Angewandte
Eine Zeitschrift der Gesellschaft Deutscher Chemiker
Chemie

Supporting Information

Palladium(II)-Catalyzed Allylic C–H Oxidation of Hindered Substrates Featuring Tunable Selectivity Over Extent of Oxidation

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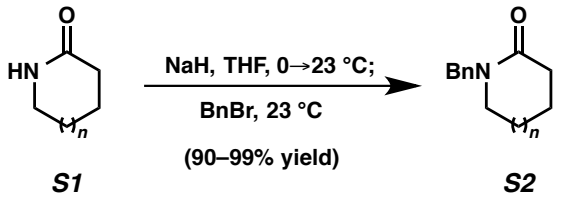
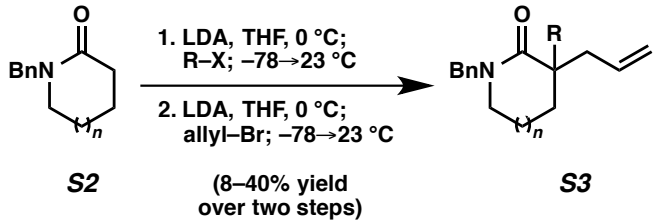
Materials and Methods

Unless noted in the specific procedure, reactions were performed in non-dry glassware under an air atmosphere. Dried and deoxygated solvents (Fisher Scientific) were prepared by passage through columns of activated aluminum before use.[1] Anhydrous carbon tetrachloride was purchased from Sigma Aldrich and used as received. Methanol (Fisher Scientific) was distilled from magnesium methoxide immediately prior to use. Commercial reagents (Sigma Aldrich or Alfa Aesar) were used as received with the exception of δ-valerolactam (Oakwood Chemical), dichloro(*p*-cymene)ruthenium(II) dimer (Strem Chemicals), triphenylphosphine (Sigma Aldrich) , lithium hexamethyldisilazide (Sigma Aldrich), zinc(II) chloride (Sigma Aldrich), and lithium tri-*tert*-butoxyaluminum hydride (Sigma Aldrich) which were stored in a nitrogen-filled govebox. Diisopropylamine (Oakwood Chemical) and trimethylsilyl chloride (Alfa Aesar) were distilled from calcium hydride immediately prior to use. The acetic acid (J. T. Baker) and acetic anhydride (Sigma Aldrich) used in the allylic acetoxylation reactions were stored in a 1:1 mixture over activated MS4Å. Brine is defined as a saturated aqueous solution of sodium chloride. Reactions requiring external heat were modulated to the specified temperatures using an IKAmag temperature controller. Reaction progress was monitored by thin-layer chromatography (TLC) or Agilent 1290 UHPLC-LCMS. TLC was performed using E. Merck silica gel 60 F254 precoated plates (0.25 mm) and visualized by UV fluorescence quenching, potassium permanganate, or *p*-anisaldehyde staining. Silia*Flash* P60 Academic Silica gel (particle size 0.040-0.063 mm) was used for flash chromatography. ^{1}H and ^{13}C NMR spectra were recorded on a Varian Inova 500 spectrometer (500 MHz and 126 MHz, respectively) or a Bruker AV III HD spectrometer equipped with a Prodigy liquid nitrogen temperature cryoprobe (400 MHz and 101 MHz, respectively), and are reported in terms of chemical shift relative to residual $CHCl_3$ (δ 7.26 and δ 77.16 ppm, respectively). Data for ^{1}H NMR spectra are reported as follows: chemical shift (δ ppm) (multiplicity, coupling constant (Hz), integration). Abbreviations are used as follows: s = singlet, bs = broad singlet, d = doublet, t = triplet, q = quartet, m = complex multiplet. Infrared (IR) spectra were recorded on a Perkin Elmer Paragon 1000 spectrometer using thin film samples on NaCl plates, and are reported in frequency of absorption (cm^{-1}). High-resolution mass spectra (HRMS) were obtained from the Caltech Mass Spectral Facility using a JEOL JMS-600H High Resolution Mass Spectrometer with fast atom bombardment (FAB+) ionization mode or were acquired using an Agilent 6200 Series TOF with an Agilent G1978A Multimode source in electrospray ionization (ESI+) mode. Melting points were measured with a BÜCHI Melting Point B-545 apparatus.

General Experimental Procedures

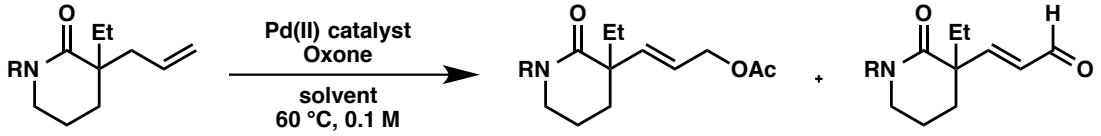


General Procedure A. *Benzyl protection of lactams.*
To a flame-dried round-bottom flask with a magnetic stir bar were added sodium hydride (60% dispersion in mineral oil, 56.5 mmol, 1.13 equiv) and THF (16 mL). The flask was capped with a rubber septum, put under a nitrogen atmosphere, and cooled to 0 °C using an ice water bath. A solution of lactam **S1** (50.0 mmol, 1.00 equiv) in THF (75 mL) was added rapidly dropwise by syringe, and the resulting mixture was allowed to warm to 23 °C and stir for 2 hours. Benzyl bromide (53.5 mmol, 1.07 equiv) was added dropwise by syringe, and the mixture stirred for another 2 hours. Upon completion (as determined by TLC analysis), the suspension was diluted with water (300 mL) and extracted with ethyl acetate (3 x 300 mL). The combined organic layers were washed with brine (1 x 300 mL), dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography, using mixture of hexanes and ethyl acetate as eluent. The products were obtained in 90–99% yield.



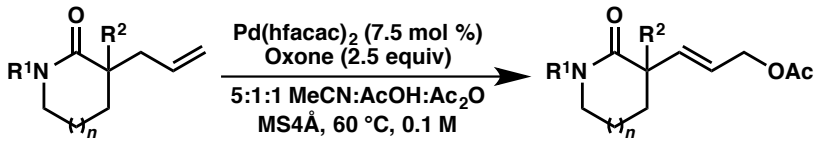
General Procedure B. *Installation of the α-substituents.*
To a flame-dried round-bottom flask with a magnetic stir bar were added diisopropylamine (25.4 mmol, 1.2 equiv) and THF (13 mL) by syringe. The solution was stirred under nitrogen and cooled to 0 °C using an ice water bath. *n*-Butyllithium (2.5 M in hexane, 25.1 mmol, 1.19 equiv) was added rapidly dropwise by syringe, and the solution was allowed to stir at 0 °C for 20 minutes. Meanwhile, lactam **S2** (21.1 mmol, 1.00 equiv) was dissolved in THF (200 mL) in a flame-dried round-bottom flask under nitrogen and cooled to 0 °C using an ice water bath. The freshly prepared LDA solution was transferred to the lactam solution rapidly dropwise via syringe, and the mixture was allowed to stir at 0 °C for 45 minutes. The solution was then cooled to –78 °C using a dry ice and acetone bath, and the appropriate alkyl halide (27.5 mmol, 1.30 equiv) was added dropwise by syringe. The flask was placed in an ice water bath and allowed to gradually warm to 23 °C overnight. Upon completion (as determined by TLC analysis), the reaction mixture was quenched by the addition of saturated aqueous ammonium chloride solution (400 mL), and the aqueous layer extracted with chloroform (3 x 300 mL). The combined organic layers were washed with brine (1 x 300 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography using mixtures of hexanes and ethyl acetate as eluent.

To a flame-dried round-bottom flask with a magnetic stir bar were added diisopropylamine (29.3 mmol, 1.50 equiv) and THF (15 mL) by syringe. The solution was stirred under nitrogen and cooled to 0 °C using an ice water bath. *n*-Butyllithium (2.5 M in hexane, 29.1 mmol, 1.49 equiv) was added rapidly dropwise by syringe, and the solution was allowed to stir at 0 °C for 20 minutes. Meanwhile, the mono-alkylated intermediate lactam (19.5 mmol, 1.00 equiv) was dissolved in THF (61 mL) in a flame-dried round-bottom flask under nitrogen and cooled to 0 °C using an ice water bath. The freshly prepared LDA solution was transferred to the lactam solution rapidly dropwise via syringe, and the mixture was allowed to stir at 0 °C for 45 minutes. The solution was then cooled to –78 °C using a dry ice and acetone bath, and allyl bromide (117.0 mmol, 6.00 equiv) was added dropwise by syringe. The flask was placed in an ice water bath and allowed to gradually warm to 23 °C overnight. Upon completion (as determined by TLC analysis), the reaction mixture was quenched by the addition of saturated aqueous ammonium chloride solution (300 mL), and the aqueous layer extracted with chloroform (3 x 200 mL). The combined organic layers were washed with brine (1 x 200 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography using mixtures of hexanes and ethyl acetate as eluent. The products were obtained in 8–40% yield over two steps.



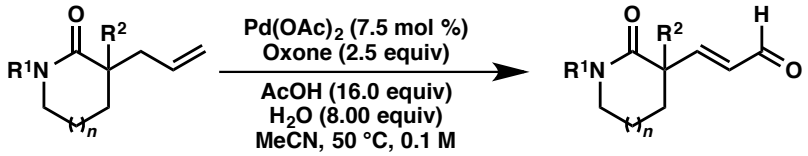
3 ***4*** ***6***

General Procedure C. *Optimization of the allylic acetoxylation reaction.*
To a flame-dried 25 mL round-bottom flask with a magnetic stir bar were added, in order, the appropriate lactam **3** (0.10 mmol, 1.00 equiv), the appropriate palladium(II) catalyst (0.075 mmol or 0.05 mmol, 0.075 equiv or 0.05 equiv), Oxone (0.15 mmol or 0.25 mmol, 1.50 equiv or 2.50 equiv), and (if indicated) hot, activated 4 Å molecular sieves (80 mg). The flask was then capped with a rubber septum and evacuated and backfilled twice with nitrogen. The appropriate solvent mixture (total volume 1 mL, 5:2 acetonitrile:acetic acid or 5:1:1 acetonitrile:acetic acid:acetic anhydride) was added by syringe. The resulting suspension was stirred under nitrogen for 5 minutes at 23 °C and then heated to 60 °C in an oil bath. Upon completion (as determined by TLC analysis), the flask was allowed to cool to 23 °C and the contents were filtered through a short plug of silica gel, rinsing with ethyl acetate. The filtrate was adsorbed onto silica gel (approx. 1 g), which was then flushed with ethyl acetate. The eluent was concentrated to give the crude product as an oil. After NMR analysis to determine the acetate:enal ratio, the crude residue was purified by silica gel column chromatography, using mixtures of hexanes and ethyl acetate as eluent.



7 ***8***

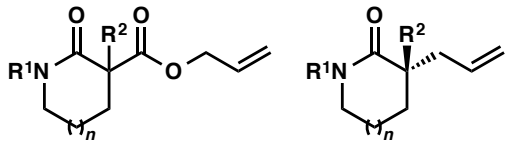
General Procedure D. *Allylic acetoxylation of α-allyl lactams.*
To a flame-dried 25 mL round-bottom flask with a magnetic stir bar were added, in order, lactam **7** (0.20 mmol, 1.00 equiv), palladium(II) hexafluoroacetylacetonate (8 mg, 0.015 mmol, 0.075 equiv), Oxone (154 mg, 0.50 mmol, 2.50 equiv), and hot, activated 4 Å molecular sieves (160 mg). The flask was then capped with a rubber septum and evacuated and backfilled twice with nitrogen. Acetonitrile (1.43 mL) and 1:1 acetic acid:acetic anhydride (571 μL) were added by syringe. The resulting suspension was stirred under nitrogen for 5 minutes at 23 °C and then heated to 60 °C in an oil bath. Upon completion (as determined by TLC analysis), the flask was allowed to cool to 23 °C and the contents were filtered through a short plug of silica gel, rinsing with ethyl acetate. The filtrate was adsorbed onto silica gel (approx. 2 g), which was then flushed with ethyl acetate. The eluent was concentrated to give the crude product as an oil. After NMR analysis to determine the acetate:enal ratio, the crude residue was purified by silica gel column chromatography, using mixtures of hexanes and ethyl acetate as eluent.



7 ***9***

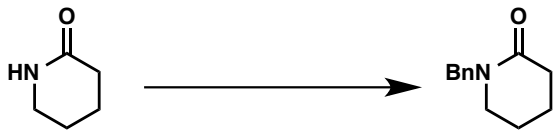
General Procedure E. *Enal formation from α-allyl lactams.*
To a 25 mL round-bottom flask with a magnetic stir bar were added, in order, lactam **7** (0.20 mmol, 1.00 equiv), palladium(II) acetate (3 mg, 0.015 mmol, 0.075 equiv), and Oxone (154 mg, 0.50 mmol, 2.50 equiv). Acetonitrile (1.82 mL), acetic acid (183 μL, 3.20 mmol, 16.00 equiv), and water (29 μL, 1.60 mmol, 8.00 equiv) were added by syringe. The resulting suspension was stirred for 5 minutes at 23 °C and then heated to 50 °C in an oil bath. Upon completion (as determined by TLC analysis), the flask was allowed to cool to 23 °C and anhydrous magnesium sulfate (approx. 200 mg) was added. After stirring for 5 minutes the contents were filtered through a short plug of silica gel, rinsing with ethyl acetate. The filtrate was adsorbed onto silica gel (approx. 2 g), which was then flushed with ethyl acetate. The eluent was concentrated to give the crude product as an oil. After NMR analysis to determine the acetate:enal ratio, the crude residue was purified by silica gel column chromatography, using mixtures of hexanes and ethyl acetate as eluent.

Substrate Synthesis and Characterization Data



1 ***2***

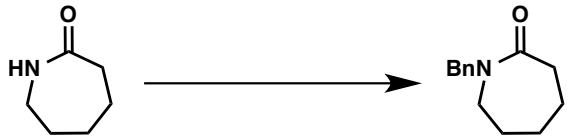
Compounds of the general structures **1** (not used in this work) and **2**, including one used in this work (R^1 = Bz, R^2 = Et, n = 1; starting material for entry 1 of Table 1) may be prepared as previously reported by our research group.[2]



S1a ***S2a***

1-benzylpiperidin-2-one (S2a):

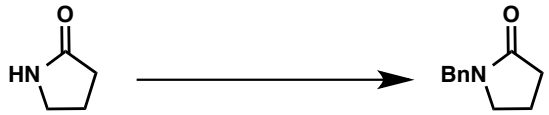
Lactam **S2a** was prepared from δ-valerolactam (**S1a**) using General Procedure A. Characterization data match those reported in the literature.[3]



S1b ***S2b***

1-benzylazepan-2-one (S2c):

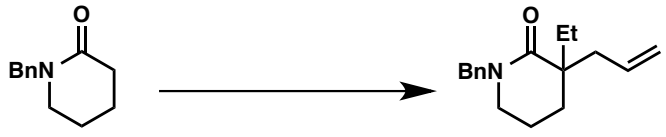
Lactam **S2c** was prepared from ε-caprolactam (**S1b**) using General Procedure A. Characterization data match those reported in the literature.[4]



S1c ***S2c***

1-benzylpyrrolidin-2-one (S2d):

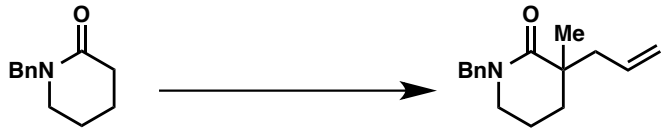
Lactam **S2d** was prepared from 2-pyrrolidinone (**S1c**) using General Procedure A. Characterization data match those reported in the literature.[5]



S2a ***7a***

3-allyl-1-benzyl-3-ethylpiperidin-2-one (7a):

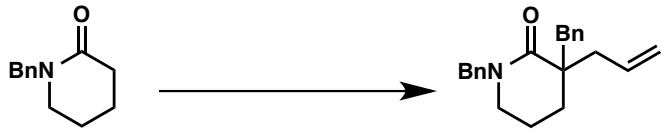
Lactam **7a** was prepared from **S2a** using General Procedure B. R*f* = 0.40 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.27 (m, 2H), 7.26–7.20 (m, 3H), 5.78 (dddd, *J* = 16.7, 10.5, 8.1, 6.7 Hz, 1H), 5.10–5.05 (m, 1H), 5.06–5.03 (m, 2H), 4.60 (d, *J* = 14.6 Hz, 1H), 4.56 (d, *J* = 14.6 Hz, 1H), 3.22–3.10 (m, 2H), 2.55 (ddt, *J* = 13.5, 6.7, 1.3 Hz, 1H), 2.21 (ddt, *J* = 13.5, 8.0, 1.1 Hz, 1H), 1.83 (dq, *J* = 13.6, 7.5 Hz, 1H), 1.78–1.63 (m, 3H), 1.52 (dq, *J* = 13.6, 7.5 Hz, 1H), 0.88 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.5, 137.7, 135.0, 128.6, 128.1, 127.3, 117.8, 50.6, 47.8, 45.3, 31.6, 28.9, 19.8, 8.9; IR (Neat Film, NaCl) 2938, 1633, 1488, 1453, 1352, 1196, 913, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{24}NO$ [M+H]$^+$: 258.1852, found 258.1856.



S2a ***7b***

3-allyl-1-benzyl-3-methylpiperidin-2-one (7b):

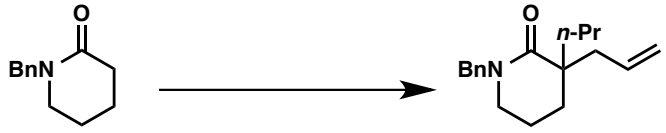
Lactam **7b** was prepared from **S2a** using General Procedure B. R*f* = 0.50 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.32–7.27 (m, 2H), 2.26–2.20 (m, 3H), 5.81–5.71 (m, 1H), 5.11–5.04 (m, 2H), 4.62 (d, *J* = 14.6 Hz, 1H), 4.50 (d, *J* = 14.6 Hz, 1H), 3.24–3.10 (m, 2H), 2.57 (ddt, *J* = 13.5, 6.7, 1.3 Hz, 1H), 2.23 (ddt, *J* = 13.4, 8.1, 1.0 Hz, 1H) 1.89–1.80 (m, 1H), 1.80–1.69 (m, 2H), 1.58–1.47 (m, 1H), 1.25 (s, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 175.1, 137.7, 143.6, 128.6, 128.0, 127.3, 118.1, 50.5, 47.9, 44.5, 41.6, 32.6, 26.0, 19.4; IR (Neat Film, NaCl) 2936, 1634, 1488, 1432, 1349, 1196, 914, 750 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{22}NO$ [M+H]$^+$: 244.1696, found 244.1699.



S2a ***7c***

3-allyl-1,3-dibenzylpiperidin-2-one (7c):

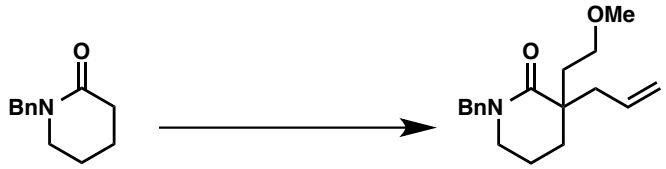
Lactam **7c** was prepared from **S2a** using General Procedure B. R*f* = 0.40 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) 7.32–7.13 (m, 10H), 5.82 (dddd, *J* = 16.8, 10.6, 8.2, 6.5 Hz, 1H), 5.15–5.11 (m, 1H), 5.11–5.06 (m, 1H), 4.68 (d, *J* = 14.5 Hz, 1H), 4.48 (d, *J* = 14.6 Hz, 1H), 3.38 (d, *J* = 13.0 Hz, 1H), 3.06 (ddd, *J* = 12.0, 7.4, 4.6 Hz, 1H), 2.99–2.87 (m, 1H), 2.72 (ddt, *J* = 13.4, 6.5, 1.4 Hz, 1H), 2.61 (d, *J* = 13.1 Hz, 1H), 2.21 (ddt, *J* = 13.4, 8.2, 1.0 Hz, 1H), 1.78–1.68 (m, 2H), 1.64 (qdd, *J* = 11.9, 5.9, 2.7 Hz, 1H), 1.46–1.34 (m, 1H); ^{13}C NMR (CDCl3, 126 MHz) δ 173.8, 138.3, 137.4, 134.5, 130.8, 128.5, 128.1, 128.1, 127.3, 126.4, 118.5, 50.8, 47.8, 46.7, 44.8, 44.6, 28.6, 19.7; IR (Neat Film, NaCl) 3027, 2939, 1631, 1495, 1453, 1353, 1194, 916, 742 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{22}H_{26}NO$ [M+H]$^+$: 320.2009, found 320.2019.



S2a ***7d***

3-allyl-1-benzyl-3-propylpiperidin-2-one (7d):

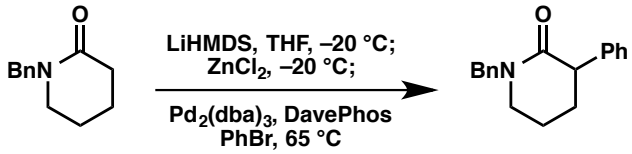
Lactam **7d** was prepared from **S2a** using General Procedure B. R*f* = 0.50 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.35–7.29 (m, 2H), 7.27–7.20 (m, 3H), 5.90–5.66 (m, 1H), 5.10–5.06 (m, 1H), 5.06–5.04 (m, 1H), 4.61 (d, *J* = 14.5 Hz, 1H), 4.55 (d, *J* = 14.5 Hz, 1H), 3.16 (td, *J* = 5.4, 4.6, 2.2 Hz, 2H), 2.56 (ddt, *J* = 13.5, 6.7, 1.3 Hz, 1H), 2.22 (ddt, *J* = 13.5, 8.1, 1.0 Hz, 1H), 1.83–1.57 (m, 5H), 1.55–1.41 (m, 1H), 1.41–1.32 (m, 1H), 1.32–1.21 (m, 1H), 0.91 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.4, 137.7, 134.9, 128.5, 128.1, 127.2, 117.8, 50.5, 47.7, 45.1, 43.7, 41.4, 29.5, 19.8, 17.6, 14.8; IR (Neat Film, NaCl) 2955, 1632, 1487, 1437, 1350, 1194, 913, 734 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{26}NO$ $[M+H]^+$: 272.2009, found 272.2014.



S2a ***7e***

3-allyl-1-benzyl-3-(2-methoxyethyl)piperidin-2-one (7e):

Lactam **7e** was prepared from **S2a** using General Procedure B. R*f* = 0.3 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.27 (m, 2H), 7.27–7.20 (m, 3H), 5.86–5.65 (m, 1H), 5.08 (dtd, *J* = 13.3, 2.4, 1.1 Hz, 2H), 4.62 (d, *J* = 14.6 Hz, 1H), 4.52 (d, *J* = 14.5 Hz, 1H), 3.56–3.37 (m, 2H), 3.29 (s, 3H), 3.24–3.12 (m, 2H), 2.56 (ddt, *J* = 13.6, 6.7, 1.3 Hz, 1H), 2.26 (ddt, *J* = 13.5, 8.0, 1.0 Hz, 1H), 2.09 (ddd, *J* = 14.1, 7.7, 6.5 Hz, 1H), 1.83–1.63 (m, 5H); ^{13}C NMR (CDCl3, 126 MHz) δ 173.9, 137.7, 134.4, 128.6, 128.1, 127.3, 118.4, 69.7, 58.7, 50.7, 47.9, 44.0, 43.7, 38.0, 30.1, 19.7; IR (Neat Film, NaCl) 2925, 1632, 1487, 1452, 1195, 1114, 915, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{26}NO_2$ $[M+H]^+$: 288.1958, found 288.1966.

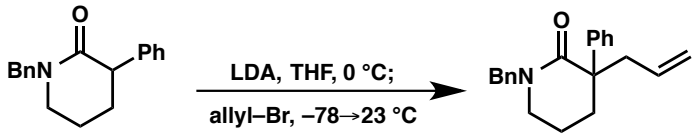


S2a **(15% yield)** ***S4***

1-benzyl-3-phenylpiperidin-2-one (S3):

Lactam **S3** was prepared from **S2a** following a known procedure.[2a] To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **S2a** (662 mg, 3.50 mmol, 2.20 equiv) and THF (6.4 mL). The solution was stirred under nitrogen and cooled to –20 °C using a dry ice and acetone bath. A solution of lithium hexamethyldisilazide (532 mg, 3.18 mmol, 2.00 equiv) in THF (1.4 mL) was added by syringe, and the reaction

mixture was allowed to stir at –20 °C for 20 minutes. A solution of zinc(II) chloride (477 mg, 3.50 mmol, 2.20 equiv) in THF (7 mL) was added, and the reaction mixture was allowed to stir at –20 °C for another 20 minutes, after which it was transferred via syringe to a flame-dried round-bottom flask with a magnetic stir bar and a reflux condenser containing tris(dibenzylideneacetone)dipalladium(0) (23 mg, 0.025 mmol, 0.015 equiv), DavePhos (30 mg, 0.076 mmol, 0.048 equiv), bromobenzene (169 μL, 1.59 mmol, 1.00 equiv), and THF (3.2 mL). The mixture was heated to 65 °C for 10 hours. Upon completion (as determined by TLC analysis), the reaction mixture was allowed to cool to 23 °C, quenched by the addition of saturated aqueous ammonium chloride solution (100 mL), and the aqueous layer was extracted with ether (3 x 200 mL). The combined organic layers were dried over magnesium sulfate and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl aceate in hexanes to 25% ethyl acetate in hexanes) to provide lactam **S3** as a colorless oil (141 mg, 15% yield). Characterization data match those reported in the literature.[5]

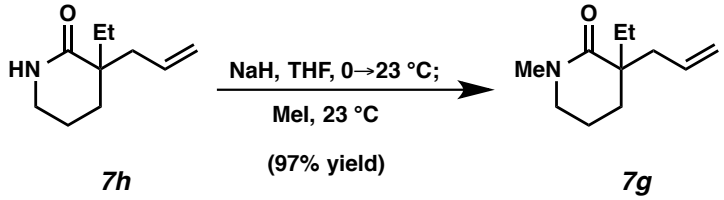


S4 ***7f***

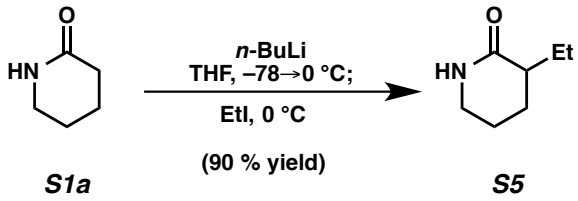
3-allyl-1-benzyl-3-phenylpiperidin-2-one (7f):

To a flame-dried round-bottom flask with a magnetic stir bar were added diisopropylamine (348 μL, 2.48 mmol, 1.50 equiv) and THF (1.3 mL) by syringe. The solution was stirred under nitrogen and cooled to 0 °C using an ice water bath. *n*-Butyllithium (2.5 M in hexane, 983 μL, 2.46 mmol, 1.49 equiv) was added rapidly dropwise by syringe, and the solution was allowed to stir at 0 °C for 20 minutes. Meanwhile, lactam **S3** (439 mg, 1.65 mmol, 1.00 equiv) was dissolved in THF (5.3 mL) in a flame-dried round-bottom flask under nitrogen and cooled to 0 °C using an ice water bath. The freshly prepared LDA solution was transferred to the lactam solution rapidly dropwise via syringe, and the mixture was allowed to stir at 0 °C for 45 minutes. The solution was then cooled to –78 °C using a dry ice and acetone bath, and allyl bromide (857 μL, 9.90 mmol, 6.00 equiv) was added dropwise by syringe. The flask was placed in an ice water bath and allowed to gradually warm to 23 °C overnight. Upon completion (as determined by TLC analysis), the reaction mixture was quenched by the addition of saturated aqueous ammonium chloride solution (100 mL), and the aqueous layer extracted with chloroform (3 x 75 mL). The combined organic layers were washed with brine (1 x 100 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (5% ethyl aceate in hexanes) to provide lactam **7f** as a colorless oil (332 mg, 66% yield). R*f* = 0.4 (10% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.41–7.26 (m, 9H), 7.25–7.19 (m, 1H), 5.76 (dddd, *J* = 17.1, 10.2, 8.2, 6.1 Hz, 1H), 5.14–5.04 (m, 2H), 4.69 (s, 2H), 3.28–3.16 (m, 1H), 3.12 (dddd, *J* = 12.1, 5.2, 3.7, 1.3 Hz, 1H), 2.96 (ddt, *J* = 13.5, 6.1, 1.4 Hz, 1H), 2.53 (ddt, *J* = 13.6, 8.2, 1.0 Hz, 1H), 2.19 (dtd, *J* = 13.9, 4.0, 1.3 Hz, 1H), 2.12–1.97 (m, 1H), 1.72–1.61 (m, 2H); ^{13}C NMR (CDCl3, 126 MHz) δ 172.4, 144.0, 137.6, 135.4, 128.7, 128.5, 128.3, 127.4, 126.8, 126.6, 118.2, 51.2, 50.8, 47.5, 45.8, 31.4, 19.0; IR

(Neat Film, NaCl) 3061, 2943, 1635, 1495, 1442, 1352, 1197, 916, 761, 699 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{21}H_{24}NO$ $[M+H]^+$: 306.1852, found 306.1850.

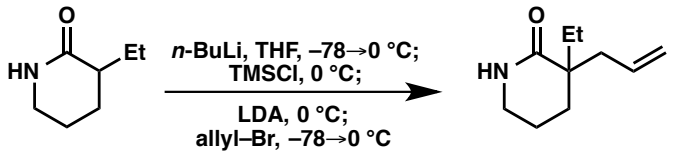


3-allyl-3-ethyl-1-methylpiperidin-2-one (7g):
To a flame-dried round-bottom flask with a magnetic stir bar were added sodium hydride (60% dispersion in mineral oil, 122 mg, 3.06 mmol, 1.10 equiv) and THF (5 mL). The flask was capped with a rubber septum, put under a nitrogen atmosphere, and cooled to 0 °C using an ice water bath. A solution of lactam **7h** (preparation described below, 465 mg, 2.78 mmol, 1.00 equiv) in THF (15 mL) was added rapidly dropwise by syringe, and the resulting mixture was allowed to warm to 23 °C and stir for 2 hours. Methyl iodide (191 μL, 3.06 mmol, 1.10 equiv) was added dropwise by syringe, and the mixture stirred for another 2 hours. Upon completion (as determined by TLC analysis), the suspension was diluted with water (100 mL) and extracted with ethyl acetate (3 x 100 mL). The combined organic layers were washed with brine (1 x 100 mL), dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (40% ethyl acetate in hexanes) to provide lactam **7g** as a colorless oil (490 mg, 97% yield). R*f* = 0.4 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 5.77–5.61 (m, 1H), 5.05–5.01 (m, 1H), 5.00 (t, *J* = 1.2 Hz, 1H), 3.29–3.15 (m, 2H), 2.89 (s, 3H), 2.45 (ddt, *J* = 13.6, 6.7, 1.4 Hz, 1H), 2.15 (ddt, *J* = 13.6, 8.1, 1.1 Hz, 1H), 1.84–1.58 (m, 5H), 1.46 (dq, *J* = 13.7, 7.4 Hz, 1H), 0.82 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 174.6, 135.1, 117.6, 50.5, 45.1, 43.0, 35.2, 31.3, 28.9, 19.7, 8.0; IR (Neat Film, NaCl) 2938, 1635, 1499, 1458, 1398, 1357, 1201, 911 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{11}H_{20}NO$ $[M+H]^+$: 182.1539, found 182.1542.



3-ethylpiperidin-2-one (S4):
Lactam **S4** was prepared from **S1a** following a known procedure.[6] To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **S1a** (2.25 g, 22.7 mmol, 1.00 equiv) and THF (50 mL). The solution was stirred under nitrogen and cooled to –78 °C using a dry ice and acetone bath. *n*-Butyllithium (2.5 M in hexane, 18.3 mL, 45.7 mmol, 2.01 equiv) was added dropwise by syringe, and the reaction mixture was allowed to warm to 0 °C and stir for 1 hour. Ethyl iodide (2.73 mL, 34.1 mmol, 1.50 equiv) was added dropwise by syringe, and the solution was stirred for 45 minutes at 0 °C. Upon completion (as determined by TLC analysis), the mixture was quenched with saturated aqueous ammonium chloride solution (100 mL) and the aqueous layer was extracted with chloroform (3 x 200 mL). The combined organic layers were washed with brine (1 x 200

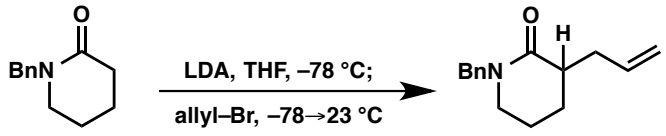
mL), dried over sodium sulfate, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (ethyl acetate) to provide lactam **S4** as a white solid (2.60 g mg, 90% yield). Characterization data match those reported in the literature.[7]



S5 **(61 % yield)** ***7h***

3-allyl-3-ethylpiperidin-2-one (7h):

Lactam **7h** was prepared from **S4** following a known procedure.[6] To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **S4** (2.60 g, 20.4 mmol, 1.00 equiv) and THF (60 mL). The solution was stirred under nitrogen and cooled to –78 °C using a dry ice and acetone bath. *n*-Butyllithium (2.5 M in hexane, 8.24 mL, 20.6 mmol, 1.01 equiv) was added dropwise by syringe, and the reaction mixture was allowed to warm to 0 °C and stir for 1.25 hours. Trimethylsilyl chloride (3.77 mL, 22.5 mmol, 1.10 equiv) was added rapidly by syringe, and the reaction mixture was allowed to stir for 1.75 hours at 0 °C. Meanwhile, to a flame-dried round-bottom flask with a magnetic stir bar were added diisopropylamine (4.29 mL, 30.6 mmol, 1.50 equiv) and THF (15 mL) by syringe. The amine solution was stirred under nitrogen and cooled to 0 °C using an ice water bath. *n*-Butyllithium (2.5 M in hexane, 12.2 mL, 30.4 mmol, 1.49 equiv) was added rapidly dropwise by syringe, and the solution was allowed to stir at 0 °C for 20 minutes. The freshly prepared LDA solution was then added to the reaction mixture rapidly by syringe, and the resulting solution was stirred for 45 minutes at 0 °C. The solution was then cooled to –78 °C using a dry ice and acetone bath, and allyl bromide (21 mL, 250 mmol, 12.3 equiv) was added dropwise by syringe. The reaction mixture was allowed to warm to 0 °C and stir for 1.25 hours. Upon completion (as determined by TLC analysis), the mixture was quenched with saturated aqueous ammonium chloride solution (100 mL) and the aqueous layer was extracted with chloroform (3 x 200 mL). The combined organic layers were washed with 1 M aqueous hydrochloric acid (2 x 100 mL), water (1 x 100 mL), brine (1 x 100 mL), dried over sodium sulfate, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (50% ethyl acetate in hexanes) to provide lactam **7h** as a colorless oil (2.09 g, 61% yield). Characterization data match those reported in the literature.[8]

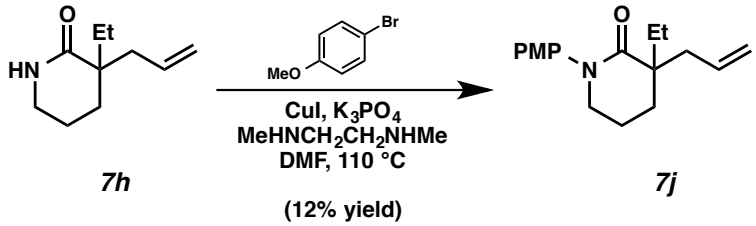


S2a **(61% yield)** ***7i***

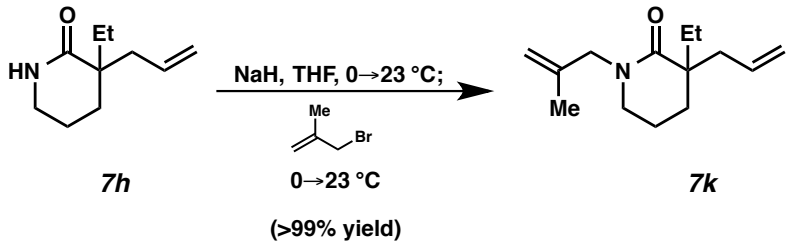
3-allyl-1-benzylpiperidin-2-one (7i):

To a flame-dried round-bottom flask with a magnetic stir bar were added diisopropylamine (2.91 mL, 20.8 mmol, 1.05 equiv) and THF (10 mL) by syringe. The solution was stirred under nitrogen and cooled to 0 °C using an ice water bath. *n*-

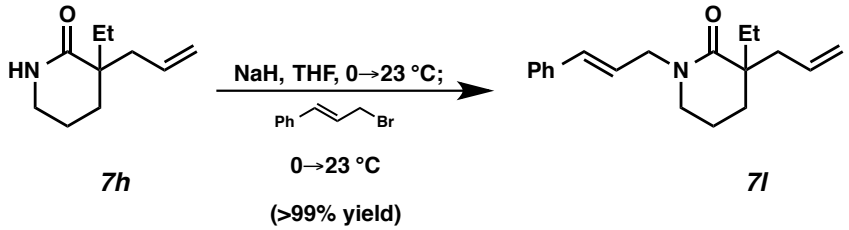
Butyllithium (2.5 M in hexane, 8.71 mL, 21.8 mmol, 1.10 equiv) was added rapidly dropwise by syringe, and the solution was allowed to stir at 0 °C for 30 minutes before being cooled to –78 °C in a dry ice and acetone bath. A solution of lactam **S2a** (3.75 g, 19.8 mmol, 1.00 equiv) in THF (60 mL) was added dropwise by cannula. The reaction mixture was stirred at –78 °C for 4 hours. Allyl bromide (1.79 mL, 20.8 mmol, 1.05 equiv) was added dropwise by syringe, and the reaction mixture was allowed to gradually warm to 23 °C and stir for 16 h. Upon completion (as determined by TLC analysis) the reaction mixture was quenched by the addition of saturated aqueous ammonium chloride solution (200 mL), and the aqueous layer extracted with chloroform (3 x 200 mL). The combined organic layers were washed with brine (1 x 200 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (25% ethyl aceate in hexanes) to provide lactam **7i** as a colorless oil (2.77 g, 61% yield). R*f* = 0.7 (50% ethyl acetate in hexanes); characterization data match those reported in the literature.[7]



3-allyl-3-ethyl-1-(4-methoxyphenyl)piperidin-2-one (7j):
The conditions for this transformation were adapted from a known procedure.[8] To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **7h** (1.00 g, 5.98 mmol, 1.20 equiv) and DMF (6 mL). The solution was stirred under nitrogen and copper(I) iodide (190 mg, 1.00 mmol, 0.20 equiv), potassium phosphate tribasic (2.12 g, 10.0 mmol, 2.00 equiv), *N*,*N*'-dimethylethylenediamine (108 μL), and 4-bromoanisole (630 μL, 5.04 mmol, 1.00 equiv) were added. The heterogeneous mixture was then heated to 110 °C under nitrogen for 20 hours. Upon completion (as determined by LCMS analysis), the mixture was filtered through a plug of sodium sulfate, rinsing with dichloromethane. The filtrate was washed with water (3 x 100 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl acetate in hexanes) to provide lactam **7j** as a colorless oil (203 mg, 12% yield). R*f* = 0.3 (20% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.17–7.04 (m, 2H), 6.95–6.83 (m, 2H), 6.01–5.69 (m, 1H), 5.14–5.10 (m, 1H), 5.10 (s, 1H), 3.80 (s, 3H), 3.58 (t, *J* = 5.9 Hz, 2H), 2.60 (ddt, *J* = 13.5, 6.7, 1.3 Hz, 1H), 2.23 (ddt, *J* = 13.4, 8.1, 1.0 Hz, 1H), 2.00–1.77 (m, 5H), 1.57 (dq, *J* = 13.6, 7.4 Hz, 1H), 0.95 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 174.9, 158.0, 137.0, 135.1, 127.5, 118.0, 114.4, 55.6, 52.5, 45.7, 43.7, 31.9, 29.3, 20.6, 9.0; IR (Neat Film, NaCl) 3072, 2937, 1646, 1511, 1457, 1293, 1243, 1199, 1105, 1134, 913, 829 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{24}NO_2$ $[M+H]^+$: 274.1802, found 274.1813.

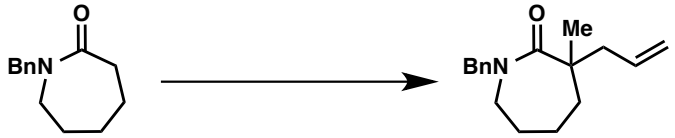


3-allyl-3-ethyl-1-(2-methylallyl)piperidin-2-one (7k):
To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **7h** (400 mg, 2.40 mmol, 1.00 equiv) and THF (12 mL). The flask was capped with a rubber septum, put under an argon atmosphere, and cooled to 0 °C using an ice water bath. Sodium hydride (60% dispersion in mineral oil, 192 mg, 4.80 mmol, 2.00 equiv) was then added in one portion, and the suspension was allowed to warm to 23 °C and stir for 2 hours. The suspension was then cooled to 0 °C using an ice water bath, and 3-bromo-2-methylpropene (267 μL, 2.64 mmol, 1.10 equiv) was added by syringe. The suspension was allowed to warm to 23 °C and stir for 1 hour. Upon completion (as determined by TLC analysis), the reaction mixture was diluted with water (100 mL) and extracted with ethyl acetate (3 x 100 mL). The combined organic layers were washed with brine (1 x 100 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (10% ethyl acetate in hexanes) to provide lactam **7k** as a colorless oil (531 mg, >99% yield). R*f* = 0.5 (20% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 5.86–5.62 (m, 1H), 5.07–5.04 (m, 1H), 5.04–5.02 (m, 1H), 4.85 (q, *J* = 1.5 Hz, 1H), 4.76 (dt, *J* = 2.4, 1.1 Hz, 1H), 4.02–3.80 (m, 2H), 3.24–3.08 (m, 2H), 2.58–2.38 (m, 1H), 2.18 (ddt, *J* = 13.5, 8.2, 1.1 Hz, 1H), 1.89–1.68 (m, 5H), 1.67 (s, 3H), 1.56–1.45 (m, 1H), 0.87 (td, *J* = 7.4, 1.2 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.3, 140.9, 135.1, 117.8, 112.0, 52.7, 47.6, 45.3, 43.4, 31.6, 29.0, 20.2, 19.9, 8.9; IR (Neat Film, NaCl) 3074, 2939, 1637, 1488, 1458, 1440, 1346, 1285, 1197, 1000, 911 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{14}H_{24}NO$ $[M+H]^+$: 222.1852, found 222.1860.



