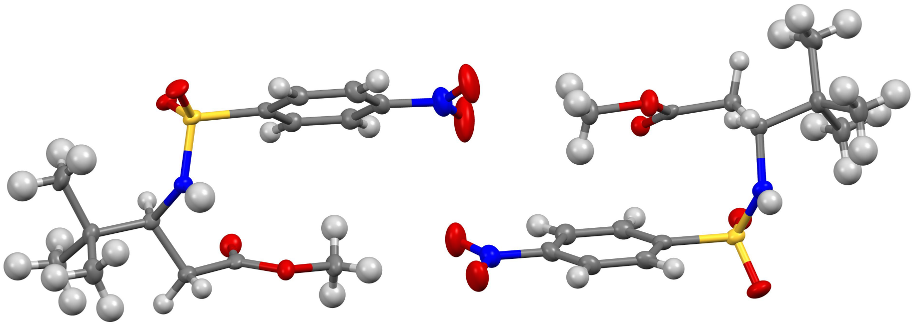


Compound (*S*)-**S8** crystallizes in the monoclinic space group $P2_1$ with two molecules in the asymmetric unit. The coordinates for the hydrogen atoms bound to N1 and N101 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H distance (0.88(4) Å).

Table 1. Crystal data and structure refinement for **S8**.

Identification code	P14222	
CCDC Deposition Number	1525616	
Empirical formula	C14 H20 N2 O6 S	
Formula weight	344.38	
Temperature	100(2) K	
Wavelength	1.54178 Å	
Crystal system	Monoclinic	
Space group	$P2_1$	
Unit cell dimensions	a = 7.2061(3) Å	α = 90°.
	b = 10.2681(5) Å	β = 94.415(2)°.
	c = 22.5477(10) Å	γ = 90°.
Volume	1663.42(13) $Å^3$	
Z	4	
Density (calculated)	1.375 Mg/m^3	
Absorption coefficient	2.023 mm^{-1}	
F(000)	728	
Crystal size	0.250 x 0.150 x 0.050 mm^3	
Theta range for data collection	3.933 to 74.535°.	
Index ranges	-9<=h<=8, -12<=k<=12, -28<=l<=28	
Reflections collected	27070	
Independent reflections	6715 [R(int) = 0.0469]	
Completeness to theta = 67.679°	99.9 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7538 and 0.6512	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	6715 / 3 / 431	
Goodness-of-fit on F^2	1.020	
Final R indices [I>2sigma(I)]	R1 = 0.0338, wR2 = 0.0802	
R indices (all data)	R1 = 0.0358, wR2 = 0.0812	
Absolute structure parameter	0.058(6)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.585 and -0.343 e.$Å^{-3}$	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **S8**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	-2169(1)	4631(1)	2134(1)	18(1)
O(1)	-2807(3)	5944(2)	2042(1)	22(1)
O(2)	-3361(3)	3569(2)	1950(1)	25(1)
N(1)	-220(3)	4504(2)	1840(1)	20(1)
C(1)	669(4)	5529(3)	1505(1)	18(1)
C(5)	352(4)	5335(3)	821(1)	23(1)
C(6)	1390(5)	4135(3)	616(1)	30(1)
C(7)	-1744(5)	5164(4)	652(2)	37(1)
C(8)	1012(5)	6548(3)	509(1)	32(1)
C(2)	2730(4)	5575(3)	1737(1)	21(1)
C(3)	2972(4)	6190(3)	2342(1)	21(1)
O(3)	2550(3)	7307(2)	2446(1)	27(1)
O(4)	3715(3)	5378(2)	2759(1)	23(1)
C(4)	4201(4)	5962(4)	3337(1)	28(1)
C(11)	-1561(4)	4387(3)	2906(1)	19(1)
C(12)	-785(4)	5413(3)	3243(1)	22(1)
C(13)	-244(4)	5197(3)	3836(1)	26(1)
C(14)	-497(5)	3967(3)	4071(1)	25(1)
N(2)	117(5)	3743(3)	4698(1)	38(1)
O(5)	1017(6)	4599(4)	4964(1)	67(1)
O(6)	-260(5)	2704(3)	4924(1)	54(1)
C(15)	-1284(5)	2952(3)	3740(1)	28(1)
C(16)	-1808(4)	3170(3)	3147(1)	24(1)
S(101)	7953(1)	6043(1)	7612(1)	21(1)
O(101)	7616(3)	7317(2)	7841(1)	28(1)
O(102)	9804(3)	5524(3)	7658(1)	32(1)
N(101)	6691(4)	5007(2)	7922(1)	22(1)
C(101)	4739(4)	5205(3)	8082(1)	19(1)
C(105)	4637(4)	5206(3)	8766(1)	24(1)
C(106)	5206(6)	3888(4)	9036(2)	35(1)
C(107)	5926(5)	6268(3)	9040(1)	32(1)

C(108)	2644(5)	5549(4)	8908(1)	34(1)
C(102)	3529(4)	4164(3)	7766(1)	20(1)
C(103)	3154(4)	4431(3)	7114(1)	18(1)
O(103)	3360(3)	5456(2)	6872(1)	22(1)
O(104)	2501(3)	3372(2)	6816(1)	29(1)
C(104)	2099(5)	3570(3)	6186(1)	31(1)
C(111)	7293(4)	6086(3)	6838(1)	20(1)
C(112)	7520(4)	4960(3)	6504(1)	24(1)
C(113)	7022(4)	4969(3)	5902(1)	26(1)
C(114)	6294(4)	6108(4)	5647(1)	25(1)
N(102)	5736(4)	6106(3)	5003(1)	31(1)
O(105)	4944(5)	7075(3)	4790(1)	48(1)
O(106)	6090(4)	5136(3)	4715(1)	45(1)
C(115)	6063(4)	7236(3)	5969(1)	27(1)
C(116)	6578(4)	7218(3)	6576(1)	24(1)

Table 3. Bond lengths [Å] and angles [°] for **S8**.

S(1)-O(2)	1.430(2)
S(1)-O(1)	1.434(2)
S(1)-N(1)	1.604(2)
S(1)-C(11)	1.778(3)
N(1)-C(1)	1.471(4)
N(1)-H(1N)	0.87(3)
C(1)-C(2)	1.537(4)
C(1)-C(5)	1.554(4)
C(1)-H(1)	1.0000
C(5)-C(8)	1.526(4)
C(5)-C(6)	1.531(4)
C(5)-C(7)	1.540(4)
C(6)-H(6A)	0.9800
C(6)-H(6B)	0.9800
C(6)-H(6C)	0.9800
C(7)-H(7A)	0.9800
C(7)-H(7B)	0.9800

C(7)-H(7C)	0.9800
C(8)-H(8A)	0.9800
C(8)-H(8B)	0.9800
C(8)-H(8C)	0.9800
C(2)-C(3)	1.502(4)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-O(3)	1.213(4)
C(3)-O(4)	1.338(4)
O(4)-C(4)	1.452(4)
C(4)-H(4A)	0.9800
C(4)-H(4B)	0.9800
C(4)-H(4C)	0.9800
C(11)-C(16)	1.380(4)
C(11)-C(12)	1.390(4)
C(12)-C(13)	1.383(4)
C(12)-H(12)	0.9500
C(13)-C(14)	1.386(4)
C(13)-H(13)	0.9500
C(14)-C(15)	1.377(5)
C(14)-N(2)	1.467(4)
N(2)-O(6)	1.222(4)
N(2)-O(5)	1.222(4)
C(15)-C(16)	1.379(5)
C(15)-H(15)	0.9500
C(16)-H(16)	0.9500
S(101)-O(102)	1.433(2)
S(101)-O(101)	1.433(2)
S(101)-N(101)	1.596(3)
S(101)-C(111)	1.773(3)
N(101)-C(101)	1.493(4)
N(101)-H(01N)	0.87(3)
C(101)-C(102)	1.521(4)
C(101)-C(105)	1.550(4)
C(101)-H(101)	1.0000
C(105)-C(106)	1.527(5)

C(105)-C(107)	1.531(5)
C(105)-C(108)	1.536(5)
C(106)-H(10A)	0.9800
C(106)-H(10B)	0.9800
C(106)-H(10C)	0.9800
C(107)-H(10D)	0.9800
C(107)-H(10E)	0.9800
C(107)-H(10F)	0.9800
C(108)-H(10G)	0.9800
C(108)-H(10H)	0.9800
C(108)-H(10I)	0.9800
C(102)-C(103)	1.500(4)
C(102)-H(10J)	0.9900
C(102)-H(10K)	0.9900
C(103)-O(103)	1.199(4)
C(103)-O(104)	1.344(4)
O(104)-C(104)	1.441(4)
C(104)-H(10L)	0.9800
C(104)-H(10M)	0.9800
C(104)-H(10N)	0.9800
C(111)-C(116)	1.385(4)
C(111)-C(112)	1.396(4)
C(112)-C(113)	1.377(4)
C(112)-H(112)	0.9500
C(113)-C(114)	1.389(5)
C(113)-H(113)	0.9500
C(114)-C(115)	1.383(5)
C(114)-N(102)	1.476(4)
N(102)-O(105)	1.227(4)
N(102)-O(106)	1.227(4)
C(115)-C(116)	1.390(4)
C(115)-H(115)	0.9500
C(116)-H(116)	0.9500

O(2)-S(1)-O(1)	119.74(13)
O(2)-S(1)-N(1)	110.06(13)

O(1)-S(1)-N(1)	107.33(13)
O(2)-S(1)-C(11)	105.91(14)
O(1)-S(1)-C(11)	109.04(13)
N(1)-S(1)-C(11)	103.60(13)
C(1)-N(1)-S(1)	125.7(2)
C(1)-N(1)-H(1N)	122(3)
S(1)-N(1)-H(1N)	112(3)
N(1)-C(1)-C(2)	107.2(2)
N(1)-C(1)-C(5)	112.4(2)
C(2)-C(1)-C(5)	113.9(2)
N(1)-C(1)-H(1)	107.7
C(2)-C(1)-H(1)	107.7
C(5)-C(1)-H(1)	107.7
C(8)-C(5)-C(6)	109.9(3)
C(8)-C(5)-C(7)	108.2(3)
C(6)-C(5)-C(7)	109.0(3)
C(8)-C(5)-C(1)	109.0(3)
C(6)-C(5)-C(1)	111.4(2)
C(7)-C(5)-C(1)	109.1(2)
C(5)-C(6)-H(6A)	109.5
C(5)-C(6)-H(6B)	109.5
H(6A)-C(6)-H(6B)	109.5
C(5)-C(6)-H(6C)	109.5
H(6A)-C(6)-H(6C)	109.5
H(6B)-C(6)-H(6C)	109.5
C(5)-C(7)-H(7A)	109.5
C(5)-C(7)-H(7B)	109.5
H(7A)-C(7)-H(7B)	109.5
C(5)-C(7)-H(7C)	109.5
H(7A)-C(7)-H(7C)	109.5
H(7B)-C(7)-H(7C)	109.5
C(5)-C(8)-H(8A)	109.5
C(5)-C(8)-H(8B)	109.5
H(8A)-C(8)-H(8B)	109.5
C(5)-C(8)-H(8C)	109.5
H(8A)-C(8)-H(8C)	109.5

H(8B)-C(8)-H(8C)	109.5
C(3)-C(2)-C(1)	111.3(2)
C(3)-C(2)-H(2A)	109.4
C(1)-C(2)-H(2A)	109.4
C(3)-C(2)-H(2B)	109.4
C(1)-C(2)-H(2B)	109.4
H(2A)-C(2)-H(2B)	108.0
O(3)-C(3)-O(4)	123.1(3)
O(3)-C(3)-C(2)	124.0(3)
O(4)-C(3)-C(2)	112.9(3)
C(3)-O(4)-C(4)	115.4(3)
O(4)-C(4)-H(4A)	109.5
O(4)-C(4)-H(4B)	109.5
H(4A)-C(4)-H(4B)	109.5
O(4)-C(4)-H(4C)	109.5
H(4A)-C(4)-H(4C)	109.5
H(4B)-C(4)-H(4C)	109.5
C(16)-C(11)-C(12)	121.9(3)
C(16)-C(11)-S(1)	118.9(2)
C(12)-C(11)-S(1)	119.1(2)
C(13)-C(12)-C(11)	118.6(3)
C(13)-C(12)-H(12)	120.7
C(11)-C(12)-H(12)	120.7
C(12)-C(13)-C(14)	118.6(3)
C(12)-C(13)-H(13)	120.7
C(14)-C(13)-H(13)	120.7
C(15)-C(14)-C(13)	122.9(3)
C(15)-C(14)-N(2)	118.9(3)
C(13)-C(14)-N(2)	118.1(3)
O(6)-N(2)-O(5)	123.3(3)
O(6)-N(2)-C(14)	118.6(3)
O(5)-N(2)-C(14)	118.1(3)
C(14)-C(15)-C(16)	118.2(3)
C(14)-C(15)-H(15)	120.9
C(16)-C(15)-H(15)	120.9
C(15)-C(16)-C(11)	119.7(3)

C(15)-C(16)-H(16)	120.2
C(11)-C(16)-H(16)	120.2
O(102)-S(101)-O(101)	119.74(15)
O(102)-S(101)-N(101)	106.17(14)
O(101)-S(101)-N(101)	109.44(14)
O(102)-S(101)-C(111)	104.94(14)
O(101)-S(101)-C(111)	106.95(14)
N(101)-S(101)-C(111)	109.24(14)
C(101)-N(101)-S(101)	126.5(2)
C(101)-N(101)-H(01N)	118(3)
S(101)-N(101)-H(01N)	113(3)
N(101)-C(101)-C(102)	107.9(2)
N(101)-C(101)-C(105)	111.0(2)
C(102)-C(101)-C(105)	113.4(2)
N(101)-C(101)-H(101)	108.1
C(102)-C(101)-H(101)	108.1
C(105)-C(101)-H(101)	108.1
C(106)-C(105)-C(107)	109.5(3)
C(106)-C(105)-C(108)	110.3(3)
C(107)-C(105)-C(108)	107.5(3)
C(106)-C(105)-C(101)	111.4(3)
C(107)-C(105)-C(101)	109.2(2)
C(108)-C(105)-C(101)	108.9(2)
C(105)-C(106)-H(10A)	109.5
C(105)-C(106)-H(10B)	109.5
H(10A)-C(106)-H(10B)	109.5
C(105)-C(106)-H(10C)	109.5
H(10A)-C(106)-H(10C)	109.5
H(10B)-C(106)-H(10C)	109.5
C(105)-C(107)-H(10D)	109.5
C(105)-C(107)-H(10E)	109.5
H(10D)-C(107)-H(10E)	109.5
C(105)-C(107)-H(10F)	109.5
H(10D)-C(107)-H(10F)	109.5
H(10E)-C(107)-H(10F)	109.5
C(105)-C(108)-H(10G)	109.5

C(105)-C(108)-H(10H)	109.5
H(10G)-C(108)-H(10H)	109.5
C(105)-C(108)-H(10I)	109.5
H(10G)-C(108)-H(10I)	109.5
H(10H)-C(108)-H(10I)	109.5
C(103)-C(102)-C(101)	112.6(2)
C(103)-C(102)-H(10J)	109.1
C(101)-C(102)-H(10J)	109.1
C(103)-C(102)-H(10K)	109.1
C(101)-C(102)-H(10K)	109.1
H(10J)-C(102)-H(10K)	107.8
O(103)-C(103)-O(104)	122.3(3)
O(103)-C(103)-C(102)	125.9(3)
O(104)-C(103)-C(102)	111.8(2)
C(103)-O(104)-C(104)	114.5(2)
O(104)-C(104)-H(10L)	109.5
O(104)-C(104)-H(10M)	109.5
H(10L)-C(104)-H(10M)	109.5
O(104)-C(104)-H(10N)	109.5
H(10L)-C(104)-H(10N)	109.5
H(10M)-C(104)-H(10N)	109.5
C(116)-C(111)-C(112)	121.3(3)
C(116)-C(111)-S(101)	120.2(2)
C(112)-C(111)-S(101)	118.4(2)
C(113)-C(112)-C(111)	119.6(3)
C(113)-C(112)-H(112)	120.2
C(111)-C(112)-H(112)	120.2
C(112)-C(113)-C(114)	118.4(3)
C(112)-C(113)-H(113)	120.8
C(114)-C(113)-H(113)	120.8
C(115)-C(114)-C(113)	123.0(3)
C(115)-C(114)-N(102)	118.9(3)
C(113)-C(114)-N(102)	118.2(3)
O(105)-N(102)-O(106)	124.1(3)
O(105)-N(102)-C(114)	117.9(3)
O(106)-N(102)-C(114)	118.0(3)

C(114)-C(115)-C(116)	118.2(3)
C(114)-C(115)-H(115)	120.9
C(116)-C(115)-H(115)	120.9
C(111)-C(116)-C(115)	119.5(3)
C(111)-C(116)-H(116)	120.2
C(115)-C(116)-H(116)	120.2

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for **S8**. The anisotropic displacement factor exponent takes the form: $-2p^2[\ h^2\ a^{*2}U^{11} + \ldots + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	13(1)	18(1)	24(1)	-1(1)	-1(1)	-1(1)
O(1)	15(1)	21(1)	29(1)	1(1)	0(1)	2(1)
O(2)	17(1)	22(1)	36(1)	-4(1)	-4(1)	-6(1)
N(1)	18(1)	17(1)	24(1)	2(1)	2(1)	2(1)
C(1)	18(1)	15(1)	22(1)	2(1)	0(1)	-1(1)
C(5)	25(2)	24(2)	21(1)	1(1)	-3(1)	2(1)
C(6)	40(2)	26(2)	24(2)	-5(1)	-1(1)	4(1)
C(7)	31(2)	55(2)	24(2)	-1(2)	-11(1)	2(2)
C(8)	45(2)	29(2)	21(2)	4(1)	1(1)	2(2)
C(2)	17(1)	22(1)	23(1)	1(1)	1(1)	-2(1)
C(3)	14(1)	25(2)	23(1)	2(1)	0(1)	-5(1)
O(3)	31(1)	18(1)	31(1)	-2(1)	-2(1)	-3(1)
O(4)	24(1)	25(1)	21(1)	2(1)	-2(1)	-5(1)
C(4)	28(2)	36(2)	20(1)	-1(1)	-4(1)	-8(1)
C(11)	18(1)	18(2)	22(1)	0(1)	4(1)	-1(1)
C(12)	22(1)	18(1)	26(1)	-1(1)	1(1)	-1(1)
C(13)	27(2)	26(2)	25(1)	-4(1)	1(1)	-4(1)
C(14)	27(2)	25(2)	22(1)	2(1)	5(1)	3(1)
N(2)	53(2)	36(2)	24(1)	0(1)	0(1)	4(2)
O(5)	113(3)	50(2)	33(1)	6(1)	-25(2)	-20(2)
O(6)	94(2)	38(2)	29(1)	12(1)	-1(1)	-6(2)
C(15)	35(2)	22(2)	29(2)	4(1)	8(1)	-1(1)

C(16)	26(2)	18(1)	29(2)	-2(1)	6(1)	-4(1)
S(101)	16(1)	22(1)	25(1)	-2(1)	0(1)	-1(1)
O(101)	30(1)	21(1)	31(1)	-6(1)	2(1)	-5(1)
O(102)	16(1)	41(1)	39(1)	-1(1)	0(1)	4(1)
N(101)	20(1)	18(1)	27(1)	-1(1)	1(1)	4(1)
C(101)	20(1)	18(1)	20(1)	0(1)	0(1)	3(1)
C(105)	29(2)	25(2)	18(1)	1(1)	0(1)	2(1)
C(106)	48(2)	32(2)	25(2)	8(1)	-2(2)	2(2)
C(107)	42(2)	32(2)	21(1)	-2(1)	-5(1)	0(2)
C(108)	36(2)	44(2)	24(2)	-6(1)	9(1)	-1(2)
C(102)	20(1)	18(1)	21(1)	1(1)	-1(1)	-2(1)
C(103)	13(1)	17(2)	24(1)	-3(1)	0(1)	2(1)
O(103)	26(1)	19(1)	23(1)	2(1)	1(1)	1(1)
O(104)	40(1)	22(1)	23(1)	-2(1)	-6(1)	-6(1)
C(104)	40(2)	30(2)	22(2)	-1(1)	-4(1)	-6(1)
C(111)	16(1)	21(1)	25(1)	0(1)	5(1)	-1(1)
C(112)	23(1)	19(2)	29(2)	0(1)	7(1)	4(1)
C(113)	28(2)	24(2)	28(2)	-2(1)	8(1)	3(1)
C(114)	26(2)	28(2)	22(1)	0(1)	6(1)	-2(1)
N(102)	34(1)	33(1)	27(1)	4(1)	4(1)	0(1)
O(105)	69(2)	42(2)	32(1)	7(1)	-5(1)	12(2)
O(106)	59(2)	49(2)	27(1)	-7(1)	1(1)	9(1)
C(115)	28(2)	22(2)	31(2)	5(1)	4(1)	0(1)
C(116)	25(2)	20(2)	30(2)	-1(1)	6(1)	-2(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10 ^{3}) for **S8**.

	x	y	z	U(eq)
H(1)	93	6380	1605	22
H(6A)	1123	4017	187	46
H(6B)	980	3363	826	46
H(6C)	2732	4256	705	46
H(7A)	-2424	5910	797	56

H(7B)	-2181	4362	831	56
H(7C)	-1962	5110	218	56
H(8A)	2371	6608	567	47
H(8B)	454	7323	676	47
H(8C)	636	6493	82	47
H(2A)	3239	4679	1757	25
H(2B)	3439	6080	1456	25
H(4A)	5166	6623	3300	42
H(4B)	4671	5287	3617	42
H(4C)	3096	6369	3484	42
H(12)	-629	6244	3069	27
H(13)	291	5877	4079	31
H(15)	-1461	2125	3916	34
H(16)	-2335	2485	2906	29
H(101)	4306	6074	7927	23
H(10A)	6482	3685	8946	53
H(10B)	4361	3212	8868	53
H(10C)	5139	3921	9469	53
H(10D)	5591	7108	8855	48
H(10E)	7218	6056	8972	48
H(10F)	5793	6319	9469	48
H(10G)	2604	5668	9338	52
H(10H)	1801	4841	8773	52
H(10I)	2256	6356	8702	52
H(10J)	4156	3310	7819	24
H(10K)	2330	4113	7951	24
H(10L)	1175	4267	6121	46
H(10M)	1604	2763	6004	46
H(10N)	3243	3816	6006	46
H(112)	8015	4193	6691	28
H(113)	7172	4213	5667	31
H(115)	5566	8001	5780	32
H(116)	6440	7977	6809	29
H(01N)	7070(60)	4210(30)	7882(18)	38(11)
H(1N)	280(70)	3740(30)	1900(20)	56(14)

Table 6. Torsion angles [°] for **S8**.

O(2)-S(1)-N(1)-C(1)	128.2(2)
O(1)-S(1)-N(1)-C(1)	-3.7(3)
C(11)-S(1)-N(1)-C(1)	-118.9(2)
S(1)-N(1)-C(1)-C(2)	134.0(2)
S(1)-N(1)-C(1)-C(5)	-100.1(3)
N(1)-C(1)-C(5)-C(8)	170.1(2)
C(2)-C(1)-C(5)-C(8)	-67.7(3)
N(1)-C(1)-C(5)-C(6)	-68.3(3)
C(2)-C(1)-C(5)-C(6)	53.8(3)
N(1)-C(1)-C(5)-C(7)	52.1(3)
C(2)-C(1)-C(5)-C(7)	174.2(3)
N(1)-C(1)-C(2)-C(3)	-73.8(3)
C(5)-C(1)-C(2)-C(3)	161.2(2)
C(1)-C(2)-C(3)-O(3)	-62.4(4)
C(1)-C(2)-C(3)-O(4)	118.0(3)
O(3)-C(3)-O(4)-C(4)	-7.2(4)
C(2)-C(3)-O(4)-C(4)	172.5(2)
O(2)-S(1)-C(11)-C(16)	17.8(3)
O(1)-S(1)-C(11)-C(16)	147.9(2)
N(1)-S(1)-C(11)-C(16)	-98.0(3)
O(2)-S(1)-C(11)-C(12)	-164.7(2)
O(1)-S(1)-C(11)-C(12)	-34.6(3)
N(1)-S(1)-C(11)-C(12)	79.5(3)
C(16)-C(11)-C(12)-C(13)	0.2(4)
S(1)-C(11)-C(12)-C(13)	-177.3(2)
C(11)-C(12)-C(13)-C(14)	0.0(4)
C(12)-C(13)-C(14)-C(15)	-0.8(5)
C(12)-C(13)-C(14)-N(2)	178.8(3)
C(15)-C(14)-N(2)-O(6)	-7.4(5)
C(13)-C(14)-N(2)-O(6)	173.0(3)
C(15)-C(14)-N(2)-O(5)	171.1(4)
C(13)-C(14)-N(2)-O(5)	-8.5(5)
C(13)-C(14)-C(15)-C(16)	1.3(5)
N(2)-C(14)-C(15)-C(16)	-178.3(3)

C(14)-C(15)-C(16)-C(11)	-1.0(5)
C(12)-C(11)-C(16)-C(15)	0.4(5)
S(1)-C(11)-C(16)-C(15)	177.8(2)
O(102)-S(101)-N(101)-C(101)	168.6(2)
O(101)-S(101)-N(101)-C(101)	38.0(3)
C(111)-S(101)-N(101)-C(101)	-78.8(3)
S(101)-N(101)-C(101)-C(102)	122.0(2)
S(101)-N(101)-C(101)-C(105)	-113.2(3)
N(101)-C(101)-C(105)-C(106)	-63.8(3)
C(102)-C(101)-C(105)-C(106)	57.9(3)
N(101)-C(101)-C(105)-C(107)	57.3(3)
C(102)-C(101)-C(105)-C(107)	179.0(3)
N(101)-C(101)-C(105)-C(108)	174.4(3)
C(102)-C(101)-C(105)-C(108)	-63.9(3)
N(101)-C(101)-C(102)-C(103)	-75.0(3)
C(105)-C(101)-C(102)-C(103)	161.7(2)
C(101)-C(102)-C(103)-O(103)	-16.8(4)
C(101)-C(102)-C(103)-O(104)	164.4(2)
O(103)-C(103)-O(104)-C(104)	0.8(4)
C(102)-C(103)-O(104)-C(104)	179.5(3)
O(102)-S(101)-C(111)-C(116)	-129.2(2)
O(101)-S(101)-C(111)-C(116)	-1.0(3)
N(101)-S(101)-C(111)-C(116)	117.4(2)
O(102)-S(101)-C(111)-C(112)	50.6(3)
O(101)-S(101)-C(111)-C(112)	178.8(2)
N(101)-S(101)-C(111)-C(112)	-62.9(3)
C(116)-C(111)-C(112)-C(113)	-0.1(4)
S(101)-C(111)-C(112)-C(113)	-179.9(2)
C(111)-C(112)-C(113)-C(114)	-0.3(4)
C(112)-C(113)-C(114)-C(115)	0.5(5)
C(112)-C(113)-C(114)-N(102)	-179.1(3)
C(115)-C(114)-N(102)-O(105)	-5.9(4)
C(113)-C(114)-N(102)-O(105)	173.7(3)
C(115)-C(114)-N(102)-O(106)	174.1(3)
C(113)-C(114)-N(102)-O(106)	-6.3(4)
C(113)-C(114)-C(115)-C(116)	-0.3(5)

N(102)-C(114)-C(115)-C(116)	179.3(3)
C(112)-C(111)-C(116)-C(115)	0.4(4)
S(101)-C(111)-C(116)-C(115)	-179.8(2)
C(114)-C(115)-C(116)-C(111)	-0.2(4)

Symmetry transformations used to generate equivalent atoms:

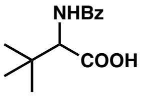
Table 7. Hydrogen bonds for **S8** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(4)-H(4A)...O(104)#1	0.98	2.49	3.467(4)	177.3
C(4)-H(4B)...O(106)	0.98	2.61	3.403(4)	138.1
C(12)-H(12)...O(104)#2	0.95	2.59	3.280(4)	129.6
C(16)-H(16)...O(103)#3	0.95	2.28	3.002(4)	132.3
C(102)-H(10J)...O(1)#3	0.99	2.64	3.381(4)	131.4
C(102)-H(10K)...O(102)#4	0.99	2.38	3.019(4)	121.6
C(116)-H(116)...O(4)#1	0.95	2.66	3.587(4)	166.9
N(101)-H(01N)...O(3)#5	0.87(3)	2.11(3)	2.957(3)	163(4)
N(1)-H(1N)...O(101)#5	0.87(3)	2.15(3)	2.979(3)	158(5)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,y+1/2,-z+1 #2 -x,y+1/2,-z+1 #3 -x,y-1/2,-z+1

#4 x-1,y,z #5 -x+1,y-1/2,-z+1



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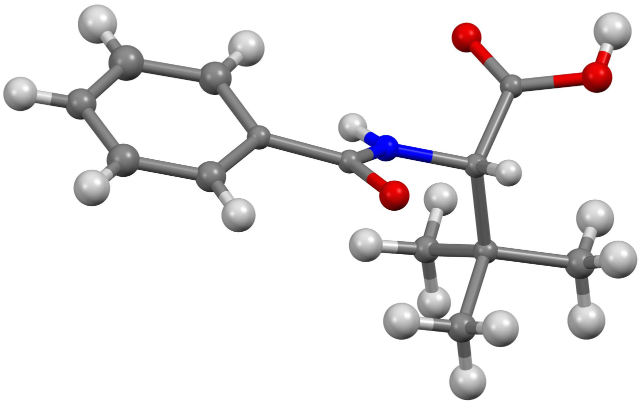


Compound **9** crystallizes in the monoclinic space group $P12_1/c1$ with one molecule in the asymmetric unit.

Table 1. Crystal data and structure refinement for **9**.

Identification code	a14415	
CCDC Deposition Number	1525611	
Empirical formula	C13 H17 N O3	
Formula weight	235.27	
Temperature	100 K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 1 21/c 1	
Unit cell dimensions	a = 10.3502(5) Å	α = 90°
	b = 12.3986(5) Å	β = 114.106(2)°
	c = 10.6650(5) Å	γ = 90°
Volume	1249.27(10) Å^3	
Z	4	
Density (calculated)	1.251 Mg/m^3	
Absorption coefficient	0.089 mm^{-1}	
F(000)	504	
Crystal size	0.43 x 0.35 x 0.09 mm^3	
Theta range for data collection	2.660 to 40.253°.	
Index ranges	-18<=h<=18, -22<=k<=22, -19<=l<=19	
Reflections collected	72079	
Independent reflections	7619 [R(int) = 0.0462]	

Completeness to theta = 25.000°	100.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	1.0000 and 0.9176
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	7619 / 0 / 222
Goodness-of-fit on F^2	1.037
Final R indices [I>2sigma(I)]	R1 = 0.0461, wR2 = 0.1186
R indices (all data)	R1 = 0.0721, wR2 = 0.1331
Extinction coefficient	n/a
Largest diff. peak and hole	0.661 and -0.262 e.Å^{-3}

Table 2. Atomic coordinates (x 10^5) and equivalent isotropic displacement parameters (Å^{2}x 10^4) for **9**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	47590(6)	13367(4)	59856(5)	182(1)
O(2)	51655(6)	50669(4)	64460(5)	175(1)
O(3)	62532(6)	45136(4)	86279(5)	187(1)
N(1)	51375(6)	30479(4)	55038(6)	131(1)
C(1)	33799(7)	19832(5)	37111(7)	135(1)
C(2)	30307(8)	9516(5)	31562(7)	186(1)
C(3)	21034(9)	8194(6)	17882(8)	226(1)
C(4)	15073(8)	17079(6)	9651(8)	218(1)
C(5)	18199(9)	27395(6)	15224(9)	253(2)
C(6)	27458(8)	28762(6)	28879(8)	225(1)
C(7)	44630(7)	20961(5)	51544(6)	131(1)
C(8)	61824(6)	32878(4)	68825(6)	120(1)
C(9)	58053(6)	43860(5)	72855(6)	124(1)
C(10)	77249(7)	32476(5)	69612(7)	138(1)
C(11)	80541(9)	20721(6)	67484(9)	219(1)
C(12)	87981(8)	36246(7)	83647(8)	237(1)
C(13)	78535(8)	39511(6)	58371(8)	210(1)

Table 3. Bond lengths [Å] and angles [°] for **9**.

O(1)-C(7)	1.2427(8)
O(2)-C(9)	1.2119(7)
O(3)-H(3)	0.949(18)
O(3)-C(9)	1.3219(8)
N(1)-H(1)	0.837(13)
N(1)-C(7)	1.3441(8)
N(1)-C(8)	1.4564(8)
C(1)-C(2)	1.3935(9)
C(1)-C(6)	1.3988(9)
C(1)-C(7)	1.4953(9)
C(2)-H(2)	0.999(13)
C(2)-C(3)	1.3902(10)
C(3)-H(3A)	0.970(14)
C(3)-C(4)	1.3866(11)
C(4)-H(4)	0.982(14)
C(4)-C(5)	1.3916(11)
C(5)-H(5)	0.999(15)
C(5)-C(6)	1.3885(11)
C(6)-H(6)	1.011(14)
C(8)-H(8)	0.973(11)
C(8)-C(9)	1.5258(8)
C(8)-C(10)	1.5649(9)
C(10)-C(11)	1.5346(9)
C(10)-C(12)	1.5279(10)
C(10)-C(13)	1.5317(10)
C(11)-H(11A)	0.966(15)
C(11)-H(11B)	0.977(14)
C(11)-H(11C)	0.969(14)
C(12)-H(12A)	0.975(14)
C(12)-H(12B)	1.005(13)
C(12)-H(12C)	0.952(15)
C(13)-H(13A)	1.012(14)
C(13)-H(13B)	0.991(13)
C(13)-H(13C)	0.998(14)

C(9)-O(3)-H(3)	109.8(10)
C(7)-N(1)-H(1)	119.2(9)
C(7)-N(1)-C(8)	123.14(5)
C(8)-N(1)-H(1)	117.6(9)
C(2)-C(1)-C(6)	119.08(6)
C(2)-C(1)-C(7)	118.59(6)
C(6)-C(1)-C(7)	122.29(5)
C(1)-C(2)-H(2)	118.4(8)
C(3)-C(2)-C(1)	120.14(6)
C(3)-C(2)-H(2)	121.5(8)
C(2)-C(3)-H(3A)	118.5(8)
C(4)-C(3)-C(2)	120.58(7)
C(4)-C(3)-H(3A)	120.9(8)
C(3)-C(4)-H(4)	119.2(8)
C(3)-C(4)-C(5)	119.61(7)
C(5)-C(4)-H(4)	121.1(8)
C(4)-C(5)-H(5)	120.0(8)
C(6)-C(5)-C(4)	120.04(7)
C(6)-C(5)-H(5)	119.9(9)
C(1)-C(6)-H(6)	121.2(8)
C(5)-C(6)-C(1)	120.50(6)
C(5)-C(6)-H(6)	118.3(8)
O(1)-C(7)-N(1)	121.24(6)
O(1)-C(7)-C(1)	121.74(5)
N(1)-C(7)-C(1)	116.99(5)
N(1)-C(8)-H(8)	107.5(7)
N(1)-C(8)-C(9)	107.26(5)
N(1)-C(8)-C(10)	111.61(5)
C(9)-C(8)-H(8)	109.0(6)
C(9)-C(8)-C(10)	112.71(5)
C(10)-C(8)-H(8)	108.7(7)
O(2)-C(9)-O(3)	124.12(6)
O(2)-C(9)-C(8)	122.61(6)
O(3)-C(9)-C(8)	113.26(5)
C(11)-C(10)-C(8)	107.79(5)

C(12)-C(10)-C(8)	111.12(6)
C(12)-C(10)-C(11)	108.60(6)
C(12)-C(10)-C(13)	109.38(6)
C(13)-C(10)-C(8)	110.66(5)
C(13)-C(10)-C(11)	109.24(6)
C(10)-C(11)-H(11A)	108.9(9)
C(10)-C(11)-H(11B)	108.1(8)
C(10)-C(11)-H(11C)	111.7(8)
H(11A)-C(11)-H(11B)	106.3(12)
H(11A)-C(11)-H(11C)	111.5(12)
H(11B)-C(11)-H(11C)	110.2(11)
C(10)-C(12)-H(12A)	112.5(8)
C(10)-C(12)-H(12B)	110.9(8)
C(10)-C(12)-H(12C)	110.8(9)
H(12A)-C(12)-H(12B)	107.4(11)
H(12A)-C(12)-H(12C)	106.5(12)
H(12B)-C(12)-H(12C)	108.5(11)
C(10)-C(13)-H(13A)	111.1(8)
C(10)-C(13)-H(13B)	109.3(7)
C(10)-C(13)-H(13C)	109.0(9)
H(13A)-C(13)-H(13B)	105.0(10)
H(13A)-C(13)-H(13C)	111.6(11)
H(13B)-C(13)-H(13C)	110.7(11)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (Å^{2}x 10^4) for **9**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	236(2)	116(2)	171(2)	41(2)	58(2)	-29(2)
O(2)	250(2)	121(2)	137(2)	30(1)	62(2)	53(2)
O(3)	264(2)	160(2)	108(2)	-7(2)	47(2)	78(2)
N(1)	166(2)	91(2)	109(2)	10(1)	29(2)	-9(2)
C(1)	139(2)	111(2)	145(2)	-6(2)	47(2)	-8(2)

C(2)	228(3)	126(2)	176(3)	-24(2)	53(2)	2(2)
C(3)	264(3)	182(3)	192(3)	-58(2)	54(3)	-10(2)
C(4)	192(3)	258(3)	163(3)	-18(2)	32(2)	-31(2)
C(5)	222(3)	212(3)	209(3)	47(2)	-29(3)	-31(2)
C(6)	216(3)	138(2)	215(3)	19(2)	-19(2)	-19(2)
C(7)	152(2)	99(2)	136(2)	5(2)	55(2)	-6(2)
C(8)	153(2)	92(2)	102(2)	7(2)	41(2)	8(2)
C(9)	147(2)	109(2)	113(2)	5(2)	50(2)	11(2)
C(10)	145(2)	129(2)	128(2)	8(2)	43(2)	24(2)
C(11)	239(3)	156(2)	269(3)	-4(2)	112(3)	62(2)
C(12)	165(3)	322(4)	176(3)	-57(3)	19(2)	11(2)
C(13)	194(3)	222(3)	233(3)	75(2)	106(2)	27(2)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **9**.

	x	y	z	U(eq)
H(3)	5970(18)	5199(14)	8821(18)	56(5)
H(1)	4935(13)	3539(11)	4916(13)	26(3)
H(2)	3463(13)	319(11)	3764(14)	31(3)
H(3A)	1895(14)	94(11)	1421(14)	34(3)
H(4)	846(14)	1596(11)	5(14)	34(3)
H(5)	1406(15)	3383(12)	931(15)	38(4)
H(6)	2943(14)	3634(11)	3269(14)	34(3)
H(8)	6090(12)	2742(9)	7496(11)	16(2)
H(11A)	8043(15)	1642(12)	7499(15)	38(4)
H(11B)	9021(15)	2041(11)	6810(14)	33(3)
H(11C)	7398(14)	1795(10)	5869(14)	30(3)
H(12A)	8699(14)	4388(11)	8526(14)	34(3)
H(12B)	9794(14)	3509(11)	8456(14)	30(3)
H(12C)	8678(15)	3242(12)	9084(15)	37(4)
H(13A)	7243(14)	3663(11)	4892(14)	31(3)
H(13B)	8835(14)	3912(10)	5903(13)	28(3)
H(13C)	7598(15)	4710(12)	5955(15)	39(4)

Table 6. Torsion angles [°] for **9**.