3-allyl-1-cinnamyl-3-ethylpiperidin-2-one (7l):
To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **7h** (400 mg, 2.40 mmol, 1.00 equiv) and THF (12 mL). The flask was capped with a rubber septum, put under an argon atmosphere, and cooled to 0 °C using an ice water bath. Sodium hydride (60% dispersion in mineral oil, 192 mg, 4.80 mmol, 2.00 equiv) was then added in one portion, and the suspension was allowed to warm to 23 °C and stir for 2 hours. The suspension was then cooled to 0 °C using an ice water bath, and 3-bromo-1-phenyl-1-propene (520 mg, 2.64 mmol, 1.10 equiv) was added by syringe. The suspension was allowed to warm to 23 °C and stir for 2 hours. Upon completion (as determined by TLC analysis), the reaction mixture was diluted with water (100 mL) and

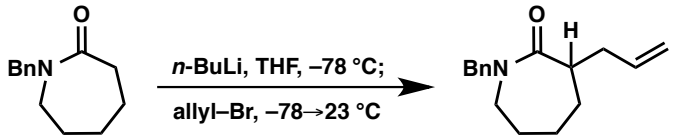
extracted with ethyl acetate (3 x 100 mL). The combined organic layers were washed with brine (1 x 100 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl acetate in hexanes) to provide lactam **7l** as a colorless oil (676 mg, >99% yield). R*f* = 0.3 (20% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.39–7.33 (m, 2H), 7.31 (ddd, *J* = 7.7, 6.7, 1.2 Hz, 2H), 7.26–7.20 (m, 1H), 6.48 (dt, *J* = 15.7, 1.5 Hz, 1H), 6.14 (dt, *J* = 15.8, 6.5 Hz, 1H), 5.90–5.57 (m, 1H), 5.08 (ddt, *J* = 5.0, 2.3, 1.3 Hz, 1H), 5.06 (t, *J* = 1.2 Hz, 1H), 4.14 (dd, *J* = 6.5, 1.4 Hz, 2H), 3.42–3.13 (m, 2H), 2.54 (ddt, *J* = 13.5, 6.7, 1.3 Hz, 1H), 2.20 (ddt, *J* = 13.5, 8.1, 1.0 Hz, 1H), 1.95–1.65 (m, 5H), 1.52 (dq, *J* = 13.5, 7.4 Hz, 1H), 0.89 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.3, 136.8, 135.1, 132.6, 128.7, 127.7, 126.5, 125.0, 117.8, 49.5, 47.9, 45.4, 43.4, 31.6, 28.9, 20.0, 8.9; IR (Neat Film, NaCl) 2938, 1631, 1487, 1448, 1352, 1282, 1196, 965, 912, 746 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{26}NO$ $[M+H]^+$: 284.2009, found 284.2019.



S2b ***7m***

3-allyl-1-benzyl-3-methylazepan-2-one (7m):

Lactam **7m** was prepared from **S2b** using General Procedure B. R*f* = 0.4 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.33–7.27 (m, 2H), 7.26–7.21 (m, 3H), 5.94–5.72 (m, 1H), 5.12–5.07 (m, 1H), 5.06 (t, *J* = 1.2 Hz, 1H), 4.69 (d, *J* = 14.6 Hz, 1H), 4.52 (d, *J* = 14.6 Hz, 1H), 3.42 (ddd, *J* = 15.2, 7.9, 4.0 Hz, 1H), 3.28 (ddd, *J* = 15.2, 6.3, 3.9 Hz, 1H), 2.54–2.34 (m, 2H), 1.76–1.59 (m, 3H), 1.59–1.45 (m, 3H), 1.28 (s, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 177.5, 138.5, 135.0, 128.5, 128.1, 127.2, 117.7, 53.2, 47.0, 46.3, 44.2, 34.9, 27.4, 26.2, 23.1; IR (Neat Film, NaCl) 2930, 1626, 1495, 1453, 1359, 1244, 913, 746 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{24}NO$ $[M+H]^+$: 258.1852, found 258.1853.



S2b ***7n***

3-allyl-1-benzylazepan-2-one (7n):

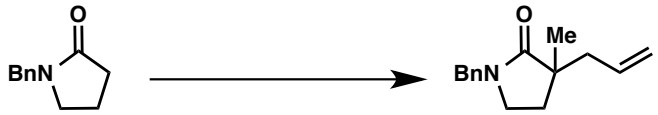
To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **S2b** (1.00 g, 4.92 mmol, 1.00 equiv) and THF (26 mL). The solution was stirred under nitrogen and cooled to –78 °C using a dry ice and acetone bath. *n*-Butyllithium (2.5 M in hexane, 2.16 mL, 5.41 mmol, 1.10 equiv) was added dropwise by syringe, and the solution was allowed to stir at –78 °C for 1 hour. Allyl bromide (510 µL, 5.90 mmol, 1.20 equiv) was then added dropwise by syringe, and the solution was allowed to gradually warm to 23 °C and stir for 17 hours. Upon completion (as determined by LCMS analysis), the reaction mixture was quenched by the addition of saturated aqueous ammonium chloride solution (100 mL), and the aqueous layer extracted with ethyl

acetate (3 x 100 mL). The combined organic layers were dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl aceate in hexanes) to provide lactam **7n** as a colorless oil (838 mg, 70% yield). R*f* = 0.2 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.28 (m, 2H), 7.27–7.22 (m, 3H), 5.88 (dddd, *J* = 17.1, 10.2, 7.9, 5.6 Hz, 1H), 5.14–4.95 (m, 2H), 4.75 (d, *J* = 14.6 Hz, 1H), 4.45 (d, *J* = 14.6 Hz, 1H), 3.56–3.40 (m, 1H), 3.17 (dddd, *J* = 15.3, 5.7, 2.1, 1.1 Hz, 1H), 2.66 (dtt, *J* = 14.3, 5.7, 1.5 Hz, 1H), 2.59 (dtd, *J* = 10.4, 6.7, 6.0, 1.5 Hz, 1H), 2.12 (dtt, *J* = 14.0, 7.6, 1.1 Hz, 1H), 1.92–1.83 (m, 1H), 1.76 (dtd, *J* = 13.9, 4.7, 1.3 Hz, 1H), 1.64 (ddt, *J* = 13.9, 5.3, 4.0 Hz, 1H), 1.51 (dtt, *J* = 13.8, 12.4, 3.9 Hz, 1H), 1.34 (dddd, *J* = 13.8, 12.5, 10.5, 3.1 Hz, 1H), 1.28–1.12 (m, 1H); ^{13}C NMR (CDCl3, 126 MHz) δ 176.7, 138.2, 137.5, 128.6, 128.3, 127.3, 116.3, 51.2, 48.1, 43.5, 36.8, 29.5, 29.3, 27.6; IR (Neat Film, NaCl) 2929, 1646, 1477, 1430, 1358, 1263, 1217, 912, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{22}NO$ $[M+H]^+$: 244.1696, found 244.1708.

S2c ***7o***

3-allyl-1-benzyl-3-methylazepan-2-one (7o):

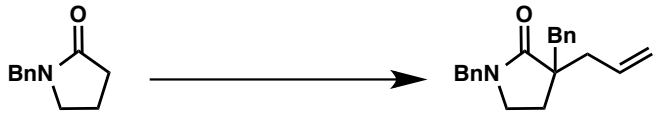
Lactam **7o** was prepared from **S2c** using General Procedure B. R*f* = 0.4 (20% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.19 (m, 5H), 5.73 (dddd, *J* = 16.8, 10.1, 8.3, 6.5 Hz, 1H), 5.16–4.97 (m, 2H), 4.47 (d, *J* = 14.6 Hz, 1H), 4.42 (d, *J* = 14.6 Hz, 1H), 3.13–3.03 (m, 2H), 2.35 (ddt, *J* = 13.6, 6.5, 1.3 Hz, 1H), 2.19 (ddt, *J* = 13.5, 8.3, 1.0 Hz, 1H), 1.97–1.86 (m, 1H), 1.86–1.77 (m, 1H), 1.64 (dq, *J* = 13.7, 7.5 Hz, 1H), 1.52 (dq, *J* = 13.7, 7.4 Hz, 1H), 0.87 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 177.7, 136.8, 134.3, 128.7, 128.3, 127.6, 118.3, 48.2, 46.8, 43.9, 41.6, 30.0, 26.8, 8.8; IR (Neat Film, NaCl) 3065, 2965, 1684, 1495, 1430, 1265, 1080, 1001, 916, 743 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{22}NO$ $[M+H]^+$: 244.1696, found 244.1705.



S2c ***7p***

3-allyl-1-benzyl-3-methylpyrrolidin-2-one (7p):

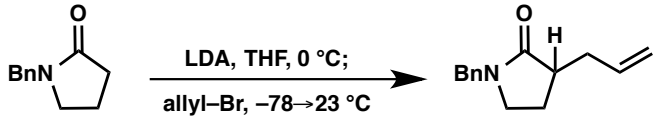
Lactam **7p** was prepared from **S2c** using General Procedure B. R*f* = 0.4 (40% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.35–7.19 (m, 5H), 5.74 (dddd, *J* = 16.9, 10.1, 8.1, 6.7 Hz, 1H), 5.15–4.98 (m, 2H), 4.46 (d, *J* = 14.7 Hz, 1H), 4.42 (d, *J* = 14.6 Hz, 1H), 3.19–3.01 (m, 2H), 2.33 (ddt, *J* = 13.6, 6.6, 1.3 Hz, 1H), 2.21 (ddt, *J* = 13.7, 8.1, 1.0 Hz, 1H), 1.99 (ddd, *J* = 12.8, 8.2, 6.4 Hz, 1H), 1.69 (ddd, *J* = 12.8, 7.9, 5.5 Hz, 1H), 1.16 (s, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 178.7, 136.9, 134.3, 128.8, 128.3, 127.7, 118.5, 47.0, 44.2, 43.6, 42.4, 30.6, 23.3; IR (Neat Film, NaCl) 2962, 1685, 1495, 1430, 1290, 917, 739 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{15}H_{20}NO$ $[M+H]^+$: 230.1539, found 230.1539.



S2c ***7q***

3-allyl-1,3-dibenzylpyrrolidin-2-one (7q):

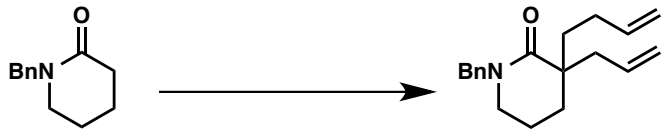
Lactam **7q** was prepared from **S2c** using General Procedure B. R*f* = 0.6 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.29–7.15 (m, 8H), 7.09–7.03 (m, 2H), 5.79 (dddd, *J* = 16.7, 10.1, 8.5, 6.2 Hz, 1H), 5.18–5.07 (m, 2H), 4.47 (d, *J* = 14.7 Hz, 1H), 4.16 (d, *J* = 14.7 Hz, 1H), 3.09 (d, *J* = 13.2 Hz, 1H), 2.86 (td, *J* = 9.2, 4.9 Hz, 1H), 2.63 (d, *J* = 13.2 Hz, 1H), 2.52 (ddt, *J* = 13.6, 6.3, 1.4 Hz, 1H), 2.39–2.19 (m, 2H), 1.98–1.78 (m, 2H); ^{13}C NMR (CDCl3, 126 MHz) δ 177.0, 137.0, 136.4, 134.0, 130.3, 128.6, 128.2, 128.2, 127.4, 126.6, 118.8, 49.5, 46.8, 43.8, 43.2, 42.8, 26.1; IR (Neat Film, NaCl) 2915, 1771, 1683, 1495, 1436, 1249, 917, 744 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{21}H_{24}NO$ $[M+H]^+$: 306.1852, found 306.1857.



S2c **(83% yield)** ***7r***

3-allyl-1-benzylpyrrolidin-2-one (7o):

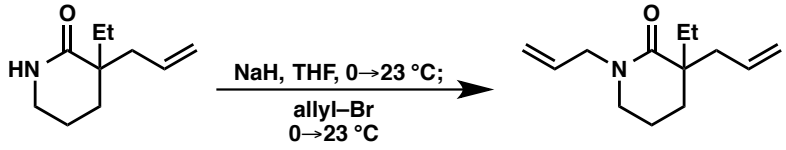
To a flame-dried round-bottom flask with a magnetic stir bar were added diisopropylamine (479 μL, 3.42 mmol, 1.20 equiv) and THF (1.72 mL) by syringe. The solution was stirred under nitrogen and cooled to 0 °C using an ice water bath. *n*-Butyllithium (2.5 M in hexane, 1.36 mL, 3.39 mmol, 1.19 equiv) was added rapidly dropwise by syringe, and the solution was allowed to stir at 0 °C for 20 minutes. Meanwhile, lactam **S2c** (500 mg, 2.85 mmol, 1.00 equiv) was dissolved in THF (9 mL) in a flame-dried round-bottom flask under nitrogen and cooled to 0 °C using an ice water bath. The freshly prepared LDA solution was transferred to the lactam solution rapidly dropwise via syringe, and the mixture was allowed to stir at 0 °C for 45 minutes. The solution was then cooled to –78 °C using a dry ice and acetone bath, and allyl bromide (321 μL, 3.71 mmol, 1.30 equiv) was added dropwise by syringe. The flask was placed in an ice water bath, allowed to gradually warm to 23 °C, and stirred for 20 hours. Upon completion (as determined by TLC analysis), the reaction mixture was quenched by the addition of saturated aqueous ammonium chloride solution (100 mL), and the aqueous layer extracted with chloroform (3 x 100 mL). The combined organic layers were washed with 1 M aqueous hydrochloric acid (2 x 100 mL), water (1 x 100 mL), brine (1 x 100 mL), dried over sodium sulfate, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl aceate in hexanes) to provide lactam **7o** as a colorless oil (509 mg, 83% yield). R*f* = 0.3 (20% ethyl acetate in hexanes); characterization data match those reported in the literature.[9]



S2a ***7s***

3-allyl-1-benzyl-3-(but-3-en-1-yl)piperidin-2-one (7s):

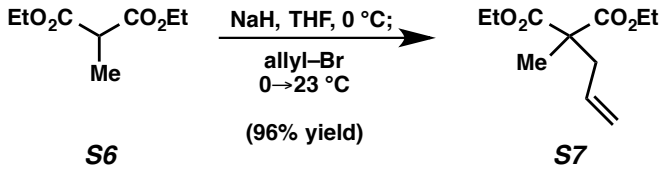
Lactam **7s** was prepared from **S2a** using General Procedure B. R*f* = 0.6 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.35–7.26 (m, 2H), 7.26–7.21 (m, 3H), 5.94–5.45 (m, 2H), 5.17–4.87 (m, 4H), 4.68–4.46 (m, 2H), 3.24–3.10 (m, 2H), 2.58 (ddt, *J* = 13.5, 6.8, 1.3 Hz, 1H), 2.26 (ddt, *J* = 13.5, 8.0, 1.0 Hz, 1H), 2.19–2.00 (m, 2H), 1.88 (ddd, *J* = 13.4, 11.9, 5.0 Hz, 1H), 1.82–1.65 (m, 4H), 1.65 (s, 1H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.2, 138.9, 137.7, 134.7, 128.6, 128.2, 127.4, 118.1, 114.5, 50.7, 47.8, 44.9, 43.6, 38.2, 29.6, 28.9, 19.8; IR (Neat Film, NaCl) 3073, 2940, 1633, 1495, 1453, 1352, 1193, 998, 911, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{26}NO$ $[M+H]^+$: 284.2009, found 284.2014.



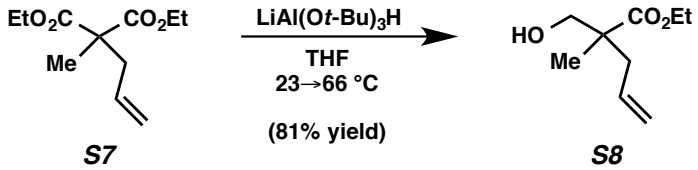
7h **(>99% yield)** ***7t***

1,3-diallyl-3-ethylpiperidin-2-one (7t):

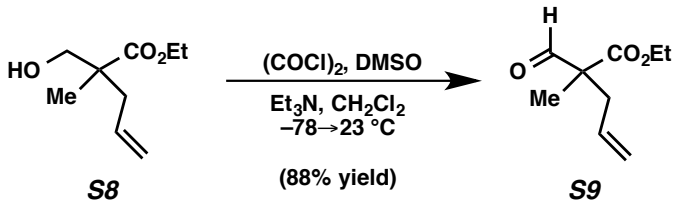
To a flame-dried round-bottom flask with a magnetic stir bar were added lactam **7h** (500 mg, 3.35 mmol, 1.00 equiv) and THF (17 mL). The flask was capped with a rubber septum, put under an argon atmosphere, and cooled to 0 °C using an ice water bath. Sodium hydride (60% dispersion in mineral oil, 268 mg, 6.70 mmol, 2.00 equiv) was then added in one portion, and the suspension was allowed to warm to 23 °C and stir for 2 hours. The suspension was then cooled to 0 °C using an ice water bath, and allyl bromide (320 μL, 3.69 mmol, 1.10 equiv) was added by syringe. The suspension was allowed to warm to 23 °C and stir for 13 hours. Upon completion (as determined by TLC analysis), the reaction mixture was diluted with water (100 mL) and extracted with ethyl acetate (3 x 100 mL). The combined organic layers were washed with brine (1 x 100 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (10% ethyl acetate in hexanes) to provide lactam **7t** as a colorless oil (690 mg, >99% yield). R*f* = 0.4 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 5.78–5.63 (m, 2H), 5.13–5.05 (m, 2H), 5.03 (ddt, *J* = 4.6, 2.3, 1.3 Hz, 1H), 5.00 (h, *J* = 1.1 Hz, 1H), 3.94 (dq, *J* = 5.9, 1.4 Hz, 2H), 3.30–2.98 (m, 2H), 2.47 (ddt, *J* = 13.5, 6.6, 1.3 Hz, 1H), 2.14 (ddt, *J* = 13.5, 8.1, 1.0 Hz, 1H), 1.89–1.58 (m, 5H), 1.45 (dq, *J* = 13.5, 7.4 Hz, 1H), 0.83 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.1, 135.0, 133.2, 117.7, 116.8, 49.9, 47.8, 45.2, 43.3, 31.5, 28.9, 19.9, 8.8; IR (Neat Film, NaCl) 3075, 2939, 1635, 1488, 1441, 1356, 1269, 1200, 998, 914 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{13}H_{22}NO$ $[M+H]^+$: 208.1696, found 208.1705.



diethyl 2-allyl-2-methylmalonate (S7):
To a flame-dried round-bottom flask with a magnetic stir bar were added sodium hydride (60% dispersion in mineral oil, 2.20 g, 55.0 mmol, 1.10 equiv) and THF (200 mL). The flask was capped with a rubber septum, put under an argon atmosphere, and cooled to 0 °C using an ice water bath. Diethyl methylmalonate (**S6**, 8.52 mL, 50.0 mmol, 1.00 equiv) was added dropwise by syringe, and the suspension was stirred at 0 °C for 1 hour. Allyl bromide (5.19 mL, 60.0 mmol, 1.20 equiv) was then added dropwise by syringe, and the suspension was allowed to warm to 23 °C and stir for 15 hours. Upon completion (as determined by TLC analysis), the reaction mixture was diluted with ethyl acetate (400 mL) and extracted with water (1 x 300 mL). The organic layer was concentrated, and the crude residue was purified by silica gel column chromatography (5% ethyl acetate in hexanes) to provide malonate **S7** as a colorless oil (10.30 g, 96% yield). R*f* = 0.4 (25% ethyl acetate in hexanes); characterization data match those reported in the literature.[10]

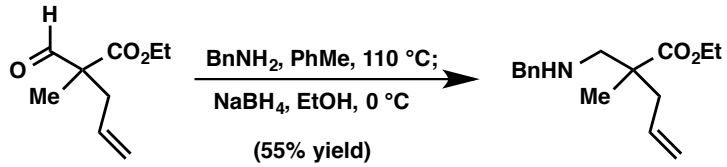


ethyl 2-(hydroxymethyl)-2-methylpent-4-enoate (S8):
To a flame-dried round-bottom flask with a magnetic stir bar were added malonate **S7** (4.00 g, 18.7 mmol, 1.00 equiv) and THF (75 mL). The flask was capped with a rubber septum and put under an argon atmosphere. A solution of lithium tri-*tert*-butoxyaluminum hydride (10.44 g, 41.1 mmol, 2.20 equiv) in THF (41 mL) was added, and the resulting mixture was heated to 65 °C for 26 hours. At this point, although TLC analysis did not show full consumption of **S7**, the mixture was quenched with 200 mL 10% aqueous sodium bisulfate. The mixture was extracted with ethyl acetate (3 x 200 mL), and the combined organic layers were dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl acetate in hexanes) to provide alcohol **S8** as a colorless oil (2.60 g, 81% yield). R*f* = 0.3 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 5.90–5.29 (m, 1H), 5.10 (ddt, *J* = 6.6, 2.1, 1.2 Hz, 1H), 5.07 (q, *J* = 1.2 Hz, 1H), 4.17 (qt, *J* = 7.1, 1.3 Hz, 2H), 3.68 (dd, *J* = 11.4, 1.0 Hz, 1H), 3.53 (dd, *J* = 11.3, 1.1 Hz, 1H), 2.39–2.32 (bs, 1H), 2.34 (ddt, *J* = 7.5, 2.3, 1.1 Hz, 2H), 1.28 (td, *J* = 7.1, 1.1 Hz, 3H), 1.17 (d, *J* = 1.0 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 176.8, 133.4, 118.6, 67.9, 60.9, 47.6, 40.1, 19.6, 14.3; IR (Neat Film, NaCl) 3461, 3078, 2980, 1722, 1641, 1467, 1369, 1324, 1218, 1146, 1044, 918, 862 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_9H_{17}O_3$ $[M+H]^+$: 173.1178, found 173.1177.



S8 ***S9***

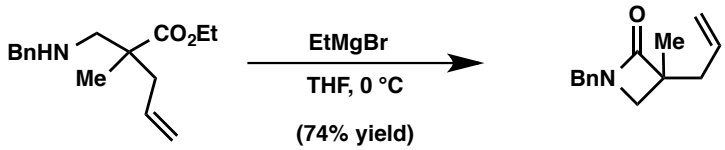
ethyl 2-formyl-2-methylpent-4-enoate (S9):
To a flame-dried round-bottom flask with a magnetic stir bar were added oxalyl chloride (1.11 mL, 13.1 mmol, 1.00 equiv) and dichloromethane (90 mL). The flask was capped with a rubber septum, put under an argon atmosphere, and cooled to –78 °C using a dry ice and acetone bath. DMSO (1.86 mL, 26.24 mmol, 2.00 equiv) was added dropwise by syringe, and the solution was stirred at –78 °C for 1 hour. A solution of alcohol **S8** (2.26 g, 13.1 mmol, 1.00 equiv) in dichloromethane (45 mL) was added dropwise by syringe, and the solution was stirred at–78 °C for 45 minutes. Triethylamine (9.14 mL, 65.6 mmol, 5.00 equiv) was added dropwise by syringe. The solution was stirred at –78 °C for 10 minutes, warmed to 0 °C over approximately 30 minutes, and allowed to warm to 23 °C over approximately 1 hour. Upon completion (as determined by TLC analysis), the reaction was quenched with 2 M aqueous hydrochloric acid (200 mL). The organic layer was washed with saturated aqueous sodium bicarbonate (200 mL), dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (10% ethyl acetate in hexanes) to provide aldehyde **S9** as a colorless oil (1.87 g, 88% yield). R*f* = 0.7 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.61 (s, 1H), 5.61 (ddt, *J* = 16.8, 10.2, 7.4 Hz, 1H), 5.08–5.04 (m, 1H), 5.04–5.01 (m, 1H), 4.14 (qd, *J* = 7.1, 1.0 Hz, 2H), 2.60–2.49 (m, 1H), 2.48–2.38 (m, 1H), 1.23 (s, 3H), 1.21 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 199.1, 171.6, 131.8, 119.4, 61.4, 57.3, 38.5, 16.7, 14.1; IR (Neat Film, NaCl) 3450, 3081, 2983, 2730, 1722, 1641, 1457, 1374, 1299, 1233, 1150, 1021, 924, 858 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_9H_{15}O_3$ $[M+H]^+$: 171.1021, found 171.1021.



S9 ***S10***

ethyl 2-((benzylamino)methyl)-2-methylpent-4-enoate (S10):
To a round-bottom flask with a magnetic stir bar were added aldehyde **S9** (1.74 g, 10.2 mmol, 1.00 equiv), toluene (16 mL), and benzylamine (1.17 mL, 10.7 mmol, 1.05 equiv). The solution was refluxed for 10 hours using a Dean–Stark trap. The solution was then allowed to cool to 23 °C and concentrated in vacuo. The residue was dissolved in ethanol (31 mL) and cooled to 0 °C using an ice water bath. Sodium borohydride (772 mg, 20.4 mmol, 2.00 equiv relative to **S9**) was added, and the mixture was stirred at 0 °C for 3 hours. Upon completion (as determined by TLC analysis), the mixture was diluted with water (200 mL) and extracted with ethyl acetate (3 x 200 mL). The combined organic layers were dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (10% ethyl acetate in hexanes) to provide amine **S10** as a colorless oil (1.47 g, 55% yield). R*f* = 0.3 (10% ethyl acetate

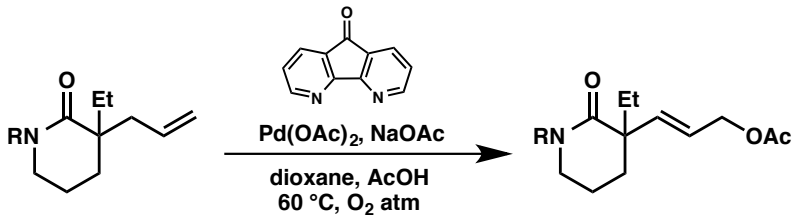
in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.30 (m, 4H), 7.26–7.23 (m, 1H), 5.72 (ddt, *J* = 16.6, 10.4, 7.4 Hz, 1H), 5.06 (ddt, *J* = 7.9, 2.1, 1.2 Hz, 1H), 5.03 (t, *J* = 1.2 Hz, 1H), 4.14 (q, *J* = 7.1 Hz, 2H), 3.79 (s, 2H), 2.78 (d, *J* = 11.8 Hz, 1H), 2.61 (d, *J* = 11.8 Hz, 1H), 2.39 (ddt, *J* = 13.7, 7.2, 1.2 Hz, 1H), 2.28 (ddt, *J* = 13.6, 7.6, 1.1 Hz, 1H), 1.47 (d, *J* = 79.2 Hz, 1H), 1.25 (t, *J* = 7.1 Hz, 3H), 1.18 (s, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 176.6, 140.7, 134.0, 128.4, 128.1, 126.9, 118.1, 60.5, 56.1, 54.4, 47.1, 41.4, 20.7, 14.4; IR (Neat Film, NaCl) 2978, 1727, 1640, 1453, 1213, 1145, 1028, 917, 737, 698 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{24}NO_2$ [M+H]$^+$: 262.1802, found 262.1812.



S10 ***7u***

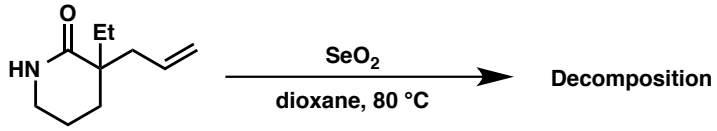
3-allyl-1-benzyl-3-methylazetidin-2-one (7u):
The conditions for this transformation were adapted from a known procedure. To a flame-dried round-bottom flask with a magnetic stir bar were added amine **S10** (500 mg, 1.91 mmol, 1.00 equiv) and THF (5 mL). The flask was capped with a rubber septum, put under an argon atmosphere, and cooled to 0 °C using an ice water bath. Ethylmagnesium bromide (1 M in THF, 1.91 mL, 1.91 mmol, 1.00 equiv) was added dropwise, and the solution was stirred at 0 °C for 2 hours. At this point, although TLC analysis did not show full consumption of **S10**, the mixture was quenched with 100 mL ice-cold saturated aqueous ammonium chloride. The aqueous solution was extracted with ether (1 x 100 mL) and dichloromethane (2 x 100 mL). The combined organic layers were dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (10% ethyl acetate in hexanes) to provide lactam **7u** as a colorless oil (303 mg, 74% yield). R*f* = 0.4 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.36–7.26 (m, 3H), 7.22 (ddt, *J* = 7.4, 1.3, 0.6 Hz, 2H), 5.77 (dddd, *J* = 16.9, 10.1, 7.8, 6.7 Hz, 1H), 5.15–5.04 (m, 2H), 4.44–4.28 (m, 2H), 3.04 (d, *J* = 5.3 Hz, 1H), 2.83 (d, *J* = 5.3 Hz, 1H), 2.39 (ddt, *J* = 14.0, 6.7, 1.3 Hz, 1H), 2.35 (s, 1H), 1.30 (s, 3H).; ^{13}C NMR (CDCl3, 126 MHz) δ 173.0, 135.8, 133.5, 128.8, 128.2, 127.7, 118.5, 54.2, 50.8, 45.7. 39.1, 19.5; IR (Neat Film, NaCl) 2961, 1748, 1496, 1454, 1402, 1354, 998, 920, 738, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{14}H_{18}NO$ [M+H]$^+$: 216.1383, found 216.1392.

Procedures for Unsuccessful Allylic Oxidations



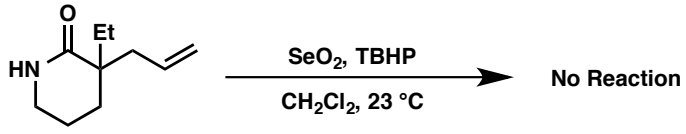
7a **R = Bn** **(low conversion)** ***8a*** **R = Bn**
7h **R = H** ***8h*** **R = H**

Allylic acetates **8a** and **8h** were prepared from **7a** and **7h** following a known procedure.[11] To a round-bottom flask with a magnetic stir bar were added, in order, sodium acetate (3.5 mg, 0.043 mmol, 0.20 equiv), palladium(II) acetate (2.4 mg, 0.011 mmol, 0.05 equiv), diazefluorenone ligand (1.9 mg, 0.011 mmol, 0.05 equiv), dioxane (600 μL), and acetic acid (190 μL). The appropriate lactam substrate (**7a** or **7h**, 0.21 mmol, 1.00 equiv) was added, and the flask was capped with a rubber septum. The solution was stirred vigorously while oxygen was bubbled through for 15 minutes. The solution was then stirred at 60 °C under an oxygen atmosphere for 41 hours. TLC analysis throughout this time showed little conversion of the starting material. After 41 hours, the reaction mixture was filtered through a plug of silica gel, rinsing with ethyl acetate, and concentrated to give the crude residue. In the case of either lactam substrate, NMR and LCMS analysis showed small amounts of the corresponding allylic acetate product (**8a** or **8h**). Characterization data for **8a** and **8h** are provided below.



7h

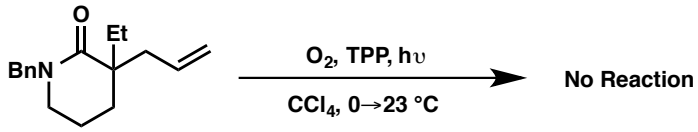
To a 1 dram screw-top vial with a magnetic stir bar were added lactam **7h** (25 mg, 0.15 mmol, 1.00 equiv) and dioxane (1.5 mL). Selenium dioxide (83 mg, 5.00 equiv) was added and the reaction mixture was stirred at 80 ºC for 2h. At this time, TLC analysis showed only baseline material, and the mixture was filtered through a plug of silica gel, rinsing with ethyl acetate. The filtrate was concentrated and NMR and LCMS analysis showed complete decomposition of the starting material.



7h

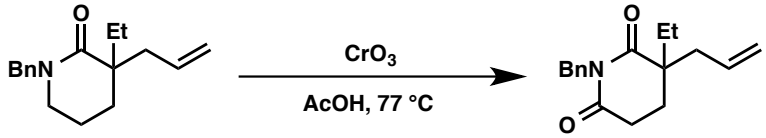
The conditions for this transformation were adapted from a known procedure.[12] To a 1 dram screw-top vial with a magnetic stir bar were added lactam **7h** (27 mg, 0.16 mmol, 1.00 equiv) and dichlomethane (1.5 mL). Selenium dioxide (9 mg, 0.08 mmol, 0.50 equiv) and TBHP (5 M in decane, 160 μL, 0.80 mmol, 5.00 equiv) were added and the reaction mixture was stirred at 23 °C for 5 hours. TLC analysis throughout this time

showed no conversion of the starting material. After 5 hours, the reaction mixture was filtered through a plug of silica gel, rinsing with ethyl acetate, and concentrated to give the crude residue. NMR and LCMS analysis showed only starting material **7h** and trace impurities.



7a

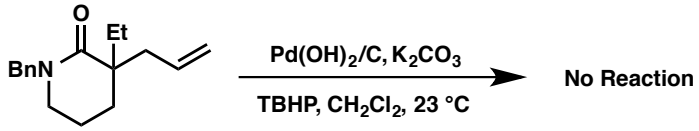
To a 1 dram screw-top vial with a magnetic stir bar were added lactam **7a** (10 mg, 0.039 mmol, 1.00 equiv) and carbon tetrachloride (2 mL). Tetraphenylporphyrin (6 mg, 0.20 mmol, 5 mM in reaction solution) was added, the vial was capped with a septum, and oxygen was bubbled through the stirring solution for 2 minutes. The vial was cooled to 0 °C using an ice water bath, and a 500 W halogen floodlight was placed at a distance d = 10 cm from the vial. The solution was irradiated and allowed to gradually warm to 23 °C over a period of 2 hours, and was further irradiated at 23 °C for an additional 12 hours. TLC analysis throughout this time showed no reactivity. After 14 hours total reaction time, the mixture was filtered through a plug of silica gel, rinsing with ethyl acetate. The filtrate was concentrated, and NMR and LCMS analysis showed only starting material **7a** and tetraphenylporphyrin.



7a ***5***

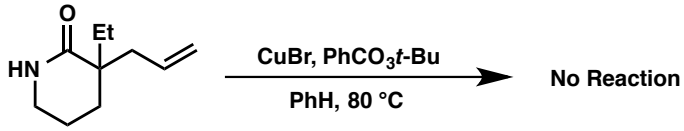
3-allyl-1-benzyl-3-ethylpiperidine-2,6-dione (5):

Imide **5** was prepared from **7a** following a known procedure.[13] Lactam **7a** (20 mg, 0.078 mmol, 1.00 equiv) was dissolved in 3.1 mL acetic acid in a 20 mL vial with a stir bar and heated to 77 °C. A solution of chromium(VI) oxide (31 mg, 0.31 mmol, 4.00 equiv) in acetic acid (1.6 mL) was added dropwise by pipette. The vial was sealed with a Teflon-lined cap and stirred at 77 °C for 1 hour. LCMS analysis at 1 hour showed full conversion of the starting material. The mixture was cooled to 23 °C, and filtered through a plug of silica gel, rinsing with ethyl acetate. The filtrate was diluted with heptanes and concentrated. The crude residue was purified by silica gel column chromatography (20% ethyl aceate in hexanes) to provide imide **5** as a colorless oil (6.6 mg, 31% yield). Rf = 0.6 (25% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.34–7.26 (m, 4H), 7.25–7.20 (m, 1H), 5.66 (dddd, J = 17.0, 10.2, 7.8, 6.9 Hz, 1H), 5.13–5.00 (m, 2H), 4.95 (s, 2H), 2.79–2.63 (m, 2H), 2.49 (ddt, J = 13.8, 6.9, 1.3 Hz, 1H), 2.29 (ddt, J = 13.9, 7.8, 1.1 Hz, 1H), 1.92–1.77 (m, 2H), 1.72 (dq, J = 14.0, 7.5 Hz, 1H), 1.68–1.58 (m, 1H), 0.84 (t, J = 7.5 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 176.5, 172.2, 137.7, 133.0, 128.7, 128.5, 127.4, 119.3, 45.2, 43.2, 40.2, 29.3, 28.7, 24.8, 8.3; IR (Neat Film, NaCl) 2967, 1722, 1676, 1455, 1345, 1164 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{22}NO_2$ $[M+H]^+$: 272.1645, found 272.1632.



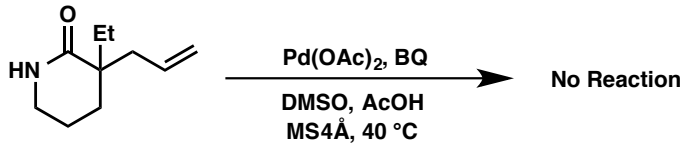
7a

The conditions for this transformation were adapted from a known procedure.[14] To an oven-dried 1 dram screw-top vial with a magnetic stir bar were added, in order, lactam **7a** (35 mg, 0.14 mmol, 1.00 equiv) potassium carbonate (5 mg, 0.036 mmol, 0.26 equiv), and dichloromethane (750 μL). Palladium hydroxide on carbon (20 wt. %, 11 mg) and *tert*-butyl hydroperoxide (5.0 M in decane, 137 μL, 0.69 mmol, 5.00 equiv) were added. The vial was sealed with a Teflon-lined cap and the reaction mixture was stirred at 23 °C for 48 hours. TLC analysis throughout this time showed very little conversion of the starting material. After 48 hours, the mixture was filtered through Celite, rinsing first with dichloromethane and later with ethyl acetate. The filtrate was concentrated and NMR and LCMS analysis showed starting material **7a** with trace impurities.



7h

The conditions for this transformation were adapted from a known procedure.[15] To a 1 dram screw-top vial with a magnetic stir bar were added lactam **7h** (17 mg, 0.10 mmol, 1.00 equiv) and benzene (1 mL). Copper(I) bromide (16 mg, 0.11 mmol, 1.10 equiv) and *tert*-butyl peroxybenzoate (110 μL, 0.60 mmol, 6.00 equiv) were added and the reaction mixture was heated to 80 °C and stirred for 5 hours. TLC and LCMS analysis throughout this time showed no conversion of the starting material. After 5 hours, the mixture was filtered through a plug of silica gel, rinsing with ethyl acetate. The filtrate was concentrated and NMR and LCMS analysis showed only starting material **7h**.



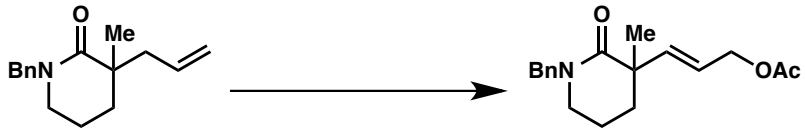
7h

The conditions for this reaction were adapted from a known procedure.[16] To a round-bottom flask with a magnetic stir bar were added, in order, palladium(II) acetate (5.5 mg, 0.025 mmol, 0.10 equiv), benzoquinone (53 mg, 0.50 mmol, 2.00 equiv), and activated 4 Å molecular sieves (53 mg). DMSO (740 μL), lactam **7h** (41 mg, 0.25 mmol, 1.00 equiv), and acetic acid (740 μL) were added. The vial was sealed with a Teflon-lined cap and heated to 40 °C for 15 hours. TLC analysis throughout this time showed no conversion of the starting material. After 15 hours, the reaction mixture was quenched with saturated aqueous ammonium chloride (10 mL) and extracted with dichloromethane (3 x 10 mL). The combined organic layers were washed with water (1 x 10 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. NMR and LCMS analysis of the crude product showed only starting material **7h** and trace impurities.

Allylic Acetate Characterization Data

7a ***8a***

(*E*)-3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)allyl acetate (8a):
Acetate **8a** was prepared from **7a** using General Procedure D. 56% isolated yield, 63% combined yield with **9a**. R*f* = 0.3 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.28 (m, 2H), 7.28–7.20 (m, 3H), 5.88 (dt, *J* = 16.0, 1.3 Hz, 1H), 5.61 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.65 (d, *J* = 14.5 Hz, 1H), 4.59–4.54 (m, 2H), 4.51 (d, *J* = 14.6 Hz, 1H), 3.26–3.04 (m, 2H), 2.06 (s, 3H), 1.95–1.84 (m, 1H), 1.84–1.70 (m, 4H), 1.70–1.59 (m, 1H), 0.85 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 172.7, 171.0, 139.5, 137.6, 128.7, 128.1, 127.4, 123.7, 65.2, 50.7, 48.5, 47.8, 31.9, 29.1, 21.2, 19.3, 8.6; IR (Neat Film, NaCl) 2939, 1738, 1634, 1495, 1453, 1361, 1231, 1028, 969, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{26}NO_3$ $[M+H]^+$: 316.1907, found 316.1913.