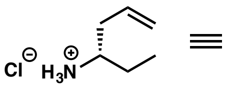
N(1)-C(8)-C(9)-O(2)	-26.48(8)
N(1)-C(8)-C(9)-O(3)	153.92(5)
N(1)-C(8)-C(10)-C(11)	-67.58(6)
N(1)-C(8)-C(10)-C(12)	173.54(5)
N(1)-C(8)-C(10)-C(13)	51.82(7)
C(1)-C(2)-C(3)-C(4)	-0.54(12)
C(2)-C(1)-C(6)-C(5)	-2.29(12)
C(2)-C(1)-C(7)-O(1)	-20.71(10)
C(2)-C(1)-C(7)-N(1)	157.28(6)
C(2)-C(3)-C(4)-C(5)	-1.27(13)
C(3)-C(4)-C(5)-C(6)	1.27(13)
C(4)-C(5)-C(6)-C(1)	0.51(13)
C(6)-C(1)-C(2)-C(3)	2.30(11)
C(6)-C(1)-C(7)-O(1)	161.59(7)
C(6)-C(1)-C(7)-N(1)	-20.42(10)
C(7)-N(1)-C(8)-C(9)	-132.07(6)
C(7)-N(1)-C(8)-C(10)	104.02(7)
C(7)-C(1)-C(2)-C(3)	-175.48(7)
C(7)-C(1)-C(6)-C(5)	175.40(7)
C(8)-N(1)-C(7)-O(1)	-4.13(10)
C(8)-N(1)-C(7)-C(1)	177.88(6)
C(9)-C(8)-C(10)-C(11)	171.64(5)
C(9)-C(8)-C(10)-C(12)	52.76(7)
C(9)-C(8)-C(10)-C(13)	-68.96(7)
C(10)-C(8)-C(9)-O(2)	96.76(7)
C(10)-C(8)-C(9)-O(3)	-82.85(7)

Symmetry transformations used to generate equivalent atoms:

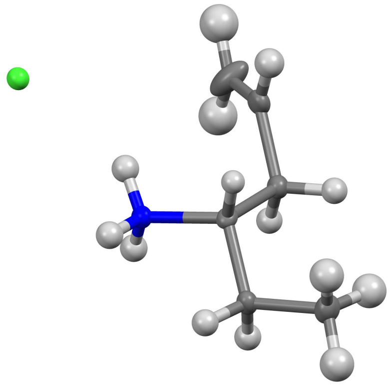
Table 7. Hydrogen bonds for **9** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(3)-H(3)...O(1)#1	0.949(18)	1.652(18)	2.5942(7)	171.7(16)

Symmetry transformations used to generate equivalent atoms:
#1 -x+1,y+1/2,-z+3/2



S11



Compound **S11** crystallizes in the tetragonal space group *I*4 with one molecule in the asymmetric unit along with one chloride anion. The coordinates for the hydrogen atoms bound to N1 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H distance (0.91(4) Å). The crystal was twinned and refined with the twin law 0 1 0 / 1 0 0 / 0 0 -1. The occupancy of the two twin domains refined to 0.4999(19):0.5001(19).

Table 1. Crystal data and structure refinement for **S11**.

Identification code	P15124
CCDC Deposition Number	1525617
Empirical formula	C6 H14 Cl N
Formula weight	135.63
Temperature	100(2) K
Wavelength	0.71073 Å

Crystal system	Tetragonal	
Space group	I4	
Unit cell dimensions	a = 15.0567(6) Å	α = 90°.
	b = 15.0567(6) Å	β = 90°.
	c = 7.3781(3) Å	γ = 90°.
Volume	1672.65(15) Å^3	
Z	8	
Density (calculated)	1.077 Mg/m^3	
Absorption coefficient	0.371 mm^{-1}	
F(000)	592	
Crystal size	0.250 x 0.100 x 0.100 mm^3	
Theta range for data collection	2.706 to 30.504°.	
Index ranges	-21<=h<=21, -18<=k<=20, -10<=l<=8	
Reflections collected	13577	
Independent reflections	2284 [R(int) = 0.0431]	
Completeness to theta = 25.242°	99.9 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7466 and 0.6900	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2284 / 4 / 84	
Goodness-of-fit on F^2	1.075	
Final R indices [I>2sigma(I)]	R1 = 0.0277, wR2 = 0.0490	
R indices (all data)	R1 = 0.0338, wR2 = 0.0506	
Absolute structure parameter	0.00(3)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.240 and -0.210 e.Å^{-3}	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **S11**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
Cl(1)	3899(1)	8887(1)	2850(1)	16(1)
N(1)	6023(1)	9057(1)	3579(2)	15(1)
C(1)	6838(1)	8635(1)	2767(4)	14(1)
C(2)	7650(1)	9088(2)	3591(4)	18(1)

C(3)	8517(1)	8836(2)	2637(4)	24(1)
C(4)	6796(1)	7638(1)	3139(3)	18(1)
C(5)	6014(2)	7205(1)	2244(4)	23(1)
C(6)	5354(2)	6830(2)	3091(5)	38(1)

Table 3. Bond lengths [Å] and angles [°] for **S11**.

N(1)-C(1)	1.507(2)
N(1)-H(1N1)	0.885(18)
N(1)-H(1N2)	0.874(18)
N(1)-H(1N3)	0.894(17)
C(1)-C(2)	1.525(3)
C(1)-C(4)	1.528(2)
C(1)-H(1)	1.0000
C(2)-C(3)	1.532(3)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-H(3A)	0.9800
C(3)-H(3B)	0.9800
C(3)-H(3C)	0.9800
C(4)-C(5)	1.499(3)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-C(6)	1.302(4)
C(5)-H(5)	0.9500
C(6)-H(6A)	0.9500
C(6)-H(6B)	0.9500
C(1)-N(1)-H(1N1)	111.7(15)
C(1)-N(1)-H(1N2)	112.0(16)
H(1N1)-N(1)-H(1N2)	105(2)
C(1)-N(1)-H(1N3)	112.7(14)
H(1N1)-N(1)-H(1N3)	108.8(19)
H(1N2)-N(1)-H(1N3)	107(2)
N(1)-C(1)-C(2)	107.80(17)

N(1)-C(1)-C(4)	108.05(15)
C(2)-C(1)-C(4)	113.64(17)
N(1)-C(1)-H(1)	109.1
C(2)-C(1)-H(1)	109.1
C(4)-C(1)-H(1)	109.1
C(1)-C(2)-C(3)	112.91(19)
C(1)-C(2)-H(2A)	109.0
C(3)-C(2)-H(2A)	109.0
C(1)-C(2)-H(2B)	109.0
C(3)-C(2)-H(2B)	109.0
H(2A)-C(2)-H(2B)	107.8
C(2)-C(3)-H(3A)	109.5
C(2)-C(3)-H(3B)	109.5
H(3A)-C(3)-H(3B)	109.5
C(2)-C(3)-H(3C)	109.5
H(3A)-C(3)-H(3C)	109.5
H(3B)-C(3)-H(3C)	109.5
C(5)-C(4)-C(1)	112.34(16)
C(5)-C(4)-H(4A)	109.1
C(1)-C(4)-H(4A)	109.1
C(5)-C(4)-H(4B)	109.1
C(1)-C(4)-H(4B)	109.1
H(4A)-C(4)-H(4B)	107.9
C(6)-C(5)-C(4)	125.2(3)
C(6)-C(5)-H(5)	117.4
C(4)-C(5)-H(5)	117.4
C(5)-C(6)-H(6A)	120.0
C(5)-C(6)-H(6B)	120.0
H(6A)-C(6)-H(6B)	120.0

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (Å^{2}x 10^3) for **S11**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}

Cl(1)	16(1)	15(1)	17(1)	-1(1)	0(1)	0(1)
N(1)	16(1)	12(1)	18(1)	0(1)	-1(1)	2(1)
C(1)	14(1)	18(1)	11(1)	2(1)	-1(1)	2(1)
C(2)	16(1)	15(1)	23(1)	-3(1)	1(1)	1(1)
C(3)	18(1)	24(1)	30(1)	0(1)	1(1)	0(1)
C(4)	17(1)	17(1)	20(1)	-2(1)	-1(1)	2(1)
C(5)	22(1)	16(1)	30(1)	-6(1)	-3(1)	4(1)
C(6)	23(1)	37(1)	54(2)	19(2)	-14(1)	-6(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10 ^{3}) for **S11**.

	x	y	z	U(eq)
H(1N1)	6018(16)	9640(12)	3410(30)	23
H(1N2)	6002(16)	8989(15)	4750(20)	23
H(1N3)	5518(12)	8830(15)	3140(30)	23
H(1)	6837	8736	1428	17
H(2A)	7693	8923	4887	22
H(2B)	7570	9740	3524	22
H(3A)	8482	9005	1356	36
H(3B)	8611	8194	2733	36
H(3C)	9014	9149	3211	36
H(4A)	7349	7355	2694	21
H(4B)	6762	7538	4463	21
H(5)	5998	7205	957	27
H(6A)	5345	6816	4378	46
H(6B)	4882	6570	2421	46

Table 6. Torsion angles [°] for P15124.

N(1)-C(1)-C(2)-C(3)	-169.76(18)
C(4)-C(1)-C(2)-C(3)	70.5(2)
N(1)-C(1)-C(4)-C(5)	62.9(3)
C(2)-C(1)-C(4)-C(5)	-177.5(2)
C(1)-C(4)-C(5)-C(6)	-115.4(2)

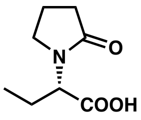
Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for **S11** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1N1)...Cl(1)#1	0.885(18)	2.260(18)	3.1437(18)	176(2)
N(1)-H(1N2)...Cl(1)#2	0.874(18)	2.294(18)	3.1633(18)	173(2)
N(1)-H(1N3)...Cl(1)	0.894(17)	2.449(18)	3.2527(19)	149.8(19)
C(1)-H(1)...Cl(1)#3	1.00	2.87	3.810(3)	157.5

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+2,z #2 -y+3/2,x+1/2,z+1/2 #3 -y+3/2,x+1/2,z-1/2



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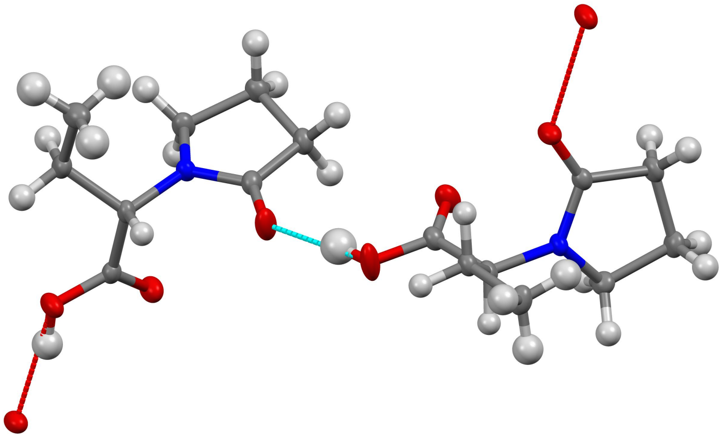


Compound **11** crystallizes in the monoclinic space group $P2_1$ with two molecules in the asymmetric unit. The coordinates for the hydrogen atoms bound to O2 and O102 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the O-H distance (0.84(4) Å). The crystal has a pseudo- center of symmetry. However the chiral space group $P2_1$ was used instead of $P2_1/c$ because the systematic absences for the c-glide plane are weaker than the 2_1- screw axis but not absent and this chiral space group refines with a Flack parameter of 0.02(6).

Table 1. Crystal data and structure refinement for **11**.

Identification code	P14214	
CCDC Deposition Number	1525615	
Empirical formula	C8 H13 N O3	
Formula weight	171.19	
Temperature	100(2) K	
Wavelength	1.54178 Å	
Crystal system	Monoclinic	
Space group	$P2_1$	
Unit cell dimensions	a = 12.7120(4) Å	α = 90°.
	b = 5.4745(2) Å	β = 105.1695(12)°.
	c = 12.9410(4) Å	γ = 90°.
Volume	869.21(5) $Å^3$	
Z	4	
Density (calculated)	1.308 Mg/m^3	
Absorption coefficient	0.834 mm^{-1}	
F(000)	368	
Crystal size	0.150 x 0.100 x 0.050 mm^3	
Theta range for data collection	3.539 to 74.351°.	
Index ranges	-15<=h<=15, -6<=k<=6, -14<=l<=16	
Reflections collected	20206	
Independent reflections	3517 [R(int) = 0.0326]	
Completeness to theta = 67.679°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7538 and 0.7049	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3517 / 2 / 225	

Goodness-of-fit on F^2	1.047
Final R indices [I>2sigma(I)]	R1 = 0.0268, wR2 = 0.0676
R indices (all data)	R1 = 0.0288, wR2 = 0.0689
Absolute structure parameter	0.02(6)
Extinction coefficient	n/a
Largest diff. peak and hole	0.187 and -0.161 e.Å^{-3}

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **11**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	862(1)	1964(3)	7877(1)	17(1)
O(1)	570(1)	3687(3)	7246(1)	23(1)
C(2)	439(2)	1405(4)	8841(1)	22(1)
C(3)	916(2)	-1111(4)	9215(1)	22(1)
C(4)	1915(1)	-1279(4)	8769(1)	21(1)
N(1)	1627(1)	317(3)	7828(1)	17(1)
C(5)	2334(1)	423(3)	7105(1)	17(1)
C(6)	3178(1)	2456(3)	7447(1)	20(1)
O(2)	3819(1)	2573(3)	6798(1)	34(1)
O(3)	3272(1)	3713(3)	8232(1)	28(1)
C(7)	1719(1)	581(3)	5916(1)	18(1)
C(8)	919(2)	-1516(4)	5577(1)	25(1)
C(101)	5779(1)	7309(3)	7788(1)	20(1)
O(101)	5403(1)	5594(3)	7177(1)	30(1)
C(102)	5450(2)	8064(3)	8776(1)	22(1)
C(103)	6021(1)	10509(4)	9086(1)	23(1)
C(104)	6968(1)	10466(4)	8549(1)	23(1)
N(101)	6590(1)	8744(3)	7664(1)	18(1)
C(105)	7188(1)	8192(3)	6875(1)	18(1)
C(106)	8219(1)	6748(3)	7403(1)	19(1)
O(102)	8870(1)	6509(3)	6767(1)	25(1)
O(103)	8387(1)	5862(3)	8288(1)	26(1)
C(107)	7384(1)	10443(3)	6248(1)	22(1)
C(108)	6317(2)	11524(4)	5582(2)	29(1)

Table 3. Bond lengths [Å] and angles [°] for **11**.

C(1)-O(1)	1.239(2)
C(1)-N(1)	1.340(2)
C(1)-C(2)	1.513(2)
C(2)-C(3)	1.532(3)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.529(2)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-N(1)	1.466(2)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
N(1)-C(5)	1.4586(19)
C(5)-C(6)	1.528(2)
C(5)-C(7)	1.535(2)
C(5)-H(5)	1.0000
C(6)-O(3)	1.207(2)
C(6)-O(2)	1.316(2)
O(2)-H(2O)	0.88(3)
C(7)-C(8)	1.520(2)
C(7)-H(7A)	0.9900
C(7)-H(7B)	0.9900
C(8)-H(8A)	0.9800
C(8)-H(8B)	0.9800
C(8)-H(8C)	0.9800
C(101)-O(101)	1.240(2)
C(101)-N(101)	1.338(2)
C(101)-C(102)	1.505(2)
C(102)-C(103)	1.526(3)
C(102)-H(10A)	0.9900
C(102)-H(10B)	0.9900
C(103)-C(104)	1.541(2)

C(103)-H(10C)	0.9900
C(103)-H(10D)	0.9900
C(104)-N(101)	1.464(2)
C(104)-H(10E)	0.9900
C(104)-H(10F)	0.9900
N(101)-C(105)	1.456(2)
C(105)-C(106)	1.530(2)
C(105)-C(107)	1.530(2)
C(105)-H(105)	1.0000
C(106)-O(103)	1.210(2)
C(106)-O(102)	1.317(2)
O(102)-H(02O)	0.89(2)
C(107)-C(108)	1.523(3)
C(107)-H(10G)	0.9900
C(107)-H(10H)	0.9900
C(108)-H(10I)	0.9800
C(108)-H(10J)	0.9800
C(108)-H(10K)	0.9800
O(1)-C(1)-N(1)	125.23(15)
O(1)-C(1)-C(2)	126.00(16)
N(1)-C(1)-C(2)	108.75(14)
C(1)-C(2)-C(3)	104.25(14)
C(1)-C(2)-H(2A)	110.9
C(3)-C(2)-H(2A)	110.9
C(1)-C(2)-H(2B)	110.9
C(3)-C(2)-H(2B)	110.9
H(2A)-C(2)-H(2B)	108.9
C(4)-C(3)-C(2)	103.52(14)
C(4)-C(3)-H(3A)	111.1
C(2)-C(3)-H(3A)	111.1
C(4)-C(3)-H(3B)	111.1
C(2)-C(3)-H(3B)	111.1
H(3A)-C(3)-H(3B)	109.0
N(1)-C(4)-C(3)	103.08(14)
N(1)-C(4)-H(4A)	111.1

C(3)-C(4)-H(4A)	111.1
N(1)-C(4)-H(4B)	111.1
C(3)-C(4)-H(4B)	111.1
H(4A)-C(4)-H(4B)	109.1
C(1)-N(1)-C(5)	125.48(14)
C(1)-N(1)-C(4)	112.86(13)
C(5)-N(1)-C(4)	119.69(13)
N(1)-C(5)-C(6)	110.28(14)
N(1)-C(5)-C(7)	114.05(13)
C(6)-C(5)-C(7)	112.59(14)
N(1)-C(5)-H(5)	106.5
C(6)-C(5)-H(5)	106.5
C(7)-C(5)-H(5)	106.5
O(3)-C(6)-O(2)	124.63(17)
O(3)-C(6)-C(5)	124.48(15)
O(2)-C(6)-C(5)	110.83(15)
C(6)-O(2)-H(2O)	111.9(18)
C(8)-C(7)-C(5)	111.93(14)
C(8)-C(7)-H(7A)	109.2
C(5)-C(7)-H(7A)	109.2
C(8)-C(7)-H(7B)	109.2
C(5)-C(7)-H(7B)	109.2
H(7A)-C(7)-H(7B)	107.9
C(7)-C(8)-H(8A)	109.5
C(7)-C(8)-H(8B)	109.5
H(8A)-C(8)-H(8B)	109.5
C(7)-C(8)-H(8C)	109.5
H(8A)-C(8)-H(8C)	109.5
H(8B)-C(8)-H(8C)	109.5
O(101)-C(101)-N(101)	123.33(16)
O(101)-C(101)-C(102)	127.08(16)
N(101)-C(101)-C(102)	109.56(15)
C(101)-C(102)-C(103)	104.21(14)
C(101)-C(102)-H(10A)	110.9
C(103)-C(102)-H(10A)	110.9
C(101)-C(102)-H(10B)	110.9