7b ***8b***

(*E*)-3-(1-benzyl-3-methyl-2-oxopiperidin-3-yl)allyl acetate (8b):
Acetate **8b** was prepared from **7b** using General Procedure D. 67% isolated yield, 74% combined yield with **9b**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.35–7.26 (m, 3H), 7.26–7.20 (m, 2H), 5.91 (dt, *J* = 15.8, 1.3 Hz, 1H), 5.63 (dt, *J* = 15.8, 6.2 Hz, 1H), 4.62 (d, *J* = 14.6 Hz, 1H), 4.56 (dt, *J* = 6.3, 1.5 Hz, 2H), 4.52 (d, *J* = 14.5 Hz, 1H), 3.29–3.06 (m, 2H), 2.06 (s, 3H), 1.95–1.86 (m, 1H), 1.86–1.78 (m, 1H), 1.78–1.69 (m, 2H), 1.36 (s, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 173.1, 170.9, 140.5, 137.6, 128.7, 128.1, 127.4, 123.2, 65.1, 50.6, 47.9, 44.7, 34.2, 26.6, 21.2, 19.5; IR (Neat Film, NaCl) 2936, 1738, 1634, 1489, 1453, 1361, 1232, 1028, 976, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO_3$ $[M+H]^+$: 302.1751, found 302.1755.

7c ***8c***

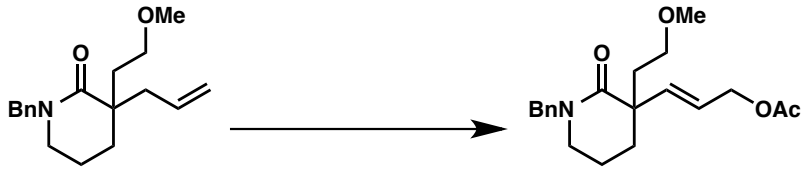
(*E*)-3-(1,3-dibenzyl-2-oxopiperidin-3-yl)allyl acetate (8c):
Acetate **8c** was prepared from **7c** using General Procedure D. 54% isolated yield, 62% combined yield with **9c**. R*f* = 0.3 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.30–7.26 (m, 2H), 7.26–7.12 (m, 8H), 5.88 (dt, *J* = 15.9, 1.4 Hz, 1H), 5.63 (dt, *J* = 15.9, 6.1 Hz, 1H), 4.76 (d, *J* = 14.6 Hz, 1H), 4.68–4.52 (m, 2H), 4.43 (d, *J* = 14.6 Hz,

1H), 3.38 (d, *J* = 13.2 Hz, 1H), 3.16–2.99 (m, 2H), 2.79 (d, *J* = 13.2 Hz, 1H), 2.08 (s, 3H), 1.87–1.53 (m, 4H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 171.8, 171.0, 139.4, 137.4, 137.3, 131.2, 128.6, 128.1, 128.0, 127.4, 126.6, 124.4, 65.0, 50.9, 49.8, 47.9, 45.0, 29.8, 21.2, 19.2; IR (Neat Film, NaCl) 2940, 1738, 1634, 1495, 1453, 1360, 1233, 1193, 1028, 979, 743 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{24}H_{28}NO_3$ $[M+H]^+$: 378.2064, found 378.2067.

7d ***8d***

(*E*)-3-(1-benzyl-2-oxo-3-propylpiperidin-3-yl)allyl acetate (8d):

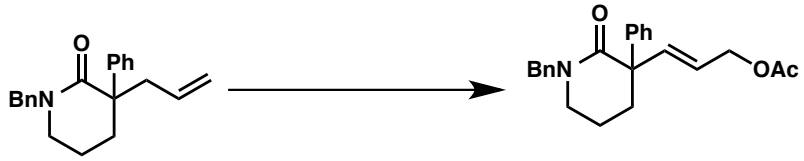
Acetate **8d** was prepared from **7d** using General Procedure D. 58% isolated yield, 66% combined yield with **9d**. R*f* = 0.3 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.34–7.26 (m, 3H), 7.26–7.20 (m, 2H), 5.89 (dt, *J* = 16.0, 1.4 Hz, 1H), 5.61 (dt, *J* = 16.0, 6.2 Hz, 1H), 4.62 (d, *J* = 14.5 Hz, 1H), 4.57 (dt, *J* = 6.3, 1.5 Hz, 2H), 4.53 (d, *J* = 14.6 Hz, 1H), 3.30–3.01 (m, 2H), 2.06 (s, 3H), 1.89–1.76 (m, 4H), 1.76–1.69 (m, 1H), 1.61 (ddd, *J* = 13.4, 12.3, 4.4 Hz, 1H), 1.39–1.14 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 172.7, 171.0, 139.8, 137.6, 128.7, 128.2, 127.4, 123.5, 65.3, 50.7, 48.4, 47.8, 41.6, 29.9, 21.2, 19.4, 17.5, 14.7; IR (Neat Film, NaCl) 2955, 1739, 1635, 1495, 1453, 1360, 1230, 1027, 979, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{20}H_{28}NO_3$ $[M+H]^+$: 330.2064, found 330.2067.



7e ***8e***

(*E*)-3-(1-benzyl-3-(2-methoxyethyl)-2-oxopiperidin-3-yl)allyl acetate (8e):

Acetate **8e** was prepared from **7e** using General Procedure D. 55% isolated yield, 61% combined yield with **9e**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.40–7.31 (m, 3H), 7.30–7.25 (m, 2H), 5.91 (dt, *J* = 15.9, 1.3 Hz, 1H), 5.68 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.69 (d, *J* = 14.5 Hz, 1H), 4.67–4.59 (m, 2H), 4.57 (d, *J* = 14.6 Hz, 1H), 3.57–3.45 (m, 2H), 3.34 (s, 3H), 3.30–3.17 (m, 2H), 2.24–2.14 (m, 1H), 2.12 (s, 3H), 2.02–1.71 (m, 5H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 172.0, 170.8, 139.0, 137.4, 128.6, 128.0, 127.3, 124.0, 69.5, 64.9, 58.5, 50.6, 47.7, 47.3, 38.4, 30.8, 21.0, 19.2; IR (Neat Film, NaCl) 2936, 2872, 1738, 1634, 1489, 1453, 1360, 1240, 1196, 1113, 1028, 972, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{20}H_{28}NO_4$ $[M+H]^+$: 346.2013, found 346.2023**.**



7f ***8f***

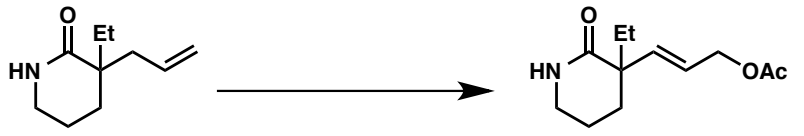
(*E*)-3-(1-benzyl-2-oxo-3-phenylpiperidin-3-yl)allyl acetate (8f):

Acetate **8f** was prepared from **7f** using General Procedure D. 62% isolated yield, 70% combined yield with **9f**. R*f* = 0.8 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.38–7.27 (m, 8H), 7.25–7.18 (m, 2H), 6.38 (dt, *J* = 16.0, 1.4 Hz, 1H), 5.69 (dt, *J* = 16.0, 6.2 Hz, 1H), 4.82 (d, *J* = 14.4 Hz, 1H), 4.64 (dt, *J* = 6.2, 1.2 Hz, 2H), 4.54 (d, *J* = 14.4 Hz, 1H), 3.34–3.12 (m, 2H), 2.32–2.13 (m, 2H), 2.08 (s, 3H), 1.83–1.71 (m, 1H), 1.71–1.59 (m, 1H); ^{13}C NMR (CDCl3, 126 MHz) δ 171.4, 171.0, 143.3, 139.3, 137.4, 128.8, 128.6, 128.5, 127.6, 127.5, 126.9, 123.7, 65.2, 53.9, 51.0, 47.6, 33.3, 21.2, 18.9; IR (Neat Film, NaCl) 2934, 1737, 1636, 1494, 1445, 1352, 1231, 1195, 1027, 761, 700 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{23}H_{26}NO_3$ $[M+H]^+$: 364.1906, found 364.1901.

7g ***8g***

(*E*)-3-(3-ethyl-1-methyl-2-oxopiperidin-3-yl)allyl acetate (8g):

Acetate **8g** was prepared from **7g** using General Procedure D. 59% isolated yield, 65% combined yield with **9g**. R*f* = 0.1 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 5.83 (dt, *J* = 16.0, 1.4 Hz, 1H), 5.55 (dt, *J* = 16.0, 6.2 Hz, 1H), 4.70–4.32 (m, 2H), 3.35–3.26 (m, 1H), 3.25–3.15 (m, 1H), 2.92 (s, 3H), 2.05 (s, 3H), 1.91–1.76 (m, 5H), 1.64 (dq, *J* = 13.7, 7.5 Hz, 1H), 0.80 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 172.8, 171.0, 139.4, 123.5, 65.2, 50.5, 48.3, 35.3, 31.7, 29.1, 21.2, 19.3, 8.5; IR (Neat Film, NaCl) 2940, 1739, 1636, 1500, 1446, 1362, 1242, 1026, 981 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{13}H_{21}NO_3$ $[M+H]^+$: 240.1594, found 240.1598.



7h ***8h***

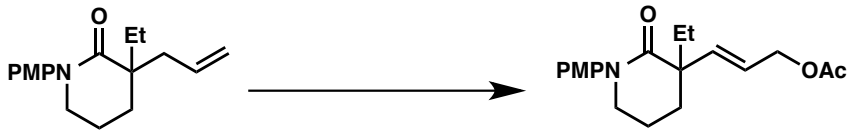
(*E*)-3-(3-ethyl-2-oxopiperidin-3-yl)allyl acetate (8h):

Acetate **8h** was prepared from **7h** using General Procedure D. 51% isolated yield, 56% combined yield with **9h**. R*f* = 0.1 (67% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 6.00 (s, 1H), 5.82 (dt, *J* = 16.0, 1.3 Hz, 1H), 5.62 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.68–4.41 (m, 2H), 3.28 (qd, *J* = 4.2, 3.6, 1.7 Hz, 2H), 2.05 (s, 3H), 1.96–1.70 (m, 5H), 1.63 (dq, *J* = 13.7, 7.5 Hz, 1H), 0.85 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 175.0, 171.0, 138.9, 123.9, 65.1, 48.2, 42.8, 31.4, 29.0, 21.2, 19.2, 8.5; IR (Neat Film,

NaCl) 3203, 2941, 1740, 1657, 1490, 1361, 1231, 1027, 980 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{12}H_{20}NO_3$ $[M+H]^+$: 226.1438, found 226.1430.

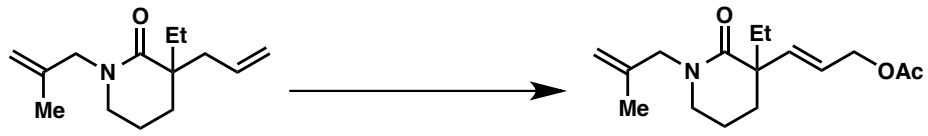
7i ***8i***

(*E*)-3-(1-benzyl-2-oxopiperidin-3-yl)allyl acetate (8i):
Acetate **8i** was prepared from **7i** using General Procedure D. 61% isolated yield. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.37–7.19 (m, 5H), 6.06 (dd, *J* = 15.7, 6.4 Hz, 1H), 5.71 (dt, *J* = 15.2, 6.3 Hz, 1H), 4.78–4.38 (m, 4H), 3.22 (t, *J* = 5.9 Hz, 2H), 3.16 (q, *J* = 7.0 Hz, 1H), 2.07 (d, *J* = 1.6 Hz, 3H), 2.06–1.70 (m, 4H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 171.0, 170.3, 137.3, 134.2, 128.7, 128.3, 127.5, 125.6, 65.1 50.5, 47.5, 44.7, 27.2, 21.4, 21.2; IR (Neat Film, NaCl) 3225, 2936, 1738, 1618, 1494, 1453, 1361, 1234, 1028, 737 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{22}NO_3$ $[M+H]^+$: 288.1594, found 288.1607.



7j ***8j***

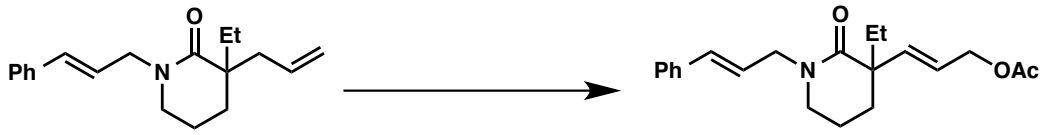
(*E*)-3-(3-ethyl-1-(4-methoxyphenyl)-2-oxopiperidin-3-yl)allyl acetate (8j):
Acetate **8j** was prepared from **7j** using General Procedure D. 54% isolated yield, 61% combined yield with **9j**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.15–7.06 (m, 2H), 6.96–6.84 (m, 2H), 5.91 (dt, *J* = 15.9, 1.3 Hz, 1H), 5.68 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.71–4.52 (m, 2H), 3.80 (s, 3H), 3.70–3.48 (m, 2H), 2.08 (s, 3H), 2.04–1.82 (m, 5H), 1.69 (dq, *J* = 13.6, 7.4 Hz, 1H), 0.90 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 173.1, 171.0, 158.2, 139.5, 136.7, 127.6, 123.7, 114.5, 65.3, 55.6, 52.5, 48.8, 32.0, 29.4, 21.2, 20.0, 8.7; IR (Neat Film, NaCl) 2939, 1739, 1645, 1607, 1511, 1464, 1294, 1243, 1030, 825 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{26}NO_4$ $[M+H]^+$: 332.1856, found 332.1871.



7k ***8k***

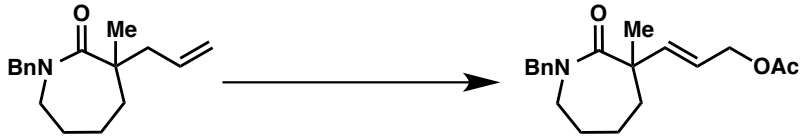
(*E*)-3-(3-ethyl-1-(2-methylallyl)-2-oxopiperidin-3-yl)allyl acetate (8k):
Acetate **8k** was prepared from **7k** using General Procedure D. 50% isolated yield, 56% combined yield with **9k**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 5.85 (dt, *J* = 15.9, 1.3 Hz, 1H), 5.60 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.86 (h, *J* = 1.3 Hz, 1H), 4.74 (qt, *J* = 1.6, 0.7 Hz, 1H), 4.63–4.49 (m, 2H), 4.02–3.95 (m, 1H), 3.94–3.87

(m, 1H), 3.32–3.05 (m, 2H), 2.06 (s, 3H), 1.95–1.74 (m, 5H), 1.73–1.49 (m, 4H), 0.84 (t, J = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 172.5, 171.0, 140.7, 139.6, 123.6, 112.0, 65.2, 52.7, 48.6, 47.7, 31.9, 29.3, 21.2, 20.2, 19.4, 8.7; IR (Neat Film, NaCl) 2939, 1740, 1636, 1489, 1441, 1362, 1230, 1198, 1025, 967, 896 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{26}NO_3$ $[M+H]^+$: 280.1907, found 280.1914.



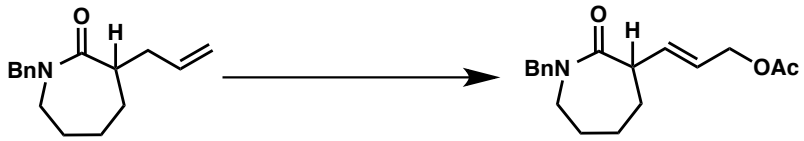
7l ***8l***

(*E*)-3-(1-cinnamyl-3-ethyl-2-oxopiperidin-3-yl)allyl acetate (8l):
Acetate **8l** was prepared from **7l** using General Procedure D. 51% isolated yield, 60% combined yield with **9l**. Rf = 0.3 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.39–7.28 (m, 4H), 7.26–7.19 (m, 1H), 6.48 (dd, J = 15.9, 1.4 Hz, 1H), 6.14 (dt, J = 15.8, 6.5 Hz, 1H), 5.87 (dt, J = 15.9, 1.3 Hz, 1H), 5.60 (dt, J = 15.9, 6.2 Hz, 1H), 4.65–4.48 (m, 2H), 4.21–4.07 (m, 2H), 3.37–3.20 (m, 2H), 2.06 (s, 3H), 1.91–1.76 (m, 4H), 1.73–1.61 (m, 2H), 0.85 (t, J = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 172.5, 171.0, 139.5, 136.7, 132.9, 128.7, 127.8, 126.5, 124.7, 123.6, 65.3, 49.6, 48.5, 47.9, 31.8, 29.1, 21.2, 19.4, 8.6; IR (Neat Film, NaCl) 2939, 1740, 1636, 1490, 1448, 1361, 1232, 1026, 967, 750, 694 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{21}H_{28}NO_3$ $[M+H]^+$: 342.2066, found 342.2077.



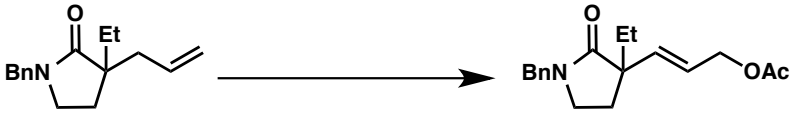
7m ***8m***

(*E*)-3-(1-benzyl-3-methyl-2-oxoazepan-3-yl)allyl acetate (8m):
Acetate **8m** was prepared from **7m** using General Procedure D. 40% isolated yield. Rf = 0.3 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.34–7.28 (m, 2H), 7.26–7.22 (m, 3H), 5.94 (dt, J = 16.0, 1.4 Hz, 1H), 5.54 (dt, J = 16.0, 6.3 Hz, 1H), 4.80 (d, J = 14.6 Hz, 1H), 4.55 (dt, J = 6.1, 1.3 Hz, 2H), 4.45 (d, J = 14.6 Hz, 1H), 3.51 (ddt, J = 15.2, 11.3, 1.1 Hz, 1H), 3.08 (ddd, J = 15.2, 5.7, 2.1 Hz, 1H), 2.03 (s, 3H), 1.84–1.64 (m, 4H), 1.64–1.52 (m, 2H), 1.35 (s, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 176.4, 170.9, 138.9, 138.4, 128.6, 128.3, 127.3, 123.3, 65.1, 53.0, 48.5, 47.6, 36.6, 27.9, 25.3, 21.1; IR (Neat Film, NaCl) 2925, 1740, 1636, 1419, 1363, 1236, 1028, 965, 745 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{26}NO_3$ $[M+H]^+$: 316.1907, found 316.1921.



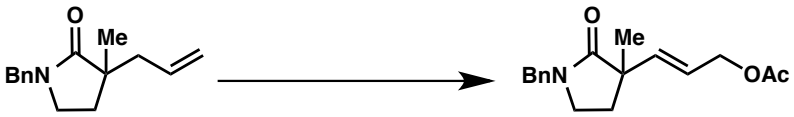
7n ***8n***

(*E*)-3-(1-benzyl-2-oxoazepan-3-yl)allyl acetate (8n):
Acetate **8n** was prepared from **7n** using General Procedure D. 53% isolated yield, 63% combined yield with **9n**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.35–7.22 (m, 5H), 6.18 (ddt, *J* = 15.6, 8.4, 1.3 Hz, 1H), 5.58 (dtd, *J* = 15.6, 6.3, 1.0 Hz, 1H), 4.71 (d, *J* = 14.6 Hz, 1H), 4.65–4.51 (m, 2H), 4.47 (d, *J* = 14.6 Hz, 1H), 3.44 (dd, *J* = 15.3, 11.1 Hz, 1H), 3.37–3.12 (m, 2H), 2.06 (s, 3H), 1.90 (dd, *J* = 11.1, 4.6 Hz, 1H), 1.84–1.71 (m, 1H), 1.71–1.57 (m, 2H), 1.36–1.17 (m, 2H); ^{13}C NMR ($CDCl_3$, 101 MHz) δ 175.5, 171.0, 137.9, 135.7, 128.7, 128.5, 127.5, 123.8, 65.2, 51.4, 48.0, 47.7, 31.1, 28.8, 27.6, 21.2; IR (Neat Film, NaCl) 2931, 1740, 1639, 1442, 1364, 1235, 1197, 1028, 972 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO_3$ $[M+H]^+$: 302.1751, found 302.1758.



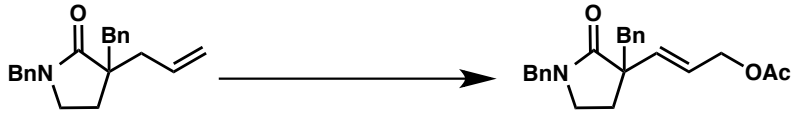
7o ***8o***

(*E*)-3-(1-benzyl-3-ethyl-2-oxopyrrolidin-3-yl)allyl acetate (8o):
Acetate **8o** was prepared from **7o** using General Procedure D. 66% isolated yield. R*f* = 0.1 (25% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.35–7.26 (m, 3H), 7.23–7.17 (m, 2H), 5.87 (dt, *J* = 15.9, 1.3 Hz, 1H), 5.64 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.61–4.52 (m, 2H), 4.50 (d, *J* = 14.7 Hz, 1H), 4.41 (d, *J* = 14.7 Hz, 1H), 3.23–3.02 (m, 2H), 2.11–2.02 (m, 1H), 2.07 (s, 3H), 2.00–1.92 (m, 1H), 1.78–1.63 (m, 1H), 0.88 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 176.2, 170.9, 136.7, 136.6, 128.8, 128.2, 127.7, 123.9, 65.0, 50.9, 46.9, 43.6, 29.7, 28.2, 21.1, 8.8; IR (Neat Film, NaCl) 2925, 1740, 1636, 1419, 1363, 1236, 1028, 965, 745 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO_3$ $[M+H]^+$: 302.1751, found 302.1759.



7p ***8p***

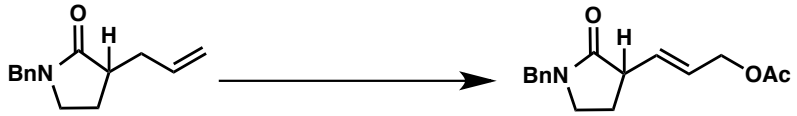
(*E*)-3-(1-benzyl-3-methyl-2-oxopyrrolidin-3-yl)allyl acetate (8p):
Acetate **8p** was prepared from **7p** using General Procedure D. 48% isolated yield, 54% combined yield with **9p**. R*f* = 0.1 (40% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.35–7.26 (m, 3H), 7.24–7.18 (m, 2H), 5.89 (dt, *J* = 15.8, 1.3 Hz, 1H), 5.66 (dt, *J* = 15.8, 6.2 Hz, 1H), 4.56 (dt, *J* = 6.2, 1.5 Hz, 2H), 4.46 (d, *J* = 3.3 Hz, 2H), 3.26–3.05 (m, 2H), 2.12 (ddd, *J* = 12.8, 7.5, 5.5 Hz, 1H), 2.07 (s, 3H), 1.89 (ddd, *J* = 12.7, 7.7, 6.4 Hz, 1H), 1.31 (s, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 176.7, 170.9, 137.5, 136.6, 128.8, 128.2, 127.7, 123.4, 64.9, 47.1, 46.7, 43.3, 32.5, 32.1, 21.1; IR (Neat Film, NaCl) 2927, 1738, 1689, 1495, 1428, 1361, 1233, 1028, 972, 740 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{22}NO_3$ $[M+H]^+$: 288.1594, found 288.1593.



7q ***8q***

(*E*)-3-(1,3-dibenzyl-2-oxopyrrolidin-3-yl)allyl acetate (8q):

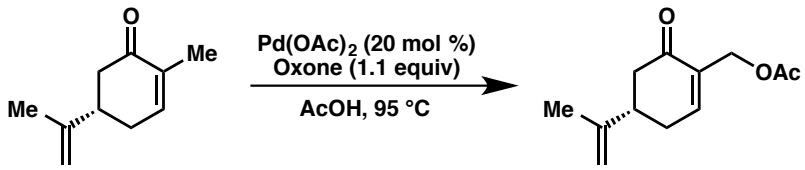
Acetate **8q** was prepared from **7q** using General Procedure D. 50% isolated yield, 58% combined yield with **9q**. R*f* = 0.2 (40% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.29–7.26 (m, 1H), 7.26–7.20 (m, 5H), 7.20–7.14 (m, 2H), 7.11–7.06 (m, 2H), 5.97 (dt, *J* = 15.9, 1.4 Hz, 1H), 5.63 (dt, *J* = 15.8, 6.1 Hz, 1H), 4.63–4.51 (m, 2H), 4.45 (d, *J* = 14.7 Hz, 1H), 4.27 (d, *J* = 14.7 Hz, 1H), 3.15 (d, *J* = 13.3 Hz, 1H), 2.98 (ddd, *J* = 9.6, 8.0, 6.2 Hz, 1H), 2.77 (d, *J* = 13.3 Hz, 1H), 2.61 (ddd, *J* = 9.6, 8.3, 4.9 Hz, 1H), 2.07 (s, 3H), 2.06–1.99 (m, 1H), 1.94 (ddd, *J* = 13.0, 8.0, 4.9 Hz, 1H); ^{13}C NMR (CDCl3, 126 MHz) δ 175.4, 170.9, 137.0, 137.0, 136.3, 130.5, 128.7, 128.2, 128.2, 127.6, 126.8, 124.1, 64.8, 51.8, 47.0, 43.5, 43.0, 28.0, 21.1; IR (Neat Film, NaCl) 2920, 1740, 1685, 1495, 1437, 1361, 1230, 1028, 973, 743 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{23}H_{26}NO_3$ $[M+H]^+$: 364.1907, found 364.1931.



7r ***8r***

(*E*)-3-(1-benzyl-2-oxopyrrolidin-3-yl)allyl acetate (8r):

Acetate **8r** was prepared from **7r** using General Procedure D. 57% isolated yield, 61% combined yield with **9r**. R*f* = 0.3 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.36–7.27 (m, 3H), 7.25–7.19 (m, 2H), 5.92 (ddt, *J* = 15.5, 6.6, 1.3 Hz, 1H), 5.76 (dtd, *J* = 15.6, 6.1, 1.4 Hz, 1H), 4.59 (dq, *J* = 6.3, 1.2 Hz, 2H), 4.49 (d, *J* = 14.6 Hz, 1H), 4.44 (d, *J* = 14.7 Hz, 1H), 3.28–3.12 (m, 3H), 2.26 (dddd, *J* = 12.8, 8.8, 6.7, 4.1 Hz, 1H), 2.08 (s, 3H), 1.91 (dq, *J* = 12.7, 8.5 Hz, 1H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.2, 170.9, 136.5, 132.2, 128.9, 128.3, 127.8, 126.7, 64.8, 47.1, 45.0, 44.9, 25.0, 21.1; IR (Neat Film, NaCl) 2923, 1735, 1685, 1430, 1363, 1238, 1027, 971 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{20}NO_3$ $[M+H]^+$: 274.1438, found 274.1447.



17 ***18***

(*S*)-(6-oxo-4-(prop-1-en-2-yl)cyclohex-1-en-1-yl)methyl acetate (18):

To a flame-dried 25 mL round-bottom flask with a magnetic stir bar were added, in order, (*S*)-carvone (**17**, 30 mg, 0.2 mmol, 1.00 equiv), palladium(II) acetate (9 mg, 0.04 mmol, 0.20 equiv), and Oxone (68 mg, 0.22 mmol, 1.10 equiv). The flask was then capped with a rubber septum and evacuated and backfilled twice with nitrogen. Acetic acid (1.00 mL) was added by syringe. The resulting suspension was stirred under nitrogen for 5 minutes at 23 °C and then heated to 95 °C in an oil bath. Although TLC analysis did not show

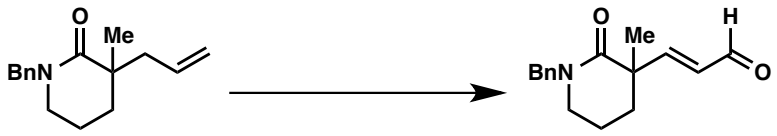
full consumption of **17**, the reaction was stopped at 16 hours. The flask was allowed to cool to 23 °C and the contents were filtered through a short plug of silica gel, rinsing with ethyl acetate. The filtrate was adsorbed onto silica gel (approx. 2 g), which was then flushed with ethyl acetate. The eluent was concentrated to give the crude product as an oil. The crude residue was purified by silica gel column chromatography (15% ethyl acetate in hexanes) to provide recovered (*S*)-carvone **(**14 mg, 0.096 mmol, 48% yield, 52% conversion) and acetate **18** as a colorless oil (8.7 mg, 21% yield, 40% yield based on recovered starting material). R*f* = 0.3 (25% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 6.75 (ddq, *J* = 5.6, 2.8, 1.4 Hz, 1H), 5.18 (q, *J* = 0.9 Hz, 1H), 5.05 (dd, *J* = 1.3, 0.7 Hz, 1H), 4.61 (dd, *J* = 12.8, 1.0 Hz, 1H), 4.59–4.53 (m, 1H), 2.87–2.74 (m, 1H), 2.64 (ddd, *J* = 16.0, 3.7, 1.6 Hz, 1H), 2.53 (dddt, *J* = 18.2, 6.0, 4.5, 1.5 Hz, 1H), 2.40 (dd, *J* = 16.1, 13.2 Hz, 1H), 2.35–2.26 (m, 1H), 2.10 (s, 3H), 1.80 (dt, *J* = 2.6, 1.4 Hz, 3H).; ^{13}C NMR ($CDCl_3$, 126 MHz) δ 199.3, 170.8, 145.4, 144.3, 135.8, 113.8, 65.9, 43.2, 38.6, 31.5, 21.1, 15.9; IR (Neat Film, NaCl) 2923, 1741, 1673, 1433, 1371, 1227, 1109, 1029, 903 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{12}H_{17}O_3$ $[M+H]^+$: 209.1178, found 209.1187.

Enal Characterization Data

7a ***9a***

(*E*)-3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)acrylaldehyde (9a):

Enal **9a** was prepared from **7a** using General Procedure E. 50% isolated yield, 56% combined yield with **8a**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.57 (d, *J* = 7.6 Hz, 1H), 7.37–7.27 (m, 3H), 7.25–7.18 (m, 2H), 7.06 (d, *J* = 16.2 Hz, 1H), 6.13 (dd, *J* = 16.2, 7.7 Hz, 1H), 4.70 (d, *J* = 14.5 Hz, 1H), 4.49 (d, *J* = 14.5 Hz, 1H), 3.45–3.05 (m, 2H), 2.03–1.89 (m, 3H), 1.85–1.69 (m, 3H), 0.88 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 194.2, 171.4, 161.9, 137.1, 131.6, 128.8, 128.1, 127.7, 50.9, 49.8, 47.7, 31.6, 28.5, 19.5, 8.6; IR (Neat Film, NaCl) 2940, 1713, 1689, 1634, 1606, 1495, 1453, 1356, 1262, 1198, 982, 735 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{22}NO_2$ [M+H]$^+$: 272.1645, found 272.1647.



7b ***9b***

(*E*)-3-(1-benzyl-3-methyl-2-oxopiperidin-3-yl)acrylaldehyde (9b):

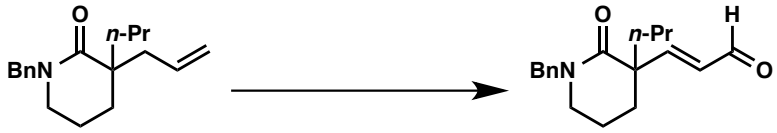
Enal **9b** was prepared from **7b** using General Procedure E. 67% isolated yield. R*f* = 0.1 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.57 (d, *J* = 7.6 Hz, 1H), 7.37–7.27 (m, 3H), 7.25–7.17 (m, 2H), 7.08 (d, *J* = 16.1 Hz, 1H), 6.15 (dd, *J* = 16.1, 7.6 Hz, 1H), 4.61 (d, *J* = 14.5 Hz, 1H), 4.56 (d, *J* = 14.5 Hz, 1H), 3.33–3.10 (m, 2H), 2.09–1.94 (m, 1H), 1.94–1.71 (m, 3H), 1.47 (s, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 194.2, 171.7, 162.5, 137.1, 130.9, 128.9, 128.2, 127.7, 50.8, 47.8, 45.8, 33.4, 26.3, 19.5; IR (Neat Film, NaCl) 2931, 1689, 1638, 1488, 1453, 1351, 1198, 1106, 978, 735, 702 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{16}H_{20}NO_2$ [M+H]$^+$: 258.1489, found 258.1500.

7c ***9c***

(*E*)-3-(1,3-dibenzyl-2-oxopiperidin-3-yl)acrylaldehyde (9c):

Enal **9c** was prepared from **7c** using General Procedure E. 50% isolated yield, 56% combined yield with **8c**. R*f* = 0.4 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.59 (d, *J* = 7.6 Hz, 1H), 7.32–7.26 (m, 4H), 7.26–7.23 (m, 2H), 7.20–7.10 (m, 4H), 7.04 (d, *J* = 16.2 Hz, 1H), 6.10 (dd, *J* = 16.1, 7.6 Hz, 1H), 4.79 (d, *J* = 14.5 Hz, 1H), 4.41 (d, *J* = 14.5 Hz, 1H), 3.46 (d, *J* = 13.3 Hz, 1H), 3.22–3.00 (m, 2H), 2.88 (d, *J* = 13.3

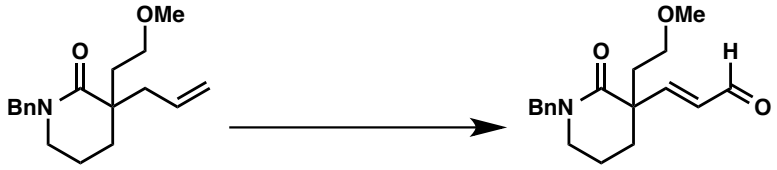
Hz, 1H), 1.99–1.77 (m, 2H), 1.79–1.61 (m, 2H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 194.0, 170.4, 161.6, 136.8, 136.2, 132.0, 131.0, 128.8, 128.3, 128.1, 127.6, 127.1, 51.2, 51.1, 47.8, 44.5, 29.3, 19.5; IR (Neat Film, NaCl) 2924, 1689, 1636, 1494, 1453, 1355, 1194, 982, 743 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{22}H_{24}NO_2$ $[M+H]^+$: 334.1802, found 334.1802.



7d ***9d***

(*E*)-3-(1-benzyl-2-oxo-3-propylpiperidin-3-yl)acrylaldehyde (9d):

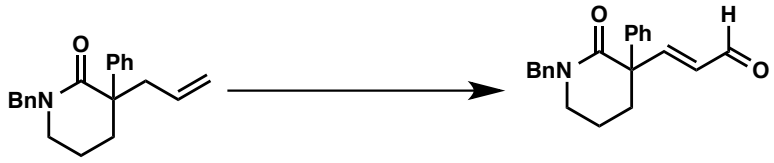
Enal **9d** was prepared from **7d** using General Procedure E. 55% isolated yield, 62% combined yield with **8d**. R*f* = 0.5 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 9.57 (d, *J* = 7.7 Hz, 1H), 7.36–7.26 (m, 3H), 7.25–7.19 (m, 2H), 7.06 (d, *J* = 16.2 Hz, 1H), 6.12 (dd, *J* = 16.2, 7.6 Hz, 1H), 4.67 (d, *J* = 14.5 Hz, 1H), 4.51 (d, *J* = 14.6 Hz, 1H), 3.40–3.03 (m, 2H), 1.93 (dd, *J* = 7.3, 4.6 Hz, 2H), 1.91–1.84 (m, 1H), 1.84–1.68 (m, 3H), 1.38–1.15 (m, 2H), 0.93 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 194.2, 171.4, 162.1, 137.1, 131.4, 128.8, 128.2, 127.7, 51.0, 49.7, 47.7, 41.1, 29.2, 19.6, 17.5, 14.5; IR (Neat Film, NaCl) 2957, 1688, 1634, 1489, 1453, 1352, 1196, 982, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO_2$ $[M+H]^+$: 286.1802, found 286.1808.



7e ***9e***

(*E*)-3-(1-benzyl-3-(2-methoxyethyl)-2-oxopiperidin-3-yl)acrylaldehyde (9e):

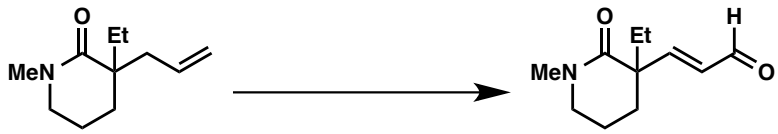
Enal **9e** was prepared from **7e** using General Procedure E. 54% isolated yield. R*f* = 0.3 (50% ethyl acetate in hexanes); 9.57 (d, *J* = 7.6 Hz, 1H), 7.36–7.27 (m, 3H), 7.25–7.21 (m, 2H), 7.03 (d, *J* = 16.1 Hz, 1H), 6.16 (dd, *J* = 16.2, 7.6 Hz, 1H), 4.71 (d, *J* = 14.5 Hz, 1H), 4.48 (d, *J* = 14.5 Hz, 1H), 3.46 (td, *J* = 6.4, 1.7 Hz, 2H), 3.28 (s, 3H), 3.26–3.16 (m, 2H), 2.22 (dt, *J* = 14.1, 6.6 Hz, 1H), 2.13–2.02 (m, 2H), 1.97 (dddd, *J* = 13.8, 6.7, 3.3, 1.1 Hz, 1H), 1.83 (ddtd, *J* = 13.5, 6.7, 5.0, 3.4 Hz, 1H), 1.79–1.66 (m, 1H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 194.1, 170.9, 161.6, 137.1, 131.6, 128.8, 128.2, 127.7, 69.2, 58.7, 51.0, 48.7, 47.8, 38.2, 30.2, 19.6; IR (Neat Film, NaCl) 2927, 1685, 1636, 1490, 1452, 1355, 1196, 1112, 979, 736 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO_3$ $[M+H]^+$: 302.1751, found 302.1759.



7f ***9f***

(*E*)-3-(1-benzyl-2-oxo-3-phenylpiperidin-3-yl)acrylaldehyde (9f):

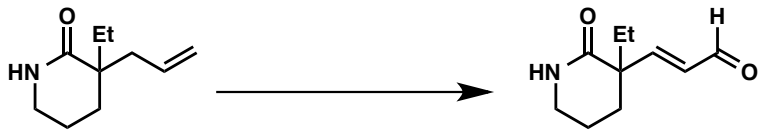
Enal **9f** was prepared from **7f** using General Procedure E. 48% isolated yield, 54% combined yield with **8f**. R*f* = 0.2 (20% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.61 (d, *J* = 7.7 Hz, 1H), 7.53 (d, *J* = 16.2 Hz, 1H), 7.42–7.26 (m, 8H), 7.25–7.21 (m, 2H), 6.17 (dd, *J* = 16.2, 7.7 Hz, 1H), 4.83 (d, *J* = 14.3 Hz, 1H), 4.59 (d, *J* = 14.3 Hz, 1H), 3.38–3.17 (m, 2H), 2.37 (ddd, *J* = 13.5, 5.5, 3.3 Hz, 1H), 2.30–2.07 (m, 1H), 1.83–1.61 (m, 2H); ^{13}C NMR (CDCl3, 126 MHz) δ 194.4, 169.9, 161.3, 140.8, 137.0, 130.5, 128.9, 128.5, 127.8, 127.6, 127.3, 54.6, 51.1, 47.4, 32.0, 18.7; IR (Neat Film, NaCl) 2937, 1683, 1634, 1494, 1446, 1352, 1196, 763 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{21}H_{22}NO_2$ $[M+H]^+$: 320.1645, found 320.1658.



7g ***9g***

(*E*)-3-(3-ethyl-1-methyl-2-oxopiperidin-3-yl)acrylaldehyde (9g):

Enal **9g** was prepared from **7g** using General Procedure E. 59% isolated yield. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.55 (d, *J* = 7.6 Hz, 1H), 7.01 (d, *J* = 16.2 Hz, 1H), 6.09 (dd, *J* = 16.2, 7.7 Hz, 1H), 3.35 (ddd, *J* = 11.9, 8.7, 5.0 Hz, 1H), 3.25 (ddd, *J* = 12.1, 5.8, 4.9 Hz, 1H), 2.95 (s, 3H), 1.97–1.72 (m, 6H), 0.84 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 194.2, 171.4, 161.9, 131.6, 50.4, 49.6, 35.5, 31.4, 28.5, 19.5, 8.5; IR (Neat Film, NaCl) 2939, 1688, 1635, 1506, 1456, 1257, 1204, 1104 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{11}H_{18}NO_2$ $[M+H]^+$: 196.1332, found 196.1328.



7h ***9h***

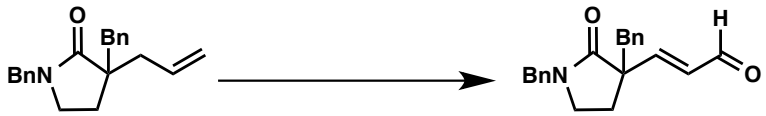
(*E*)-3-(3-ethyl-2-oxopiperidin-3-yl)acrylaldehyde (9h):

Enal **9h** was prepared from **7h** using General Procedure E. 44% isolated yield, 53% combined yield with **8h**. R*f* = 0.1 (20% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 9.55 (d, *J* = 7.6 Hz, 1H), 6.98 (d, *J* = 16.1 Hz, 1H), 6.14 (dd, *J* = 16.2, 7.6 Hz, 1H), 5.85 (s, 1H), 3.46–3.26 (m, 2H), 2.01–1.90 (m, 3H), 1.90–1.84 (m, 1H), 1.84–1.73 (m, 2H), 0.90 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 194.1, 173.4, 161.1, 131.8, 49.4, 42.8, 31.1, 28.3, 19.3, 8.4; IR (Neat Film, NaCl) 3287, 2941, 1687, 1662,

1489, 1464, 1354, 1107, 983 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{10}H_{16}NO_2$ $[M+H]^+$: 182.1176, found 182.1177.

7j ***9j***

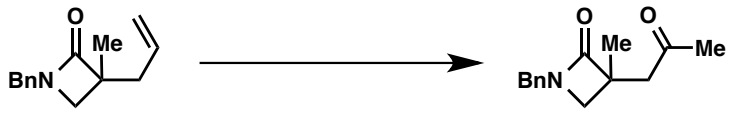
(*E*)-3-(3-ethyl-1-(4-methoxyphenyl)-2-oxopiperidin-3-yl)acrylaldehyde (9j):
Enal **9j** was prepared from **7j** using General Procedure E. 53% isolated yield, 58% combined yield with **8j**. R*f* = 0.2 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 9.58 (d, *J* = 7.6 Hz, 1H), 7.14–7.10 (m, 2H), 7.07 (d, *J* = 16.2 Hz, 1H), 6.94–6.87 (m, 2H), 6.19 (dd, *J* = 16.2, 7.6 Hz, 1H), 3.81 (s, 3H), 3.66 (ddd, *J* = 12.1, 8.7, 5.0 Hz, 1H), 3.62–3.52 (m, 1H), 2.16–1.89 (m, 5H), 1.83 (dq, *J* = 13.7, 7.5 Hz, 1H), 0.94 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 194.2, 171.7, 161.9, 158.4, 136.2, 131.6, 127.5, 114.6, 55.6, 52.5, 50.1, 31.7, 28.7, 20.1, 8.6; IR (Neat Film, NaCl) 2938, 1685, 1647, 1510, 1295, 1243, 1130, 1032, 982, 827 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{22}NO_3$ $[M+H]^+$: 288.1594, found 288.1604.



7q ***9q***

(*E*)-3-(1,3-dibenzyl-2-oxopyrrolidin-3-yl)acrylaldehyde (9q):
Enal **9q** was prepared from **7q** using General Procedure E. 30% isolated yield. R*f* = 0.4 (33% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 9.58 (d, *J* = 7.6 Hz, 1H), 7.30–7.26 (m, 3H), 7.26–7.22 (m, 3H), 7.20–7.14 (m, 2H), 7.12–7.04 (m, 3H), 6.12 (dd, *J* = 16.0, 7.6 Hz, 1H), 4.45 (d, *J* = 14.7 Hz, 1H), 4.26 (d, *J* = 14.6 Hz, 1H), 3.24 (d, *J* = 13.4 Hz, 1H), 3.07–2.88 (m, 1H), 2.83 (d, *J* = 13.4 Hz, 1H), 2.69–2.52 (m, 1H), 2.18 (ddd, *J* = 13.3, 8.2, 5.2 Hz, 1H), 2.11–1.98 (m, 1H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 193.8, 173.8, 158.9, 135.9, 131.7, 130.4, 128.9, 128.6, 128.3, 127.9, 127.4, 53.1, 47.3, 43.5, 42.8, 27.4; IR (Neat Film, NaCl) 2921, 1738, 1683, 1495, 1454, 1246, 981, 745, 702 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{21}H_{22}NO_2$ $[M+H]^+$: 320.1645, found 320.1640.

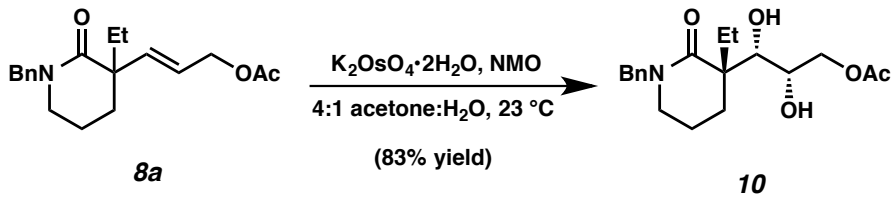
Attempted Enal Formation on 18



7u ***16***

1-benzyl-3-methyl-3-(2-oxopropyl)azetidin-2-one (16):
Ketone **16** was prepared from **17** using General Procedure E (0.2 mmol **7u**, 1.5 hour reaction time). 45% isolated yield. R*f* = 0.1 (25% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.39–7.27 (m, 3H), 7.25–7.21 (m, 2H), 4.40 (d, *J* = 14.9 Hz, 1H), 4.33 (d, *J* = 14.9 Hz, 1H), 3.18 (d, *J* = 5.9 Hz, 1H), 3.07–3.01 (m, 1H), 2.83 (d, *J* = 17.6 Hz, 1H), 2.72 (d, *J* = 17.6 Hz, 1H), 2.16 (s, 3H), 1.35 (s, 3H).; ^{13}C NMR ($CDCl_3$, 126 MHz) δ 206.3, 172.5, 135.7, 129.0, 128.3, 127.9, 52.3, 51.5, 46.8, 45.9, 31.0, 19.6; IR (Neat Film, NaCl) 2961, 2894, 1746, 1716, 1455, 1410, 1361, 1177, 739, 700 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{14}H_{18}NO_2$ $[M+H]^+$: 232.1332, found 232.1333.

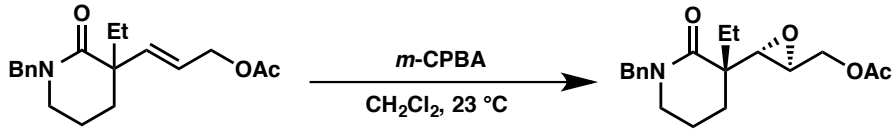
Allylic Acetate Derivitization Procedures and Characterization Data



8a ***10***

3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)-2,3-dihydroxypropyl acetate (10):
To a 1 dram screw-top vial with a magnetic stir bar were added, in order, acetate **8a** (18 mg, 0.057 mmol, 1.00 equiv), acetone (reagent grade, 540 μL), deionized water (180 μL), potassium osmate(VI) dehydrate (2 mg, 0.006 mmol, 0.10 equiv), and 4-methylmorpholine *N*-oxide (13 mg, 0.144 mmol, 2.00 equiv). The vial was sealed with a Teflon-lined cap and the purple solution was stirred at 23 °C for 3 hours. Upon completion (as determined by TLC analysis), the reaction mixture was adsorbed onto Celite and purified by silica gel column chromatography (50% ethyl acetate in hexanes) to provide the major diastereomer **10** as colorless crystals (16.5 mg, 83% yield). R*f* = 0.3 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.36–7.30 (m, 2H), 7.29–7.26 (m, 2H), 7.26–7.23 (m, 1H), 5.96 (d, *J* = 8.5 Hz, 1H), 4.60 (d, *J* = 14.7 Hz, 1H), 4.56 (d, *J* = 14.8 Hz, 1H), 4.28 (dd, *J* = 11.5, 7.5 Hz, 1H), 4.22 (dd, *J* = 11.5, 4.8 Hz, 1H), 3.96 (dddd, *J* = 9.6, 7.5, 4.8, 1.5 Hz, 1H), 3.52 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.31–3.07 (m, 2H), 2.27 (d, *J* = 9.7 Hz, 1H), 2.10 (s, 3H), 2.03–1.93 (m, 1H), 1.93–1.85 (m, 1H), 1.85–1.77 (m, 2H), 1.77–1.63 (m, 2H), 0.92 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 176.9, 171.3, 136.7, 128.8, 128.1, 127.6, 75.8, 69.8, 67.5, 50.5, 47.1, 45.4, 30.2, 27.3, 21.2, 20.0, 8.1; IR (Neat Film, NaCl) 3382, 2936, 2878, 1736, 1606, 1495, 1453, 1362, 1248, 1206, 1039, 737 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{28}NO_5$ $[M+H]^+$: 350.1962, found 350.1977.

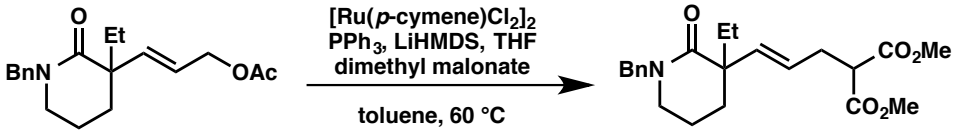
Colorless, translucent X-ray quality crystals of diol **10** were obtained by slow diffusion of 2% benzene in pentane into a solution of **10** in ether at –20 °C, mp: 86–88 °C.



8a ***11***

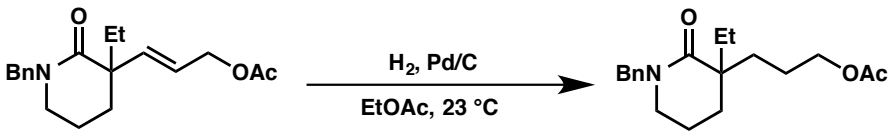
(3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)oxiran-2-yl)methyl acetate (11):
To a 1 dram screw-top vial with a magnetic stir bar were added, in order, acetate **8a** (10 mg, 0.032 mmol, 1.00 equiv), 3-chloroperbezoic acid (54 mg, 0.32 mmol, 10.00 equiv), and dichloromethane (320 μL). The vial was sealed with a Teflon-lined cap and the pale yellow solution was stirred at 23 °C for 12 hours. Upon completion (as determined by TLC analysis), the reaction mixture was diluted with dichloromethane (3 mL) and quenched with saturated aqueous sodium thiosulfate (3 mL). The organic layer was separated and washed with saturated aqueous sodium bicarbonate solution (3 x 3 mL), dried over sodium sulfate, filtered, and concentrated in vacuo. NMR analysis of the crude reaction mixture showed a single diasteromer. The crude was residue purified by

silica gel column chromatography (25% ethyl acetate and 1% triethylamine in hexanes) to provide epoxide **11** as a colorless oil (9.9 mg, 93% yield, single diastereomer). R*f* = 0.5 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.36–7.27 (m, 3H), 7.24 (ddt, *J* = 7.6, 1.4, 0.7 Hz, 2H), 4.67 (d, *J* = 14.6 Hz, 1H), 4.56 (d, *J* = 14.6 Hz, 1H), 4.42 (dd, *J* = 12.2, 3.1 Hz, 1H), 3.97 (dd, *J* = 12.3, 6.3 Hz, 1H), 3.46 (d, *J* = 2.3 Hz, 1H), 3.20–3.15 (m, 2H), 3.13 (ddd, *J* = 6.3, 3.1, 2.4 Hz, 1H), 2.11 (s, 3H), 1.90 (dq, *J* = 13.8, 7.5 Hz, 1H), 1.85–1.72 (m, 1H), 1.68 (dt, *J* = 13.8, 7.5 Hz, 1H), 1.61–1.51 (m, 2H), 0.91 (t, *J* = 7.5 Hz, 4H); ^{13}C NMR (CDCl3, 126 MHz) δ 172.6, 170.9, 137.3, 128.8, 128.0, 127.5, 64.8, 60.9, 52.2, 50.9, 47.6, 45.4, 28.9, 24.2, 20.9, 19.8, 8.7; IR (Neat Film, NaCl) 2940, 1744, 1632, 1494, 1453, 1364, 1232, 1037, 907, 735 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{26}NO_4$ $[M+H]^+$: 332.1856, found 332.1853.



8a ***12***

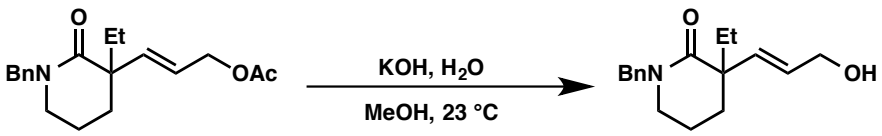
dimethyl (*E*)-2-(3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)allyl)malonate (12):
The conditions for the transformation were adapted from a known procedure.[17] In a nitrogen-filled glovebox, an oven-dried 1 dram screw-top vial with a magnetic stir bar was charged with dichloro(*p*-cymene)ruthenium(II) dimer (12 mg, 0.019 mmol, 0.50 equiv), triphenylphosphine (10 mg, 0.038 mmol, 1.00 equiv), and toluene (150 μL). To this solution was added a solution of acetate **8a** (12 mg, 0.038 mmol, 1.00 equiv) in toluene (100 μL). Dimethyl malonate (7 μL, 0.057 mmol, 1.50 equiv) was then added, followed by a solution of lithium hexamethyldisilazide (9 mg, 0.052 mmol, 1.40 equiv) in THF (100 μL). The vial was sealed with a Teflon-lined cap and heated at 60 °C for 90 hours. Upon completion (as determined by LCMS analysis) the reaction was removed from the glovebox, adsorbed onto Celite, and purified by silica gel column chromatography (20% ethyl acetate in hexanes) to provide malonate **12** as a colorless oil (12.1 mg, 82% yield. R*f* = 0.2 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.35–7.28 (m, 3H), 7.25–7.20 (m, 2H), 5.65 (dt, *J* = 15.8, 1.3 Hz, 1H), 5.44 (dt, *J* = 15.8, 7.0 Hz, 1H), 4.62 (d, *J* = 14.6 Hz, 1H), 4.53 (d, *J* = 14.5 Hz, 1H), 3.71 (s, 3H), 3.71 (s, 3H), 3.45 (t, *J* = 7.6 Hz, 1H), 3.32–3.04 (m, 2H), 2.66 (ddd, *J* = 7.5, 7.0, 1.3 Hz, 2H), 1.84 (dq, *J* = 13.5, 7.4 Hz, 1H), 1.80–1.67 (m, 4H), 1.67–1.58 (m, 1H), 0.83 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 173.0, 169.5, 169.5, 138.1, 137.7, 128.7, 128.1, 127.4, 125.0, 52.6, 52.6, 52.0, 50.6, 48.6, 47.8, 32.3, 32.1, 29.3, 19.3, 8.6; IR (Neat Film, NaCl) 2952, 1734, 1635, 1437, 1350, 1261, 1195, 1153, 740 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{22}H_{30}NO_5$ $[M+H]^+$: 388.2118, found 388.2110.



8a ***S11***

3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)propyl acetate (S11):

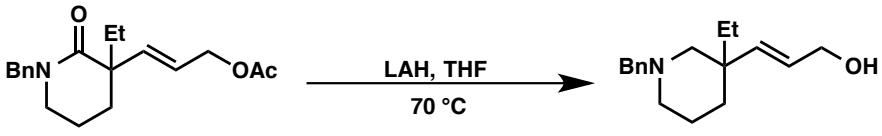
To a round-bottom flask with a magnetic stir bar were added acetate **8a** (40 mg, 0.13 mmol, 1.00 equiv) and ethyl acetate (750 μL). Palladium on carbon (10 wt. %, 2 mg) was added, and the suspension was stirred vigorously while the air atmosphere was replaced with hydrogen by three evacuation/back-fill cycles. The reaction mixture was then stirred at 23 °C under an atmosphere of hydrogen (supplied by a balloon) for 5 hours. As TLC analysis showed remaining starting material, an additional 5 mg of palladium on carbon (10 wt. %) was added. After letting the reaction mixture stir for an additional 19 hours, TLC analysis showed full conversion. The mixture was filtered through Celite, rinsing with ethyl acetate. The filtrate was concentrated and the crude residue was purified by silica gel column chromatography (25% ethyl acetate in hexanes) to provide aliphatic acetate **S11** as a colorless oil (34.0 mg, 99% yield). R*f* = 0.7 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.37–7.27 (m, 2H), 7.25–7.19 (m, 3H), 4.66 (d, *J* = 14.5 Hz, 1H), 4.50 (d, *J* = 14.5 Hz, 1H), 4.22–3.85 (m, 2H), 3.29–3.13 (m, 2H), 2.05 (s, 3H), 1.94–1.50 (m, 10H), 0.89 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 174.6, 171.3, 137.8, 128.7, 128.2, 127.4, 65.1, 50.7, 47.8, 44.9, 34.9, 31.6, 29.4, 24.0, 21.2, 20.0, 8.9; IR (Neat Film, NaCl) 2936, 1737, 1631, 1453, 1362, 1241, 1038, 738, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{19}H_{28}NO_3$ [M+H]$^+$: 318.2064, found 318.2051.



8a ***S12***

(*E*)-1-benzyl-3-ethyl-3-(3-hydroxyprop-1-en-1-yl)piperidin-2-one (S12):

To a 1 dram screw-top vial with a magnetic stir bar were added, in order, acetate **8a** (102 mg, 0.32 mmol, 1.00 equiv), freshly powdered potassium hydroxide (27 mg, 0.49 mmol, 1.50 equiv), methanol (1.3 mL), and water (300 μL). The vial was sealed with a Teflon-lined cap and the solution was stirred at 23 °C for 4 minutes. Upon completion (as determined by TLC analysis), the reaction mixture was adsorbed onto Celite and purified by silica gel column chromatography (50% ethyl acetate in hexanes) to provide allylic alcohol **S12** as a colorless oil (88.0 mg, >99% yield). R*f* = 0.2 (50% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.35–7.26 (m, 3H), 7.25–7.21 (m, 2H), 5.83 (dt, *J* = 15.9, 1.4 Hz, 1H), 5.75–5.65 (m, 1H), 4.68 (d, *J* = 14.5 Hz, 1H), 4.50 (d, *J* = 14.6 Hz, 1H), 4.26–4.05 (m, 2H), 3.35–3.06 (m, 2H), 1.97–1.86 (m, 1H), 1.86–1.64 (m, 6H), 0.86 (td, *J* = 7.4, 1.2 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 173.1, 137.6, 136.6, 128.8, 128.7, 128.2, 127.4, 63.9, 50.7, 48.4, 47.9, 32.0, 29.3, 19.4, 8.7; IR (Neat Film, NaCl) 3402, 2936, 2863, 1617, 1494, 1452, 1353, 1196, 981, 734, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{24}NO_2$ [M+H]$^+$: 274.1802, found 274.1803.

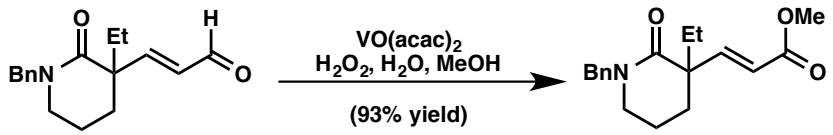


8a ***S13***

(*E*)-3-(1-benzyl-3-ethylpiperidin-3-yl)prop-2-en-1-ol (S13):

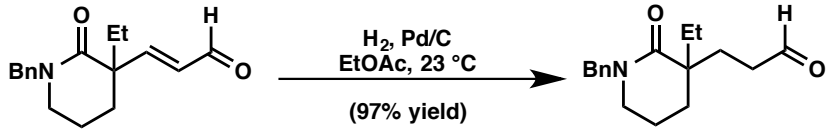
To an oven-dried 1 dram screw-top vial with a magnetic stir bar were added, in order, acetate **8a** (30 mg, 0.095 mmol, 1.00 equiv), lithium aluminum hydride (72 mg, 1.90 mmol, 20.00 equiv), and THF (500 μL). The vial was sealed with a Teflon-lined cap and the suspension was stirred at 70 °C for 10 hours. Upon completion (as determined by TLC analysis), the reaction mixture cooled to 0 °C using an ice water bath. 1.5 mL water was added slowly dropwise, followed by 1.5 mL NaOH (15 wt. %), followed by 4.5 mL water. The suspension was stirred until the color turned white (45 minutes), after which it was filtered through Celite, rinsing with ether. The filtrate was concentrated and the crude residue was purified by silica gel column chromatography (50% ethyl acetate and 1% triethylamine in hexanes with) to provide amine **S13** as a colorless oil (23.9 mg, 97 % yield). R_f = 0.3 (50% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.33–7.27 (m, 4H), 7.26–7.21 (m, 1H), 5.58 (dt, *J* = 16.0, 5.7 Hz, 1H), 5.50 (dt, *J* = 15.9, 1.0 Hz, 1H), 4.12 (d, *J* = 5.6 Hz, 2H), 3.44 (s, 2H), 2.51–1.95 (m, 4H), 1.75 (s, 1H), 1.59 (m, 1H), 1.50 (d, *J* = 15.5 Hz, 3H), 1.37 (dt, *J* = 13.8, 7.2 Hz, 2H), 0.70 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 139.7, 139.0, 129.1, 128.2, 127.6, 127.0, 64.5, 63.7, 62.8, 54.8, 39.3, 33.4, 22.3, 7.9; IR (Neat Film, NaCl) 3326, 2934, 1453, 1349, 1091, 974, 739, 698 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{26}NO$ $[M+H]^+$: 260.2009, found 260.2018.

Enal Derivitization Procedures and Characterization Data



9a ***13***

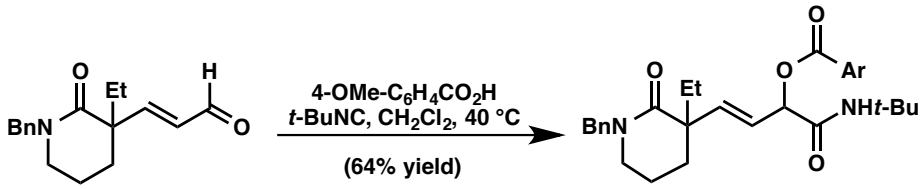
(*E*)-1-benzyl-3-(buta-1,3-dien-1-yl)-3-ethylpiperidin-2-one (13):
The conditions for the transformation were adapted from a known procedure.[18] To a 1 dram screw-top vial with a magnetic stir bar were added, in order, vanadyl acetylacetonate (1 mg, 0.001 mmol, 0.04 equiv) and hydrogen peroxide (35 wt. % in water, 50 μL). A solution of enal **9a** (10 mg, 0.04 mmol, 1.00 equiv) in methanol (200 μL) was then added. The vial was sealed with a Teflon-lined cap and the solution was stirred at 23 °C for 17 hours. Upon completion (as determined by TLC analysis), the reaction mixture was diluted with dichloromethane (3 mL), adsorbed onto Celite and purified by silica gel column chromatography (25% ethyl acetate in hexanes) to provide enoate **13** as a colorless oil (11.2 mg, 93% yield). R*f* = 0.4 (10% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 7.37–7.26 (m, 3H), 7.25–7.18 (m, 2H), 7.04 (d, *J* = 16.1 Hz, 1H), 5.90 (d, *J* = 16.1 Hz, 1H), 4.68 (d, *J* = 14.5 Hz, 1H), 4.51 (d, *J* = 14.5 Hz, 1H), 3.74 (s, 3H), 3.32–3.09 (m, 2H), 1.95 (dq, *J* = 13.5, 7.4 Hz, 1H), 1.91–1.82 (m, 2H), 1.82–1.67 (m, 3H), 0.88 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 171.4, 167.2, 152.6, 137.4, 128.8, 128.2, 127.5, 120.8, 51.7, 50.9, 49.3, 47.8, 31.6, 29.3, 19.5, 8.7; IR (Neat Film, NaCl) 2946, 1723, 1631, 1434, 1341, 1273, 1197, 1020, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO_3$ $[M+H]^+$: 302.1751, found 302.1754.



9a ***14***

3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)propanal (14):
To a round-bottom flask with a magnetic stir bar were added enal **9a** (30 mg, 0.11 mmol, 1.00 equiv) and ethyl acetate (320 μL). Palladium on carbon (10 wt. %, 2 mg) was added, and the suspension was stirred vigorously while the air atmosphere was replaced with hydrogen by three evacuation/back-fill cycles. The reaction mixture was then stirred at 23 °C under one atmosphere of hydrogen (supplied by a balloon) for 1.25 hours. After completion (as determined by TLC analysis), the mixture was filtered through Celite, rinsing with ethyl acetate. The filtrate was concentrated and the crude residue was purified by silica gel column chromatography (25% ethyl acetate in hexanes) to provide aliphatic aldehyde **14** as a colorless oil (29.3 mg, 97% yield). R*f* = 0.5 (50% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 9.77 (t, *J* = 1.5 Hz, 1H), 7.37–7.27 (m, 3H), 7.25–7.18 (m, 2H), 4.65 (d, *J* = 14.5 Hz, 1H), 4.48 (d, *J* = 14.5 Hz, 1H), 3.36–3.06 (m, 2H), 2.59 (dddd, *J* = 17.4, 10.1, 5.7, 1.6 Hz, 1H), 2.49 (dddd, *J* = 17.3, 10.1, 5.6, 1.5 Hz, 1H), 1.98 (ddd, *J* = 14.0, 10.1, 5.6 Hz, 1H), 1.93–1.85 (m, 1H), 1.85–1.71 (m, 3H), 1.67–1.50 (m, 3H), 0.89 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 202.6, 174.1, 137.7, 128.7, 128.1, 127.5, 50.7, 47.8, 44.4, 39.8, 31.1, 30.3, 29.9, 19.7, 8.6; IR (Neat

Film, NaCl) 2937, 1722, 1628, 1494, 1452, 1351, 1194, 736, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{17}H_{24}NO_2$ $[M+H]^+$: 274.1802, found 274.1805.

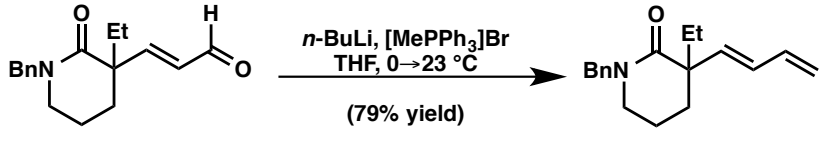


9a ***15***

Ar = 4-OMeC$_6$H$_4$

(*E*)-4-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)-1-(*tert*-butylamino)-1-oxobut-3-en-2-yl 4-methoxybenzoate (15):

The conditions for the transformation were adapted from a known procedure.[19] To a 0.5 dram screw-top vial with a magnetic stir bar were added, in order, enal **9a** (10 mg, 0.037 mmol, 1.00 equiv), *tert*-butyl isocyanide (42 µL, 0.37 mmol, 10.0 equiv), 4-methoxybenzoic acid (56 mg, 0.37 mmol, 10.0 equiv), and dichloromethane (50 µL). The vial was sealed with a Teflon-lined cap and the white suspension was stirred at 23 °C for 21 hours, and then at 40 °C for 12 additional hours. Upon completion (as determined by LCMS analysis), the reaction mixture was diluted with dichloromethane (2 mL) and washed with saturated aqueous sodium bicarbonate solution (1 x 2 mL). The organic layer was dried over sodium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (25% ethyl acetate in hexanes) to provide the products as an inseparable 1:1 mixture of diastereomers (12.1 mg, 64% yield). R*f* = 0.3 (25% ethyl acetate in hexanes); ^{1}H NMR ($CDCl_3$, 500 MHz) δ 8.04 (dd, *J* = 2.1, 1.5 Hz, 1H), 8.03 (dd, *J* = 2.1, 1.5 Hz, 1H), 7.35–7.27 (m, 1H), 7.25–7.16 (m, 3H), 6.96 (d, *J* = 2.5 Hz, 1H), 6.94 (t, *J* = 2.4 Hz, 1H), 6.07 (ddd, *J* = 15.9, 9.9, 1.2 Hz, 1H), 5.87 (d, *J* = 8.6 Hz, 1H), 5.78 (ddd, *J* = 15.9, 9.8, 6.7 Hz, 1H), 5.69 (ddd, *J* = 6.9, 3.3, 1.2 Hz, 1H), 4.64 (dd, *J* = 26.6, 14.6 Hz, 1H), 4.52 (dd, *J* = 14.6, 6.6 Hz, 1H), 3.88 (d, *J* = 1.1 Hz, 3H), 3.33–3.02 (m, 2H), 1.96–1.80 (m, 3H), 1.80–1.61 (m, 1H), 1.35 (d, *J* = 1.7 Hz, 9H), 0.86 (td, *J* = 7.4, 5.8 Hz, 3H); ^{13}C NMR ($CDCl_3$, 126 MHz) δ 172.7, 172.7, 167.8, 167.7, 164.8, 163.9, 163.9, 140.0, 139.8, 137.5, 132.4, 132.0, 132.0, 128.7, 128.7, 128.0, 128.0, 127.4, 127.4, 124.2, 124.0, 121.9, 121.9, 114.0, 114.0, 113.8, 75.0, 74.8, 55.7, 51.5, 51.5, 50.7, 50.6, 48.7, 48.6, 47.8, 47.8, 36.8, 32.0, 31.7, 29.1, 29.1, 28.8, 24.8, 19.4, 19.3, 8.6, 8.6; IR (Neat Film, NaCl) 3320, 2965, 1691, 1606, 1453, 1256, 1168, 1102, 1028 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{30}H_{39}N_2O_5$ $[M+H]^+$: 507.2853, found 507.2857.



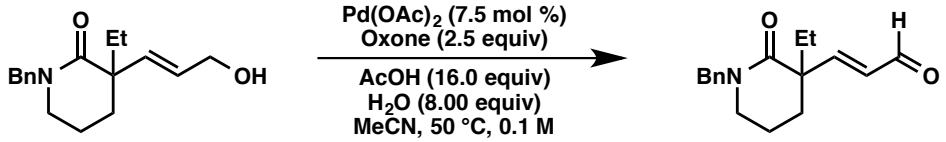
9a ***S14***

(*E*)-1-benzyl-3-(buta-1,3-dien-1-yl)-3-ethylpiperidin-2-one (S14):

To a flame-dried round-bottom flask with a magnetic stir bar were added methyl triphenylphosphonium bromide (64 mg, 0.18 mmol, 1.25 equiv) and THF (0.9 mL). The

white suspension was cooled to 0 °C using an ice water bath and *n*-butyllithium (2.5 M in hexanes, 72 μL, 1.25 equiv) was added dropwise by syringe. The mixture was stirred for 15 minutes at 0 °C and a solution of enal **9a** (40 mg, 0.15 mmol, 1.00 equiv) in THF (180 μL) was added dropwise by syringe. The mixture was stirred for 1 hour at 0 °C and 20 hours at 23 °C. As the reaction was not progressing, additional ylide (1.25 equiv, generated as described above) was added by syringe at 0 °C. The reaction was allowed to stir at 23 °C for 5 hours, at which point additional ylide (2.50 equiv, generated as described above) was added at 0 °C. After stirring for 3 hours at 23 °C, TLC analysis showed complete consumption of the starting material. The reaction was quenched by addition of saturated aqueous ammonium chloride solution (5 mL). The mixture was extracted with ether (3 x 5 mL), and the combined organic layers were washed with brine (1 x 5 mL), dried over magnesium sulfate, filtered, and concentrated in vacuo. The crude residue was purified by silica gel column chromatography (20% ethyl aceate in hexanes) to provide diene **S14** as a colorless oil (32.1 mg, 79% yield). R*f* = 0.5 (25% ethyl acetate in hexanes); ^{1}H NMR (CDCl3, 500 MHz) δ 7.34–7.26 (m, 2H), 7.26–7.21 (m, 3H), 6.35 (dtd, *J* = 16.9, 10.2, 0.7 Hz, 1H), 6.10 (ddd, *J* = 15.7, 10.2, 0.7 Hz, 1H), 5.81 (dd, *J* = 15.7, 0.8 Hz, 1H), 5.14 (ddt, *J* = 17.0, 1.6, 0.7 Hz, 1H), 5.03 (ddt, *J* = 10.1, 1.6, 0.7 Hz, 1H), 4.62 (d, *J* = 14.6 Hz, 1H), 4.57 (d, *J* = 14.6 Hz, 1H), 3.35–2.98 (m, 2H), 1.90 (dq, *J* = 13.6, 7.5 Hz, 1H), 1.86–1.78 (m, 3H), 1.78–1.64 (m, 2H), 0.86 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (CDCl3, 126 MHz) δ 172.9, 139.0, 137.7, 137.3, 130.3 128.7, 128.2, 127.4, 116.4, 50.7, 48.8, 47.9, 32.2, 29.4, 19.5, 8.8; IR (Neat Film, NaCl) 2966, 1635, 1600, 1488, 1452, 1352, 1196, 1007, 733, 701 cm^{-1}; HRMS (ESI+) *m/z* calc'd for $C_{18}H_{24}NO$ $[M+H]^+$: 270.1853, found 270.1851.

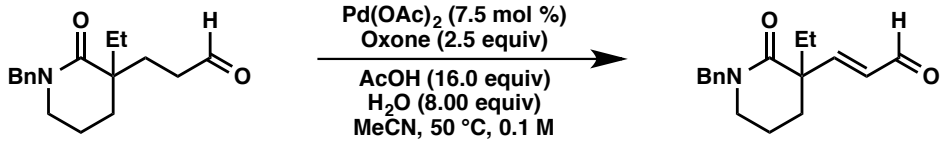
Mechanistic Investigation Experiments



S12 ***9a***

Oxidation of allylic alcohol S12 to enal 9a:

To a 0.5 dram vial with a magnetic stir bar were added, in order, allylic alcohol **S12** (11 mg, 0.04 mmol, 1.00 equiv), palladium(II) acetate (1 mg, 0.03 mmol, 0.075 equiv), and Oxone (31 mg, 0.10 mmol, 2.5 equiv). Acetonitrile (400 μL), acetic acid (37 μL, 3.2 mmol, 16.00 equiv), and water (6 μL, 1.6 mmol, 8.00 equiv) were added by syringe. The resulting suspension was stirred for 5 minutes at 23 °C and then heated to 50 °C in an oil bath. Upon completion (as determined by TLC analysis), the flask was allowed to cool to 23 °C. The reaction mixture was filtered through a plug of silica gel, rinsing with ethyl acetate, and concentrated to give the crude product, which was identical to **9a** by ^{1}H NMR, TLC, and LCMS analysis.



14 ***9a***

Oxidation of aliphatic aldehyde 14 to enal 9a:

To a 0.5 dram vial with a magnetic stir bar were added, in order, aliphatic aldehyde **14** (3 mg, 0.011 mmol, 1.00 equiv), palladium(II) acetate (<1 mg, 0.015 mmol, 0.075 equiv), and Oxone (8 mg, 0.028 mmol, 2.5 equiv). Acetonitrile (100 μL), acetic acid (10 μL, 3.2 mmol, 16.00 equiv), and water (2 μL, 1.6 mmol, 8.00 equiv) were added by syringe. The resulting suspension was stirred for 5 minutes at 23 °C and then heated to 50 °C in an oil bath. Upon completion (as determined by TLC analysis), the flask was allowed to cool to 23 °C. The reaction mixture was filtered through a plug of silica gel, rinsing with ethyl acetate, and concentrated to give the crude product, which was identical to **9a** by ^{1}H NMR, TLC, and LCMS analysis.

Notes and References

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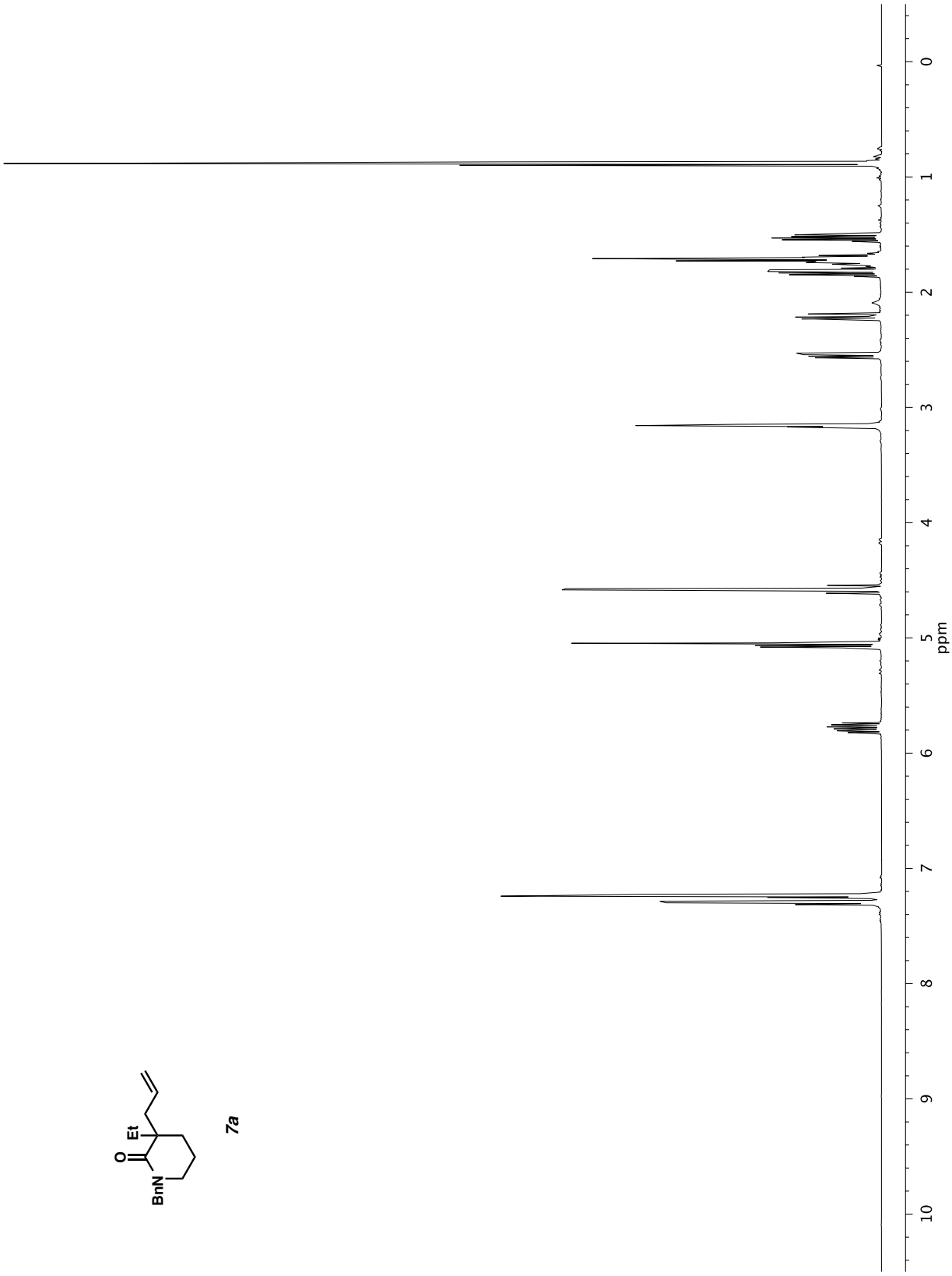
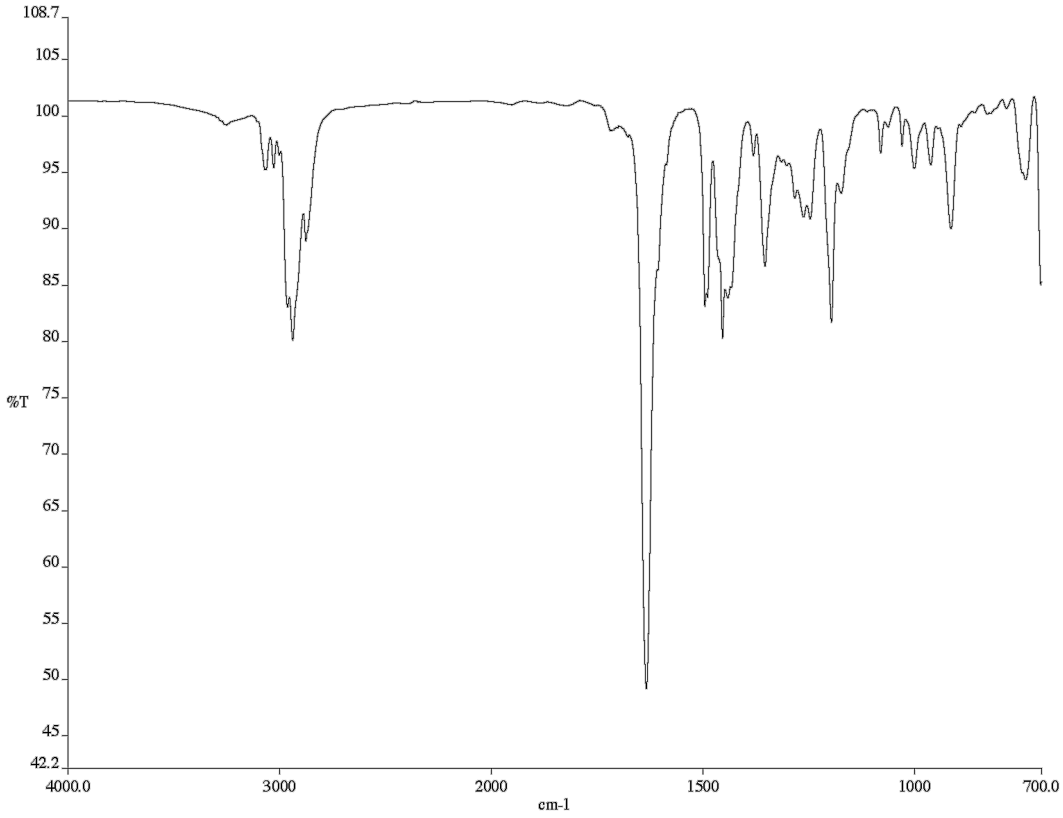
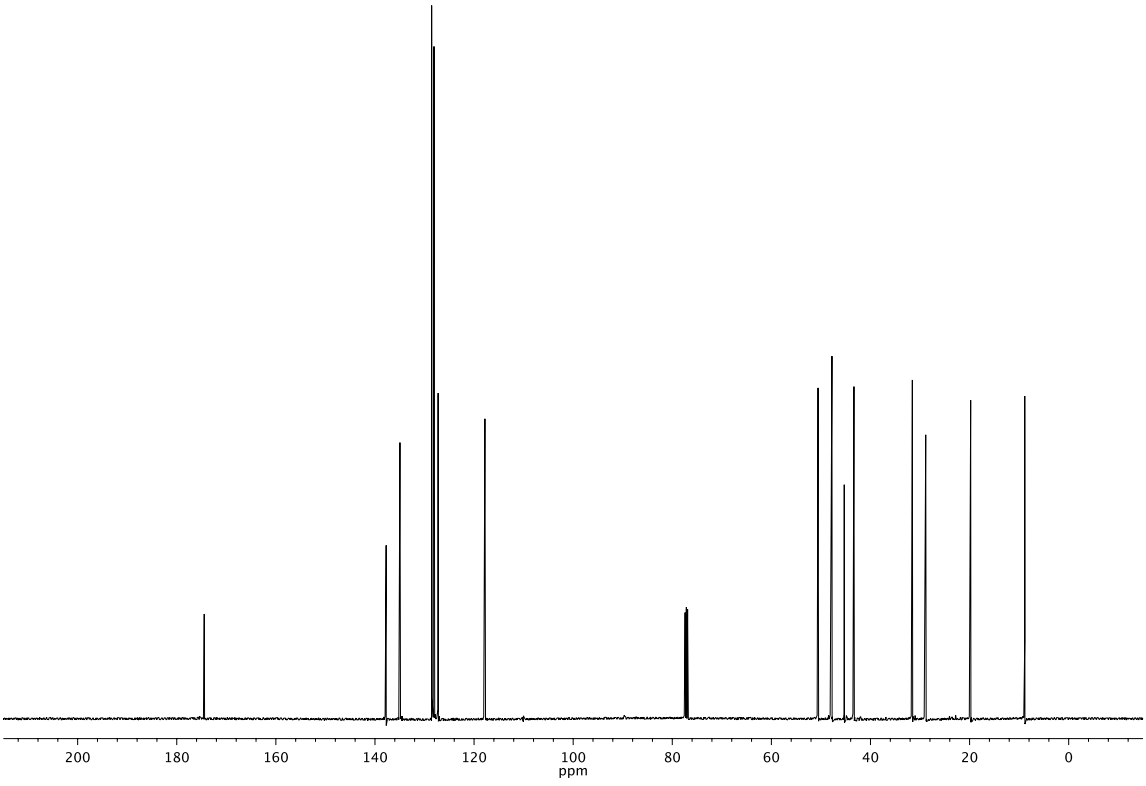


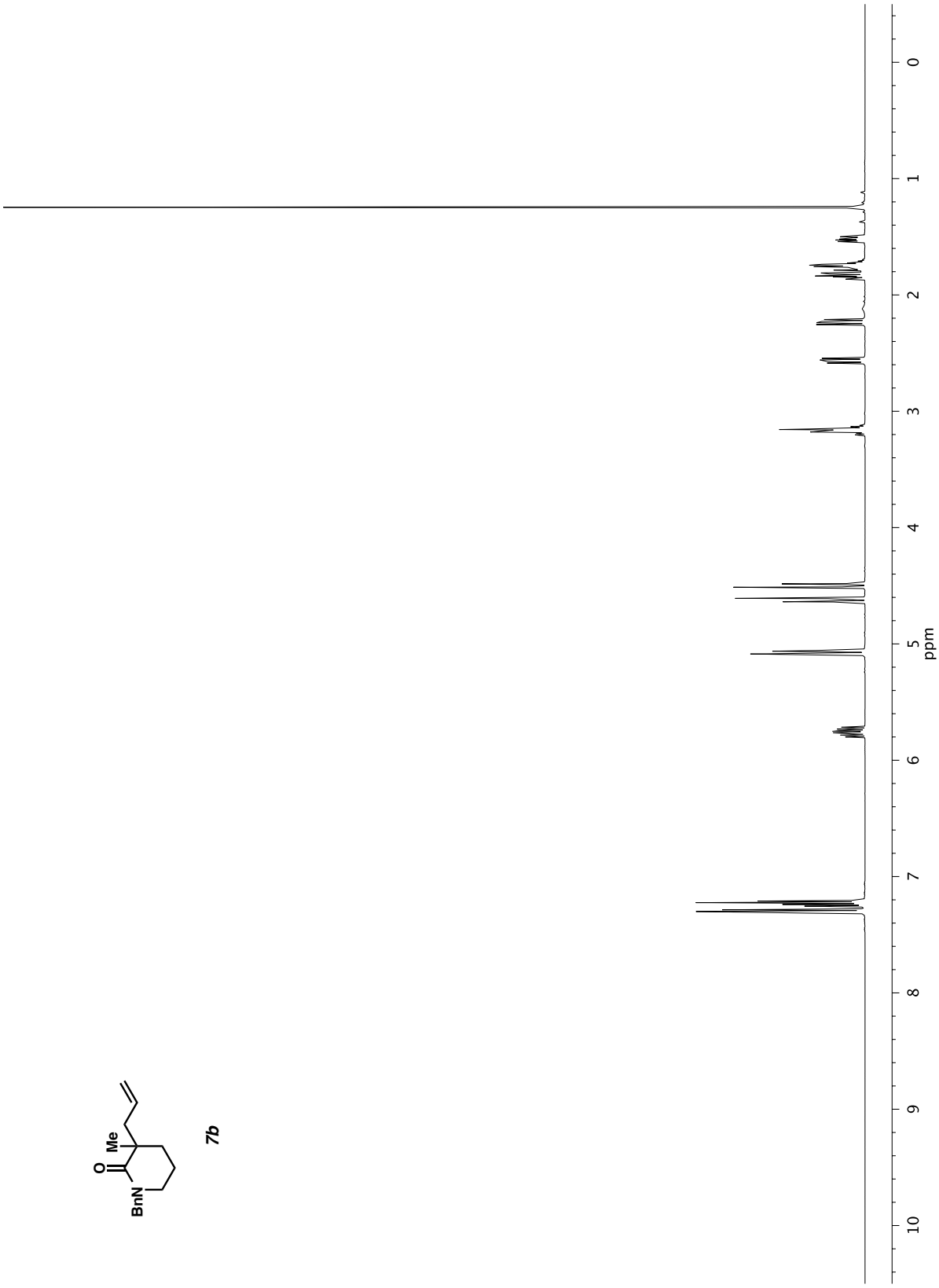
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7a**.