C(103)-C(102)-H(10B)	110.9
H(10A)-C(102)-H(10B)	108.9
C(102)-C(103)-C(104)	104.01(15)
C(102)-C(103)-H(10C)	111.0
C(104)-C(103)-H(10C)	111.0
C(102)-C(103)-H(10D)	111.0
C(104)-C(103)-H(10D)	111.0
H(10C)-C(103)-H(10D)	109.0
N(101)-C(104)-C(103)	103.14(14)
N(101)-C(104)-H(10E)	111.1
C(103)-C(104)-H(10E)	111.1
N(101)-C(104)-H(10F)	111.1
C(103)-C(104)-H(10F)	111.1
H(10E)-C(104)-H(10F)	109.1
C(101)-N(101)-C(105)	121.45(15)
C(101)-N(101)-C(104)	112.97(14)
C(105)-N(101)-C(104)	123.88(14)
N(101)-C(105)-C(106)	109.71(13)
N(101)-C(105)-C(107)	113.03(14)
C(106)-C(105)-C(107)	114.46(14)
N(101)-C(105)-H(105)	106.3
C(106)-C(105)-H(105)	106.3
C(107)-C(105)-H(105)	106.3
O(103)-C(106)-O(102)	124.53(16)
O(103)-C(106)-C(105)	123.30(15)
O(102)-C(106)-C(105)	112.11(14)
C(106)-O(102)-H(02O)	111.0(15)
C(108)-C(107)-C(105)	111.68(15)
C(108)-C(107)-H(10G)	109.3
C(105)-C(107)-H(10G)	109.3
C(108)-C(107)-H(10H)	109.3
C(105)-C(107)-H(10H)	109.3
H(10G)-C(107)-H(10H)	107.9
C(107)-C(108)-H(10I)	109.5
C(107)-C(108)-H(10J)	109.5
H(10I)-C(108)-H(10J)	109.5

C(107)-C(108)-H(10K)	109.5
H(10I)-C(108)-H(10K)	109.5
H(10J)-C(108)-H(10K)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (Å^{2}x 10^3) for **11**. The anisotropic displacement factor exponent takes the form: -2p^2[h^2 a*^{2}U^{11} + ... + 2 h k a* b* U^{12}]

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	17(1)	20(1)	16(1)	-2(1)	5(1)	-1(1)
O(1)	24(1)	24(1)	23(1)	5(1)	10(1)	7(1)
C(2)	24(1)	28(1)	17(1)	-1(1)	11(1)	1(1)
C(3)	27(1)	26(1)	16(1)	1(1)	9(1)	-3(1)
C(4)	24(1)	22(1)	17(1)	3(1)	5(1)	1(1)
N(1)	16(1)	21(1)	14(1)	1(1)	6(1)	1(1)
C(5)	15(1)	21(1)	17(1)	0(1)	7(1)	1(1)
C(6)	17(1)	24(1)	19(1)	-1(1)	6(1)	-1(1)
O(2)	31(1)	46(1)	32(1)	-17(1)	19(1)	-23(1)
O(3)	25(1)	31(1)	29(1)	-12(1)	10(1)	-7(1)
C(7)	18(1)	23(1)	16(1)	0(1)	6(1)	-1(1)
C(8)	27(1)	29(1)	18(1)	-1(1)	5(1)	-9(1)
C(101)	17(1)	23(1)	20(1)	1(1)	5(1)	-2(1)
O(101)	28(1)	34(1)	31(1)	-12(1)	15(1)	-16(1)
C(102)	21(1)	27(1)	21(1)	0(1)	9(1)	-3(1)
C(103)	24(1)	25(1)	21(1)	-4(1)	8(1)	-1(1)
C(104)	23(1)	24(1)	24(1)	-7(1)	8(1)	-6(1)
N(101)	18(1)	18(1)	18(1)	-3(1)	7(1)	-2(1)
C(105)	18(1)	19(1)	18(1)	-1(1)	8(1)	-3(1)
C(106)	19(1)	17(1)	21(1)	0(1)	7(1)	-3(1)
O(102)	24(1)	31(1)	23(1)	5(1)	12(1)	7(1)
O(103)	28(1)	31(1)	23(1)	7(1)	11(1)	6(1)
C(107)	25(1)	22(1)	23(1)	2(1)	11(1)	-2(1)
C(108)	34(1)	30(1)	25(1)	4(1)	11(1)	7(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for **11**.

	x	y	z	U(eq)
H(2A)	-368	1359	8641	27
H(2B)	692	2645	9409	27
H(3A)	1127	-1221	10006	27
H(3B)	387	-2425	8921	27
H(4A)	2578	-687	9297	25
H(4B)	2037	-2978	8565	25
H(5)	2749	-1148	7197	21
H(2O)	4350(20)	3650(60)	7020(20)	51
H(7A)	1318	2149	5781	22
H(7B)	2250	557	5477	22
H(8A)	1299	-3071	5778	37
H(8B)	610	-1468	4799	37
H(8C)	331	-1362	5935	37
H(10A)	5695	6848	9356	27
H(10B)	4649	8249	8622	27
H(10C)	6296	10656	9874	28
H(10D)	5520	11887	8815	28
H(10E)	7094	12106	8282	28
H(10F)	7650	9886	9053	28
H(105)	6715	7068	6341	22
H(02O)	9413(18)	5490(50)	7045(18)	37
H(10G)	7780	11692	6756	27
H(10H)	7845	9982	5771	27
H(10I)	5911	10275	5096	44
H(10J)	6474	12906	5164	44
H(10K)	5881	12089	6057	44

Table 6. Torsion angles [°] for **11**.

O(1)-C(1)-C(2)-C(3)	170.64(16)
N(1)-C(1)-C(2)-C(3)	-10.81(18)
C(1)-C(2)-C(3)-C(4)	23.29(17)
C(2)-C(3)-C(4)-N(1)	-26.98(17)
O(1)-C(1)-N(1)-C(5)	7.4(3)
C(2)-C(1)-N(1)-C(5)	-171.13(14)
O(1)-C(1)-N(1)-C(4)	171.29(16)
C(2)-C(1)-N(1)-C(4)	-7.27(19)
C(3)-C(4)-N(1)-C(1)	22.16(19)
C(3)-C(4)-N(1)-C(5)	-172.94(15)
C(1)-N(1)-C(5)-C(6)	71.58(19)
C(4)-N(1)-C(5)-C(6)	-91.27(18)
C(1)-N(1)-C(5)-C(7)	-56.2(2)
C(4)-N(1)-C(5)-C(7)	140.90(16)
N(1)-C(5)-C(6)-O(3)	3.1(2)
C(7)-C(5)-C(6)-O(3)	131.68(19)
N(1)-C(5)-C(6)-O(2)	-179.85(15)
C(7)-C(5)-C(6)-O(2)	-51.2(2)
N(1)-C(5)-C(7)-C(8)	-55.9(2)
C(6)-C(5)-C(7)-C(8)	177.46(15)
O(101)-C(101)-C(102)-C(103)	-170.15(18)
N(101)-C(101)-C(102)-C(103)	11.81(19)
C(101)-C(102)-C(103)-C(104)	-22.00(18)
C(102)-C(103)-C(104)-N(101)	24.16(18)
O(101)-C(101)-N(101)-C(105)	-8.1(3)
C(102)-C(101)-N(101)-C(105)	170.05(15)
O(101)-C(101)-N(101)-C(104)	-173.79(17)
C(102)-C(101)-N(101)-C(104)	4.3(2)
C(103)-C(104)-N(101)-C(101)	-18.4(2)
C(103)-C(104)-N(101)-C(105)	176.34(15)
C(101)-N(101)-C(105)-C(106)	-94.54(18)
C(104)-N(101)-C(105)-C(106)	69.6(2)
C(101)-N(101)-C(105)-C(107)	136.39(17)
C(104)-N(101)-C(105)-C(107)	-59.5(2)

N(101)-C(105)-C(106)-O(103)	11.8(2)
C(107)-C(105)-C(106)-O(103)	140.11(18)
N(101)-C(105)-C(106)-O(102)	-170.72(15)
C(107)-C(105)-C(106)-O(102)	-42.4(2)
N(101)-C(105)-C(107)-C(108)	-63.72(19)
C(106)-C(105)-C(107)-C(108)	169.70(15)

Symmetry transformations used to generate equivalent atoms:

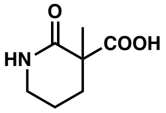
Table 7. Hydrogen bonds for **11** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(3)-H(3A)...O(103)#1	0.99	2.42	3.301(2)	148.4
C(3)-H(3B)...O(103)#2	0.99	2.63	3.535(2)	151.9
C(4)-H(4B)...O(3)#3	0.99	2.51	3.406(2)	150.9
O(2)-H(2O)...O(101)	0.88(3)	1.68(3)	2.5521(19)	168(3)
C(7)-H(7A)...O(1)	0.99	2.48	3.050(2)	116.3
C(103)-H(10C)...O(3)#4	0.99	2.60	3.491(2)	150.4
C(104)-H(10E)...O(103)#5	0.99	2.63	3.523(2)	150.0
O(102)-H(02O)...O(1)#6	0.89(2)	1.73(2)	2.5964(18)	163(2)

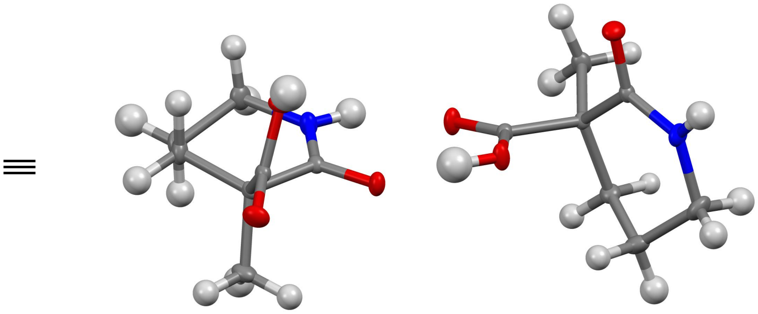
Symmetry transformations used to generate equivalent atoms:

#1 -x+1,y-1/2,-z+2   #2 x-1,y-1,z   #3 x,y-1,z

#4 -x+1,y+1/2,-z+2   #5 x,y+1,z   #6 x+1,y,z



S14



Compound (±)-**S14** crystallizes in the monoclinic space group *P*12$_1$/*n*1 with two molecules in the asymmetric unit.

Table 1. Crystal data and structure refinement for **S14**.

Identification code	a14192	
CCDC Deposition Number	1525608	
Empirical formula	C7 H11 N O3	
Formula weight	157.17	
Temperature	100 K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 1 21/n 1	
Unit cell dimensions	a = 7.0375(4) Å	α = 90°
	b = 9.3775(4) Å	β = 97.139(3)°
	c = 24.0033(12) Å	γ = 90°
Volume	1571.80(14) Å^3	
Z	8	
Density (calculated)	1.328 Mg/m^3	
Absorption coefficient	0.104 mm^{-1}	
F(000)	672	
Crystal size	0.59 x 0.26 x 0.08 mm^3	
Theta range for data collection	1.710 to 38.050°.	
Index ranges	-12<=h<=11, -16<=k<=16, -40<=l<=40	
Reflections collected	81135	
Independent reflections	8190 [R(int) = 0.0394]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	

Max. and min. transmission	1.0000 and 0.9385
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	8190 / 0 / 287
Goodness-of-fit on F^2	1.705
Final R indices [I>2sigma(I)]	R1 = 0.0398, wR2 = 0.1045
R indices (all data)	R1 = 0.0507, wR2 = 0.1074
Extinction coefficient	n/a
Largest diff. peak and hole	0.599 and -0.210 e.Å^{-3}

Table 2. Atomic coordinates (x 10^5) and equivalent isotropic displacement parameters (Å^{2}x 10^4) for **S14**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	81793(6)	77726(5)	100423(2)	150(1)
O(2)	88029(7)	58400(5)	110717(2)	156(1)
O(3)	86983(8)	79042(5)	115362(2)	198(1)
N(1)	109268(8)	67503(6)	98434(2)	152(1)
C(1)	98739(8)	73855(6)	101908(2)	114(1)
C(2)	107244(8)	77206(6)	107923(2)	115(1)
C(3)	126553(9)	69588(7)	109615(3)	170(1)
C(4)	139030(9)	70098(8)	104866(3)	198(1)
C(5)	128977(9)	62321(8)	99796(3)	185(1)
C(6)	92830(8)	71924(6)	111727(2)	115(1)
C(7)	109337(11)	93463(7)	108409(3)	196(1)
O(1B)	38224(7)	51826(5)	83866(2)	167(1)
O(2B)	61334(7)	74963(5)	91153(2)	161(1)
O(3B)	87581(6)	70250(5)	87133(2)	168(1)
N(1B)	22581(7)	72610(6)	81984(2)	153(1)
C(1B)	38299(8)	64654(6)	82431(2)	108(1)
C(2B)	57234(8)	71180(6)	81240(2)	100(1)
C(3B)	55009(9)	86444(6)	78804(3)	147(1)
C(4B)	40166(11)	95129(7)	81409(3)	198(1)
C(5B)	21017(10)	87674(7)	80280(3)	215(1)
C(6B)	70240(8)	71923(6)	86832(2)	104(1)
C(7B)	66477(9)	61477(7)	77201(3)	151(1)

Table 3. Bond lengths [Å] and angles [°] for **S14**.

O(1)-C(1)	1.2552(7)
O(2)-C(6)	1.3270(7)
O(2)-H(2)	0.991(15)
O(3)-C(6)	1.2105(7)
N(1)-C(1)	1.3240(8)
N(1)-C(5)	1.4676(9)
N(1)-H(1)	0.913(12)
C(1)-C(2)	1.5252(8)
C(2)-C(3)	1.5443(9)
C(2)-C(6)	1.5293(8)
C(2)-C(7)	1.5347(8)
C(3)-C(4)	1.5237(10)
C(3)-H(3A)	1.007(11)
C(3)-H(3B)	0.991(11)
C(4)-C(5)	1.5163(10)
C(4)-H(4A)	1.000(11)
C(4)-H(4B)	0.999(13)
C(5)-H(5A)	0.967(10)
C(5)-H(5B)	0.904(12)
C(7)-H(7A)	0.992(12)
C(7)-H(7B)	0.980(11)
C(7)-H(7C)	0.943(11)
O(1B)-C(1B)	1.2515(7)
O(2B)-C(6B)	1.3081(7)
O(2B)-H(2B)	0.894(15)
O(3B)-C(6B)	1.2236(7)
N(1B)-C(1B)	1.3275(7)
N(1B)-C(5B)	1.4710(9)
N(1B)-H(1B)	0.903(12)
C(1B)-C(2B)	1.5253(8)
C(2B)-C(3B)	1.5468(8)
C(2B)-C(6B)	1.5295(8)
C(2B)-C(7B)	1.5322(8)
C(3B)-C(4B)	1.5191(9)

C(3B)-H(3BA)	0.983(11)
C(3B)-H(3BB)	0.959(10)
C(4B)-C(5B)	1.5124(11)
C(4B)-H(4BA)	0.976(11)
C(4B)-H(4BB)	0.973(11)
C(5B)-H(5BA)	0.976(11)
C(5B)-H(5BB)	0.980(12)
C(7B)-H(7BA)	1.005(10)
C(7B)-H(7BB)	0.964(10)
C(7B)-H(7BC)	1.032(11)

C(6)-O(2)-H(2)	111.0(8)
C(1)-N(1)-C(5)	126.59(5)
C(1)-N(1)-H(1)	115.2(8)
C(5)-N(1)-H(1)	118.2(8)
O(1)-C(1)-N(1)	122.52(5)
O(1)-C(1)-C(2)	117.16(5)
N(1)-C(1)-C(2)	120.29(5)
C(1)-C(2)-C(3)	112.50(5)
C(1)-C(2)-C(6)	106.69(5)
C(1)-C(2)-C(7)	107.42(5)
C(6)-C(2)-C(3)	108.68(5)
C(6)-C(2)-C(7)	109.93(5)
C(7)-C(2)-C(3)	111.50(5)
C(2)-C(3)-H(3A)	108.3(7)
C(2)-C(3)-H(3B)	108.0(7)
C(4)-C(3)-C(2)	111.02(5)
C(4)-C(3)-H(3A)	111.4(7)
C(4)-C(3)-H(3B)	110.0(6)
H(3A)-C(3)-H(3B)	108.0(9)
C(3)-C(4)-H(4A)	109.0(7)
C(3)-C(4)-H(4B)	111.1(7)
C(5)-C(4)-C(3)	109.30(5)
C(5)-C(4)-H(4A)	110.4(6)
C(5)-C(4)-H(4B)	108.8(7)
H(4A)-C(4)-H(4B)	108.3(10)

N(1)-C(5)-C(4)	110.69(5)
N(1)-C(5)-H(5A)	108.6(6)
N(1)-C(5)-H(5B)	104.7(7)
C(4)-C(5)-H(5A)	110.2(6)
C(4)-C(5)-H(5B)	110.4(8)
H(5A)-C(5)-H(5B)	112.2(10)
O(2)-C(6)-C(2)	111.91(5)
O(3)-C(6)-O(2)	123.86(6)
O(3)-C(6)-C(2)	124.19(5)
C(2)-C(7)-H(7A)	107.0(7)
C(2)-C(7)-H(7B)	111.0(6)
C(2)-C(7)-H(7C)	111.5(6)
H(7A)-C(7)-H(7B)	106.7(9)
H(7A)-C(7)-H(7C)	111.9(9)
H(7B)-C(7)-H(7C)	108.7(9)
C(6B)-O(2B)-H(2B)	108.3(9)
C(1B)-N(1B)-C(5B)	126.51(5)
C(1B)-N(1B)-H(1B)	114.2(7)
C(5B)-N(1B)-H(1B)	119.3(7)
O(1B)-C(1B)-N(1B)	122.04(5)
O(1B)-C(1B)-C(2B)	118.09(5)
N(1B)-C(1B)-C(2B)	119.87(5)
C(1B)-C(2B)-C(3B)	113.10(5)
C(1B)-C(2B)-C(6B)	107.17(4)
C(1B)-C(2B)-C(7B)	109.26(5)
C(6B)-C(2B)-C(3B)	108.12(4)
C(6B)-C(2B)-C(7B)	109.12(5)
C(7B)-C(2B)-C(3B)	109.96(5)
C(2B)-C(3B)-H(3BA)	109.3(6)
C(2B)-C(3B)-H(3BB)	108.3(6)
C(4B)-C(3B)-C(2B)	112.52(5)
C(4B)-C(3B)-H(3BA)	111.4(6)
C(4B)-C(3B)-H(3BB)	108.4(6)
H(3BA)-C(3B)-H(3BB)	106.7(9)
C(3B)-C(4B)-H(4BA)	111.1(6)
C(3B)-C(4B)-H(4BB)	110.6(7)

C(5B)-C(4B)-C(3B)	108.75(6)
C(5B)-C(4B)-H(4BA)	110.9(6)
C(5B)-C(4B)-H(4BB)	109.2(7)
H(4BA)-C(4B)-H(4BB)	106.2(9)
N(1B)-C(5B)-C(4B)	111.09(5)
N(1B)-C(5B)-H(5BA)	105.8(6)
N(1B)-C(5B)-H(5BB)	106.4(6)
C(4B)-C(5B)-H(5BA)	111.1(7)
C(4B)-C(5B)-H(5BB)	112.7(7)
H(5BA)-C(5B)-H(5BB)	109.3(10)
O(2B)-C(6B)-C(2B)	114.35(5)
O(3B)-C(6B)-O(2B)	123.63(5)
O(3B)-C(6B)-C(2B)	121.98(5)
C(2B)-C(7B)-H(7BA)	109.1(6)
C(2B)-C(7B)-H(7BB)	110.1(6)
C(2B)-C(7B)-H(7BC)	108.3(6)
H(7BA)-C(7B)-H(7BB)	108.0(8)
H(7BA)-C(7B)-H(7BC)	112.2(9)
H(7BB)-C(7B)-H(7BC)	109.1(9)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2$x 10^4) for **S14**. The anisotropic displacement factor exponent takes the form: $-2p^2[\, h^2 a^{*2}U^{11} + ... + 2\, h\, k\, a^*\, b^*\, U^{12}\,]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	115(2)	220(2)	114(2)	3(2)	3(1)	19(2)
O(2)	179(2)	123(2)	180(2)	-8(2)	72(2)	-39(2)
O(3)	251(2)	192(2)	164(2)	-47(2)	80(2)	-19(2)
N(1)	112(2)	229(2)	116(2)	-21(2)	20(2)	2(2)
C(1)	110(2)	126(2)	107(2)	13(2)	17(2)	-17(2)
C(2)	117(2)	124(2)	102(2)	2(2)	6(2)	-27(2)
C(3)	110(2)	244(3)	150(2)	16(2)	-1(2)	-1(2)
C(4)	100(2)	287(3)	208(3)	1(2)	19(2)	-25(2)
C(5)	117(2)	255(3)	190(3)	-16(2)	45(2)	13(2)