Infrared spectrum (Thin Film, NaCl) of compound **7a**.

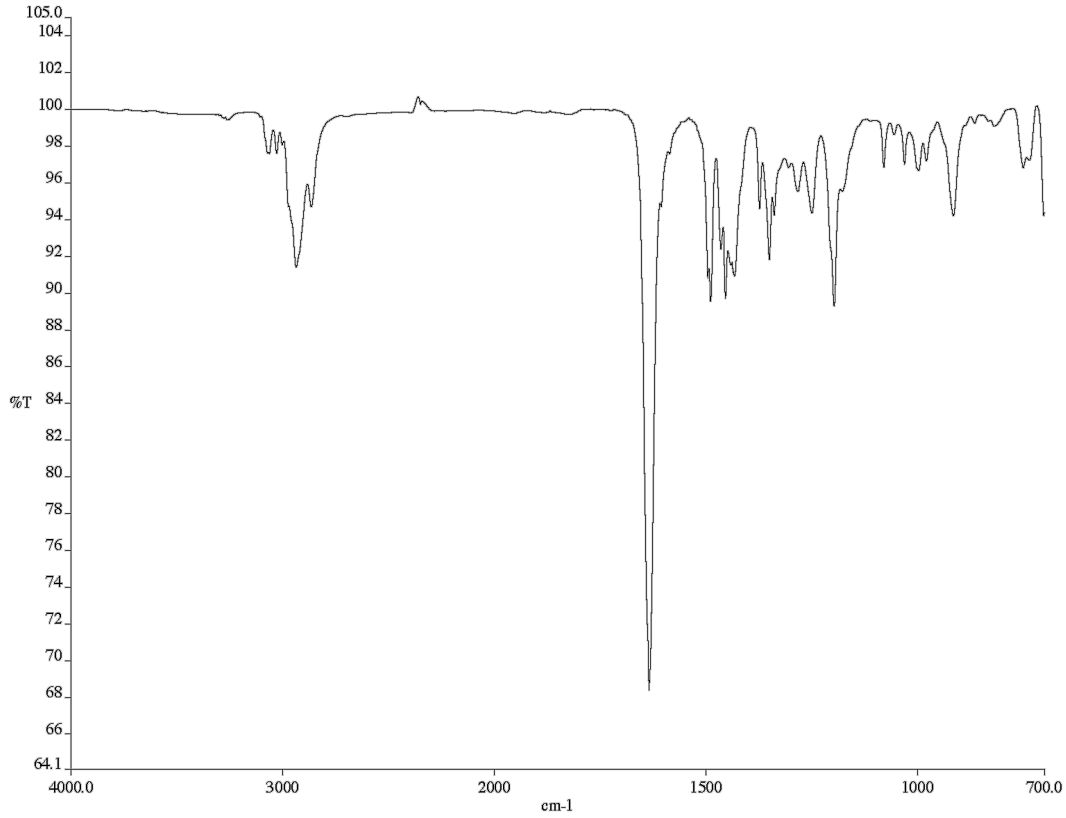


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7a**.

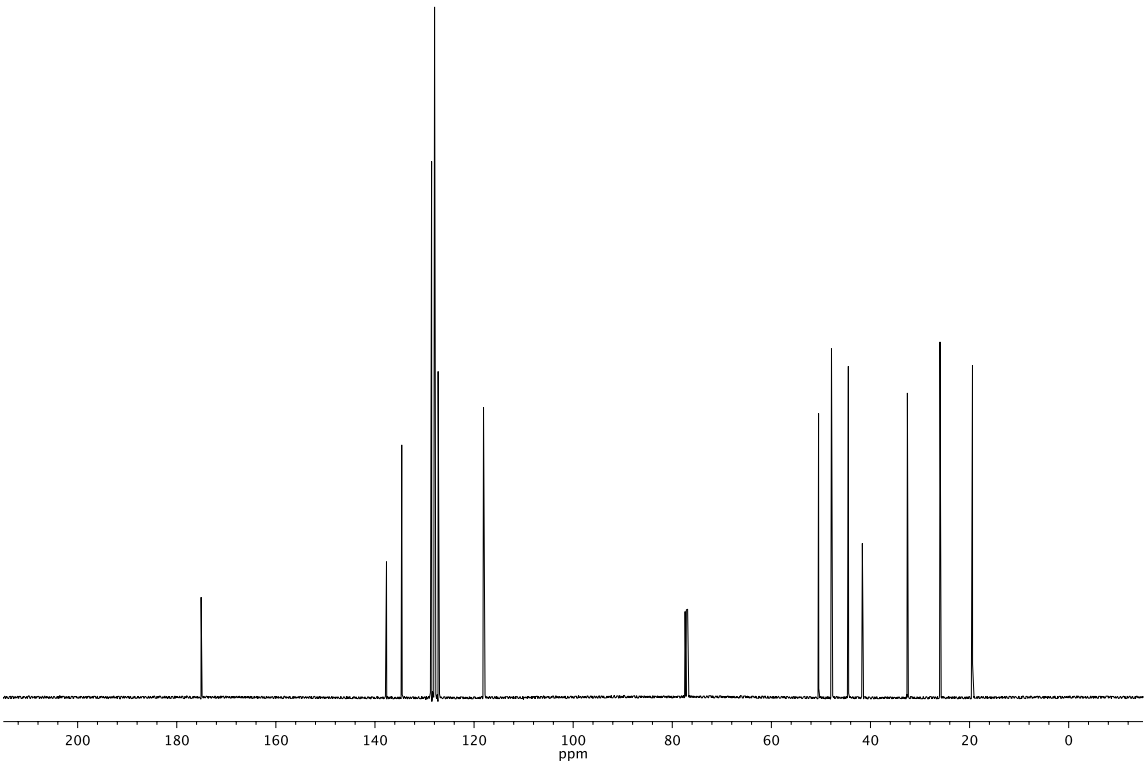


^{1}H NMR (500 MHz, $CDCl_3$) of compound **7b**.

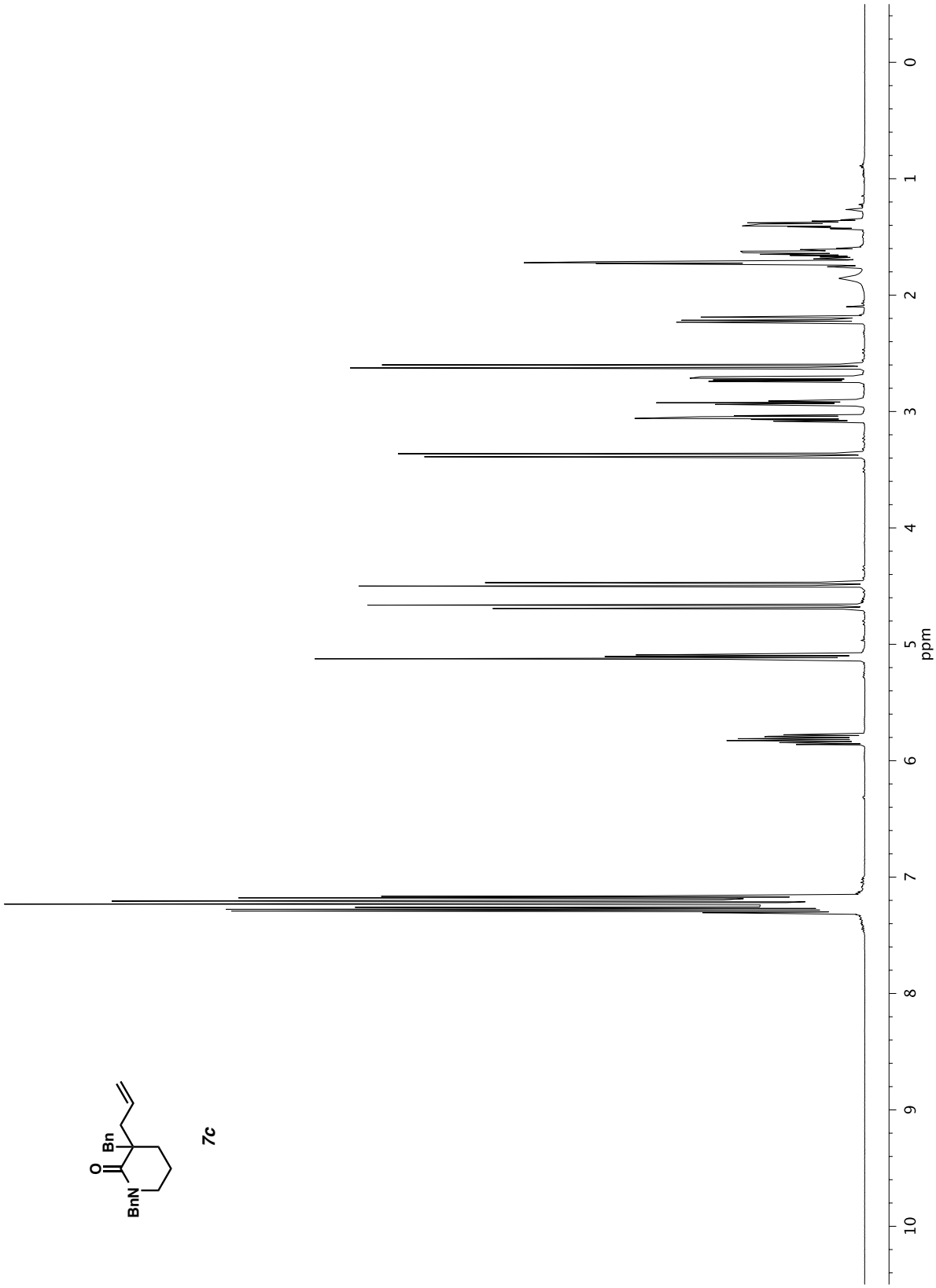
7b



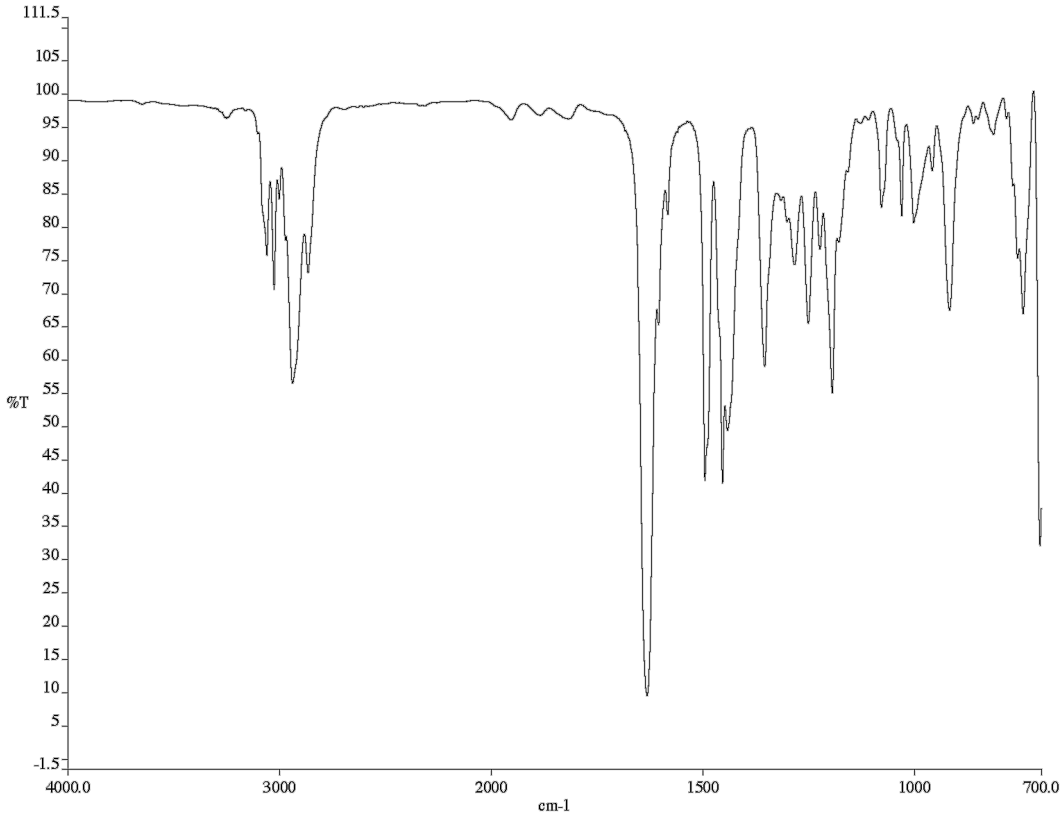
Infrared spectrum (Thin Film, NaCl) of compound **7b**.



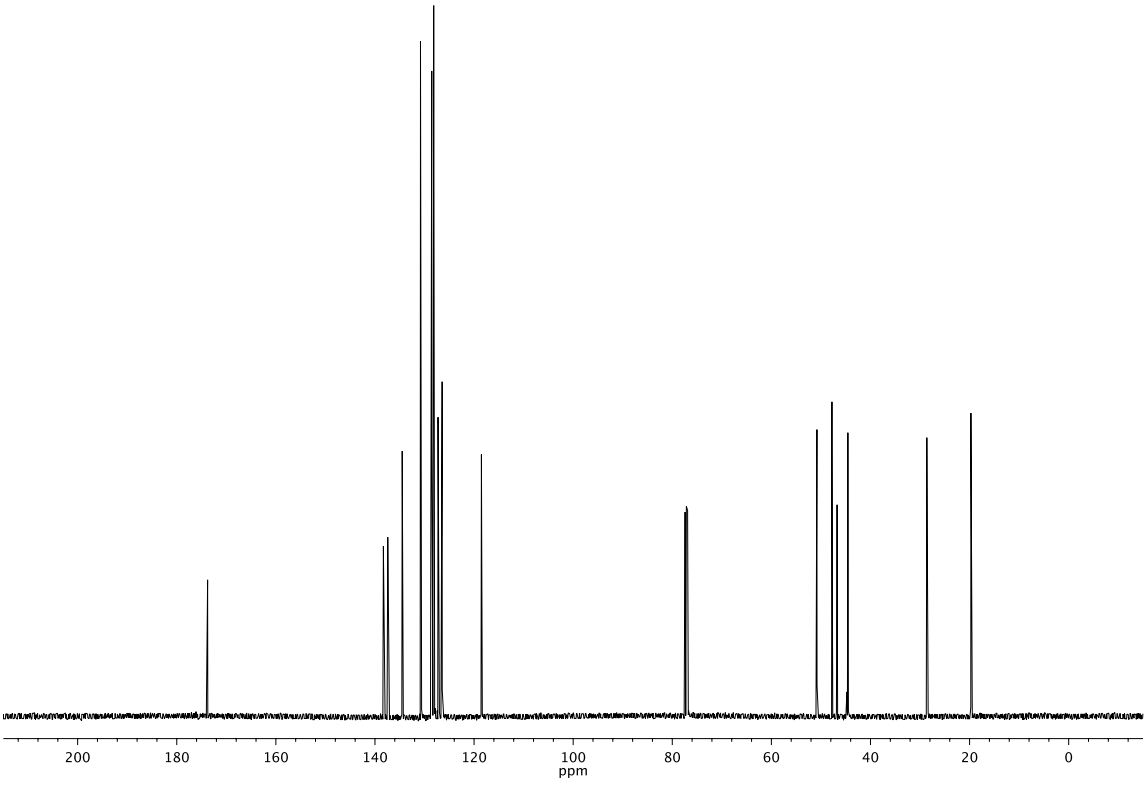
^{13}C NMR (126 MHz, $CDCl_3$) of compound **7b**.



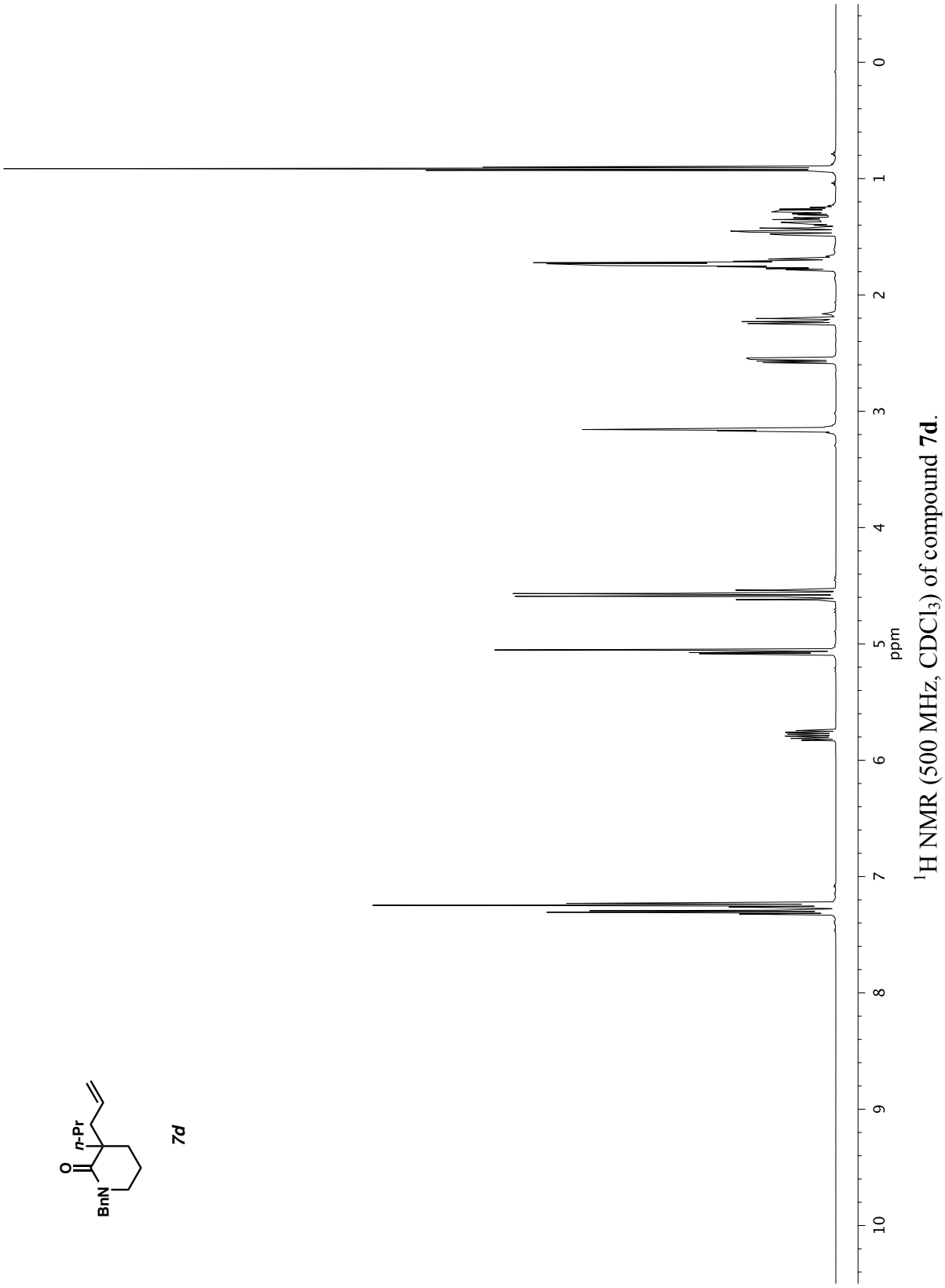
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7c**.



Infrared spectrum (Thin Film, NaCl) of compound **7c**.

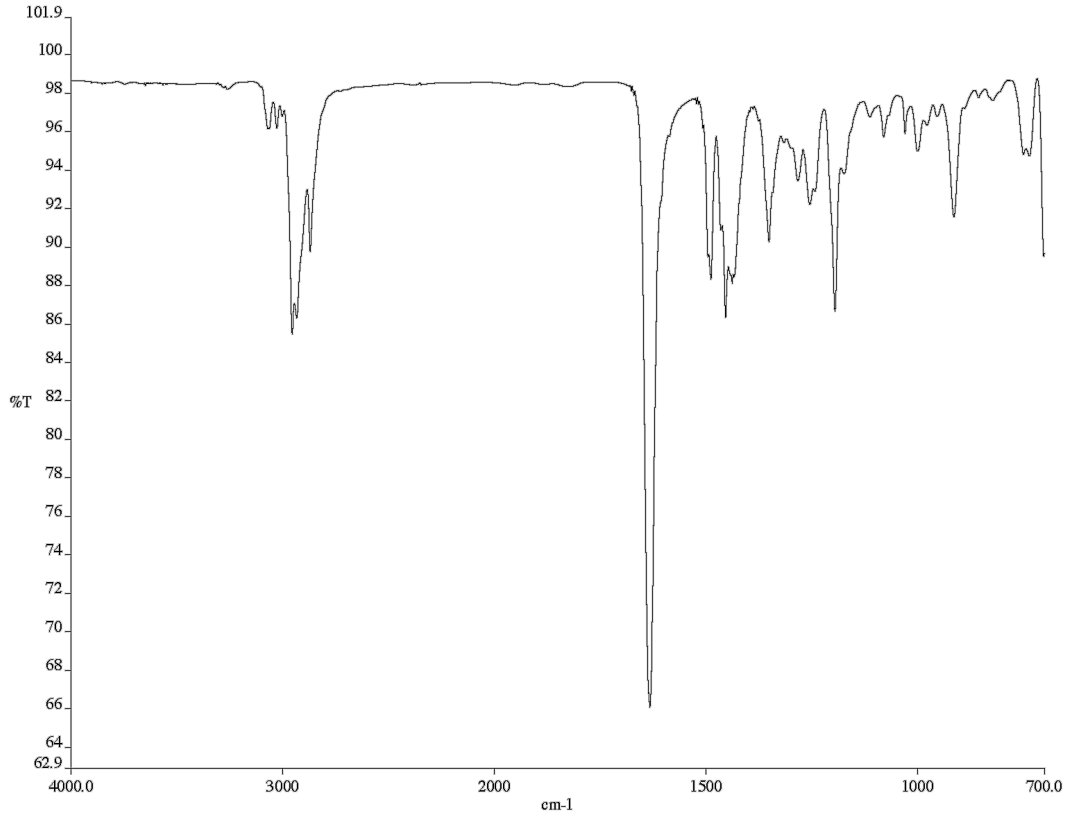


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7c**.

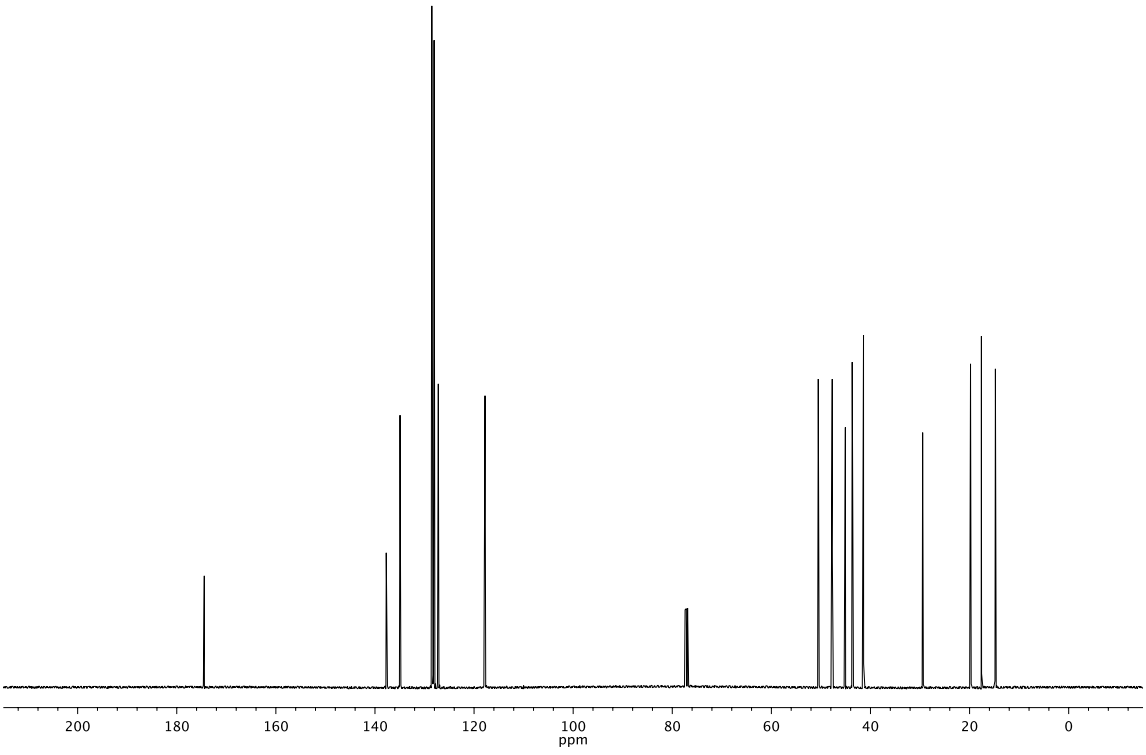


^{1}H NMR (500 MHz, $CDCl_3$) of compound **7d**.

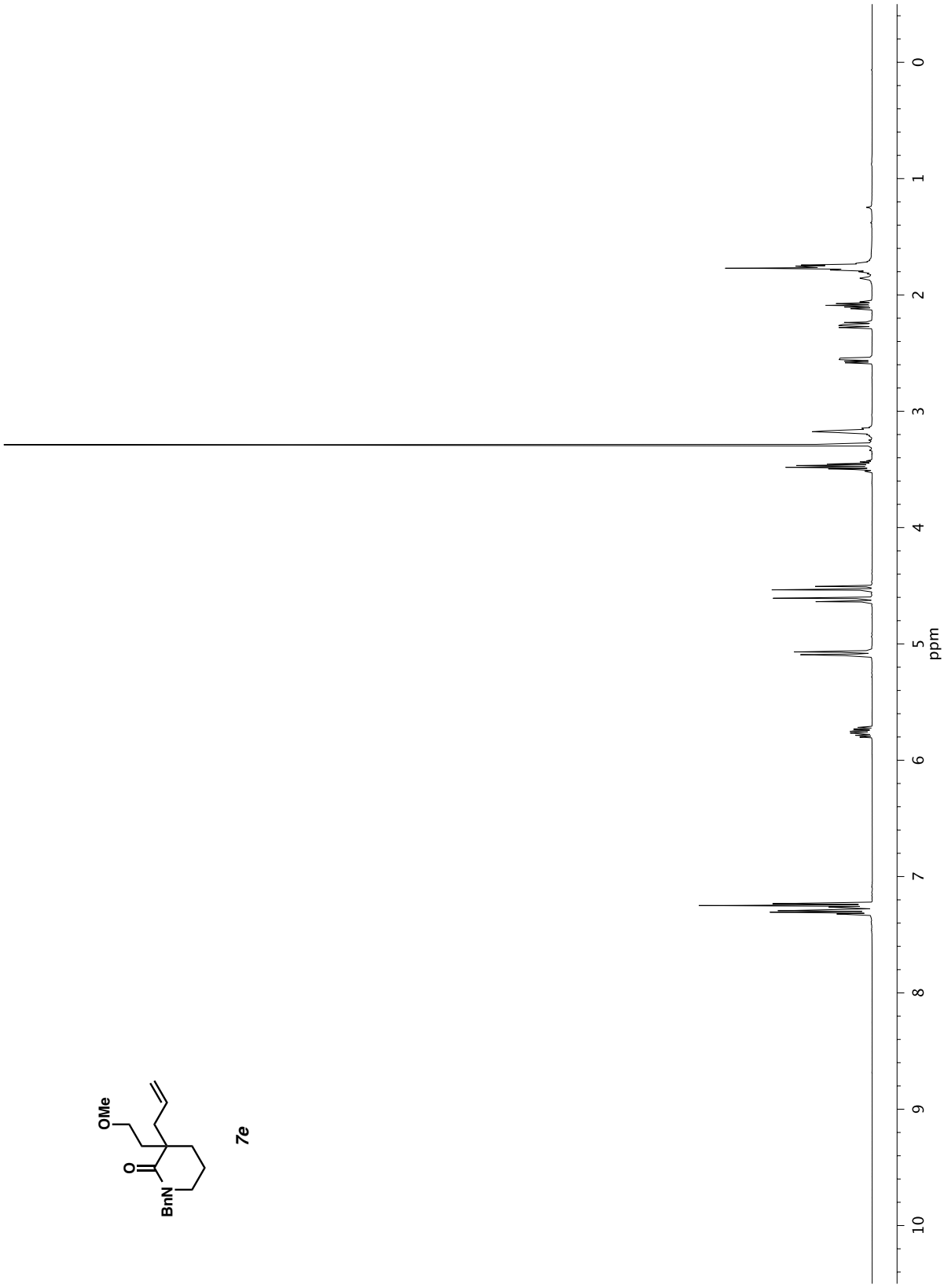
7d



Infrared spectrum (Thin Film, NaCl) of compound **7d**.



^{13}C NMR (126 MHz, $CDCl_3$) of compound **7d**.



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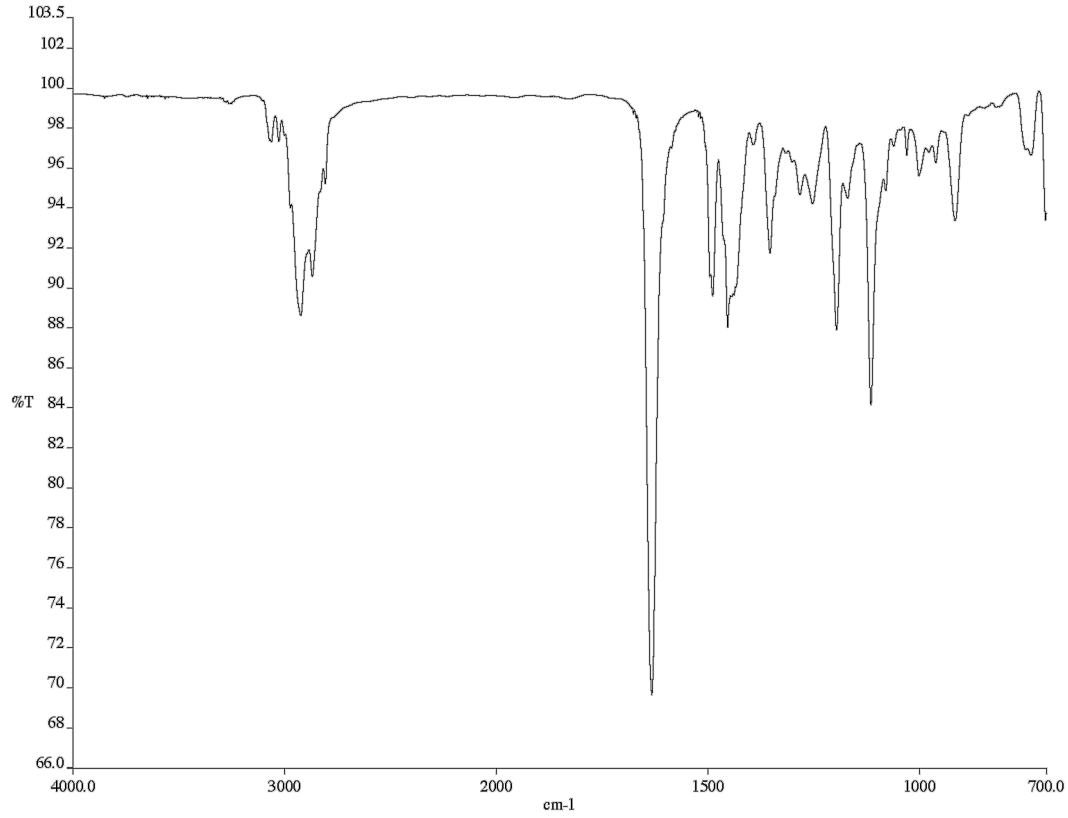
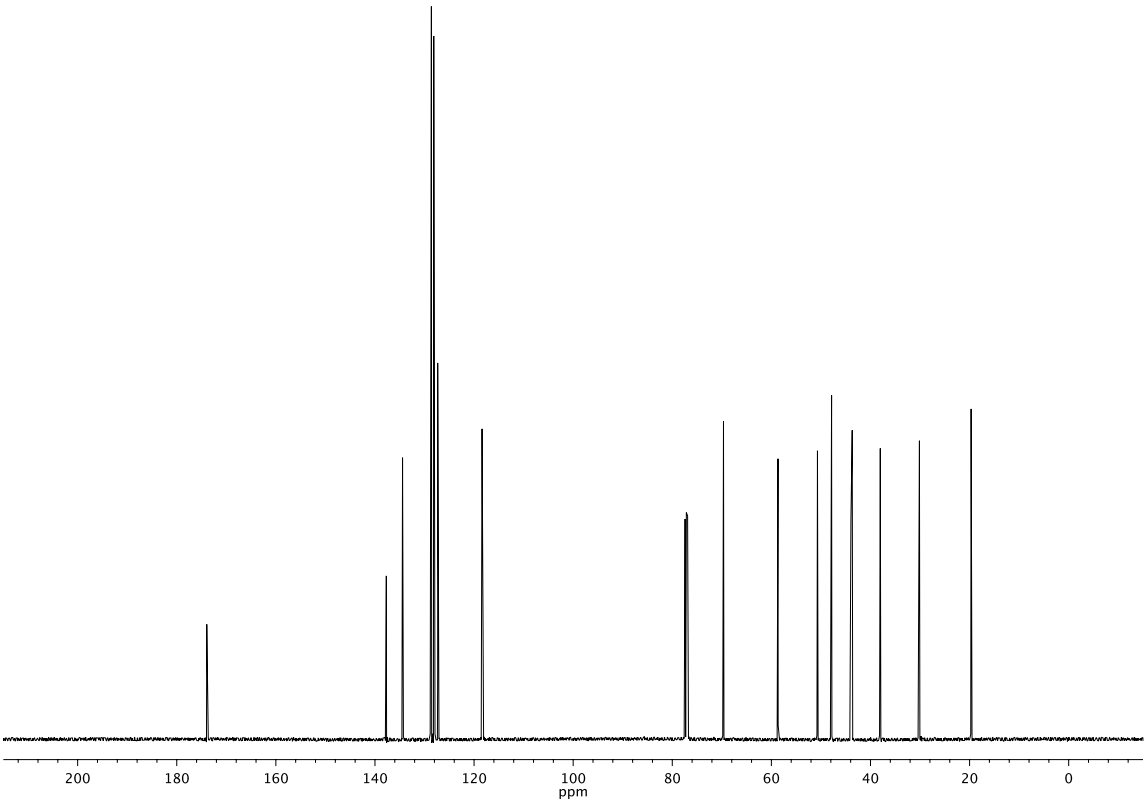
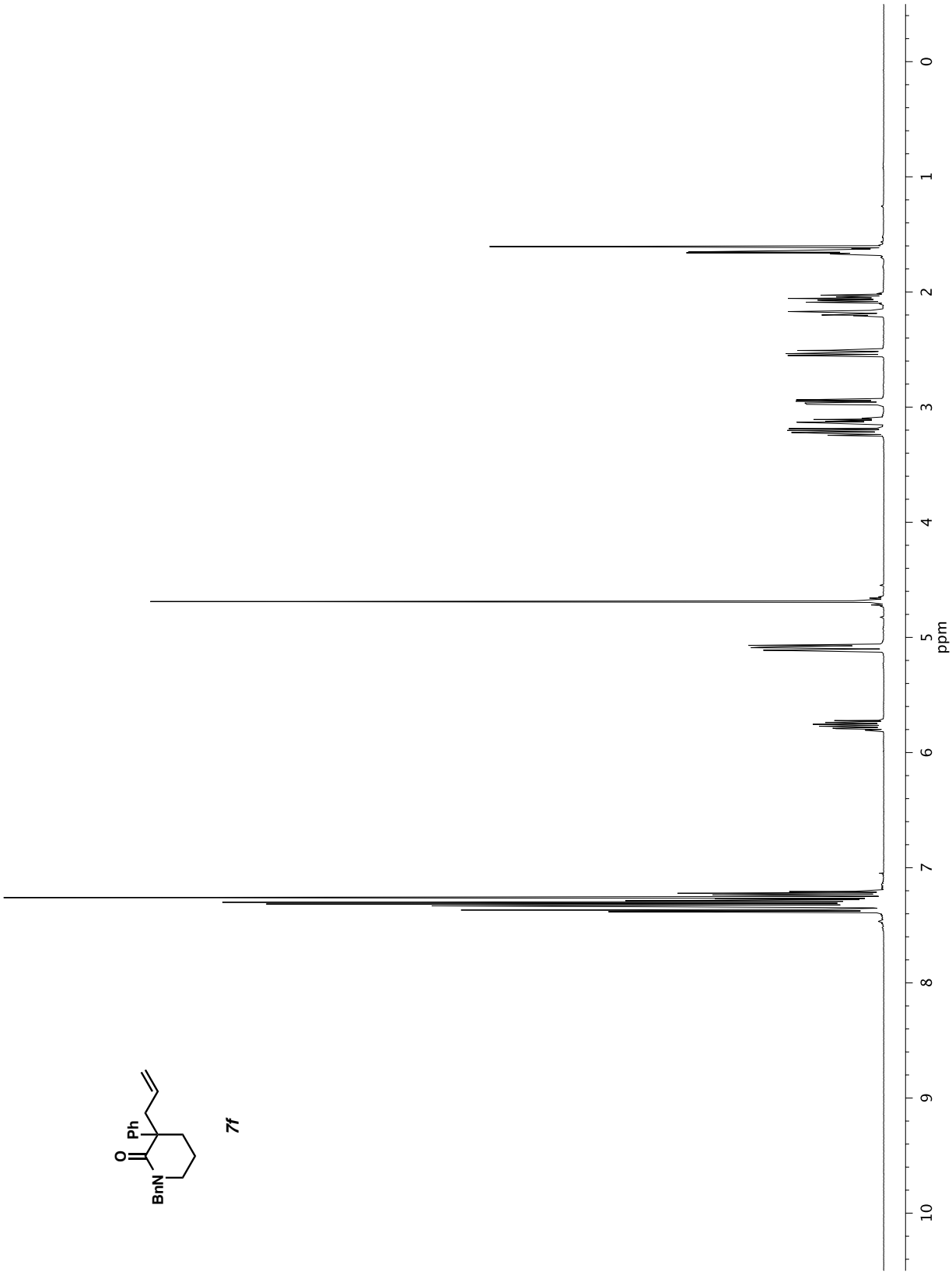


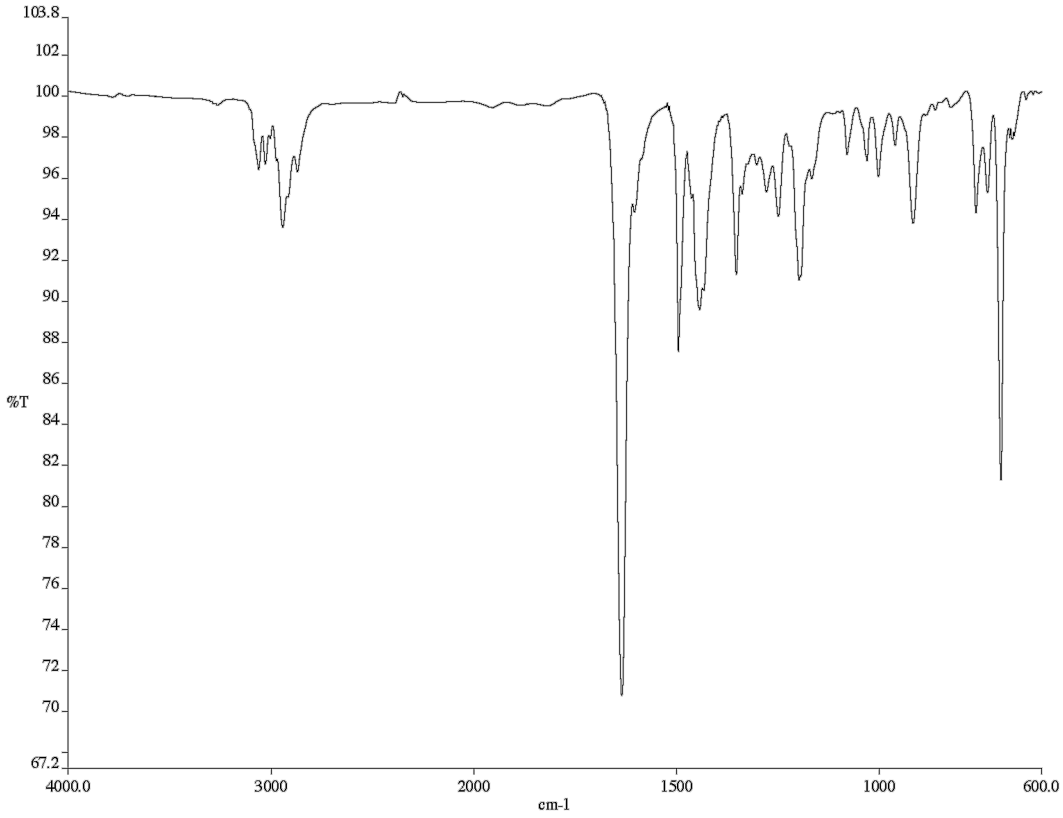
Infrared spectrum (Thin Film, NaCl) of compound **7e**.