C(6)	114(2)	128(2)	101(2)	7(2)	0(2)	-4(2)
C(7)	259(3)	131(2)	200(3)	-9(2)	33(2)	-67(2)
O(1B)	154(2)	137(2)	219(2)	33(2)	54(2)	-24(2)
O(2B)	98(2)	284(2)	102(2)	-30(2)	24(1)	7(2)
O(3B)	82(2)	284(2)	140(2)	-8(2)	22(1)	14(2)
N(1B)	84(2)	197(2)	183(2)	27(2)	32(2)	15(2)
C(1B)	89(2)	137(2)	100(2)	-1(2)	19(2)	-9(2)
C(2B)	83(2)	123(2)	99(2)	3(2)	24(2)	-6(2)
C(3B)	164(2)	138(2)	142(2)	36(2)	31(2)	-16(2)
C(4B)	251(3)	133(2)	212(3)	15(2)	45(2)	41(2)
C(5B)	177(3)	213(3)	260(3)	52(2)	46(2)	90(2)
C(6B)	87(2)	116(2)	112(2)	4(2)	28(2)	-8(2)
C(7B)	126(2)	197(3)	137(2)	-39(2)	48(2)	4(2)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10 ^{3}) for **S14**.

	x	y	z	U(eq)
H(2)	7890(20)	5508(14)	11325(6)	48(4)
H(1)	10349(17)	6644(12)	9483(5)	34(3)
H(3A)	13310(17)	7426(11)	11311(5)	30(3)
H(3B)	12382(16)	5956(11)	11053(5)	26(3)
H(4A)	14132(17)	8028(12)	10391(5)	29(3)
H(4B)	15171(19)	6546(13)	10600(5)	39(3)
H(5A)	12858(15)	5220(11)	10054(4)	23(2)
H(5B)	13469(17)	6429(12)	9671(5)	32(3)
H(7A)	11814(17)	9644(12)	10570(5)	36(3)
H(7B)	9707(16)	9822(11)	10726(4)	24(2)
H(7C)	11386(16)	9626(11)	11211(4)	25(3)
H(2B)	7010(20)	7577(13)	9418(6)	47(4)
H(1B)	1213(17)	6805(12)	8292(5)	30(3)
H(3BA)	6756(16)	9120(10)	7926(4)	23(2)
H(3BB)	5107(14)	8574(10)	7484(4)	17(2)
H(4BA)	4388(15)	9642(11)	8543(4)	23(2)

H(4BB)	3908(17)	10465(12)	7979(5)	30(3)
H(5BA)	1639(17)	8762(11)	7627(5)	29(3)
H(5BB)	1126(17)	9192(11)	8234(5)	29(3)
H(7BA)	6845(15)	5175(11)	7893(4)	24(2)
H(7BB)	5814(15)	6050(10)	7372(4)	19(2)
H(7BC)	7919(16)	6608(12)	7640(5)	29(3)

Table 6. Torsion angles [°] for **S14**.

O(1)-C(1)-C(2)-C(3)	169.32(5)
O(1)-C(1)-C(2)-C(6)	50.24(7)
O(1)-C(1)-C(2)-C(7)	-67.60(7)
N(1)-C(1)-C(2)-C(3)	-12.62(8)
N(1)-C(1)-C(2)-C(6)	-131.71(6)
N(1)-C(1)-C(2)-C(7)	110.46(6)
C(1)-N(1)-C(5)-C(4)	-23.16(9)
C(1)-C(2)-C(3)-C(4)	41.68(7)
C(1)-C(2)-C(6)-O(2)	52.74(6)
C(1)-C(2)-C(6)-O(3)	-129.68(6)
C(2)-C(3)-C(4)-C(5)	-61.91(7)
C(3)-C(2)-C(6)-O(2)	-68.80(6)
C(3)-C(2)-C(6)-O(3)	108.78(7)
C(3)-C(4)-C(5)-N(1)	50.95(8)
C(5)-N(1)-C(1)-O(1)	-178.57(6)
C(5)-N(1)-C(1)-C(2)	3.48(9)
C(6)-C(2)-C(3)-C(4)	159.59(5)
C(7)-C(2)-C(3)-C(4)	-79.08(7)
C(7)-C(2)-C(6)-O(2)	168.91(5)
C(7)-C(2)-C(6)-O(3)	-13.51(8)
O(1B)-C(1B)-C(2B)-C(3B)	172.83(5)
O(1B)-C(1B)-C(2B)-C(6B)	-68.10(6)
O(1B)-C(1B)-C(2B)-C(7B)	50.00(7)
N(1B)-C(1B)-C(2B)-C(3B)	-7.83(7)
N(1B)-C(1B)-C(2B)-C(6B)	111.24(6)
N(1B)-C(1B)-C(2B)-C(7B)	-130.66(6)

C(1B)-N(1B)-C(5B)-C(4B)	-24.23(9)
C(1B)-C(2B)-C(3B)-C(4B)	37.54(7)
C(1B)-C(2B)-C(6B)-O(2B)	-36.61(6)
C(1B)-C(2B)-C(6B)-O(3B)	145.67(6)
C(2B)-C(3B)-C(4B)-C(5B)	-60.03(7)
C(3B)-C(2B)-C(6B)-O(2B)	85.61(6)
C(3B)-C(2B)-C(6B)-O(3B)	-92.10(6)
C(3B)-C(4B)-C(5B)-N(1B)	51.70(8)
C(5B)-N(1B)-C(1B)-O(1B)	-179.29(6)
C(5B)-N(1B)-C(1B)-C(2B)	1.40(9)
C(6B)-C(2B)-C(3B)-C(4B)	-80.97(6)
C(7B)-C(2B)-C(3B)-C(4B)	159.98(5)
C(7B)-C(2B)-C(6B)-O(2B)	-154.81(5)
C(7B)-C(2B)-C(6B)-O(3B)	27.48(7)

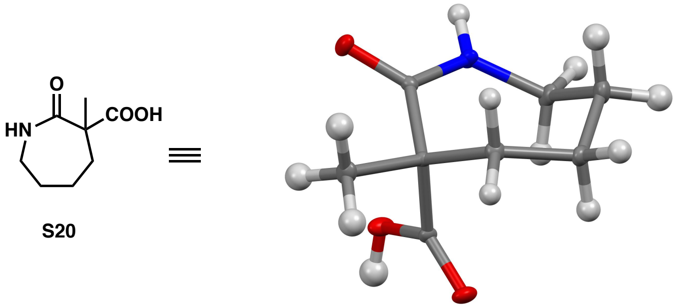
Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for **S14** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(2)-H(2)...O(1B)#1	0.991(15)	1.597(14)	2.5731(7)	167.5(13)
N(1)-H(1)...O(3B)	0.913(12)	2.070(12)	2.9540(7)	162.5(11)
O(2B)-H(2B)...O(1)	0.894(15)	1.629(15)	2.5091(6)	167.2(14)
N(1B)-H(1B)...O(3B)#2	0.903(12)	2.118(12)	2.8983(7)	144.1(10)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,-z+2 #2 x-1,y,z



S20

Compound (±)-**S20** crystallizes in the monoclinic space group *C*12/*c*1 with one molecule in the asymmetric unit.

Table 1. Crystal data and structure refinement for **S20**.

Identification code	a14357	
CCDC Deposition Number	1525609	
Empirical formula	C8 H13 N O3	
Formula weight	171.19	
Temperature	100 K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	C 1 2/c 1	
Unit cell dimensions	a = 22.4726(11) Å	α = 90°
	b = 7.5874(4) Å	β = 94.969(3)°
	c = 10.1108(5) Å	γ = 90°
Volume	1717.50(15) Å^3	
Z	8	
Density (calculated)	1.324 Mg/m^3	
Absorption coefficient	0.101 mm^{-1}	
F(000)	736	
Crystal size	0.34 x 0.32 x 0.19 mm^3	
Theta range for data collection	1.819 to 42.956°.	
Index ranges	-42<=h<=42, -14<=k<=14, -19<=l<=19	
Reflections collected	84401	
Independent reflections	6290 [R(int) = 0.0308]	
Completeness to theta = 25.000°	100.0 %	
Absorption correction	Semi-empirical from equivalents	

Max. and min. transmission	1.0000 and 0.9685
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	6290 / 0 / 161
Goodness-of-fit on F^2	1.082
Final R indices [I>2sigma(I)]	R1 = 0.0319, wR2 = 0.0906
R indices (all data)	R1 = 0.0401, wR2 = 0.0957
Extinction coefficient	n/a
Largest diff. peak and hole	0.564 and -0.260 e.Å^{-3}

Table 2. Atomic coordinates (x 10^5) and equivalent isotropic displacement parameters (Å^{2}x 10^4) for **S20**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	67822(2)	14231(4)	49668(3)	129(1)
O(2)	65218(2)	8334(5)	80687(3)	155(1)
O(3)	57490(2)	24845(4)	86075(3)	148(1)
N(1)	70693(2)	36932(5)	62707(3)	114(1)
C(1)	66585(2)	25224(5)	58204(3)	84(1)
C(2)	60380(2)	25567(5)	63491(4)	84(1)
C(3)	57105(2)	43361(5)	61044(4)	115(1)
C(4)	59202(2)	59423(5)	69285(4)	145(1)
C(5)	65645(2)	65022(6)	68127(5)	168(1)
C(6)	70119(2)	50673(6)	72667(4)	146(1)
C(7)	60849(2)	20075(5)	78081(4)	96(1)
C(8)	56473(2)	11201(6)	56280(4)	142(1)

Table 3. Bond lengths [Å] and angles [°] for **S20**.

O(1)-C(1)	1.2487(5)
O(2)-H(2)	0.901(11)
O(2)-C(7)	1.3350(5)
O(3)-C(7)	1.2081(5)
N(1)-H(1)	0.893(10)
N(1)-C(1)	1.3326(5)

N(1)-C(6)	1.4630(5)
C(1)-C(2)	1.5363(5)
C(2)-C(3)	1.5473(5)
C(2)-C(7)	1.5276(5)
C(2)-C(8)	1.5426(5)
C(3)-H(3A)	1.002(9)
C(3)-H(3B)	1.006(9)
C(3)-C(4)	1.5276(6)
C(4)-H(4A)	0.965(10)
C(4)-H(4B)	1.008(10)
C(4)-C(5)	1.5231(7)
C(5)-H(5A)	0.980(10)
C(5)-H(5B)	0.994(10)
C(5)-C(6)	1.5254(7)
C(6)-H(6A)	0.968(9)
C(6)-H(6B)	0.991(9)
C(8)-H(8A)	0.982(9)
C(8)-H(8B)	1.029(9)
C(8)-H(8C)	1.005(9)

C(7)-O(2)-H(2)	113.8(7)
C(1)-N(1)-H(1)	115.3(6)
C(1)-N(1)-C(6)	127.62(3)
C(6)-N(1)-H(1)	117.1(6)
O(1)-C(1)-N(1)	119.49(3)
O(1)-C(1)-C(2)	120.99(3)
N(1)-C(1)-C(2)	119.52(3)
C(1)-C(2)-C(3)	113.12(3)
C(1)-C(2)-C(8)	108.67(3)
C(7)-C(2)-C(1)	110.04(3)
C(7)-C(2)-C(3)	112.61(3)
C(7)-C(2)-C(8)	104.62(3)
C(8)-C(2)-C(3)	107.31(3)
C(2)-C(3)-H(3A)	107.3(5)
C(2)-C(3)-H(3B)	106.8(5)
H(3A)-C(3)-H(3B)	106.9(7)

C(4)-C(3)-C(2)	119.27(3)
C(4)-C(3)-H(3A)	108.5(5)
C(4)-C(3)-H(3B)	107.5(5)
C(3)-C(4)-H(4A)	106.1(6)
C(3)-C(4)-H(4B)	109.8(5)
H(4A)-C(4)-H(4B)	109.5(8)
C(5)-C(4)-C(3)	115.53(3)
C(5)-C(4)-H(4A)	108.2(6)
C(5)-C(4)-H(4B)	107.6(5)
C(4)-C(5)-H(5A)	110.4(6)
C(4)-C(5)-H(5B)	111.5(6)
C(4)-C(5)-C(6)	112.58(4)
H(5A)-C(5)-H(5B)	105.2(8)
C(6)-C(5)-H(5A)	109.3(6)
C(6)-C(5)-H(5B)	107.6(6)
N(1)-C(6)-C(5)	113.37(4)
N(1)-C(6)-H(6A)	104.9(6)
N(1)-C(6)-H(6B)	109.0(5)
C(5)-C(6)-H(6A)	110.9(6)
C(5)-C(6)-H(6B)	111.1(5)
H(6A)-C(6)-H(6B)	107.2(8)
O(2)-C(7)-C(2)	111.14(3)
O(3)-C(7)-O(2)	124.00(4)
O(3)-C(7)-C(2)	124.72(3)
C(2)-C(8)-H(8A)	112.2(5)
C(2)-C(8)-H(8B)	109.6(5)
C(2)-C(8)-H(8C)	109.5(6)
H(8A)-C(8)-H(8B)	111.3(7)
H(8A)-C(8)-H(8C)	104.3(8)
H(8B)-C(8)-H(8C)	109.8(7)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2$x 10^4) for **S20**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	118(1)	139(1)	137(1)	-66(1)	46(1)	-22(1)
O(2)	163(1)	166(1)	145(1)	67(1)	60(1)	81(1)
O(3)	157(1)	170(1)	127(1)	20(1)	69(1)	48(1)
N(1)	89(1)	123(1)	134(1)	-46(1)	32(1)	-27(1)
C(1)	81(1)	91(1)	82(1)	-8(1)	15(1)	-5(1)
C(2)	75(1)	91(1)	89(1)	-3(1)	16(1)	-1(1)
C(3)	110(1)	118(1)	118(1)	16(1)	8(1)	25(1)
C(4)	167(2)	105(1)	168(2)	-6(1)	43(1)	29(1)
C(5)	195(2)	102(1)	212(2)	-33(1)	51(1)	-21(1)
C(6)	132(1)	151(2)	155(2)	-69(1)	18(1)	-27(1)
C(7)	95(1)	91(1)	105(1)	12(1)	28(1)	8(1)
C(8)	106(1)	150(2)	171(2)	-47(1)	18(1)	-36(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^{3}) for **S20**.

	x	y	z	U(eq)
H(2)	6508(5)	280(16)	8854(11)	38(3)
H(1)	7416(5)	3635(13)	5901(10)	25(2)
H(3A)	5724(4)	4632(13)	5141(9)	21(2)
H(3B)	5279(4)	4126(12)	6253(9)	20(2)
H(4A)	5663(4)	6902(14)	6620(10)	27(2)
H(4B)	5874(4)	5714(13)	7896(10)	23(2)
H(5A)	6656(5)	7577(12)	7328(10)	27(2)
H(5B)	6633(4)	6814(14)	5884(10)	25(2)
H(6A)	7409(4)	5552(13)	7436(9)	20(2)
H(6B)	6907(4)	4512(12)	8103(9)	20(2)
H(8A)	5823(4)	-59(12)	5754(9)	21(2)
H(8B)	5574(4)	1430(11)	4637(9)	18(2)
H(8C)	5256(4)	1038(13)	6034(9)	26(2)

Table 6. Torsion angles [°] for **S20**.

O(1)-C(1)-C(2)-C(3)	-120.61(4)
O(1)-C(1)-C(2)-C(7)	112.47(4)
O(1)-C(1)-C(2)-C(8)	-1.54(5)
N(1)-C(1)-C(2)-C(3)	58.80(5)
N(1)-C(1)-C(2)-C(7)	-68.12(4)
N(1)-C(1)-C(2)-C(8)	177.87(3)
C(1)-N(1)-C(6)-C(5)	-66.65(6)
C(1)-C(2)-C(3)-C(4)	-72.96(4)
C(1)-C(2)-C(7)-O(2)	-32.33(4)
C(1)-C(2)-C(7)-O(3)	151.90(4)
C(2)-C(3)-C(4)-C(5)	59.70(5)
C(3)-C(2)-C(7)-O(2)	-159.54(3)
C(3)-C(2)-C(7)-O(3)	24.70(5)
C(3)-C(4)-C(5)-C(6)	-60.79(5)
C(4)-C(5)-C(6)-N(1)	79.33(5)
C(6)-N(1)-C(1)-O(1)	-179.61(4)
C(6)-N(1)-C(1)-C(2)	0.97(6)
C(7)-C(2)-C(3)-C(4)	52.59(5)
C(8)-C(2)-C(3)-C(4)	167.19(3)
C(8)-C(2)-C(7)-O(2)	84.24(4)
C(8)-C(2)-C(7)-O(3)	-91.52(5)

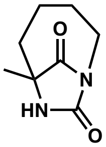
Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for **S20** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(2)-H(2)...O(1)#1	0.901(11)	1.788(12)	2.6005(4)	148.8(11)

Symmetry transformations used to generate equivalent atoms:

#1 x,-y,z+1/2



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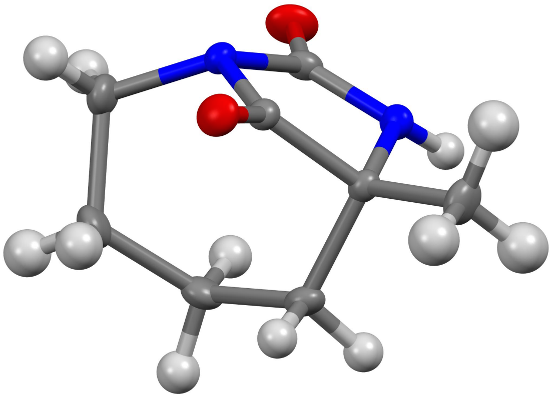


Compound (±)-**20** crystallizes in the orthorhombic space group *Pbca* with one molecule in the asymmetric unit. The coordinates for the hydrogen atoms bound to N2 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H distance (0.88(4) Å).

Table 1. Crystal data and structure refinement for **20**.

Identification code	A14219	
CCDC Deposition Number	1525604	
Empirical formula	C8 H12 N2 O2	
Formula weight	168.20	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	P b c a	
Unit cell dimensions	a = 7.5218(5) Å	α = 90°.
	b = 12.0554(6) Å	β = 90°.
	c = 18.3287(10) Å	γ = 90°.
Volume	1662.02(17) Å^3	
Z	8	
Density (calculated)	1.344 Mg/m^3	
Absorption coefficient	0.098 mm^{-1}	
F(000)	720	
Crystal size	0.500 x 0.450 x 0.300 mm^3	
Theta range for data collection	2.222 to 36.360°.	

Index ranges	-12<=h<=5, -19<=k<=20, -28<=l<=30
Reflections collected	28055
Independent reflections	4035 [R(int) = 0.0352]
Completeness to theta = 25.242°	99.5 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7471 and 0.6484
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4035 / 1 / 113
Goodness-of-fit on F^2	1.071
Final R indices [I>2sigma(I)]	R1 = 0.0415, wR2 = 0.1107
R indices (all data)	R1 = 0.0500, wR2 = 0.1173
Extinction coefficient	n/a
Largest diff. peak and hole	0.498 and -0.230 e.Å^{-3}

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **20**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
N(1)	11341(1)	4100(1)	6034(1)	15(1)
C(1)	12388(1)	3079(1)	6165(1)	24(1)
C(2)	11108(1)	2104(1)	6299(1)	28(1)
C(3)	9449(1)	2393(1)	6760(1)	23(1)
C(4)	7876(1)	2967(1)	6370(1)	19(1)
C(5)	8242(1)	4139(1)	6047(1)	15(1)
C(7)	6645(1)	4634(1)	5663(1)	26(1)
N(2)	9000(1)	4868(1)	6604(1)	17(1)
C(8)	10758(1)	4669(1)	6666(1)	16(1)
O(2)	11738(1)	4936(1)	7169(1)	26(1)
C(6)	9864(1)	3936(1)	5578(1)	14(1)
O(1)	9928(1)	3564(1)	4966(1)	23(1)

Table 3. Bond lengths [Å] and angles [°] for **20**.

N(1)-C(6)	1.4038(8)
N(1)-C(8)	1.4166(8)
N(1)-C(1)	1.4807(9)
C(1)-C(2)	1.5385(11)
C(1)-H(1A)	0.9900
C(1)-H(1B)	0.9900
C(2)-C(3)	1.5470(11)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.5458(10)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-C(5)	1.5570(9)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(2)	1.4623(8)
C(5)-C(6)	1.5116(8)
C(5)-C(7)	1.5142(9)
C(7)-H(7A)	0.9800
C(7)-H(7B)	0.9800
C(7)-H(7C)	0.9800
N(2)-C(8)	1.3490(9)
N(2)-H(2N)	0.894(10)
C(8)-O(2)	1.2226(8)
C(6)-O(1)	1.2097(8)
C(6)-N(1)-C(8)	108.05(5)
C(6)-N(1)-C(1)	113.63(5)
C(8)-N(1)-C(1)	115.71(5)
N(1)-C(1)-C(2)	109.15(6)
N(1)-C(1)-H(1A)	109.8
C(2)-C(1)-H(1A)	109.8
N(1)-C(1)-H(1B)	109.8
C(2)-C(1)-H(1B)	109.8

H(1A)-C(1)-H(1B)	108.3
C(1)-C(2)-C(3)	114.82(6)
C(1)-C(2)-H(2A)	108.6
C(3)-C(2)-H(2A)	108.6
C(1)-C(2)-H(2B)	108.6
C(3)-C(2)-H(2B)	108.6
H(2A)-C(2)-H(2B)	107.5
C(4)-C(3)-C(2)	117.70(6)
C(4)-C(3)-H(3A)	107.9
C(2)-C(3)-H(3A)	107.9
C(4)-C(3)-H(3B)	107.9
C(2)-C(3)-H(3B)	107.9
H(3A)-C(3)-H(3B)	107.2
C(3)-C(4)-C(5)	116.53(5)
C(3)-C(4)-H(4A)	108.2
C(5)-C(4)-H(4A)	108.2
C(3)-C(4)-H(4B)	108.2
C(5)-C(4)-H(4B)	108.2
H(4A)-C(4)-H(4B)	107.3
N(2)-C(5)-C(6)	100.34(5)
N(2)-C(5)-C(7)	113.38(6)
C(6)-C(5)-C(7)	116.10(6)
N(2)-C(5)-C(4)	110.45(5)
C(6)-C(5)-C(4)	102.20(5)
C(7)-C(5)-C(4)	113.18(6)
C(5)-C(7)-H(7A)	109.5
C(5)-C(7)-H(7B)	109.5
H(7A)-C(7)-H(7B)	109.5
C(5)-C(7)-H(7C)	109.5
H(7A)-C(7)-H(7C)	109.5
H(7B)-C(7)-H(7C)	109.5
C(8)-N(2)-C(5)	109.55(5)
C(8)-N(2)-H(2N)	117.1(7)
C(5)-N(2)-H(2N)	121.5(7)
O(2)-C(8)-N(2)	127.45(7)
O(2)-C(8)-N(1)	123.89(6)

N(2)-C(8)-N(1)	108.66(5)
O(1)-C(6)-N(1)	124.93(6)
O(1)-C(6)-C(5)	128.26(6)
N(1)-C(6)-C(5)	106.14(5)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (Å^{2}x 10^3) for **20**. The anisotropic displacement factor exponent takes the form: $-2p^2[\,h^2 a^{*2}U^{11} + \ldots + 2\,h\,k\,a^*\,b^*\,U^{12}\,]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
N(1)	13(1)	17(1)	16(1)	0(1)	0(1)	0(1)
C(1)	16(1)	24(1)	31(1)	2(1)	0(1)	6(1)
C(2)	29(1)	16(1)	38(1)	3(1)	2(1)	6(1)
C(3)	26(1)	17(1)	24(1)	6(1)	0(1)	-4(1)
C(4)	18(1)	21(1)	20(1)	-1(1)	1(1)	-6(1)
C(5)	12(1)	18(1)	13(1)	-2(1)	-1(1)	0(1)
C(7)	16(1)	34(1)	26(1)	1(1)	-4(1)	6(1)
N(2)	18(1)	17(1)	14(1)	-4(1)	1(1)	0(1)
C(8)	19(1)	15(1)	15(1)	0(1)	-2(1)	-4(1)
O(2)	29(1)	29(1)	21(1)	-2(1)	-10(1)	-10(1)
C(6)	15(1)	16(1)	12(1)	0(1)	0(1)	0(1)
O(1)	26(1)	29(1)	13(1)	-5(1)	2(1)	-1(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10 ^{3}) for **20**.

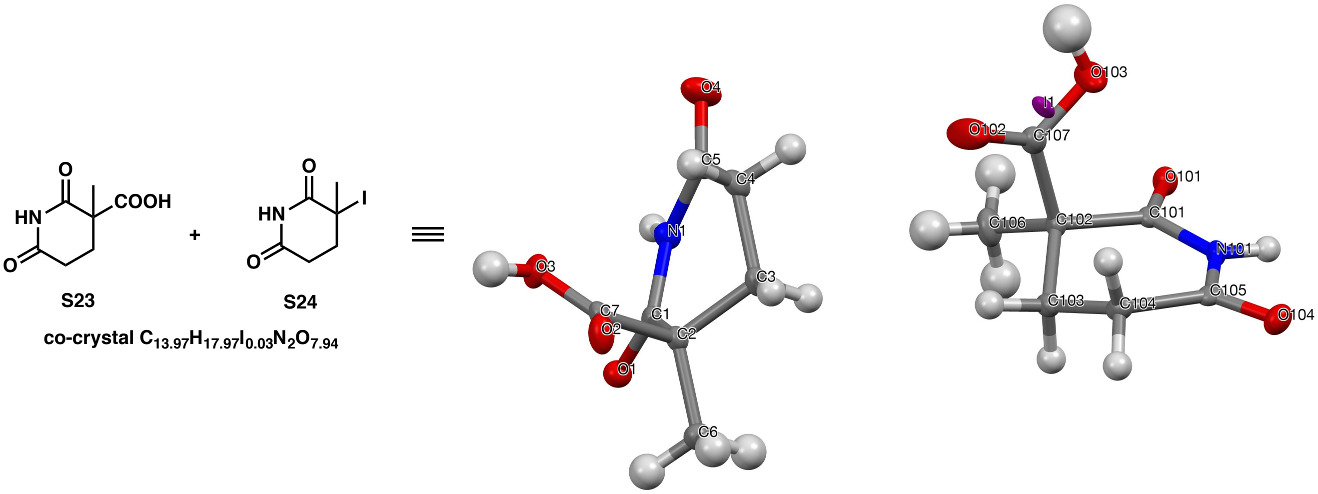
	x	y	z	U(eq)
H(1A)	13166	3182	6595	29
H(1B)	13148	2920	5737	29
H(2A)	11769	1503	6548	33
H(2B)	10709	1815	5821	33
H(3A)	9000	1698	6980	27

H(3B)	9834	2880	7166	27
H(4A)	6881	3029	6720	23
H(4B)	7475	2478	5968	23
H(7A)	5681	4741	6016	38
H(7B)	6249	4130	5277	38
H(7C)	6973	5351	5450	38
H(2N)	8409(14)	5029(9)	7014(6)	20

Table 6. Hydrogen bonds for **20** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
C(1)-H(1B)...O(1)#1	0.99	2.58	3.4460(9)	146.2
C(2)-H(2A)...O(2)#2	0.99	2.48	3.4646(10)	176.7
N(2)-H(2N)...O(2)#3	0.894(10)	1.958(10)	2.8214(8)	161.6(10)

Symmetry transformations used to generate equivalent atoms:
#1 x+1/2,-y+1/2,-z+1 #2 -x+5/2,y-1/2,z #3 x-1/2,y,-z+3/2


S23 **S24**

co-crystal $C_{13.97}H_{17.97}I_{0.03}N_2O_{7.94}$

Compounds (±)-**S23** and (±)-**S24** co-crystallizes in the monoclinic space group *P*2_1/*c* with two molecules in the asymmetric unit. The second molecule was refined as a mixture of CO_2H and I at bound to C102. The occupancy of the two components was refined freely and converged at 0.9680(9):0.0320(9). The coordinates for the hydrogen atoms bound to N1, O3 N101, and O103 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H and O-H distances (0.88(4) and 0.84(4) Å).

Table 1. Crystal data and structure refinement for (±)-**S23**/(±)-**S24**.

Identification code	P14101	
CCDC Deposition Number	1525607	
Empirical formula	C13.97 H17.97 I0.03 N2 O7.94	
Formula weight	344.96	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	$P2_1/c$	
Unit cell dimensions	a = 11.9551(7) Å	α = 90°.
	b = 10.7898(7) Å	β = 114.629(2)°.
	c = 12.9431(9) Å	γ = 90°.
Volume	1517.68(17) $Å^3$	
Z	4	
Density (calculated)	1.510 Mg/m^3	
Absorption coefficient	0.190 mm^{-1}	
F(000)	724	
Crystal size	0.250 x 0.250 x 0.250 mm^3	
Theta range for data collection	2.561 to 30.497°.	
Index ranges	-17<=h<=17, -15<=k<=15, -18<=l<=18	
Reflections collected	44627	
Independent reflections	4622 [R(int) = 0.0839]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7471 and 0.6940	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	4622 / 4 / 241	
Goodness-of-fit on F^2	1.054	

Final R indices [I>2sigma(I)]	R1 = 0.0566, wR2 = 0.1448
R indices (all data)	R1 = 0.0851, wR2 = 0.1540
Extinction coefficient	n/a
Largest diff. peak and hole	0.454 and -0.510 e.Å^{-3}

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for (±)-**S23**/(±)-**S24**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
N(1)	4250(1)	8370(1)	5030(1)	17(1)
C(1)	5092(1)	8555(2)	6128(2)	15(1)
O(1)	5677(1)	9520(1)	6393(1)	19(1)
C(2)	5259(1)	7512(2)	6978(2)	15(1)
C(3)	4040(2)	6799(2)	6625(2)	18(1)
C(4)	3598(2)	6314(2)	5410(2)	20(1)
C(6)	5679(2)	8046(2)	8176(2)	21(1)
C(7)	6241(1)	6598(2)	6967(2)	17(1)
O(2)	6626(1)	5768(1)	7653(1)	25(1)
O(3)	6576(1)	6787(1)	6122(1)	22(1)
C(5)	3558(2)	7304(2)	4574(2)	21(1)
O(4)	2976(2)	7211(2)	3562(1)	34(1)
N(101)	-1033(1)	4666(1)	8029(1)	14(1)
C(101)	-649(1)	5022(2)	7212(1)	13(1)
O(101)	-1326(1)	5644(1)	6404(1)	17(1)
C(102)	635(1)	4621(2)	7366(2)	15(1)
C(103)	1472(2)	4440(2)	8626(2)	17(1)
C(104)	891(2)	3594(2)	9208(2)	17(1)
C(106)	1173(2)	5583(2)	6822(2)	27(1)
C(107)	552(3)	3397(3)	6713(3)	19(1)
O(102)	1434(2)	2821(2)	6805(2)	46(1)
O(103)	-575(2)	3094(2)	6034(2)	38(1)
I(1)	252(4)	3068(5)	6411(4)	13(1)
C(105)	-403(2)	3967(2)	8977(2)	15(1)
O(104)	-922(1)	3683(1)	9584(1)	21(1)

Table 3. Bond lengths [Å] and angles [°] for (±)-**S23**/(±)-**S24**.

N(1)-C(1)	1.372(2)
N(1)-C(5)	1.396(2)
N(1)-H(1N)	0.848(16)
C(1)-O(1)	1.221(2)
C(1)-C(2)	1.528(2)
C(2)-C(6)	1.529(3)
C(2)-C(7)	1.538(2)
C(2)-C(3)	1.539(2)
C(3)-C(4)	1.528(3)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-C(5)	1.508(3)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(6)-H(6A)	0.9800
C(6)-H(6B)	0.9800
C(6)-H(6C)	0.9800
C(7)-O(2)	1.210(2)
C(7)-O(3)	1.328(2)
O(3)-H(3O)	0.867(16)
C(5)-O(4)	1.204(2)
N(101)-C(105)	1.368(2)
N(101)-C(101)	1.372(2)
N(101)-H(01N)	0.840(15)
C(101)-O(101)	1.223(2)
C(101)-C(102)	1.526(2)
C(102)-C(103)	1.530(2)
C(102)-C(106)	1.538(2)
C(102)-C(107)	1.548(4)
C(102)-I(1)	2.018(6)
C(103)-C(104)	1.523(3)
C(103)-H(10A)	0.9900
C(103)-H(10B)	0.9900
C(104)-C(105)	1.503(2)

C(104)-H(10C)	0.9900
C(104)-H(10D)	0.9900
C(106)-H(10E)	0.9800
C(106)-H(10F)	0.9800
C(106)-H(10G)	0.9800
C(107)-O(102)	1.187(3)
C(107)-O(103)	1.307(4)
O(103)-H(03O)	0.894(18)
C(105)-O(104)	1.226(2)

C(1)-N(1)-C(5)	127.39(15)
C(1)-N(1)-H(1N)	114.2(16)
C(5)-N(1)-H(1N)	118.4(16)
O(1)-C(1)-N(1)	120.11(16)
O(1)-C(1)-C(2)	122.62(16)
N(1)-C(1)-C(2)	117.27(15)
C(1)-C(2)-C(6)	109.97(14)
C(1)-C(2)-C(7)	109.65(13)
C(6)-C(2)-C(7)	108.78(14)
C(1)-C(2)-C(3)	109.36(14)
C(6)-C(2)-C(3)	111.07(14)
C(7)-C(2)-C(3)	107.98(14)
C(4)-C(3)-C(2)	110.83(14)
C(4)-C(3)-H(3A)	109.5
C(2)-C(3)-H(3A)	109.5
C(4)-C(3)-H(3B)	109.5
C(2)-C(3)-H(3B)	109.5
H(3A)-C(3)-H(3B)	108.1
C(5)-C(4)-C(3)	112.94(15)
C(5)-C(4)-H(4A)	109.0
C(3)-C(4)-H(4A)	109.0
C(5)-C(4)-H(4B)	109.0
C(3)-C(4)-H(4B)	109.0
H(4A)-C(4)-H(4B)	107.8
C(2)-C(6)-H(6A)	109.5
C(2)-C(6)-H(6B)	109.5

H(6A)-C(6)-H(6B)	109.5
C(2)-C(6)-H(6C)	109.5
H(6A)-C(6)-H(6C)	109.5
H(6B)-C(6)-H(6C)	109.5
O(2)-C(7)-O(3)	124.42(16)
O(2)-C(7)-C(2)	121.78(16)
O(3)-C(7)-C(2)	113.76(15)
C(7)-O(3)-H(3O)	108.7(17)
O(4)-C(5)-N(1)	120.00(17)
O(4)-C(5)-C(4)	123.58(18)
N(1)-C(5)-C(4)	116.42(16)
C(105)-N(101)-C(101)	127.55(14)
C(105)-N(101)-H(01N)	114.5(15)
C(101)-N(101)-H(01N)	117.9(15)
O(101)-C(101)-N(101)	119.86(14)
O(101)-C(101)-C(102)	122.60(15)
N(101)-C(101)-C(102)	117.53(14)
C(101)-C(102)-C(103)	110.51(13)
C(101)-C(102)-C(106)	109.82(14)
C(103)-C(102)-C(106)	111.21(15)
C(101)-C(102)-C(107)	109.79(16)
C(103)-C(102)-C(107)	109.74(17)
C(106)-C(102)-C(107)	105.66(17)
C(101)-C(102)-I(1)	101.31(17)
C(103)-C(102)-I(1)	115.33(18)
C(106)-C(102)-I(1)	108.18(19)
C(104)-C(103)-C(102)	111.91(14)
C(104)-C(103)-H(10A)	109.2
C(102)-C(103)-H(10A)	109.2
C(104)-C(103)-H(10B)	109.2
C(102)-C(103)-H(10B)	109.2
H(10A)-C(103)-H(10B)	107.9
C(105)-C(104)-C(103)	112.63(14)
C(105)-C(104)-H(10C)	109.1
C(103)-C(104)-H(10C)	109.1
C(105)-C(104)-H(10D)	109.1

C(103)-C(104)-H(10D)	109.1
H(10C)-C(104)-H(10D)	107.8
C(102)-C(106)-H(10E)	109.5
C(102)-C(106)-H(10F)	109.5
H(10E)-C(106)-H(10F)	109.5
C(102)-C(106)-H(10G)	109.5
H(10E)-C(106)-H(10G)	109.5
H(10F)-C(106)-H(10G)	109.5
O(102)-C(107)-O(103)	124.1(3)
O(102)-C(107)-C(102)	122.7(3)
O(103)-C(107)-C(102)	113.2(2)
C(107)-O(103)-H(03O)	106(2)
O(104)-C(105)-N(101)	118.44(15)
O(104)-C(105)-C(104)	124.02(16)
N(101)-C(105)-C(104)	117.54(14)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2$x 10^3) for (±)-**S23**/(±)-**S24**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
N(1)	16(1)	18(1)	14(1)	4(1)	5(1)	1(1)
C(1)	11(1)	18(1)	16(1)	1(1)	7(1)	2(1)
O(1)	20(1)	18(1)	19(1)	0(1)	7(1)	-1(1)
C(2)	12(1)	18(1)	16(1)	1(1)	5(1)	0(1)
C(3)	13(1)	22(1)	18(1)	4(1)	7(1)	0(1)
C(4)	15(1)	21(1)	21(1)	1(1)	4(1)	-4(1)
C(6)	21(1)	25(1)	17(1)	0(1)	7(1)	-2(1)
C(7)	11(1)	18(1)	20(1)	2(1)	5(1)	-1(1)
O(2)	20(1)	24(1)	33(1)	12(1)	14(1)	6(1)
O(3)	19(1)	27(1)	23(1)	5(1)	11(1)	9(1)
C(5)	16(1)	24(1)	20(1)	2(1)	5(1)	-2(1)
O(4)	35(1)	42(1)	18(1)	0(1)	5(1)	-15(1)
N(101)	11(1)	16(1)	16(1)	1(1)	7(1)	2(1)

C(101)	13(1)	11(1)	15(1)	-3(1)	6(1)	-2(1)
O(101)	15(1)	18(1)	18(1)	3(1)	7(1)	4(1)
C(102)	12(1)	17(1)	17(1)	0(1)	7(1)	2(1)
C(103)	12(1)	21(1)	17(1)	-4(1)	4(1)	1(1)
C(104)	17(1)	19(1)	14(1)	0(1)	4(1)	5(1)
C(106)	20(1)	29(1)	34(1)	7(1)	15(1)	0(1)
C(107)	16(1)	24(1)	16(1)	2(1)	6(1)	1(1)
O(102)	29(1)	51(1)	43(1)	-24(1)	0(1)	16(1)
O(103)	24(1)	38(1)	52(1)	-28(1)	15(1)	-5(1)
I(1)	7(3)	19(2)	10(2)	1(2)	-1(2)	-1(2)
C(105)	18(1)	12(1)	15(1)	-4(1)	7(1)	0(1)
O(104)	25(1)	21(1)	20(1)	3(1)	13(1)	3(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for (±)-**S23**/(±)-**S24**.

	x	y	z	U(eq)
H(1N)	4180(20)	8976(18)	4589(18)	20
H(3A)	4158	6095	7151	21
H(3B)	3407	7354	6679	21
H(4A)	4153	5640	5394	24
H(4B)	2764	5957	5172	24
H(6A)	6451	8501	8377	32
H(6B)	5808	7369	8719	32
H(6C)	5047	8609	8199	32
H(3O)	7223(19)	6340(20)	6240(20)	33
H(01N)	-1743(15)	4880(20)	7944(19)	17
H(10A)	2264	4079	8702	21
H(10B)	1646	5257	9010	21
H(10C)	886	2734	8940	21
H(10D)	1399	3609	10038	21
H(10E)	627	5669	6013	40
H(10F)	1988	5310	6904	40
H(10G)	1247	6384	7202	40

H(03O)	-520(30)	2470(20)	5600(30)	58

Table 6. Torsion angles [°] for (±)-**S23**/(±)-**S24**.