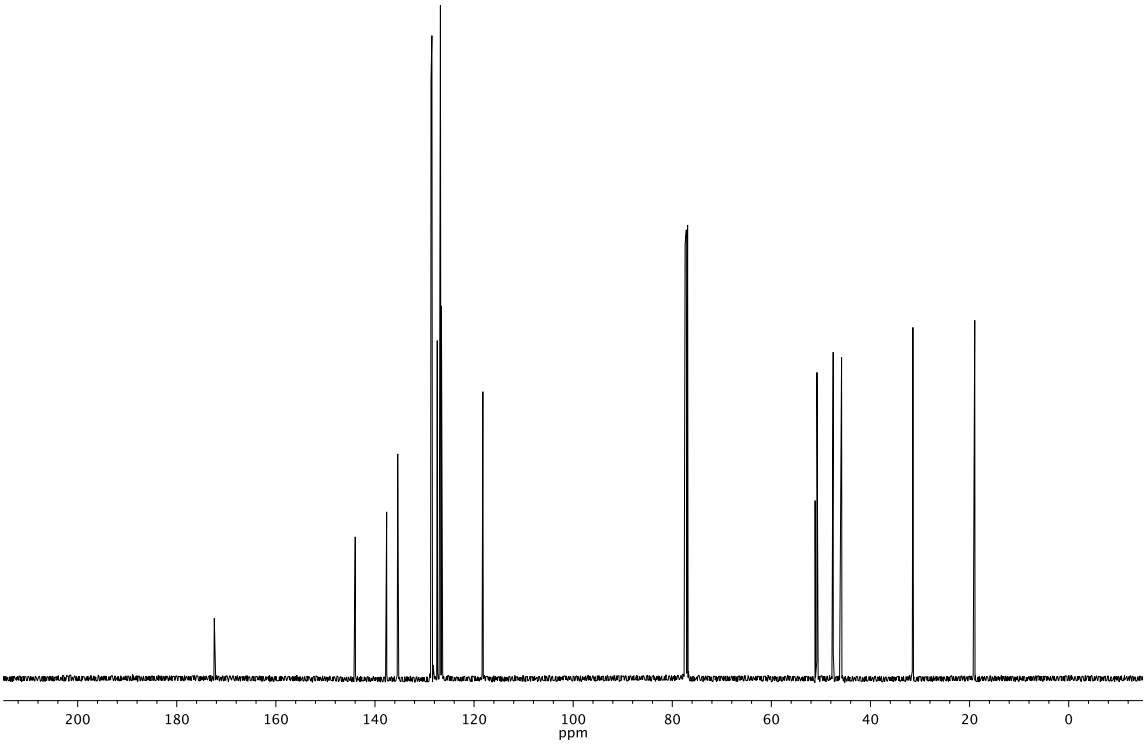
^{13}C NMR (126 MHz, $CDCl_3$) of compound **7e**.



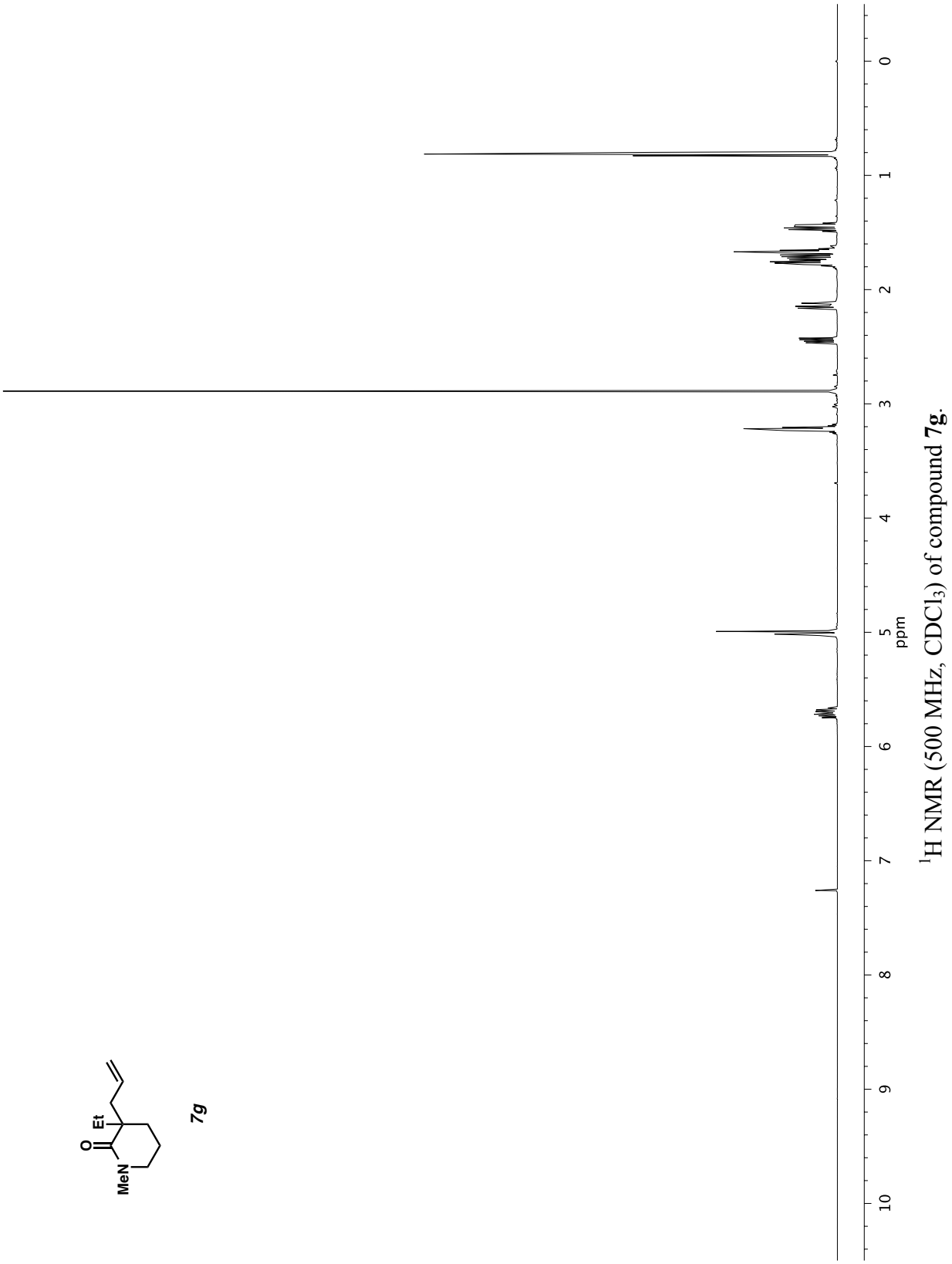
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7f**.



Infrared spectrum (Thin Film, NaCl) of compound **7f**.

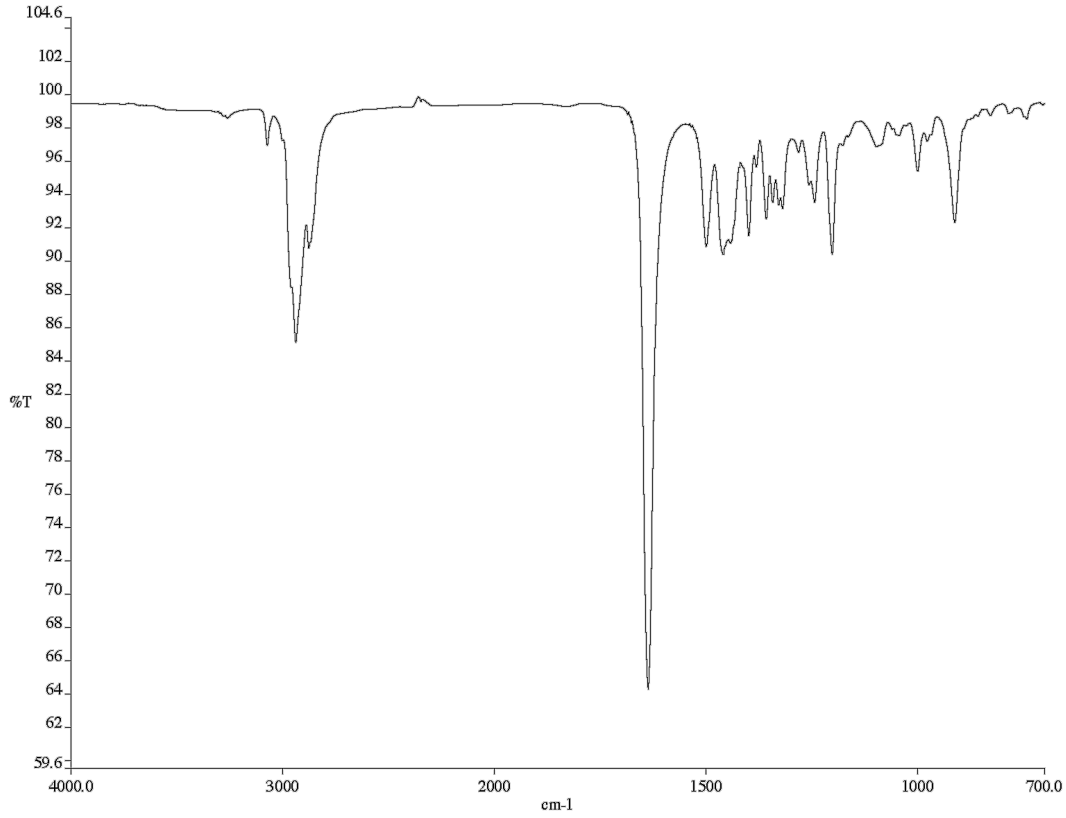


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7f**.

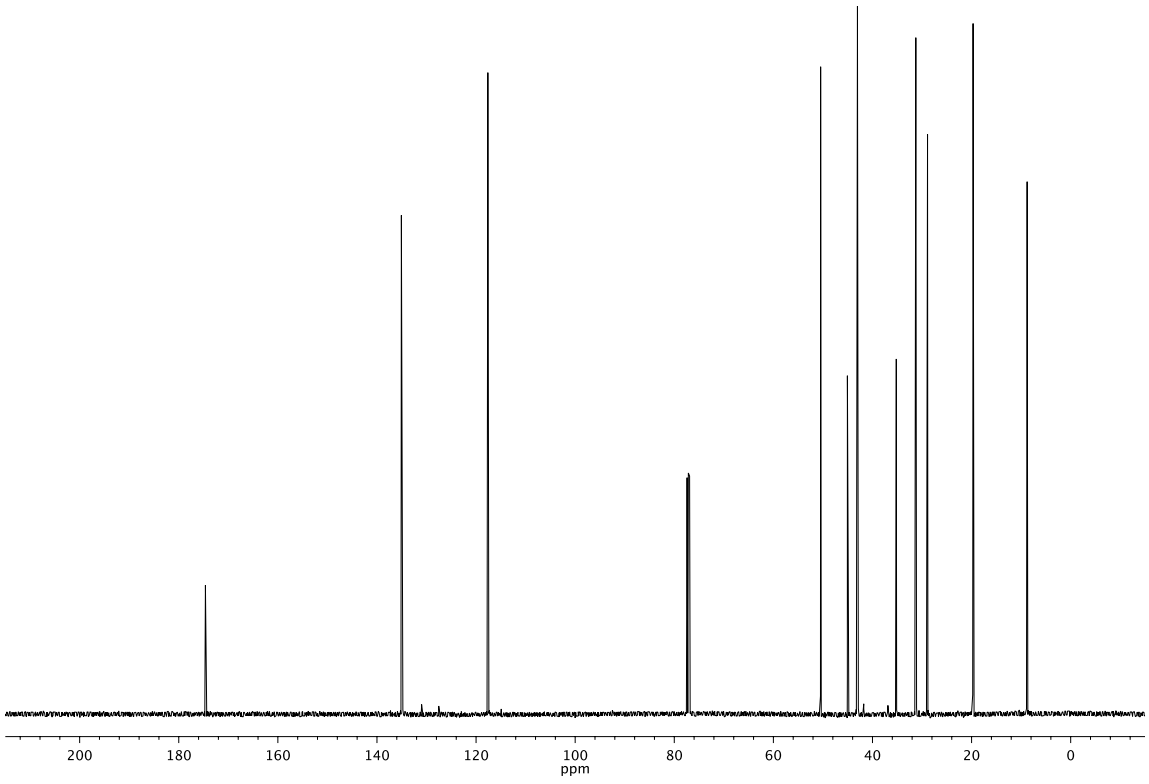


7g

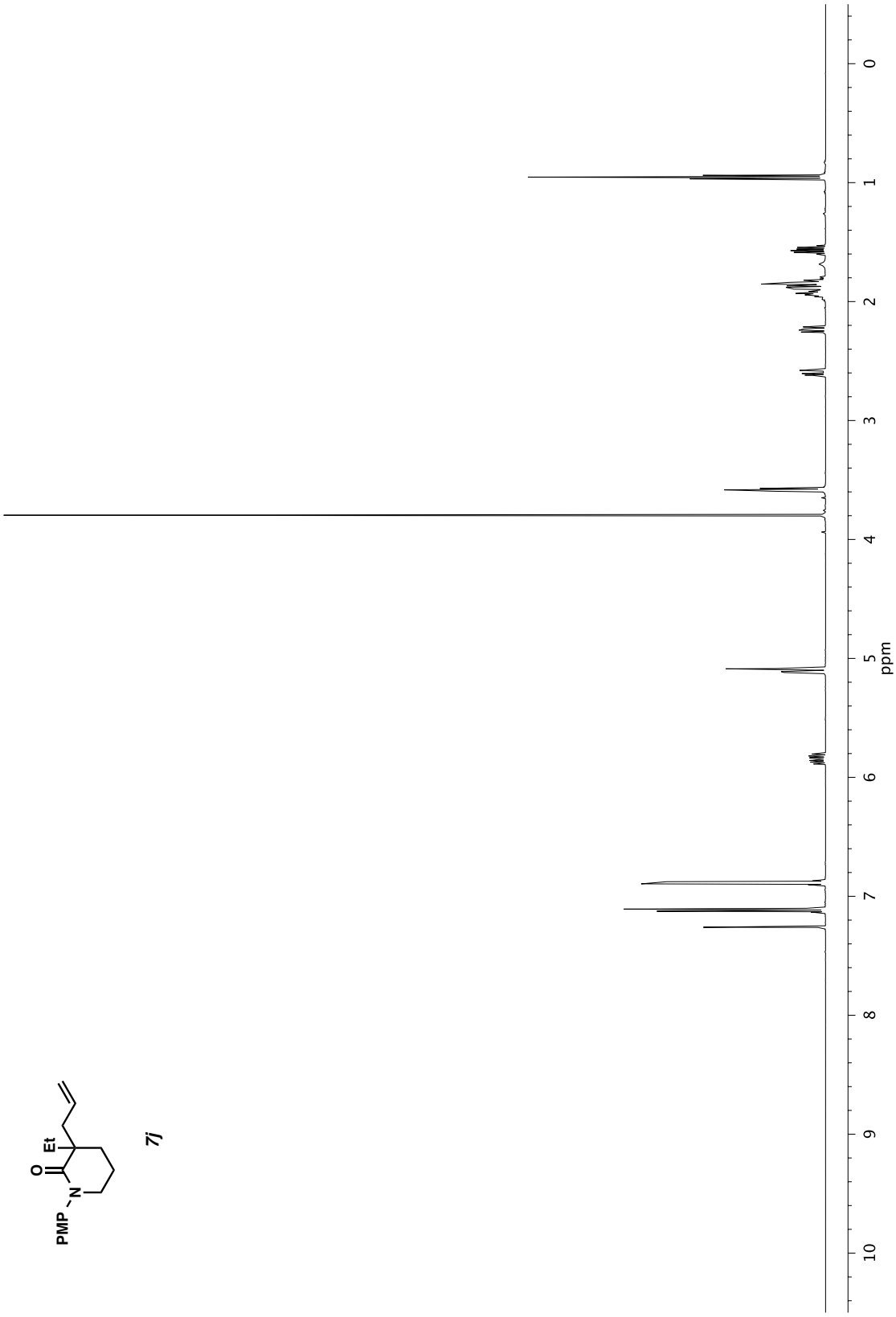
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7g**.



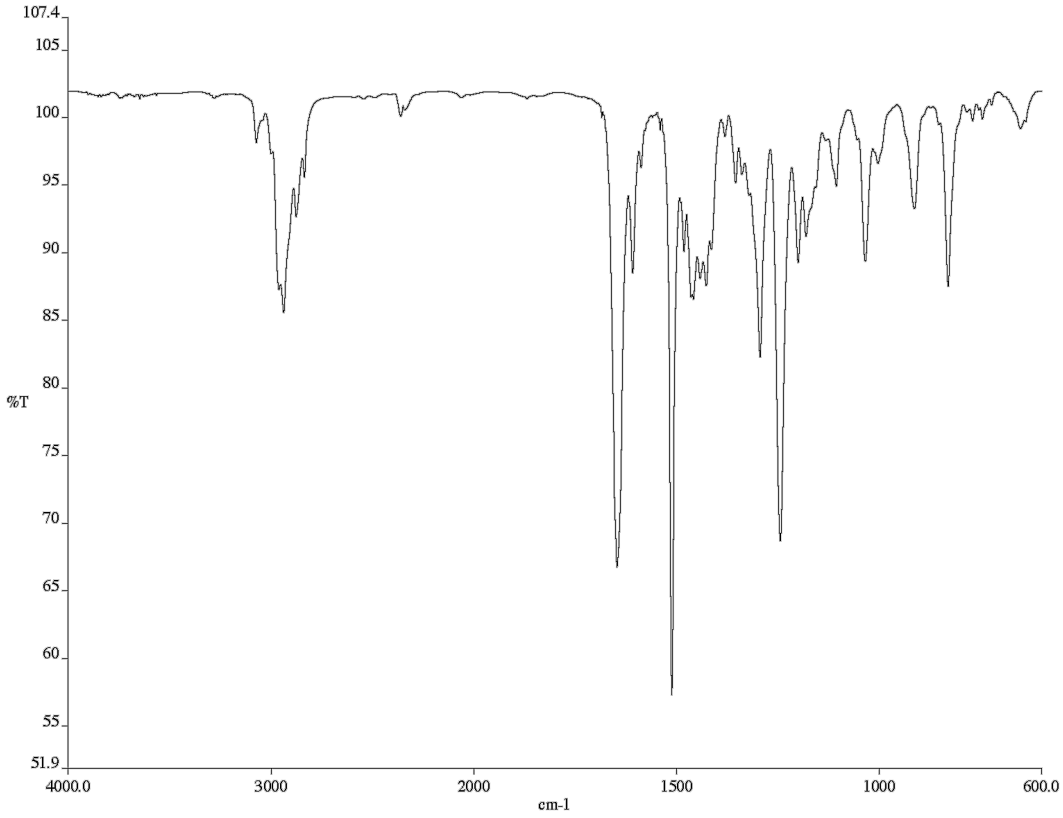
Infrared spectrum (Thin Film, NaCl) of compound **7g**.



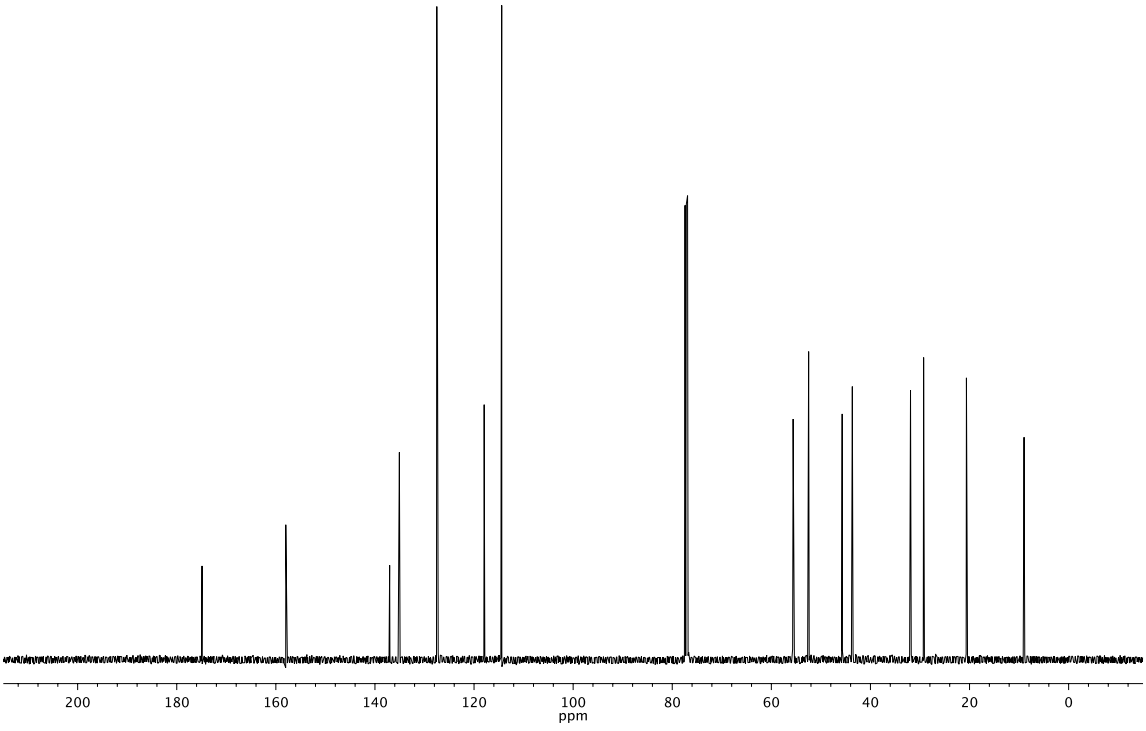
^{13}C NMR (126 MHz, $CDCl_3$) of compound **7g**.



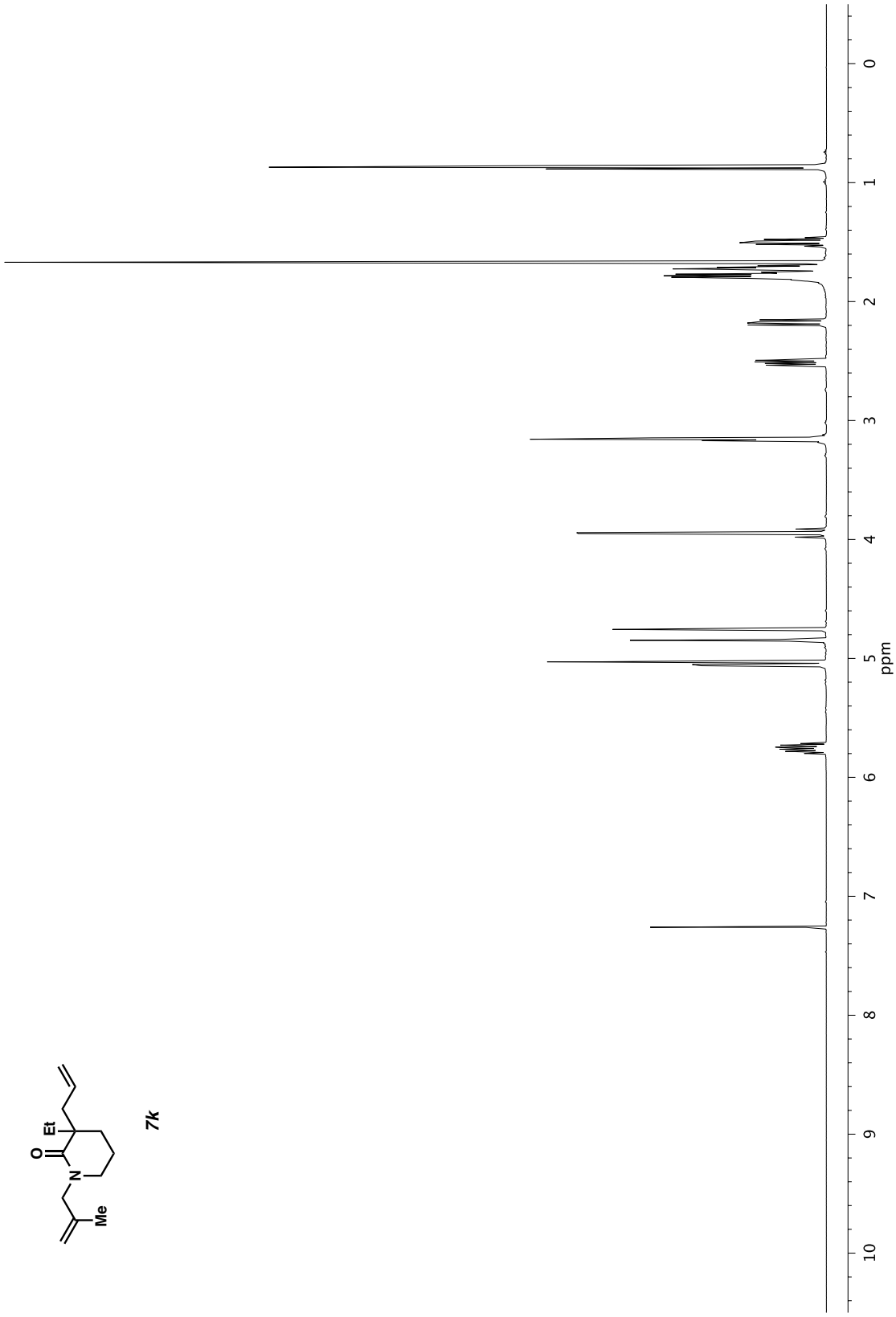
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7j**.



Infrared spectrum (Thin Film, NaCl) of compound **7j**.

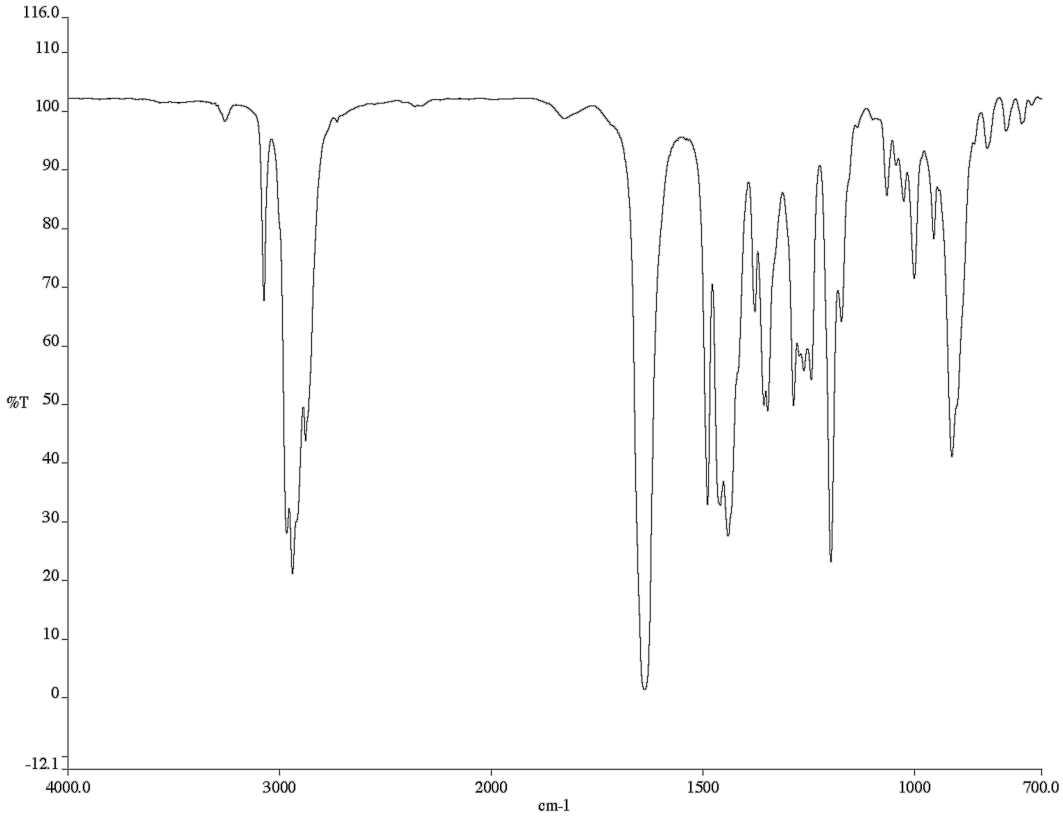


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7j**.

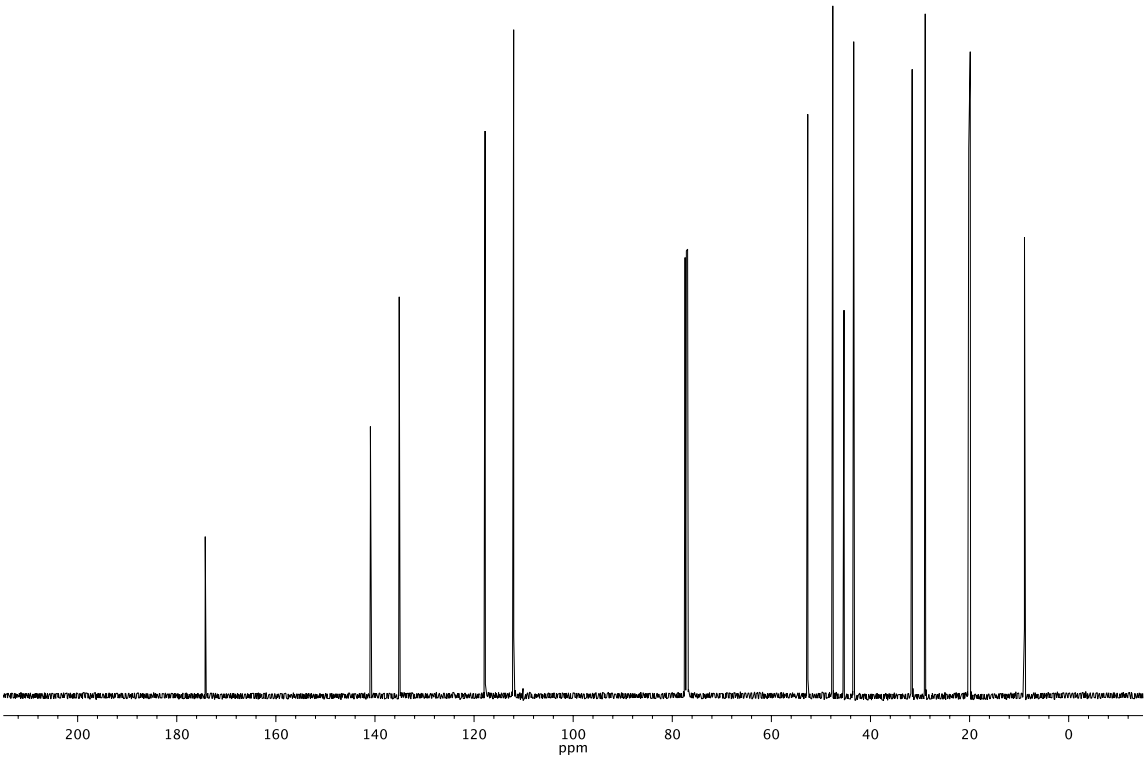


7k

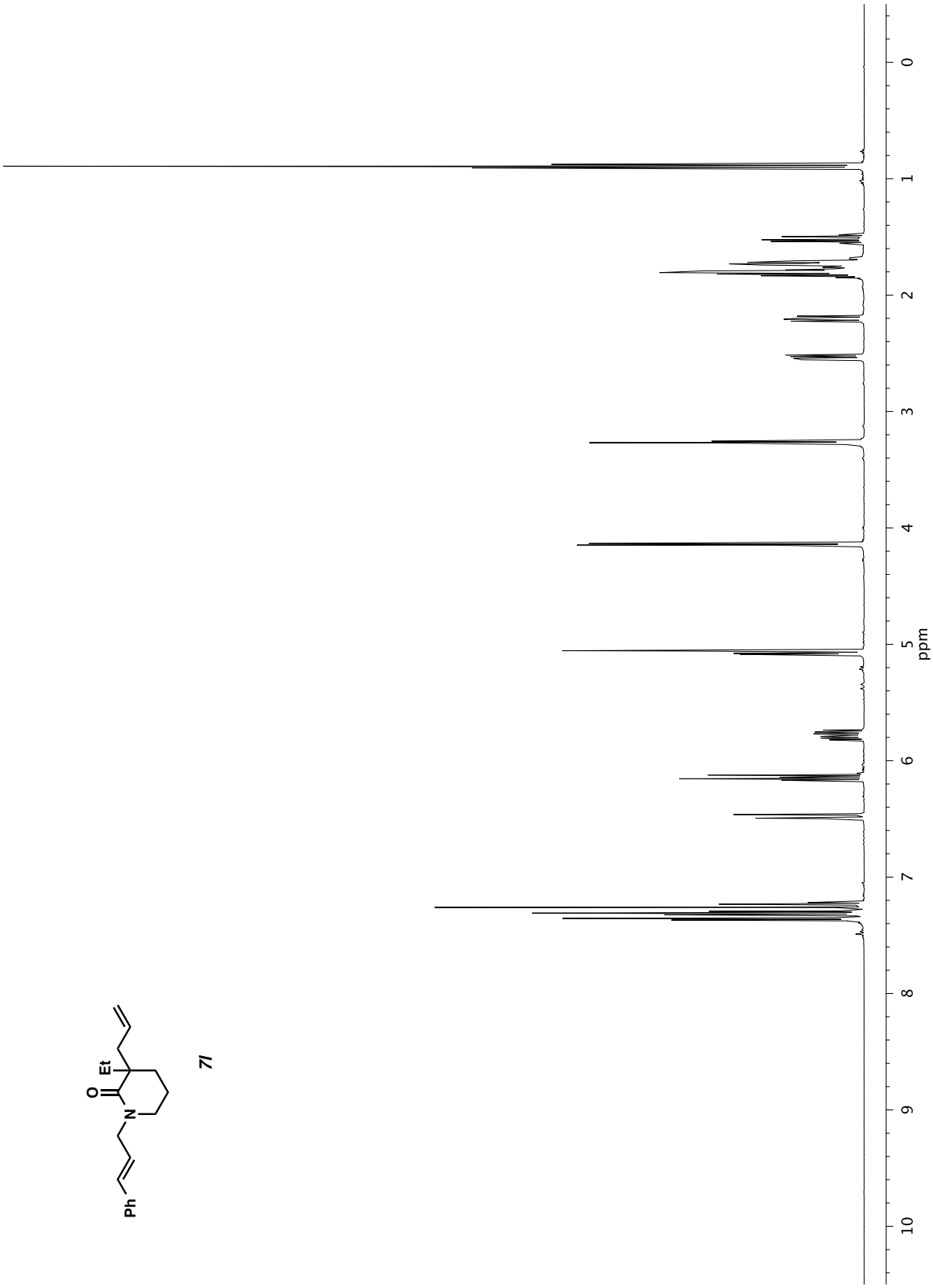
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7k**.



Infrared spectrum (Thin Film, NaCl) of compound **7k**.

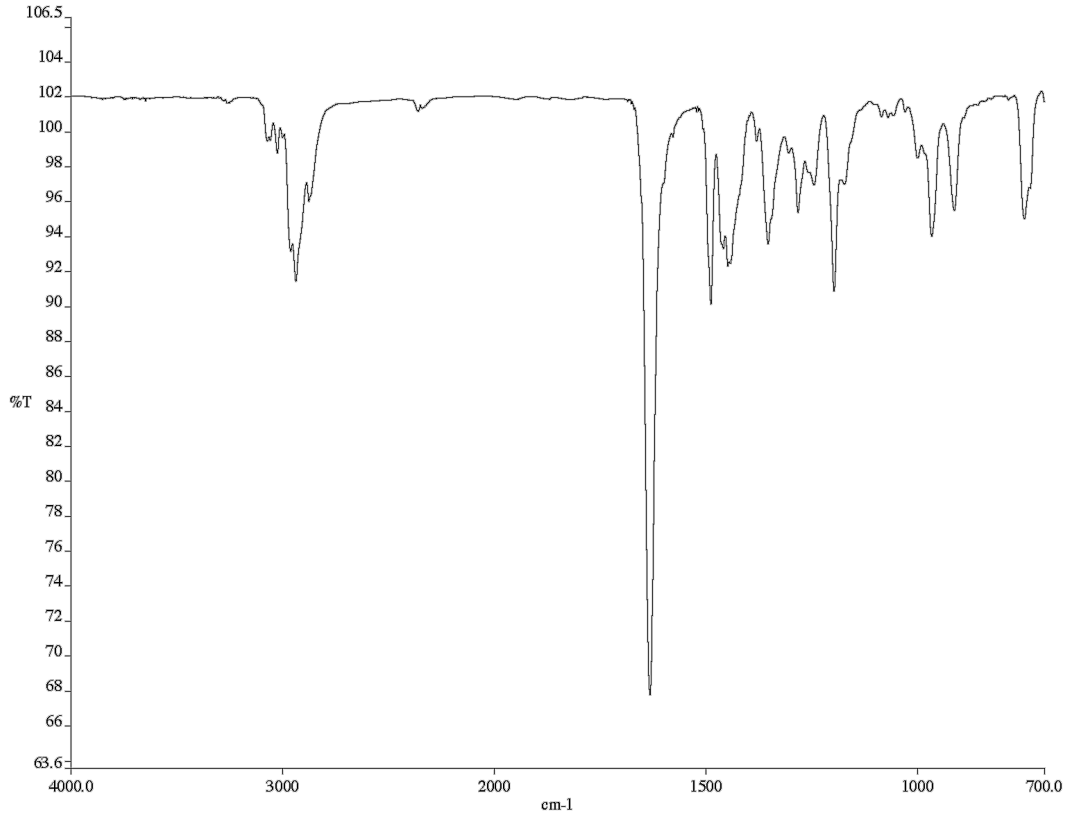


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7k**.