C(5)-N(1)-C(1)-O(1)	176.27(16)
C(5)-N(1)-C(1)-C(2)	-3.5(2)
O(1)-C(1)-C(2)-C(6)	28.2(2)
N(1)-C(1)-C(2)-C(6)	-152.06(14)
O(1)-C(1)-C(2)-C(7)	-91.35(19)
N(1)-C(1)-C(2)-C(7)	88.38(17)
O(1)-C(1)-C(2)-C(3)	150.42(15)
N(1)-C(1)-C(2)-C(3)	-29.85(19)
C(1)-C(2)-C(3)-C(4)	56.12(18)
C(6)-C(2)-C(3)-C(4)	177.67(15)
C(7)-C(2)-C(3)-C(4)	-63.14(18)
C(2)-C(3)-C(4)-C(5)	-51.37(19)
C(1)-C(2)-C(7)-O(2)	171.99(16)
C(6)-C(2)-C(7)-O(2)	51.7(2)
C(3)-C(2)-C(7)-O(2)	-68.9(2)
C(1)-C(2)-C(7)-O(3)	-10.2(2)
C(6)-C(2)-C(7)-O(3)	-130.47(16)
C(3)-C(2)-C(7)-O(3)	108.90(16)
C(1)-N(1)-C(5)-O(4)	-170.00(17)
C(1)-N(1)-C(5)-C(4)	9.8(3)
C(3)-C(4)-C(5)-O(4)	-161.51(18)
C(3)-C(4)-C(5)-N(1)	18.7(2)
C(105)-N(101)-C(101)-O(101)	179.52(16)
C(105)-N(101)-C(101)-C(102)	-1.0(2)
O(101)-C(101)-C(102)-C(103)	152.38(16)
N(101)-C(101)-C(102)-C(103)	-27.1(2)
O(101)-C(101)-C(102)-C(106)	29.3(2)
N(101)-C(101)-C(102)-C(106)	-150.14(16)
O(101)-C(101)-C(102)-C(107)	-86.4(2)
N(101)-C(101)-C(102)-C(107)	94.10(19)
O(101)-C(101)-C(102)-I(1)	-84.9(2)

N(101)-C(101)-C(102)-I(1)	95.6(2)
C(101)-C(102)-C(103)-C(104)	51.76(19)
C(106)-C(102)-C(103)-C(104)	174.01(14)
C(107)-C(102)-C(103)-C(104)	-69.45(19)
I(1)-C(102)-C(103)-C(104)	-62.4(2)
C(102)-C(103)-C(104)-C(105)	-49.95(19)
C(101)-C(102)-C(107)-O(102)	-171.1(3)
C(103)-C(102)-C(107)-O(102)	-49.4(3)
C(106)-C(102)-C(107)-O(102)	70.5(3)
C(101)-C(102)-C(107)-O(103)	10.9(3)
C(103)-C(102)-C(107)-O(103)	132.5(2)
C(106)-C(102)-C(107)-O(103)	-107.5(2)
C(101)-N(101)-C(105)-O(104)	-176.08(16)
C(101)-N(101)-C(105)-C(104)	3.8(2)
C(103)-C(104)-C(105)-O(104)	-157.86(16)
C(103)-C(104)-C(105)-N(101)	22.2(2)

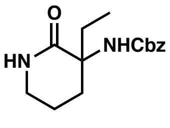
Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for (±)-**S23**/(±)-**S24** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1N)...O(1)#1	0.848(16)	2.111(16)	2.952(2)	171(2)
C(4)-H(4B)...O(103)#2	0.99	2.63	3.366(3)	131.1
O(3)-H(3O)...O(101)#3	0.867(16)	1.821(17)	2.6792(17)	170(3)
N(101)-H(01N)...O(2)#4	0.840(15)	2.063(16)	2.8887(18)	167(2)
C(103)-H(10A)...O(1)#5	0.99	2.56	3.420(2)	145.2
C(103)-H(10B)...O(104)#6	0.99	2.59	3.342(2)	133.2
C(104)-H(10C)...O(101)#7	0.99	2.40	3.372(2)	167.6
C(104)-H(10D)...I(1)#8	0.99	3.22	3.708(6)	112.4
C(106)-H(10E)...I(1)#2	0.98	3.17	4.073(6)	153.6
C(106)-H(10G)...O(4)#9	0.98	2.58	3.367(3)	137.8
O(103)-H(03O)...O(104)#10	0.894(18)	1.73(2)	2.593(2)	161(3)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+2,-z+1 #2 -x,-y+1,-z+1 #3 x+1,y,z
#4 x-1,y,z #5 -x+1,y-1/2,-z+3/2 #6 -x,-y+1,-z+2
#7 -x,y-1/2,-z+3/2 #8 x,-y+1/2,z+1/2 #9 x,-y+3/2,z+1/2
#10 x,-y+1/2,z-1/2



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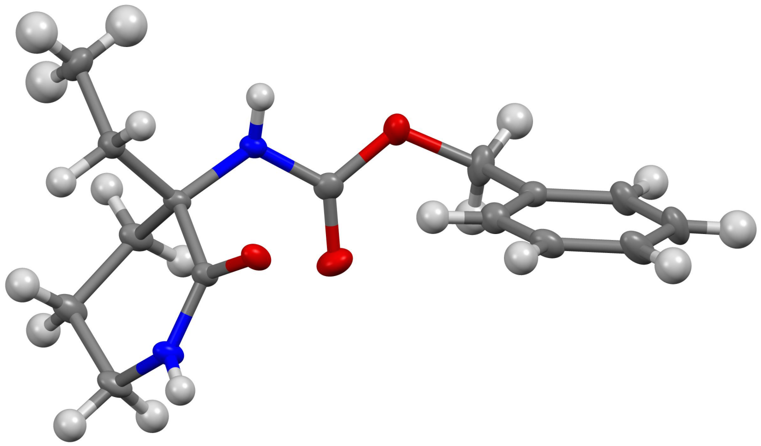


Compound (±)-**26** crystallizes in the orthorhombic space group *P*$2_12_12_1$ with one molecule in the asymmetric unit. The coordinates for the hydrogen atoms bound to N1 and N2 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H distance (0.88(4) and 0.91(4) Å).

Table 1. Crystal data and structure refinement for (±)-**26**.

Identification code	P14078	
CCDC Deposition Number	1525606	
Empirical formula	C15 H20 N2 O3	
Formula weight	276.33	
Temperature	100(2) K	
Wavelength	1.54178 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 8.2736(4) Å	α = 90°.
	b = 10.1225(4) Å	β = 90°.

	c = 17.1621(7) Å	γ = 90°.
Volume	1437.32(11) Å^3	
Z	4	
Density (calculated)	1.277 Mg/m^3	
Absorption coefficient	0.729 mm^{-1}	
F(000)	592	
Crystal size	0.250 x 0.150 x 0.100 mm^3	
Theta range for data collection	5.072 to 74.419°.	
Index ranges	-8<=h<=10, -12<=k<=11, -18<=l<=20	
Reflections collected	10233	
Independent reflections	2744 [R(int) = 0.0294]	
Completeness to theta = 67.679°	99.5 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7542 and 0.6747	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2744 / 2 / 188	
Goodness-of-fit on F^2	1.091	
Final R indices [I>2sigma(I)]	R1 = 0.0295, wR2 = 0.0705	
R indices (all data)	R1 = 0.0316, wR2 = 0.0719	
Absolute structure parameter	-0.07(8)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.166 and -0.202 e.Å^{-3}	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for (±)-**26**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	5758(1)	2788(1)	5061(1)	19(1)
C(1)	6129(2)	2583(2)	4370(1)	16(1)
N(1)	7663(2)	2560(2)	4135(1)	19(1)
C(2)	8242(2)	2460(2)	3334(1)	23(1)
C(3)	7021(2)	1777(2)	2813(1)	24(1)
C(4)	5356(2)	2385(2)	2932(1)	21(1)
C(5)	4791(2)	2225(2)	3780(1)	16(1)
C(6)	4342(2)	778(2)	3976(1)	19(1)

C(7)	2971(2)	204(2)	3494(1)	29(1)
N(2)	3376(2)	3052(1)	3931(1)	16(1)
C(8)	3581(2)	4376(2)	3999(1)	19(1)
O(2)	4783(2)	4981(1)	3810(1)	27(1)
O(3)	2238(2)	4948(1)	4306(1)	23(1)
C(9)	2338(3)	6354(2)	4433(1)	27(1)
C(11)	2815(2)	6709(2)	5254(1)	19(1)
C(12)	3697(2)	5862(2)	5732(1)	23(1)
C(13)	4095(2)	6247(2)	6487(1)	24(1)
C(14)	3656(2)	7485(2)	6758(1)	28(1)
C(15)	2809(2)	8336(2)	6278(1)	31(1)
C(16)	2379(2)	7947(2)	5535(1)	25(1)

Table 3. Bond lengths [Å] and angles [°] for (±)-**26**.

O(1)-C(1)	1.244(2)
C(1)-N(1)	1.332(2)
C(1)-C(5)	1.543(2)
N(1)-C(2)	1.459(2)
N(1)-H(1N)	0.851(17)
C(2)-C(3)	1.515(2)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.522(2)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-C(5)	1.536(2)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(2)	1.463(2)
C(5)-C(6)	1.548(2)
C(6)-C(7)	1.519(2)
C(6)-H(6A)	0.9900
C(6)-H(6B)	0.9900
C(7)-H(7A)	0.9800

C(7)-H(7B)	0.9800
C(7)-H(7C)	0.9800
N(2)-C(8)	1.356(2)
N(2)-H(2N)	0.885(17)
C(8)-O(2)	1.212(2)
C(8)-O(3)	1.359(2)
O(3)-C(9)	1.443(2)
C(9)-C(11)	1.506(2)
C(9)-H(9A)	0.9900
C(9)-H(9B)	0.9900
C(11)-C(16)	1.390(2)
C(11)-C(12)	1.394(2)
C(12)-C(13)	1.391(3)
C(12)-H(12)	0.9500
C(13)-C(14)	1.385(3)
C(13)-H(13)	0.9500
C(14)-C(15)	1.383(3)
C(14)-H(14)	0.9500
C(15)-C(16)	1.382(3)
C(15)-H(15)	0.9500
C(16)-H(16)	0.9500
O(1)-C(1)-N(1)	121.80(15)
O(1)-C(1)-C(5)	119.23(14)
N(1)-C(1)-C(5)	118.75(14)
C(1)-N(1)-C(2)	126.79(14)
C(1)-N(1)-H(1N)	116.6(14)
C(2)-N(1)-H(1N)	116.6(14)
N(1)-C(2)-C(3)	111.61(14)
N(1)-C(2)-H(2A)	109.3
C(3)-C(2)-H(2A)	109.3
N(1)-C(2)-H(2B)	109.3
C(3)-C(2)-H(2B)	109.3
H(2A)-C(2)-H(2B)	108.0
C(2)-C(3)-C(4)	109.87(15)
C(2)-C(3)-H(3A)	109.7

C(4)-C(3)-H(3A)	109.7
C(2)-C(3)-H(3B)	109.7
C(4)-C(3)-H(3B)	109.7
H(3A)-C(3)-H(3B)	108.2
C(3)-C(4)-C(5)	111.13(14)
C(3)-C(4)-H(4A)	109.4
C(5)-C(4)-H(4A)	109.4
C(3)-C(4)-H(4B)	109.4
C(5)-C(4)-H(4B)	109.4
H(4A)-C(4)-H(4B)	108.0
N(2)-C(5)-C(4)	110.60(14)
N(2)-C(5)-C(1)	108.82(13)
C(4)-C(5)-C(1)	112.18(13)
N(2)-C(5)-C(6)	108.12(13)
C(4)-C(5)-C(6)	112.28(14)
C(1)-C(5)-C(6)	104.58(13)
C(7)-C(6)-C(5)	114.97(14)
C(7)-C(6)-H(6A)	108.5
C(5)-C(6)-H(6A)	108.5
C(7)-C(6)-H(6B)	108.5
C(5)-C(6)-H(6B)	108.5
H(6A)-C(6)-H(6B)	107.5
C(6)-C(7)-H(7A)	109.5
C(6)-C(7)-H(7B)	109.5
H(7A)-C(7)-H(7B)	109.5
C(6)-C(7)-H(7C)	109.5
H(7A)-C(7)-H(7C)	109.5
H(7B)-C(7)-H(7C)	109.5
C(8)-N(2)-C(5)	118.76(14)
C(8)-N(2)-H(2N)	115.6(13)
C(5)-N(2)-H(2N)	118.4(13)
O(2)-C(8)-N(2)	125.39(17)
O(2)-C(8)-O(3)	124.04(16)
N(2)-C(8)-O(3)	110.57(15)
C(8)-O(3)-C(9)	115.58(15)
O(3)-C(9)-C(11)	113.07(15)

O(3)-C(9)-H(9A)	109.0
C(11)-C(9)-H(9A)	109.0
O(3)-C(9)-H(9B)	109.0
C(11)-C(9)-H(9B)	109.0
H(9A)-C(9)-H(9B)	107.8
C(16)-C(11)-C(12)	119.05(16)
C(16)-C(11)-C(9)	118.11(16)
C(12)-C(11)-C(9)	122.83(16)
C(13)-C(12)-C(11)	120.02(17)
C(13)-C(12)-H(12)	120.0
C(11)-C(12)-H(12)	120.0
C(14)-C(13)-C(12)	120.26(17)
C(14)-C(13)-H(13)	119.9
C(12)-C(13)-H(13)	119.9
C(15)-C(14)-C(13)	119.80(17)
C(15)-C(14)-H(14)	120.1
C(13)-C(14)-H(14)	120.1
C(16)-C(15)-C(14)	120.15(18)
C(16)-C(15)-H(15)	119.9
C(14)-C(15)-H(15)	119.9
C(15)-C(16)-C(11)	120.70(17)
C(15)-C(16)-H(16)	119.7
C(11)-C(16)-H(16)	119.7

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2$x 10^3) for (±)-**26**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	16(1)	29(1)	13(1)	-2(1)	-1(1)	1(1)
C(1)	15(1)	18(1)	16(1)	1(1)	-1(1)	0(1)
N(1)	13(1)	29(1)	13(1)	-1(1)	-1(1)	-1(1)
C(2)	16(1)	37(1)	16(1)	1(1)	4(1)	1(1)
C(3)	19(1)	40(1)	14(1)	-2(1)	2(1)	2(1)

C(4)	17(1)	33(1)	13(1)	1(1)	-1(1)	0(1)
C(5)	12(1)	21(1)	15(1)	-1(1)	-1(1)	0(1)
C(6)	18(1)	20(1)	19(1)	0(1)	0(1)	1(1)
C(7)	28(1)	22(1)	37(1)	-4(1)	-8(1)	-2(1)
N(2)	13(1)	19(1)	17(1)	1(1)	0(1)	-1(1)
C(8)	18(1)	23(1)	16(1)	0(1)	-5(1)	0(1)
O(2)	25(1)	25(1)	32(1)	3(1)	-2(1)	-8(1)
O(3)	22(1)	21(1)	27(1)	-4(1)	-4(1)	4(1)
C(9)	40(1)	19(1)	24(1)	-3(1)	-10(1)	8(1)
C(11)	16(1)	22(1)	18(1)	1(1)	-1(1)	-1(1)
C(12)	23(1)	23(1)	23(1)	1(1)	-1(1)	2(1)
C(13)	17(1)	34(1)	21(1)	4(1)	-2(1)	4(1)
C(14)	20(1)	46(1)	19(1)	-7(1)	-4(1)	8(1)
C(15)	27(1)	36(1)	30(1)	-11(1)	-4(1)	13(1)
C(16)	23(1)	28(1)	23(1)	-2(1)	-3(1)	9(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10 ^{3}) for (±)-**26**.

	x	y	z	U(eq)
H(1N)	8380(20)	2630(20)	4488(11)	22
H(2A)	9269	1959	3325	28
H(2B)	8460	3357	3129	28
H(3A)	6984	823	2939	29
H(3B)	7348	1873	2261	29
H(4A)	4572	1952	2580	25
H(4B)	5395	3335	2798	25
H(6A)	5312	219	3903	23
H(6B)	4037	730	4533	23
H(7A)	1994	736	3570	44
H(7B)	2763	-707	3659	44
H(7C)	3273	213	2942	44
H(2N)	2570(20)	2714(19)	4205(10)	19
H(9A)	1276	6758	4315	33

H(9B)	3139	6734	4067	33
H(12)	4027	5022	5544	27
H(13)	4670	5659	6817	29
H(14)	3937	7748	7272	34
H(15)	2522	9191	6460	37
H(16)	1778	8531	5213	30

Table 6. Torsion angles [°] for (±)-**26**.