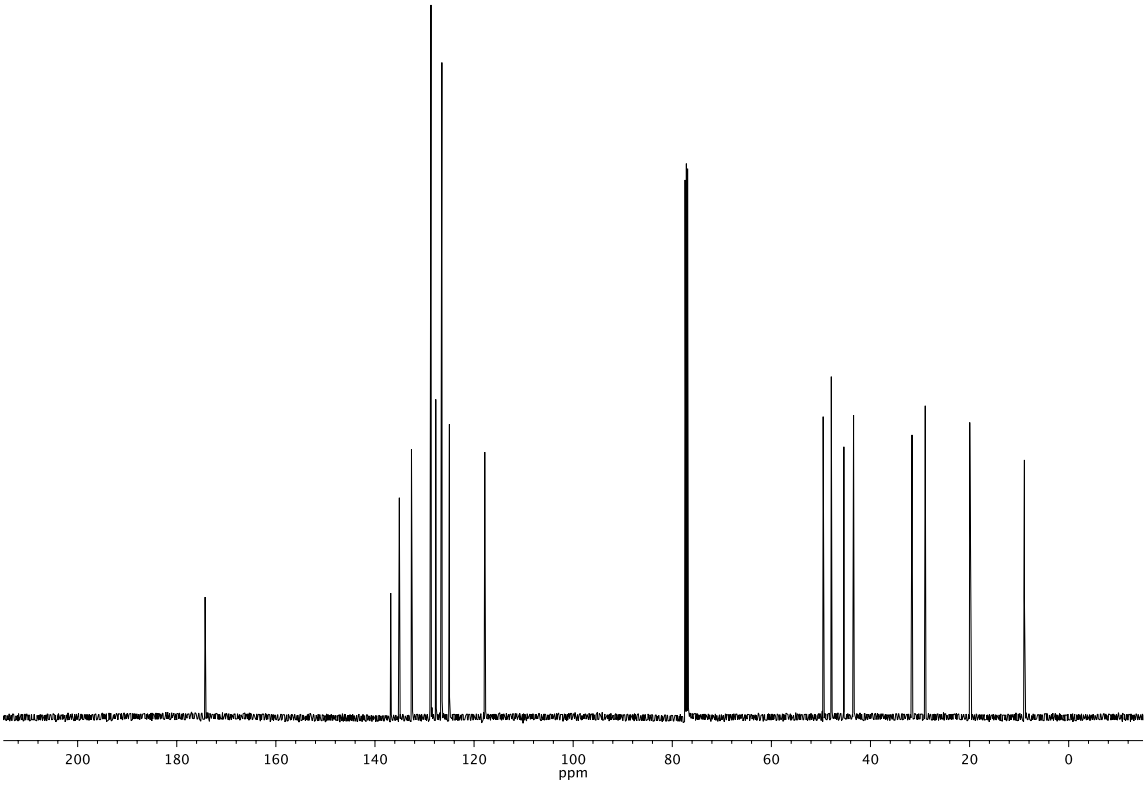


7l

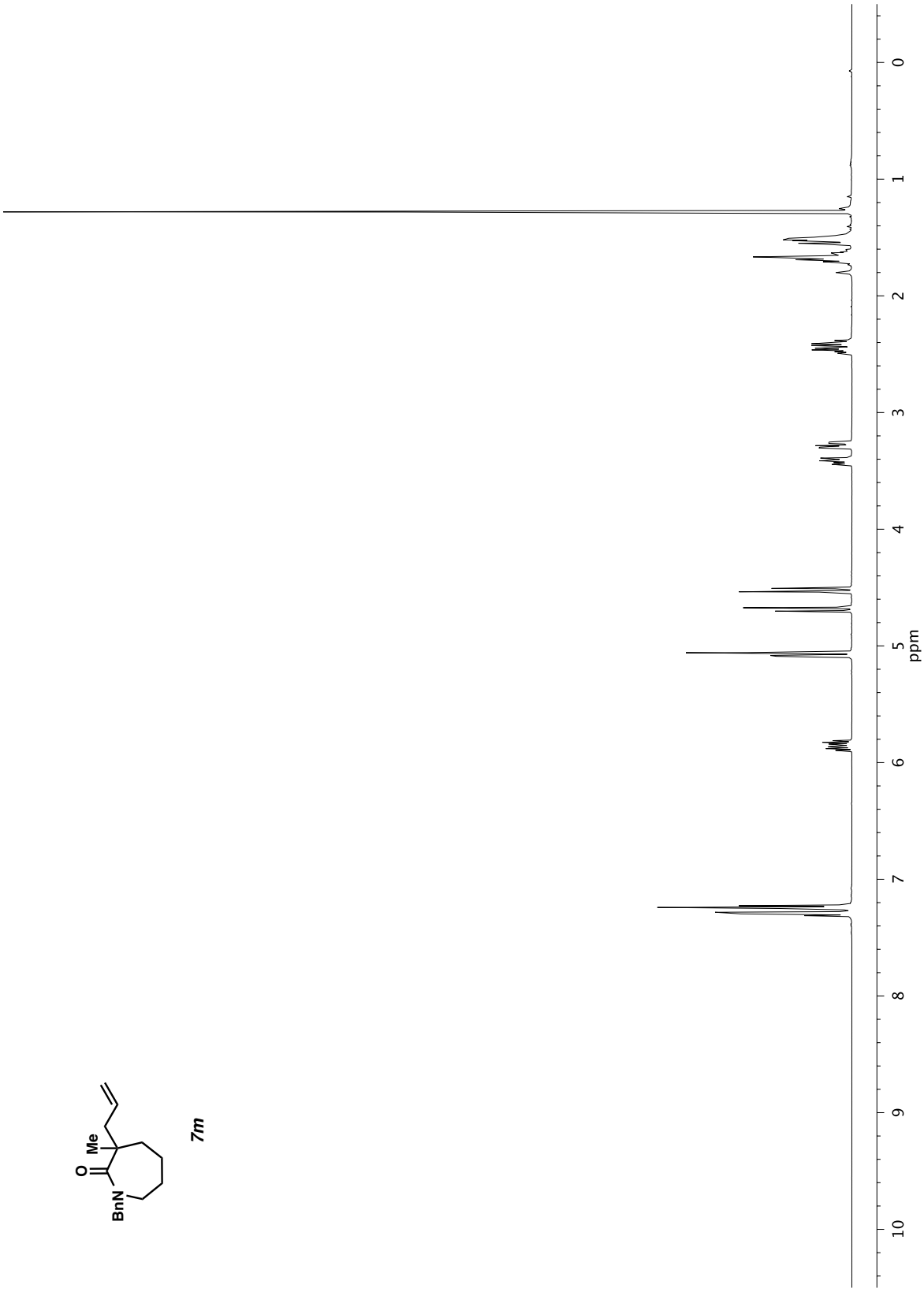
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7l**.



Infrared spectrum (Thin Film, NaCl) of compound **7l**.

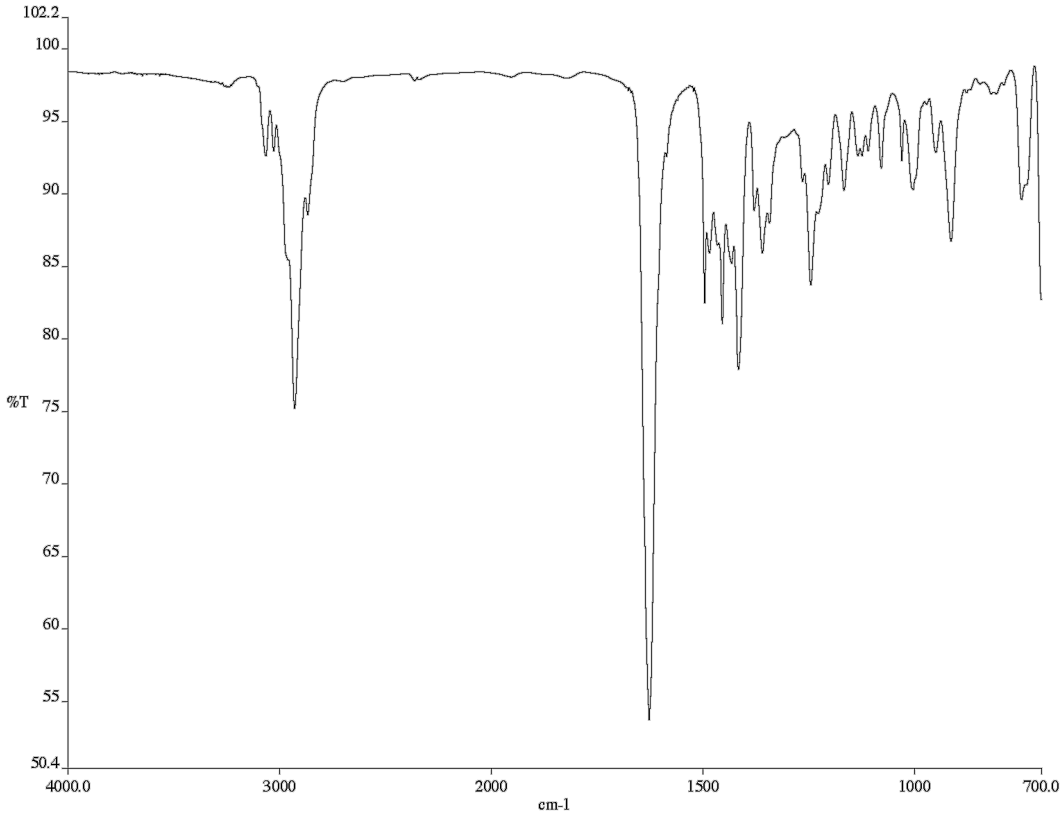


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7l**.

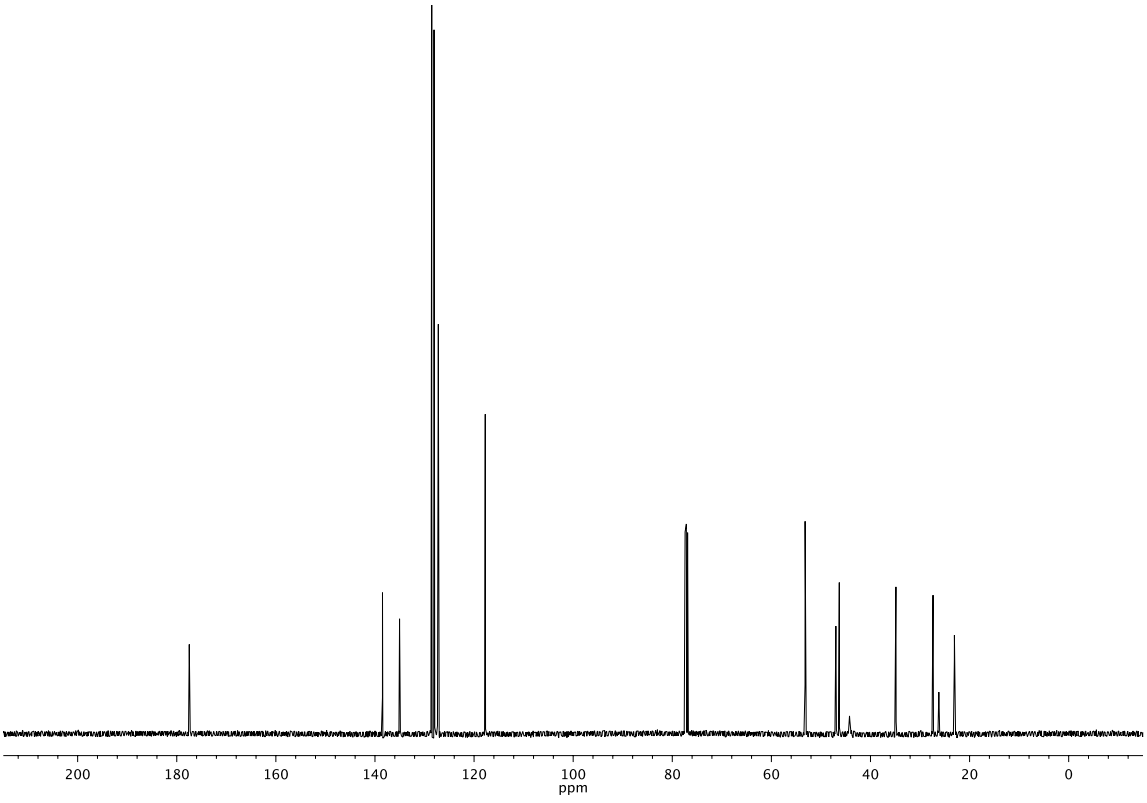


^{1}H NMR (500 MHz, $CDCl_3$) of compound **7m**.

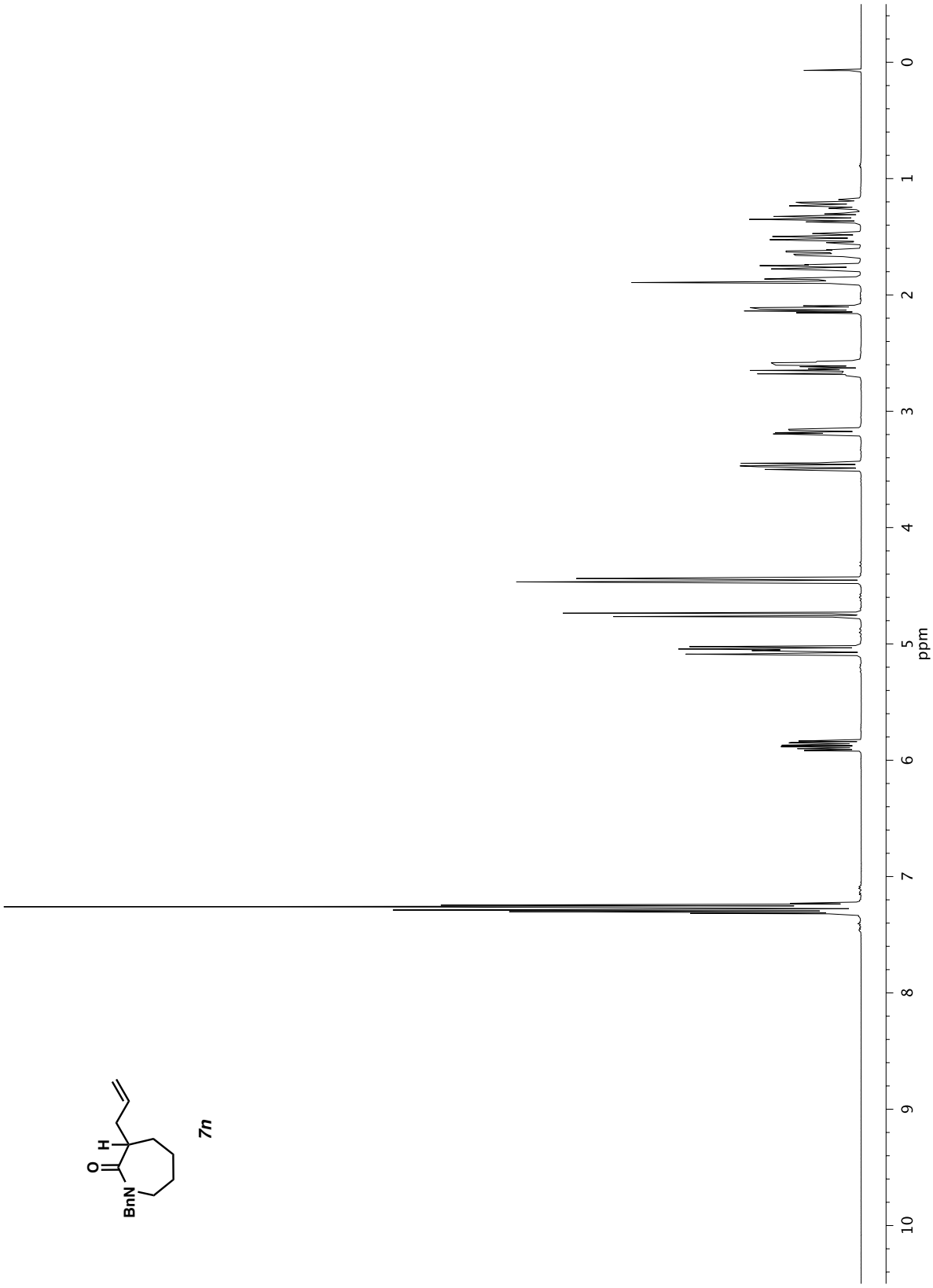
7m



Infrared spectrum (Thin Film, NaCl) of compound **7m**.

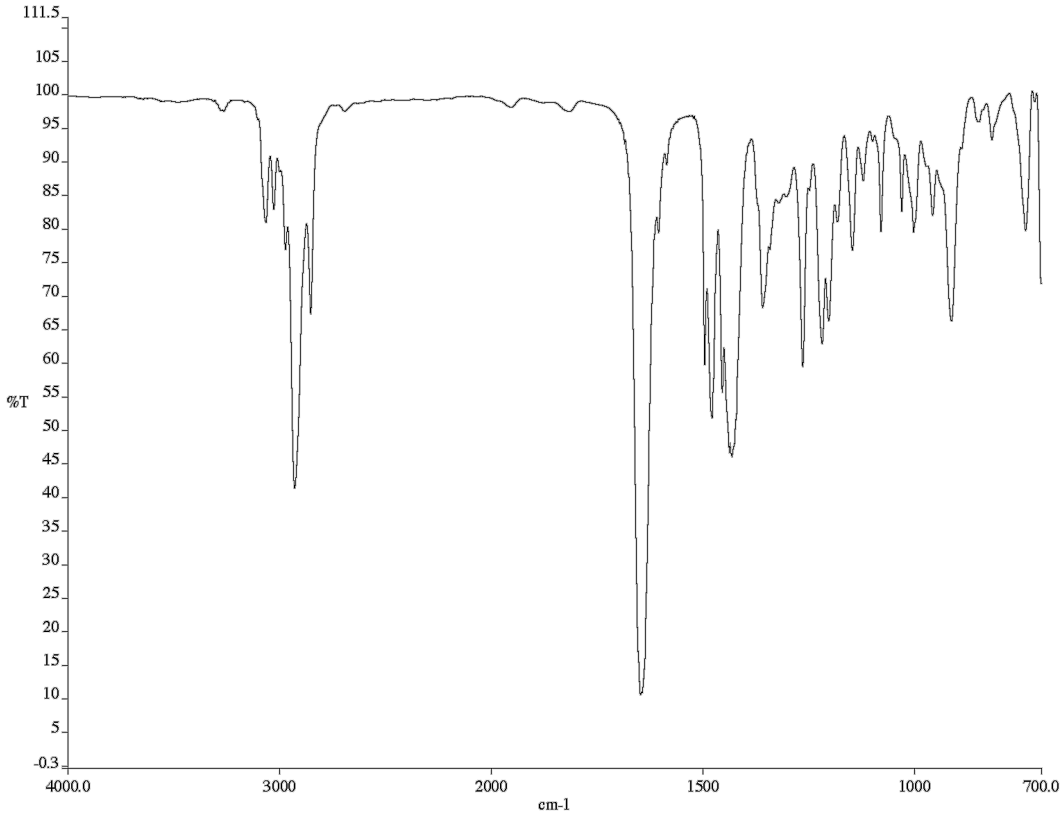


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7m**.

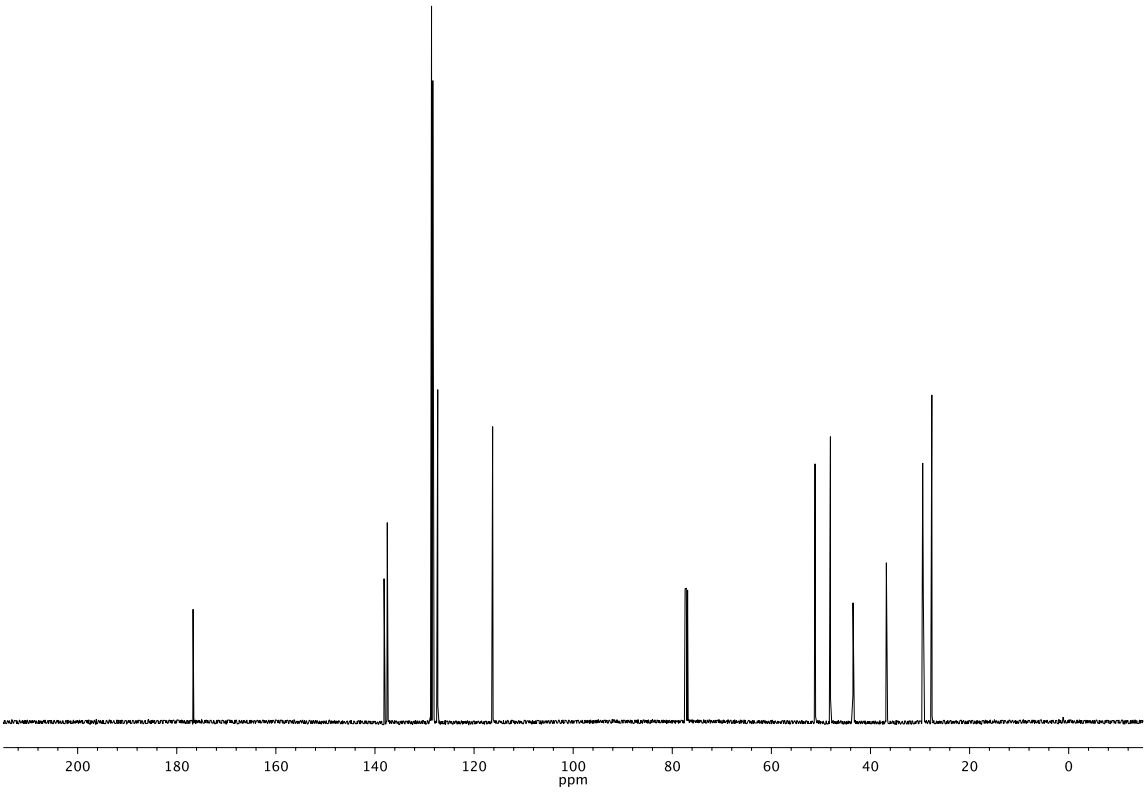


7n

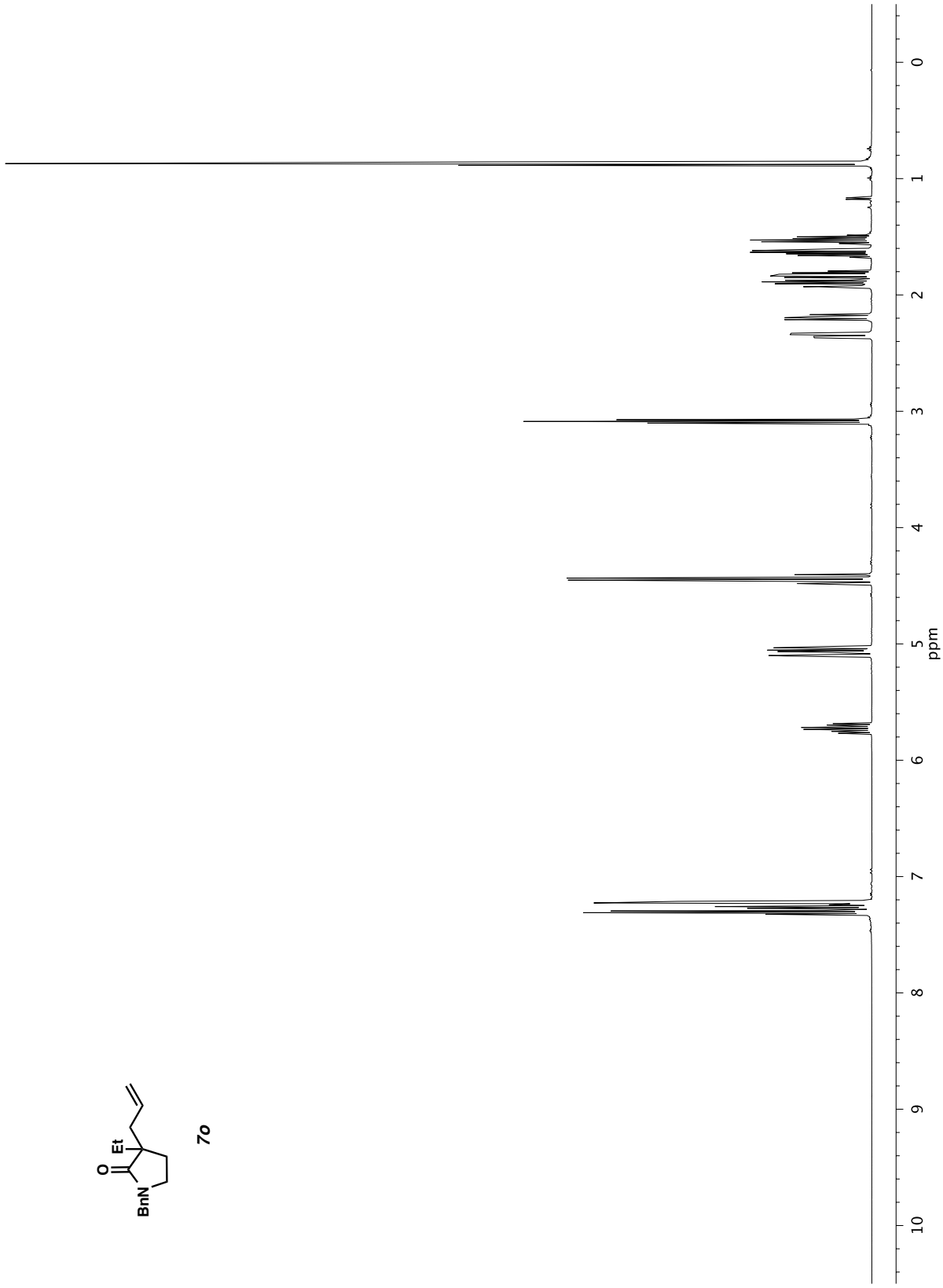
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7n**.



Infrared spectrum (Thin Film, NaCl) of compound **7n**.

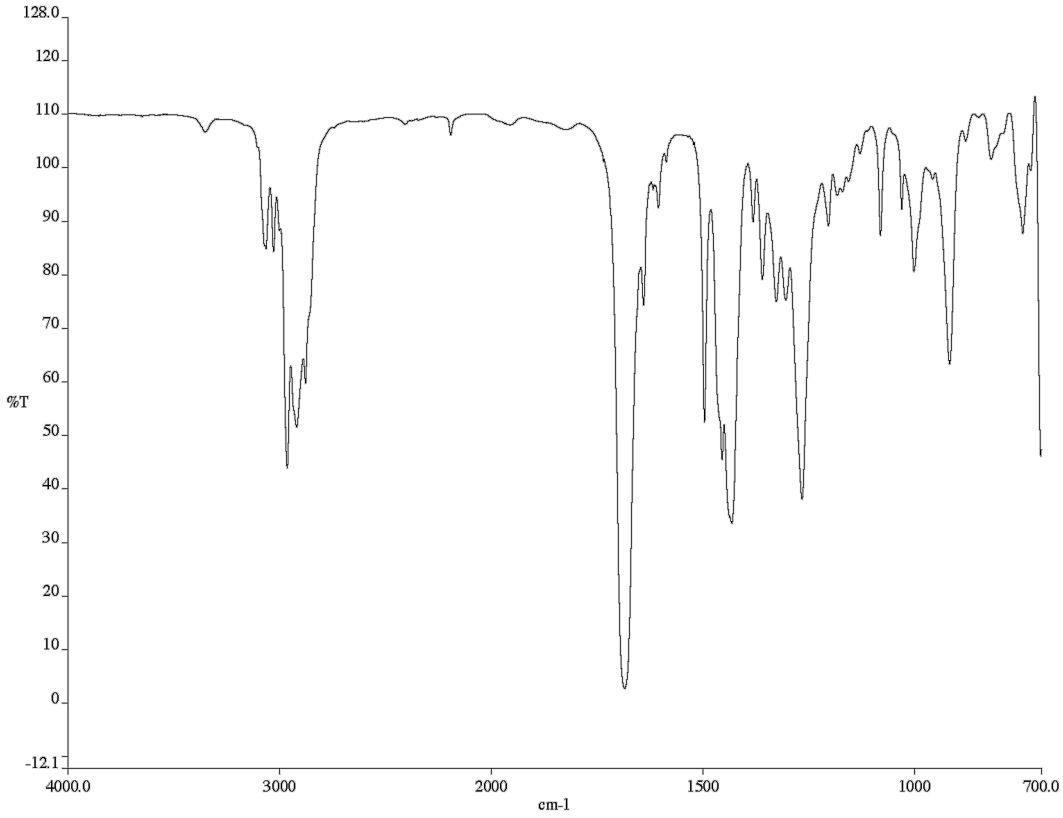


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7n**.

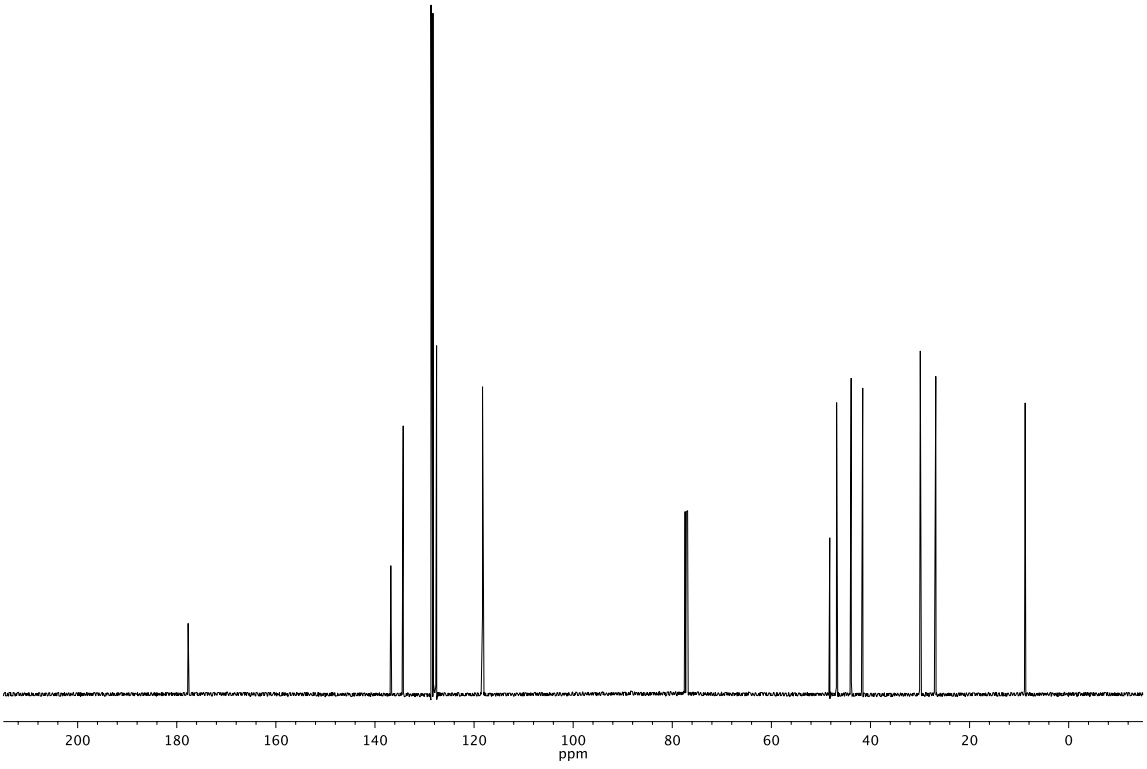


7o

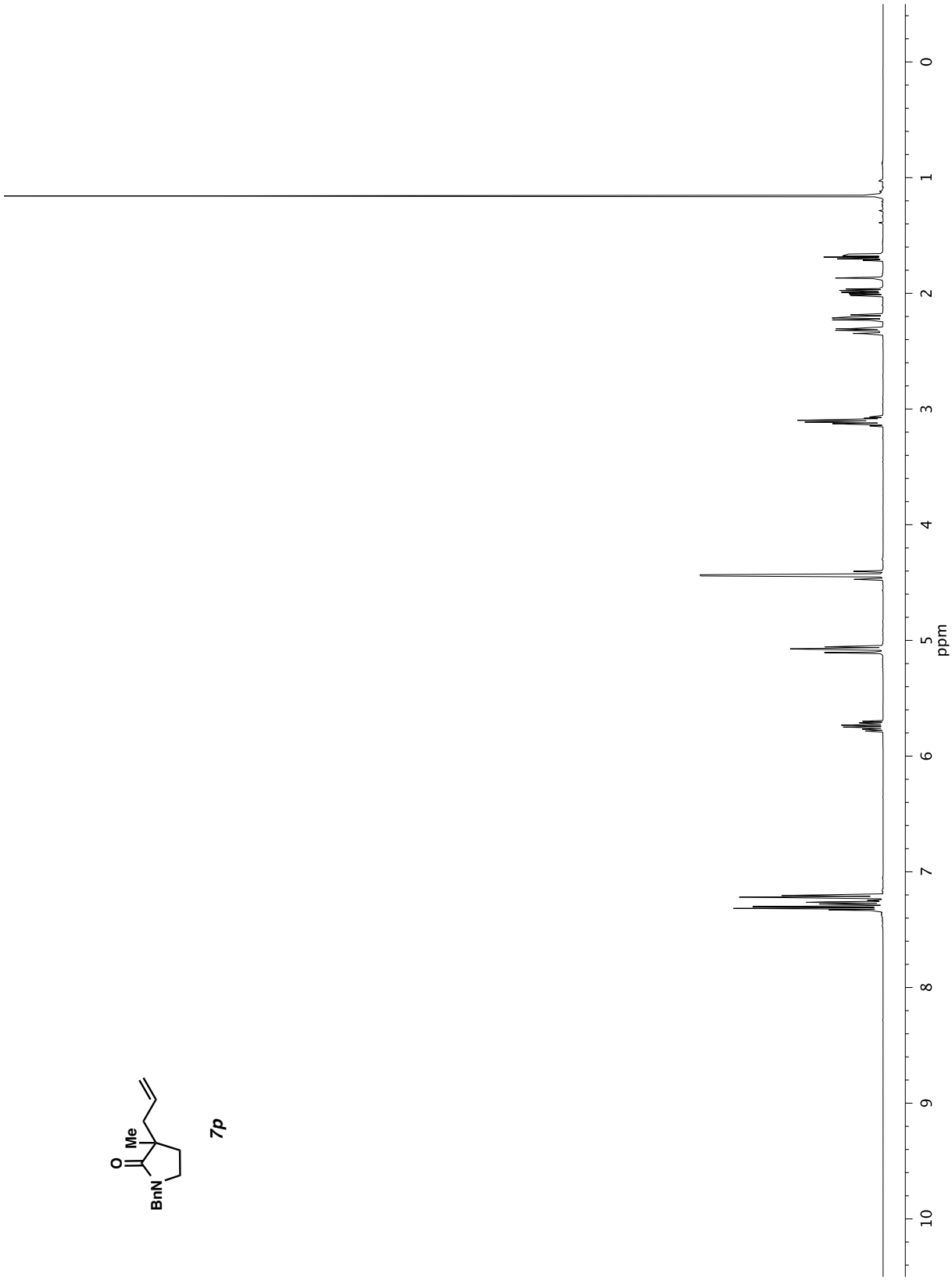
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7o**.



Infrared spectrum (Thin Film, NaCl) of compound **7o**.

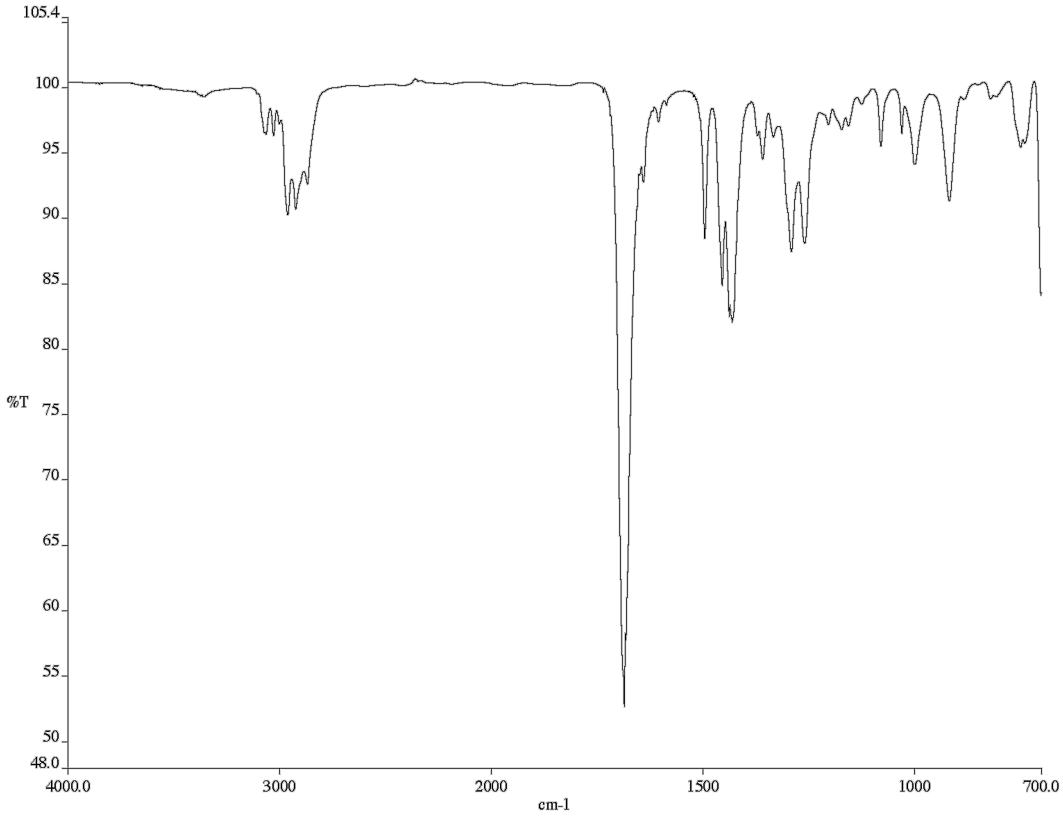


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7o**.

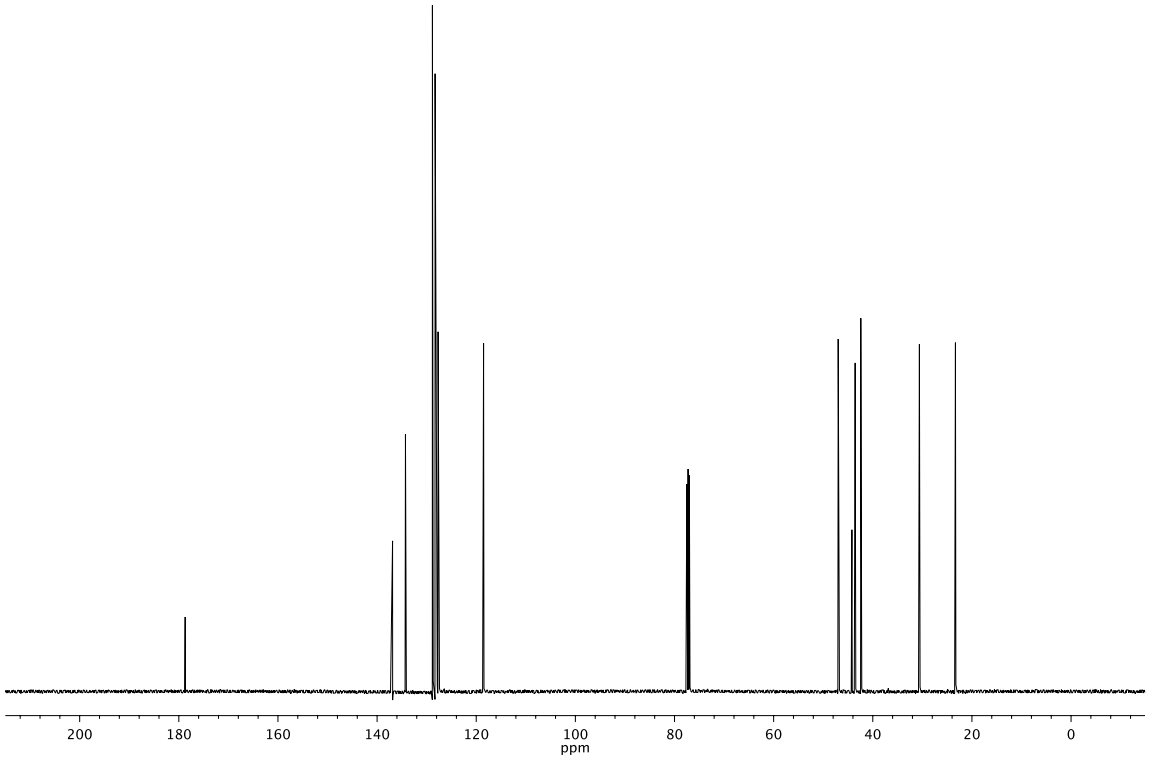


^{1}H NMR (500 MHz, $CDCl_3$) of compound **7p**.