O(1)-C(1)-N(1)-C(2)	-173.52(17)
C(5)-C(1)-N(1)-C(2)	12.0(3)
C(1)-N(1)-C(2)-C(3)	-26.0(3)
N(1)-C(2)-C(3)-C(4)	48.7(2)
C(2)-C(3)-C(4)-C(5)	-60.7(2)
C(3)-C(4)-C(5)-N(2)	167.52(14)
C(3)-C(4)-C(5)-C(1)	45.8(2)
C(3)-C(4)-C(5)-C(6)	-71.62(18)
O(1)-C(1)-C(5)-N(2)	41.3(2)
N(1)-C(1)-C(5)-N(2)	-144.02(15)
O(1)-C(1)-C(5)-C(4)	164.04(15)
N(1)-C(1)-C(5)-C(4)	-21.3(2)
O(1)-C(1)-C(5)-C(6)	-74.02(18)
N(1)-C(1)-C(5)-C(6)	100.63(17)
N(2)-C(5)-C(6)-C(7)	61.38(18)
C(4)-C(5)-C(6)-C(7)	-60.90(19)
C(1)-C(5)-C(6)-C(7)	177.22(15)
C(4)-C(5)-N(2)-C(8)	-73.64(18)
C(1)-C(5)-N(2)-C(8)	50.01(19)
C(6)-C(5)-N(2)-C(8)	163.05(14)
C(5)-N(2)-C(8)-O(2)	13.9(3)
C(5)-N(2)-C(8)-O(3)	-166.47(13)
O(2)-C(8)-O(3)-C(9)	-2.7(2)
N(2)-C(8)-O(3)-C(9)	177.71(14)
C(8)-O(3)-C(9)-C(11)	-95.57(18)
O(3)-C(9)-C(11)-C(16)	-156.16(16)

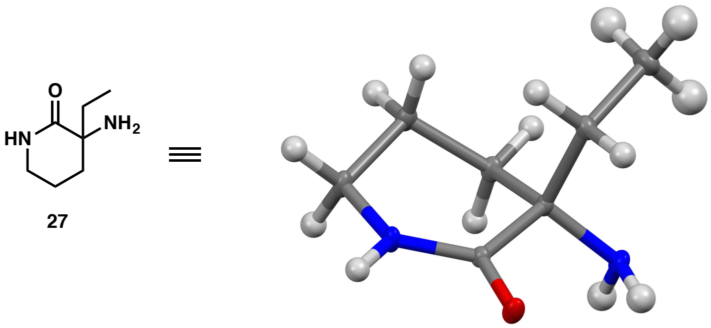
O(3)-C(9)-C(11)-C(12)	25.2(3)
C(16)-C(11)-C(12)-C(13)	1.6(3)
C(9)-C(11)-C(12)-C(13)	-179.78(18)
C(11)-C(12)-C(13)-C(14)	-1.8(3)
C(12)-C(13)-C(14)-C(15)	0.5(3)
C(13)-C(14)-C(15)-C(16)	1.0(3)
C(14)-C(15)-C(16)-C(11)	-1.2(3)
C(12)-C(11)-C(16)-C(15)	-0.1(3)
C(9)-C(11)-C(16)-C(15)	-178.80(18)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for (±)-**26** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1N)...O(1)#1	0.851(17)	2.155(19)	2.9296(19)	151.2(19)
C(4)-H(4B)...O(2)	0.99	2.46	3.066(2)	119.2
N(2)-H(2N)...O(1)#2	0.885(17)	2.023(17)	2.8988(18)	170.5(18)

Symmetry transformations used to generate equivalent atoms:
#1 x+1/2,-y+1/2,-z+1 #2 x-1/2,-y+1/2,-z+1



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Compound (±)-**27** crystallizes in the triclinic space group *P*-1 with one molecule in the asymmetric unit. The coordinates for the hydrogen atoms bound to N1 and N2 were located in the difference Fourier synthesis and refined semi-freely with the help of a restraint on the N-H distance (0.88(4) Å for N1 and 0.91(4) Å for N2).

Table 1. Crystal data and structure refinement for (±)-**27**.

Identification code	A14346	
CCDC Deposition Number	1525605	
Empirical formula	C7 H14 N2 O	
Formula weight	142.20	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	a = 5.4402(3) Å	α = 98.224(3)°.
	b = 7.1156(4) Å	β = 101.633(3)°.
	c = 10.9891(5) Å	γ = 108.971(3)°.
Volume	383.90(4) $Å^3$	
Z	2	
Density (calculated)	1.230 Mg/m^3	
Absorption coefficient	0.084 mm^{-1}	
F(000)	156	
Crystal size	0.300 x 0.150 x 0.100 mm^3	
Theta range for data collection	1.942 to 36.452°.	
Index ranges	-9<=h<=9, -11<=k<=11, -18<=l<=18	
Reflections collected	24158	
Independent reflections	3736 [R(int) = 0.0307]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7471 and 0.6966	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3736 / 3 / 101	
Goodness-of-fit on F^2	1.058	
Final R indices [I>2sigma(I)]	R1 = 0.0353, wR2 = 0.0949	
R indices (all data)	R1 = 0.0442, wR2 = 0.1000	
Extinction coefficient	n/a	

Largest diff. peak and hole	0.516 and -0.181 e.Å^{-3}

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for (±)-**27**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	2104(1)	7223(1)	4568(1)	14(1)
C(1)	2587(1)	5949(1)	3842(1)	10(1)
N(1)	1445(1)	3945(1)	3764(1)	12(1)
C(2)	1992(1)	2297(1)	3039(1)	13(1)
C(3)	3237(1)	2962(1)	1979(1)	14(1)
C(4)	5477(1)	5052(1)	2503(1)	12(1)
C(5)	4390(1)	6680(1)	2958(1)	10(1)
N(2)	6680(1)	8577(1)	3589(1)	14(1)
C(6)	2565(1)	7125(1)	1849(1)	13(1)
C(7)	3897(1)	7710(1)	792(1)	19(1)

Table 3. Bond lengths [Å] and angles [°] for (±)-**27**.

O(1)-C(1)	1.2490(7)
C(1)-N(1)	1.3395(7)
C(1)-C(5)	1.5401(7)
N(1)-C(2)	1.4678(8)
N(1)-H(1N)	0.892(9)
C(2)-C(3)	1.5189(8)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.5237(8)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-C(5)	1.5301(8)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(2)	1.4646(7)

C(5)-C(6)	1.5492(8)
N(2)-H(2N1)	0.893(10)
N(2)-H(2N2)	0.894(10)
C(6)-C(7)	1.5254(9)
C(6)-H(6A)	0.9900
C(6)-H(6B)	0.9900
C(7)-H(7A)	0.9800
C(7)-H(7B)	0.9800
C(7)-H(7C)	0.9800

O(1)-C(1)-N(1)	121.21(5)
O(1)-C(1)-C(5)	119.52(5)
N(1)-C(1)-C(5)	119.16(5)
C(1)-N(1)-C(2)	127.07(5)
C(1)-N(1)-H(1N)	115.7(6)
C(2)-N(1)-H(1N)	116.9(6)
N(1)-C(2)-C(3)	111.67(5)
N(1)-C(2)-H(2A)	109.3
C(3)-C(2)-H(2A)	109.3
N(1)-C(2)-H(2B)	109.3
C(3)-C(2)-H(2B)	109.3
H(2A)-C(2)-H(2B)	107.9
C(2)-C(3)-C(4)	109.17(5)
C(2)-C(3)-H(3A)	109.8
C(4)-C(3)-H(3A)	109.8
C(2)-C(3)-H(3B)	109.8
C(4)-C(3)-H(3B)	109.8
H(3A)-C(3)-H(3B)	108.3
C(3)-C(4)-C(5)	111.66(5)
C(3)-C(4)-H(4A)	109.3
C(5)-C(4)-H(4A)	109.3
C(3)-C(4)-H(4B)	109.3
C(5)-C(4)-H(4B)	109.3
H(4A)-C(4)-H(4B)	107.9
N(2)-C(5)-C(4)	108.46(5)
N(2)-C(5)-C(1)	112.22(4)

C(4)-C(5)-C(1)	110.43(4)
N(2)-C(5)-C(6)	107.91(5)
C(4)-C(5)-C(6)	112.68(5)
C(1)-C(5)-C(6)	105.14(4)
C(5)-N(2)-H(2N1)	111.8(7)
C(5)-N(2)-H(2N2)	111.3(7)
H(2N1)-N(2)-H(2N2)	109.6(9)
C(7)-C(6)-C(5)	113.91(5)
C(7)-C(6)-H(6A)	108.8
C(5)-C(6)-H(6A)	108.8
C(7)-C(6)-H(6B)	108.8
C(5)-C(6)-H(6B)	108.8
H(6A)-C(6)-H(6B)	107.7
C(6)-C(7)-H(7A)	109.5
C(6)-C(7)-H(7B)	109.5
H(7A)-C(7)-H(7B)	109.5
C(6)-C(7)-H(7C)	109.5
H(7A)-C(7)-H(7C)	109.5
H(7B)-C(7)-H(7C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (Å^{2}x 10^3) for (±)-**27**. The anisotropic displacement factor exponent takes the form: $-2p^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	16(1)	11(1)	16(1)	1(1)	10(1)	4(1)
C(1)	9(1)	9(1)	11(1)	2(1)	4(1)	2(1)
N(1)	13(1)	9(1)	15(1)	3(1)	9(1)	3(1)
C(2)	16(1)	8(1)	17(1)	3(1)	8(1)	4(1)
C(3)	16(1)	10(1)	15(1)	1(1)	8(1)	4(1)
C(4)	12(1)	11(1)	16(1)	3(1)	8(1)	4(1)
C(5)	10(1)	9(1)	11(1)	2(1)	5(1)	2(1)
N(2)	12(1)	10(1)	15(1)	1(1)	5(1)	-1(1)
C(6)	14(1)	13(1)	14(1)	5(1)	5(1)	5(1)

C(7)	22(1)	21(1)	15(1)	8(1)	8(1)	6(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for (±)-**27**.

	x	y	z	U(eq)
H(1N)	373(19)	3598(15)	4276(9)	14
H(2A)	287	1109	2666	16
H(2B)	3234	1865	3624	16
H(3A)	1842	3031	1271	16
H(3B)	3979	1960	1644	16
H(4A)	6377	5445	1831	15
H(4B)	6838	4977	3224	15
H(2N1)	6210(20)	9444(15)	4079(10)	20
H(2N2)	8040(20)	8333(16)	4056(10)	20
H(6A)	905	5900	1476	16
H(6B)	2026	8249	2196	16
H(7A)	5690	8768	1169	29
H(7B)	2789	8229	215	29
H(7C)	4069	6506	314	29

Table 6. Hydrogen bonds for (±)-**27** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(1)-H(1N)...O(1)#1	0.892(9)	2.040(9)	2.9326(7)	179.4(10)
C(2)-H(2A)...N(2)#2	0.99	2.67	3.4510(8)	135.5
N(2)-H(2N1)...O(1)#3	0.893(10)	2.388(10)	3.1488(7)	143.1(9)
N(2)-H(2N2)...O(1)#4	0.894(10)	2.565(10)	3.4144(8)	158.8(9)

Symmetry transformations used to generate equivalent atoms:

#1 -x,-y+1,-z+1 #2 x-1,y-1,z #3 -x+1,-y+2,-z+1

#4 x+1,y,z

References:

[1] The procedure was adapted from: Liu, G.; Cogan, D. A.; Ellman, J. A. *J. Am. Chem. Soc.* **1997**, *119*, 9913-9914.

[2] The analytical data were identical to those reported in the literature: Reeves, J. T.; Tan, Z.; Herbage, M. A.; Han, Z. S.; Marsini, M. A.; Li, Z.; Li, G.; Xu, Y.; Fandrick, K. R.; Gonnella, N. C.; Campbell, S.; Ma, S.; Grinberg, N.; Lee, H.; Lu, B. Z.; Senanayake, C. H. *J. Am. Chem. Soc.* **2013**, *135*, 5565-5568.

[3] The data collection of the crystal was not completed, since the X-ray structure was known in the literature. The analytical data were identical to those reported previously: Arava, V. R.; Gorentla, L.; Dubey, P. K. *Beilstein J. Org. Chem.* **2011**, *7*, 9-12; Cutter, A. C.; Miller, I. R.; Keily, J. F.; Bellingham, R. K.; Light, M. E.; Brown, R. C. D. *Org. Lett.* **2011**, *13*, 3988-3991.

[4] A single diastereoisomer was observed according to ^{1}H-NMR relative to an authentic sample of a 1:1 mixture of diastereoisomers. The exact diastereoisomeric excess was determined later in the synthesis by chiral HPLC analysis of the derivatized amino acids (98% *de*).

[5] The racemic disubstituted alkene is known in the literature and was recently used as a substrate in a ruthenium catalyzed tandem olefin isomerization and hydroesterification reaction: Armanino, N.; Lafrance, M.; Carreira, E. M. *Org. Lett.* **2014**, *16*, 572-575.

[6] Commercially available *L-tert*-leucine: $[a]^{25}_{D}$ −8.9° (*c* 1.36, H_2O).

[7] Hayashi, T.; Konishi, M.; Fukushima, M.; Kanehira, K.; Hioki, T.; Kumada, M. *J. Org. Chem.* **1983**, *48*, 2195-2202.

[8] Miyazawa, T.; Takashima, K.; Mitsuda, Y.; Yamada, T.; Kuwata, S.; Watanabe, H. *Bull. Chem. Soc. Jpn.* **1979**, *52*, 1539-1540.

[9] Pracejus, H.; Winter, S. *Chem. Ber.* **1964**, *97*, 3173-3182.

[10] The procedure was first conducted with commercially available *L*-*tert*-leucine in order to exclude racemization during derivatization.

[11] Stains very well with $KMnO_4$ (a little weaker with ninhydrin, orange).

[12] Ter Wiel, M. K. J.; Arnold, M.; Peter, S.; Troltsch, I.; Merget, S.; Glaser, F.; Schwarm, M.; Bhatti, H. S.; Kuriakose, B.; Pol, S. S.; Balamurugan, M.; Joshi, V. V. *Tetrahedron: Asymmetry* **2009**, *20*, 478-482.

[13] Lazar, L.; Martinek, T.; Bernath, G.; Fulop, F. *Synth. Commun.* **1998**, *28*, 219-224.

[14] The corresponding *tert*-butyl sulfonyl amide derivative was not enough UV-active for HPLC analysis (compare with the derivatization of *D*-*tert*-leucine). Moreover, all attempts to synthesize the corresponding Mosher amide failed. The separation of the corresponding *N*-tosyl derivative by chiral HPLC was worse than with the *N*-nosyl derivative.

[15] In order to remove more of the remaining silanol, the crude amine was further concentrated under reduced pressure, which led to a significant loss of product (only 1.68 g left, very volatile amine).

[16] The analytical data were identical to those reported in the literature: Hart, D. J.; Kanai, K.; Thomas, D. G.; Yang, T. K. *J. Org. Chem.* **1983**, *48*, 288-294.

[17] Imine was prepared according to: Liu, G.; Cogan, D. A.; Ellman, J. A. *J. Am. Chem. Soc.* **1997**, *119*, 9913-9914; Ouizem, S.; Chemla, F.; Ferreira, F.; Perez-Luna, A. *Synlett* **2012**, *23*, 1374-1378.

[18] Sun, X.-W.; Xu, M.-H.; Lin, G.-Q. *Org. Lett.* **2006**, *8*, 4979-4982.

[19] The carboxylic acid is not fully soluble in acetone.

[20] Boschi, F.; Camps, P.; Comes-Franchini, M.; Munoz-Torrero, D.; Ricci, A.; Sanchez, L. *Tetrahedron: Asymmetry* **2005**, *16*, 3739-3745.

[21] Mujahid, M.; Mujumdar, P.; Sasikumar, M.; Kunte, S. S.; Muthukrishnan, M. *Tetrahedron: Asymmetry* **2012**, *23*, 1512-1515.

[22] Prepared according to: D. C. Behenna, Y. Liu, T. Yurino, J. Kim, D. E. White, S. C. Virgil, B. M. Stoltz, *Nat. Chem.* **2012**, *4*, 130-133.

[23] A racemic sample of the carboxylic acid was prepared and characterized as described below.

[24] Racemic ethyl ester was prepared according to: Khoukhi, M.; Vaultier, M.; Carrie, R. *Tetrahedron Lett.* **1986**, *27*, 1031-1034.

[25] Caution: MeOH is not a suitable solvent for the filtration, since the amino acid is not well soluble as we have observed in the racemic synthesis.

[26] The KBr pellet was prepared in a nitrogen-filled glovebox (highly hygroscopic amino acid).

[27] Y. Yamamoto, M. Kirihata, I. Ichimoto, H. Ueda, *Agric. Biol. Chem.* **1985**, *49*, 1761-1765.

[28] Prepared according to: Behenna, D. C.; Liu, Y.; Yurino, T.; Kim, J.; White, D. E.; Virgil, S. C.; Stoltz, B. M. *Nature Chem.* **2012**, *4*, 130-133.

[29] The analytical data were identical to those reported previously: Behenna, D. C.; Liu, Y.; Yurino, T.; Kim, J.; White, D. E.; Virgil, S. C.; Stoltz, B. M. *Nature Chem.* **2012**, *4*, 130-133.

[30] An analytical pure sample of the internal alkene was characterized previously: Liu, Y.; Liniger, M.; McFadden, R. M.; Roizen, J. L.; Malette, J.; Reeves, C. M.; Behenna, D. C.; Seto, M.; Kim, J.; Mohr, J. T.; Virgil, S. C.; Stoltz, B. M. *Beilstein J. Org. Chem.* **2014**, *10*, 2501-2512.

[31] A racemic sample of the carboxylic acid was prepared and characterized as described below.

[32] An analytical pure sample of the internal alkene was characterized previously: Liu, Y.; Liniger, M.; McFadden, R. M.; Roizen, J. L.; Malette, J.; Reeves, C. M.; Behenna, D. C.; Seto,

M.; Kim, J.; Mohr, J. T.; Virgil, S. C.; Stoltz, B. M. *Beilstein J. Org. Chem.* **2014**, *10*, 2501-2512.

[33] Racemice ester was prepared in multi-gram quantities according to: Padwa, A.; Price, A. T. *J. Org. Chem.* **1998**, *63*, 556-565. Padwa's reported procedure for ester saponification using aq. KOH failed.

[34] The KBr pellet was prepared in a nitrogen-filled glovebox (highly hygroscopic amino acid).

[35] Prepared according to: Behenna, D. C.; Liu, Y.; Yurino, T.; Kim, J.; White, D. E.; Virgil, S. C.; Stoltz, B. M. *Nature Chem.* **2012**, *4*, 130-133.

[36] During the racemic synthesis, we have prepared and fully characterized the carboxylic acid as described below.

[37] A X-ray structure of the hydantoin was obtained in the racemic synthesis, which also avoids contamination with diphenylphosphorylazide, as described below.

[38] Separation of the impurity with the aforementioned recrystallization procedure failed (it co-crystallized).

[39] The impurity was identified as diphenylphosphoramidate and fully characterized (CAS 2015-56-7). The proposed structure matched all analytical data, which were identical to those reported in the literature. L'Abbé, G.; Ykman, P.; Smets, G. *Tetrahedron* **1969**, *25*, 5421-5426.

[40] Allyl ester was prepared according to: Behenna, D. C.; Liu, Y.; Yurino, T.; Kim, J.; White, D. E.; Virgil, S. C.; Stoltz, B. M. *Nature Chem.* **2012**, *4*, 130-133.

[41] Gander-Coquoz, M.; Seebach, D. *Helv. Chim. Acta* **1988**, *71*, 224-236.

[42] Prepared according to: Behenna, D. C.; Liu, Y.; Yurino, T.; Kim, J.; White, D. E.; Virgil, S. C.; Stoltz, B. M. *Nature Chem.* **2012**, *4*, 130-133.

[43] An analytical sample of the racemic carboxylic acid was crystallized and fully characterized as described below.

[44] Caution: Methyl glutamic acid stains only very weakly with ninhydrin (not at all with $KMnO_4$, anisaldehyde or iodine). After the eluent was changed to 2 M NH_4OH, all fractions with pH 14 were collected (the first pH 14 fraction is very hot + the next 140 mL were collected).

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[46] Aebi, J. D.; Seebach, D. *Helv. Chim. Acta* **1985**, *68*, 1507-1518.

[47] Kagan, H. M.; Manning, L. R.; Meister, A. *Biochemistry* **1965**, *4*, 1063-1068.

[48] The crude carboxylic acid **25** was prepared as an intermediate in the synthesis of isocyanate **16**. See above.

[49] The KBr pellet was prepared in a nitrogen-filled glovebox.

[50] The salt melted very slowly over a rather broad temperature range (50 °C). The salt was transferred to the capillary in a nitrogen-filled glovebox (highly hygroscopic solid).

[51] Sheldrick, G. M. *Acta Cryst.* **1990**, A46, 467-473.

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[53] Müller, P. *Crystallogr. Rev.* **2009**, *15*, 57-83.