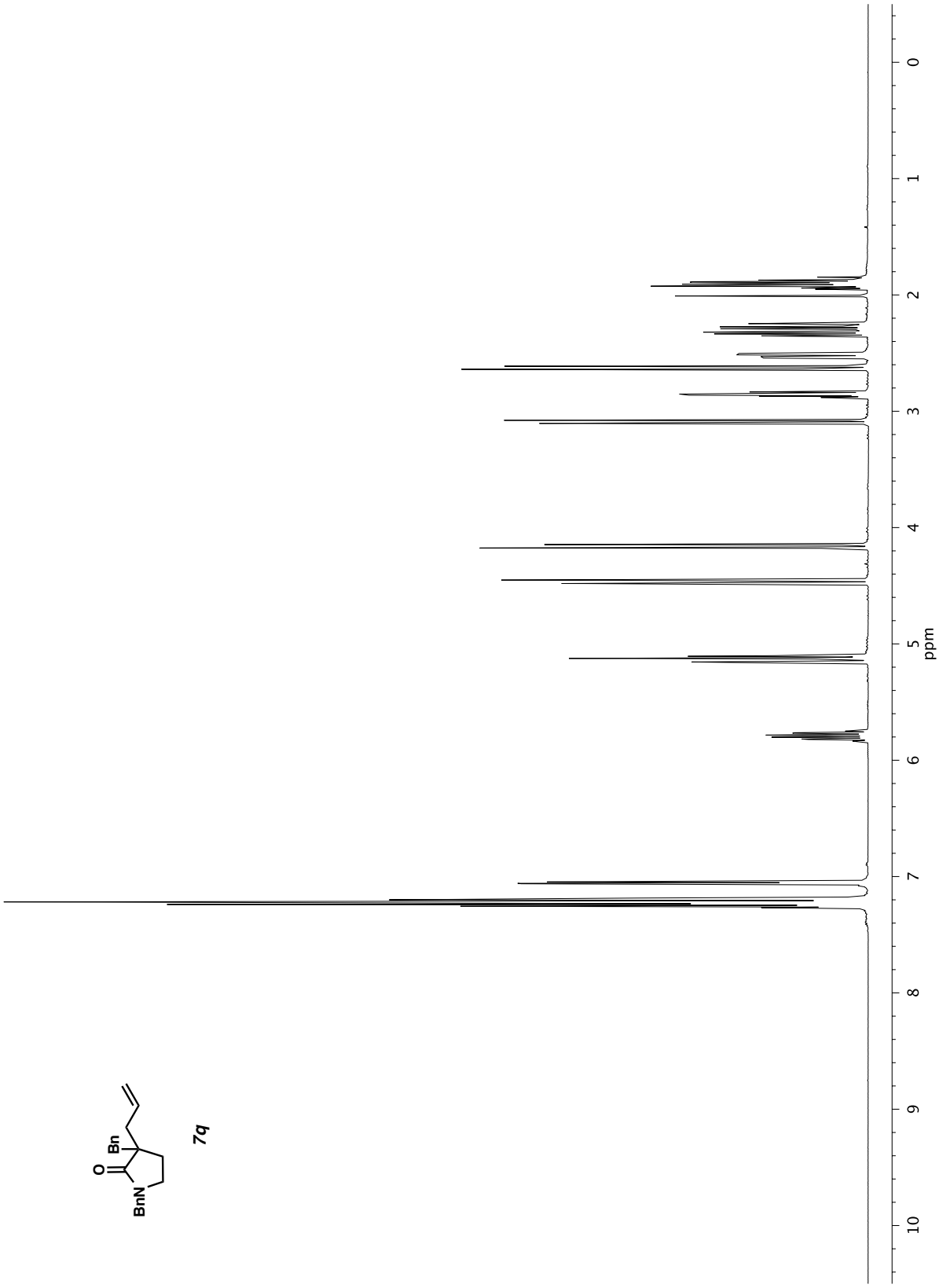
7p



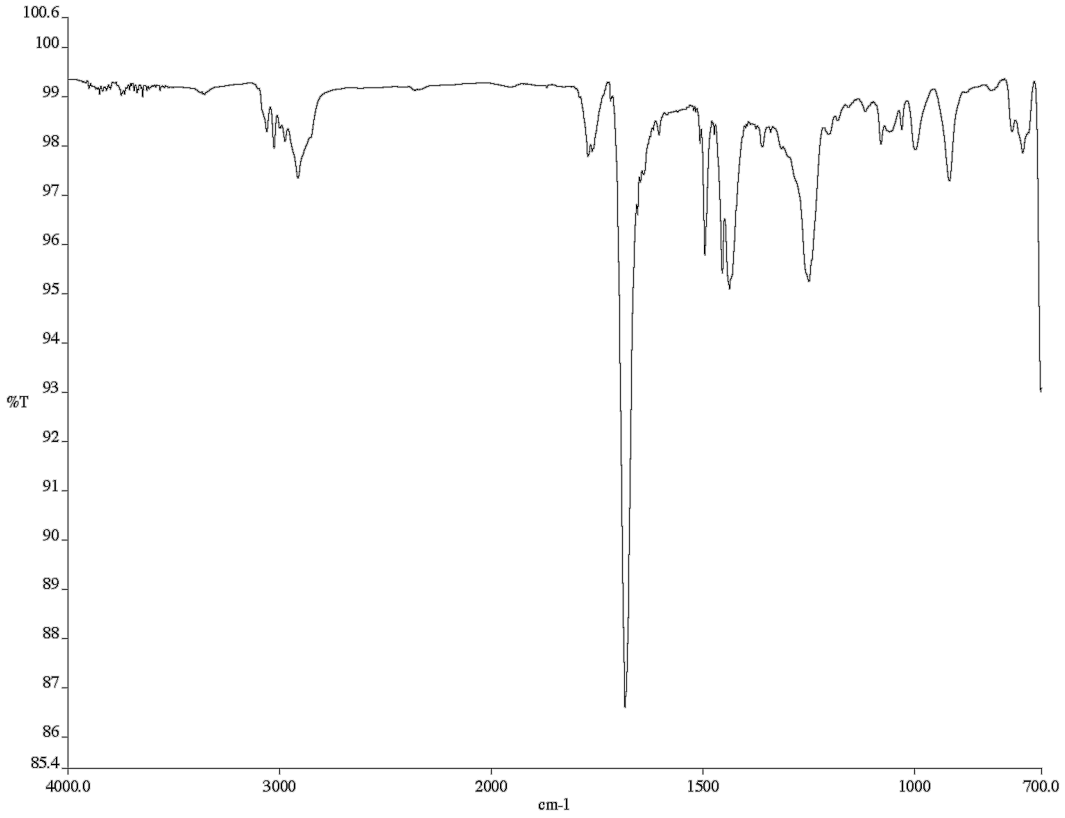
Infrared spectrum (Thin Film, NaCl) of compound **7p**.



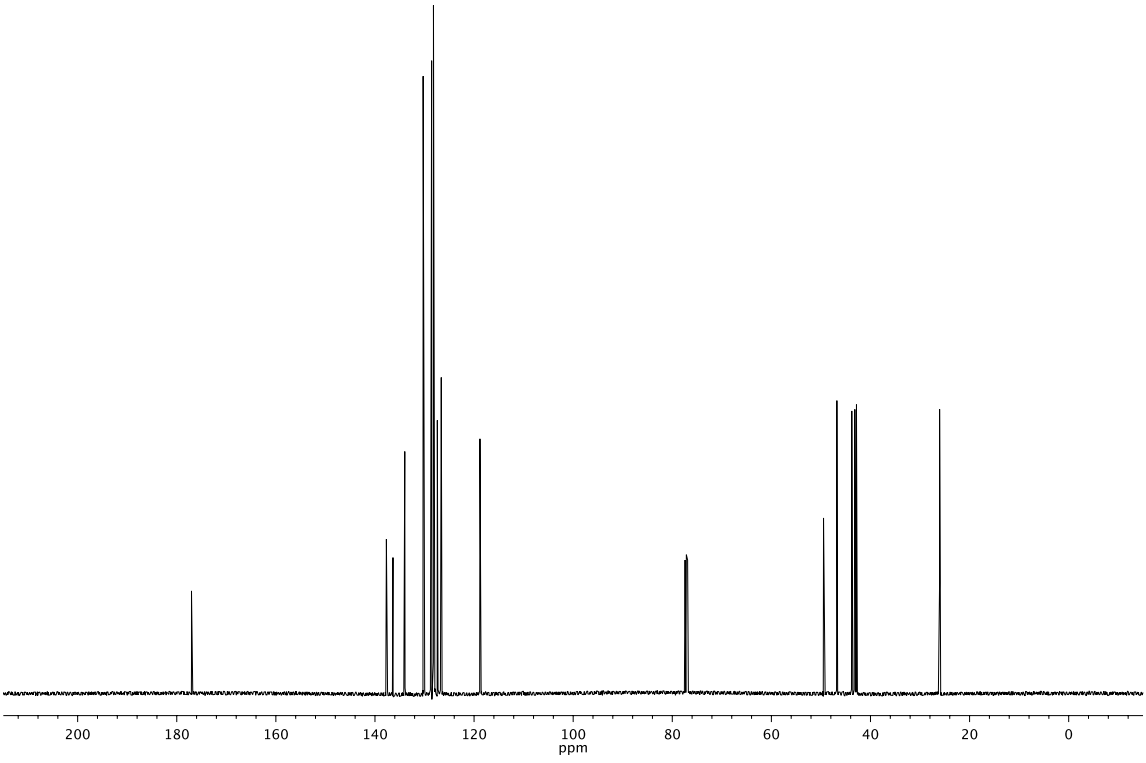
^{13}C NMR (126 MHz, $CDCl_3$) of compound **7p**.



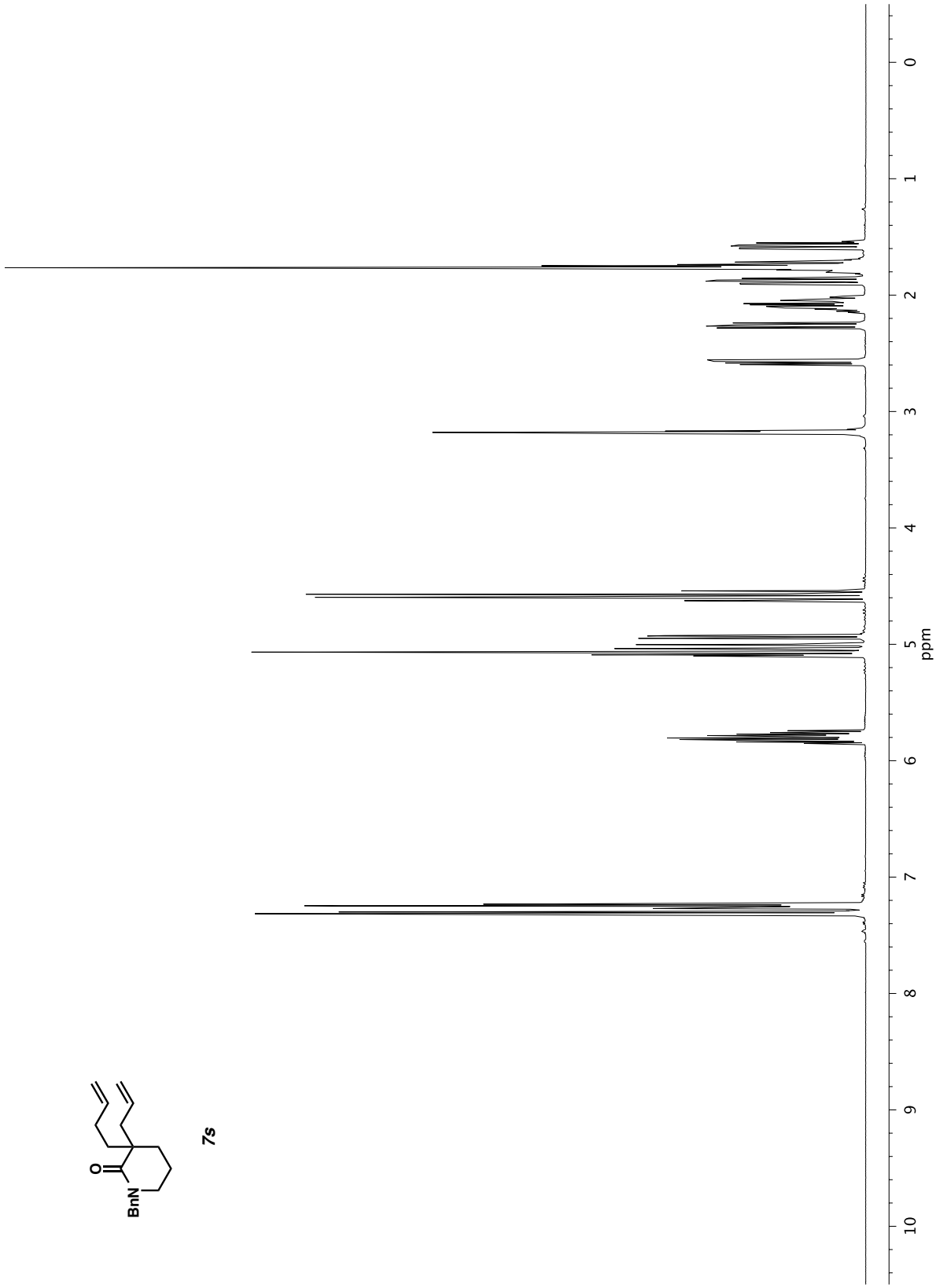
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7q**.



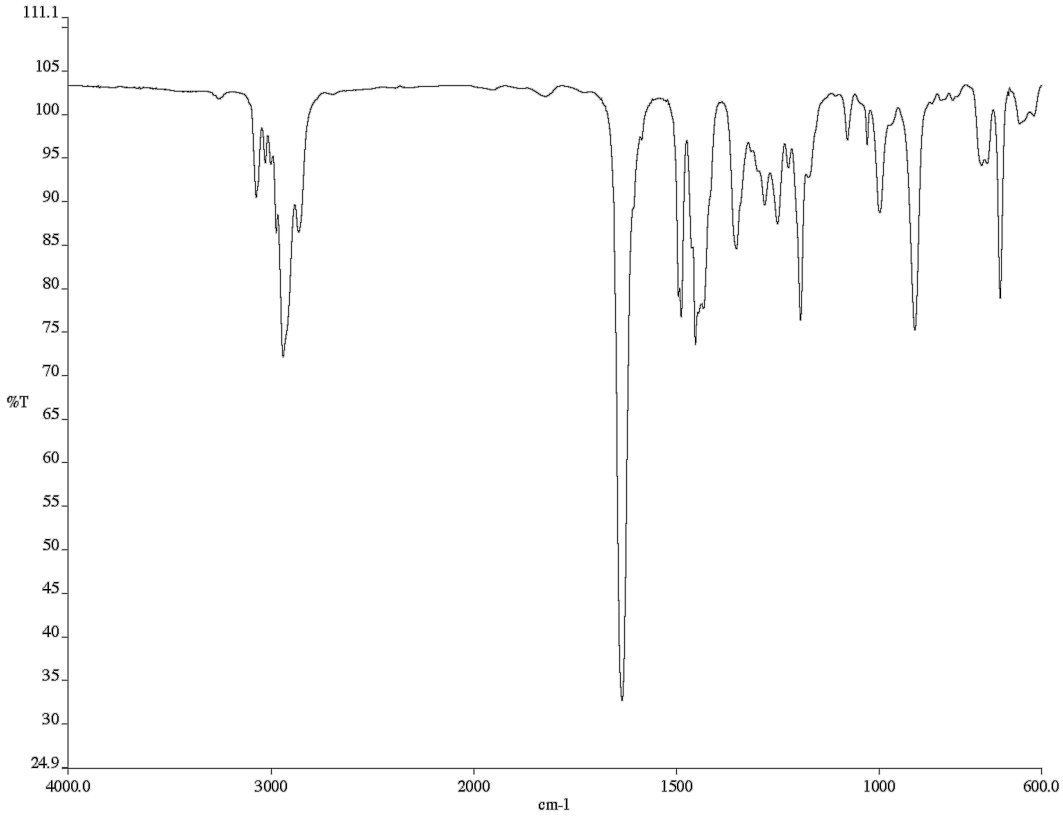
Infrared spectrum (Thin Film, NaCl) of compound **7q**.



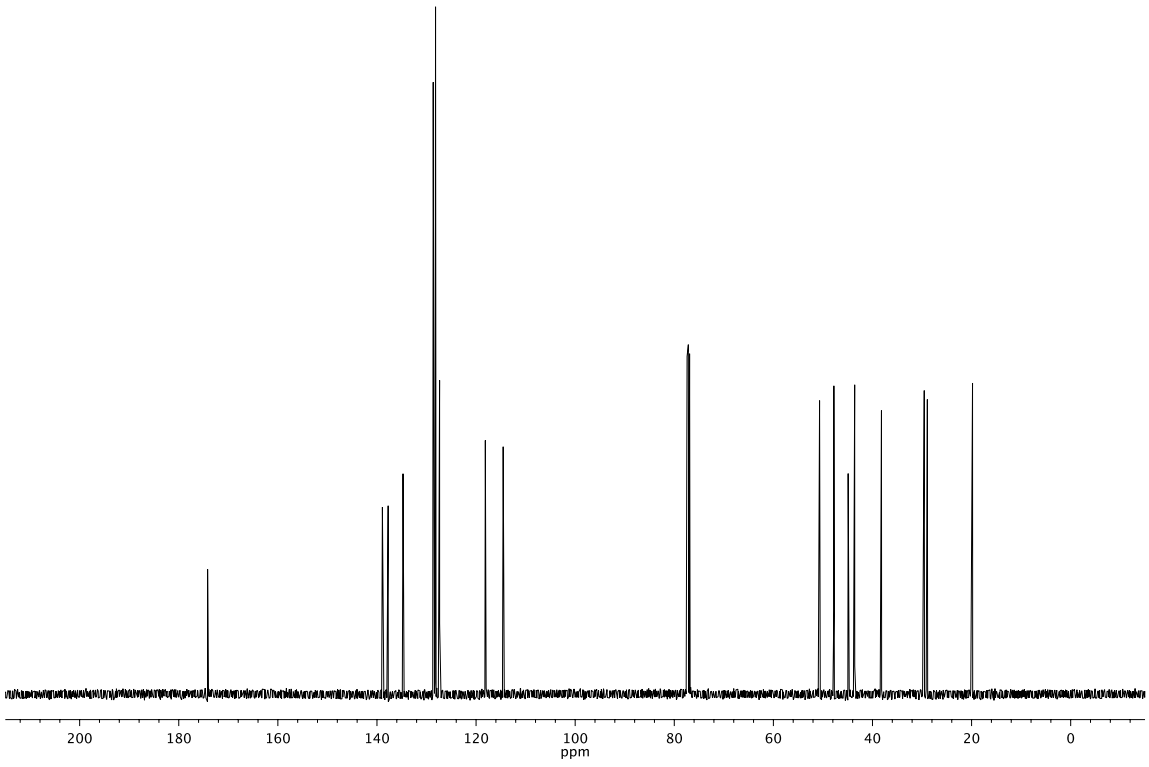
^{13}C NMR (126 MHz, $CDCl_3$) of compound **7q**.



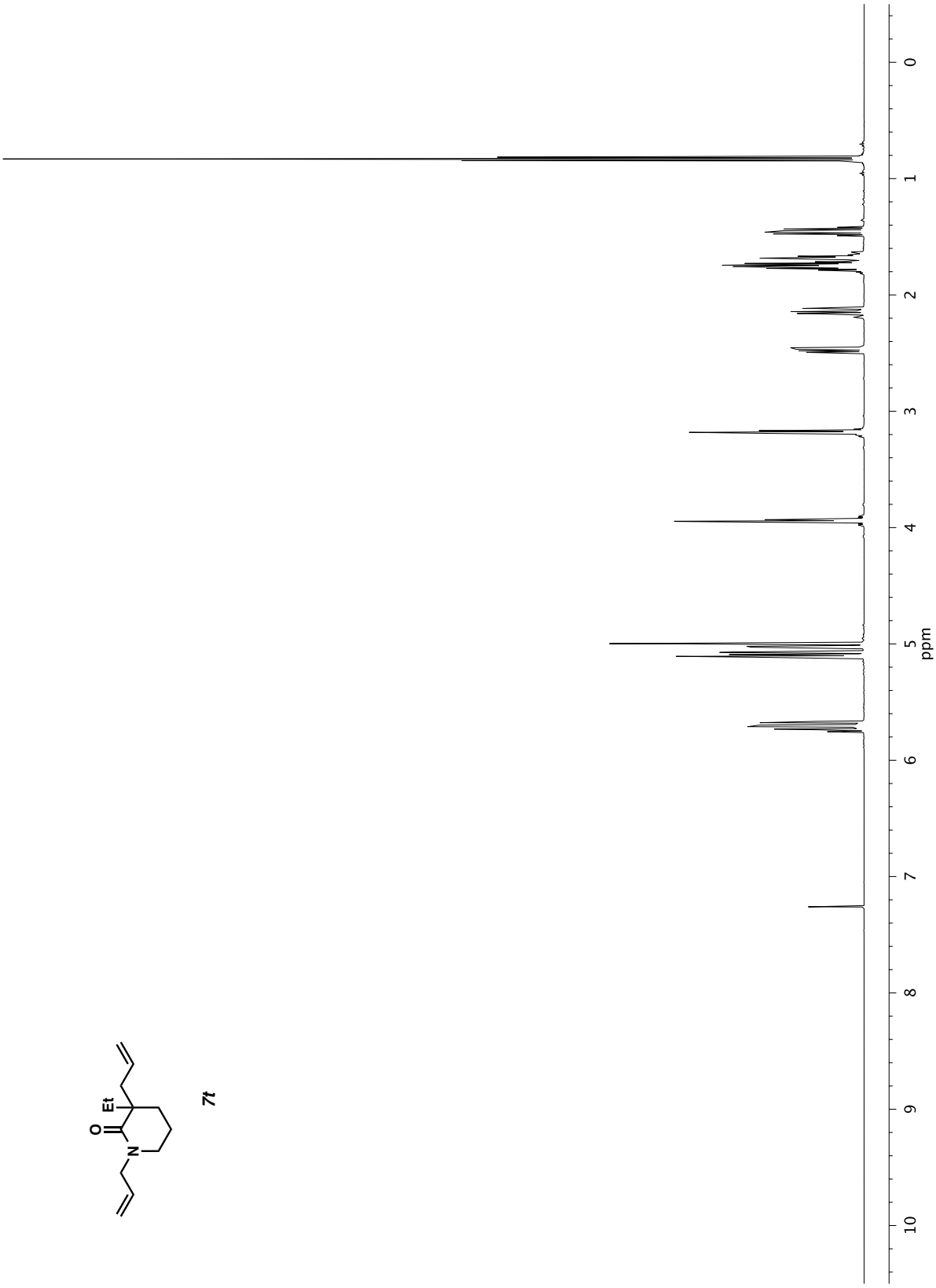
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7s**.



Infrared spectrum (Thin Film, NaCl) of compound **7s**.

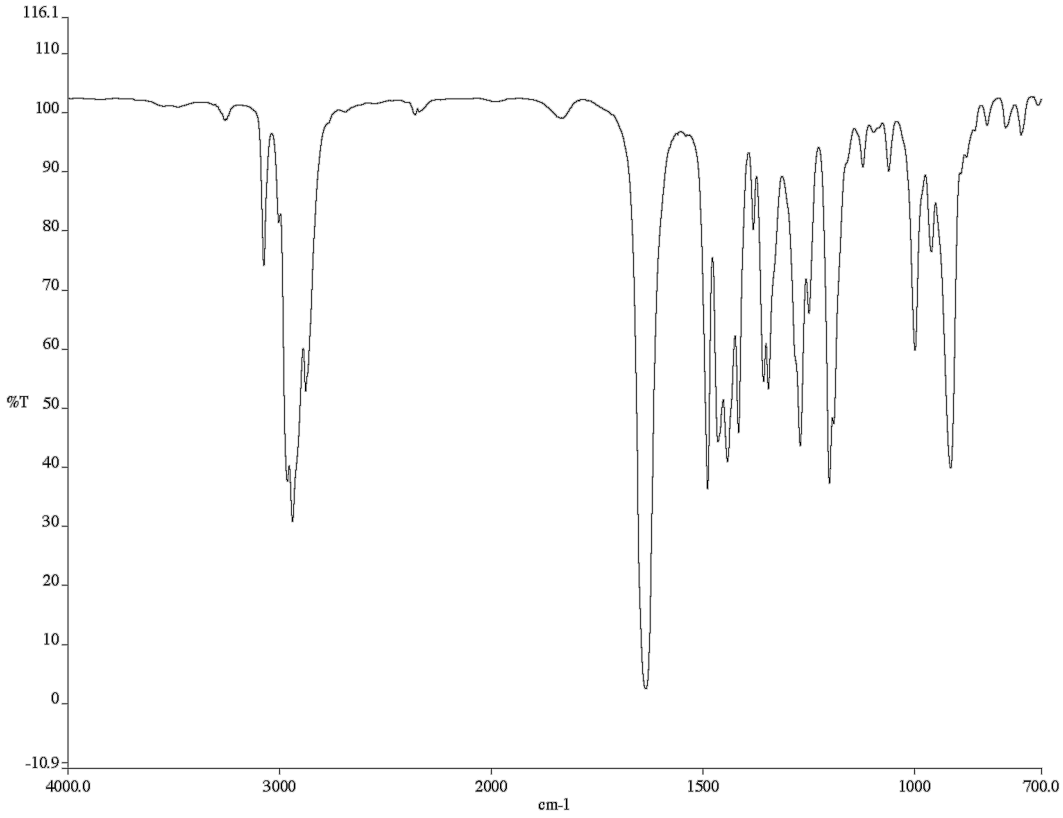


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7s**.

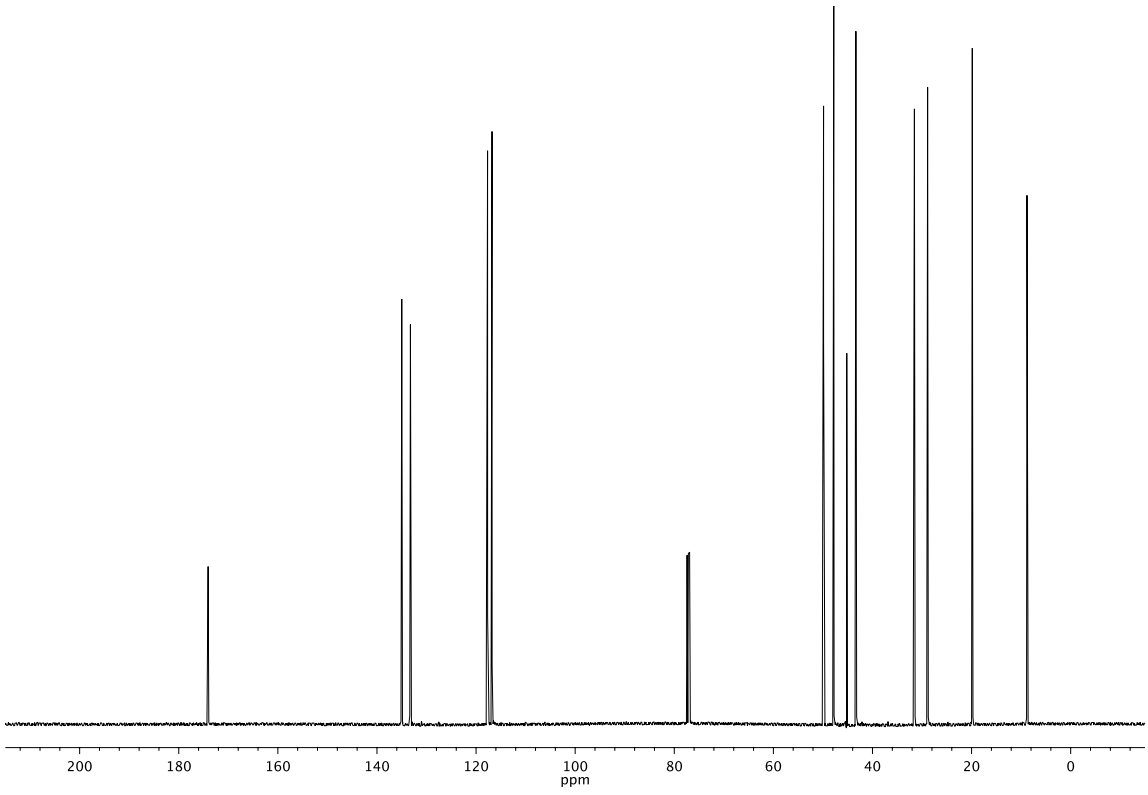


^{1}H NMR (500 MHz, $CDCl_3$) of compound **7t**.

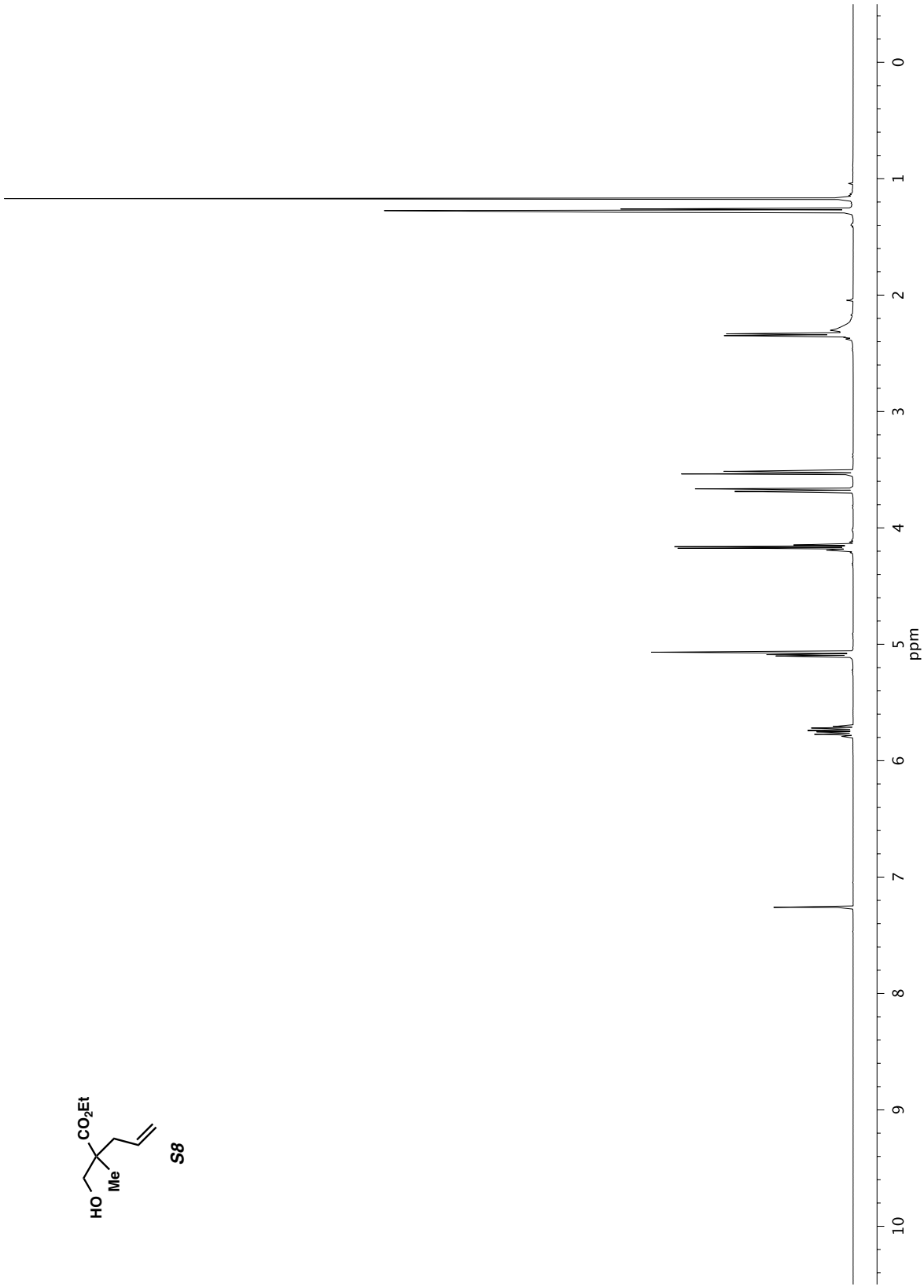
7t



Infrared spectrum (Thin Film, NaCl) of compound **7t**.

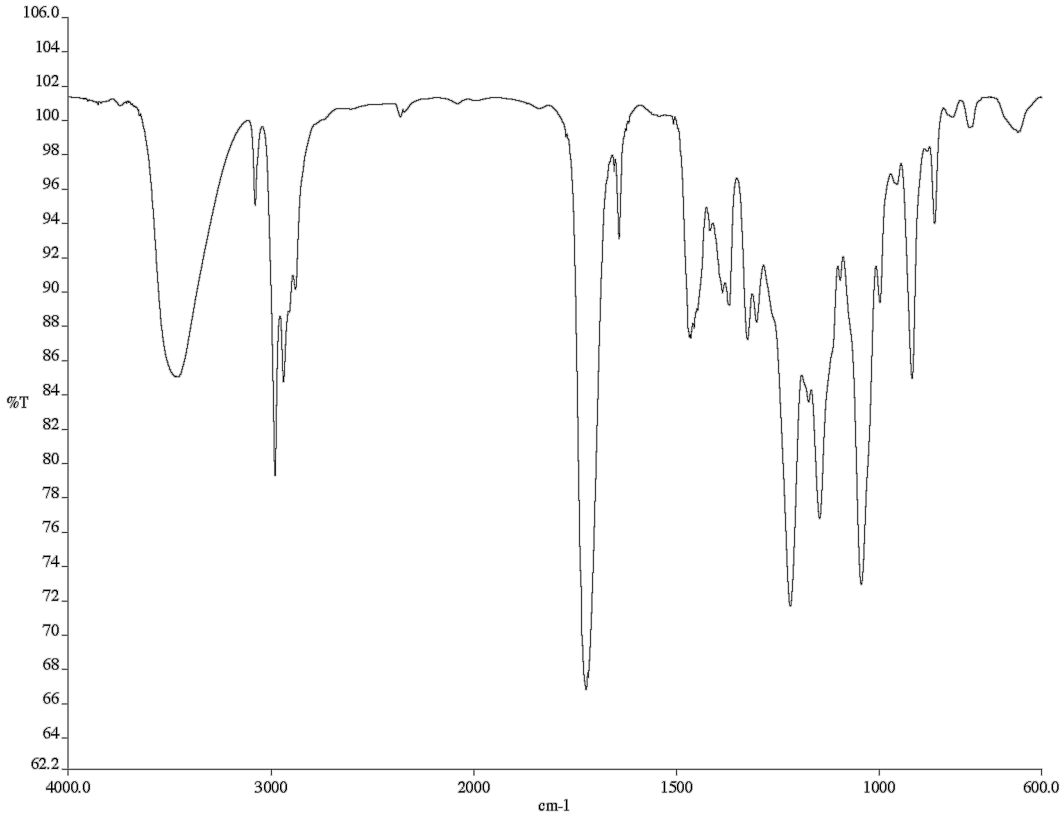


^{13}C NMR (126 MHz, $CDCl_3$) of compound **7t**.

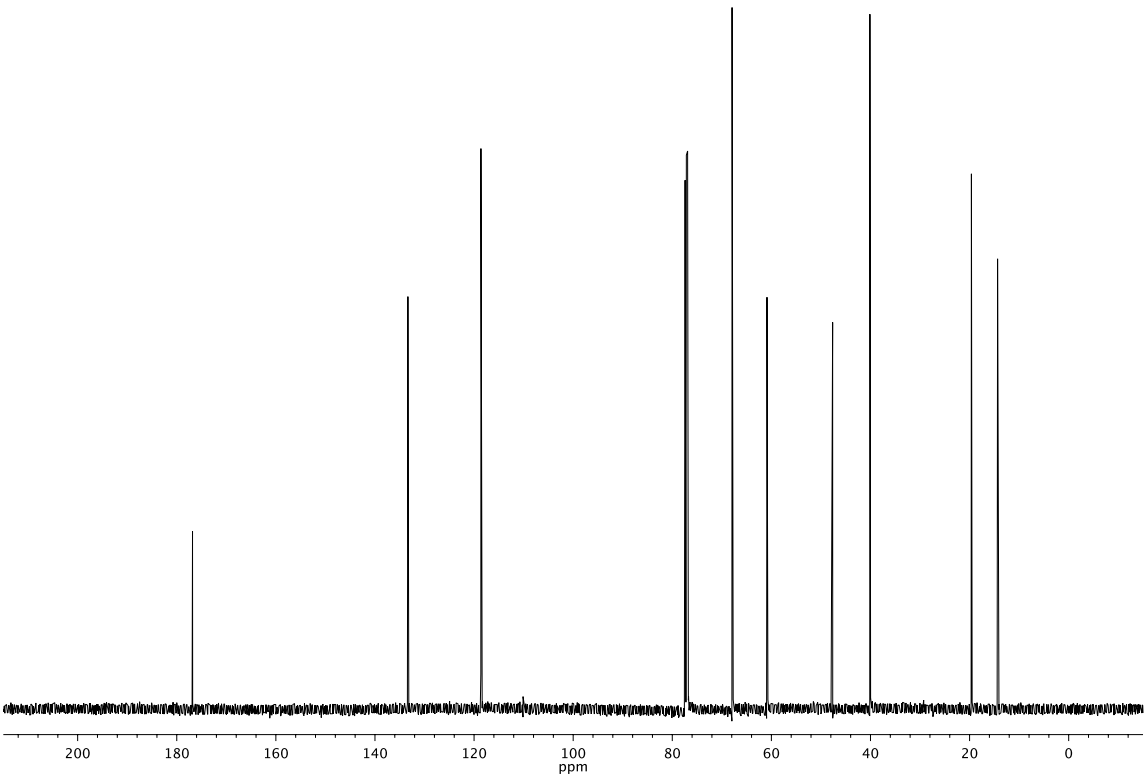


^{1}H NMR (500 MHz, $CDCl_3$) of compound **S8**.

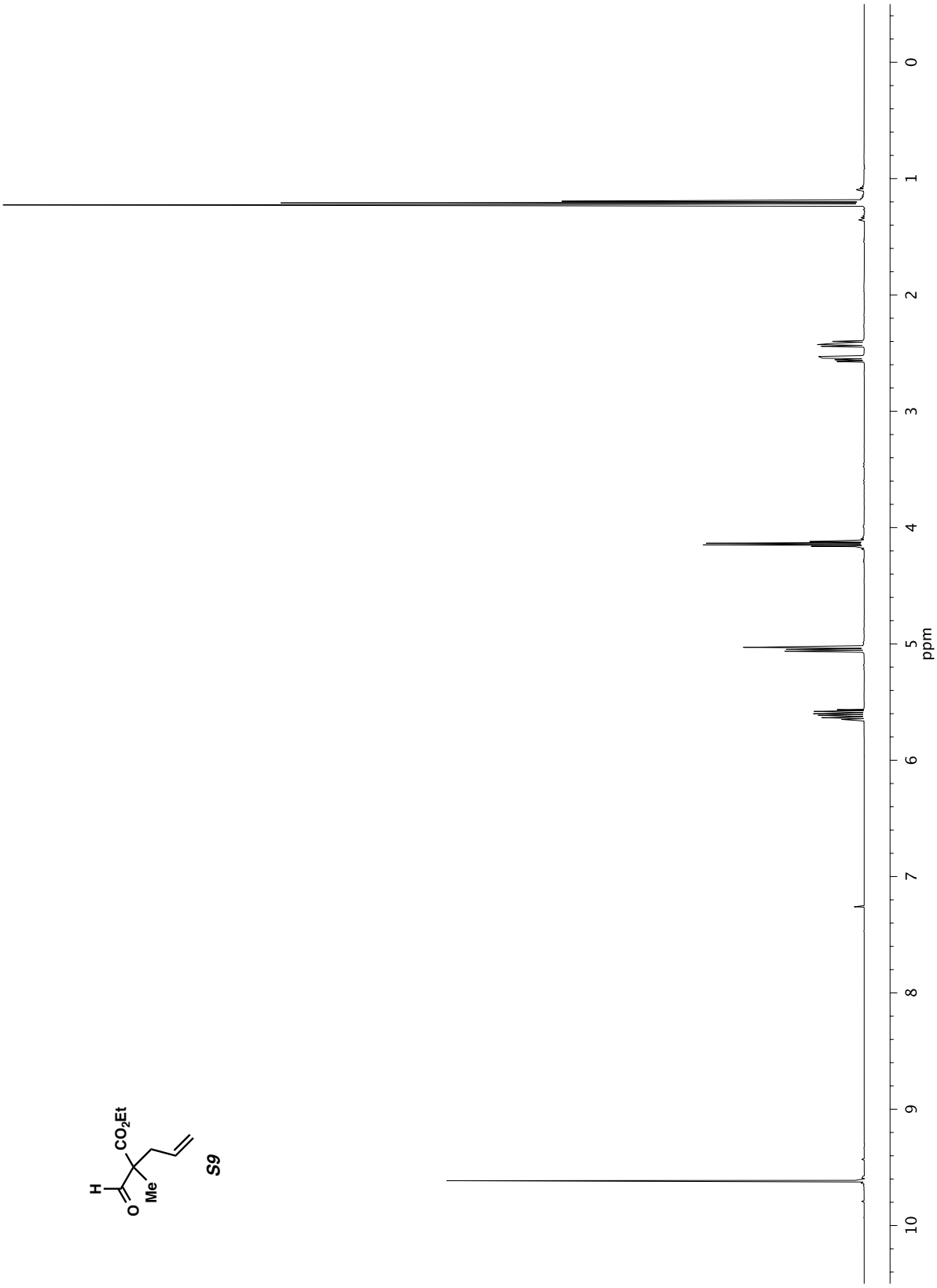
S8



Infrared spectrum (Thin Film, NaCl) of compound **S8**.

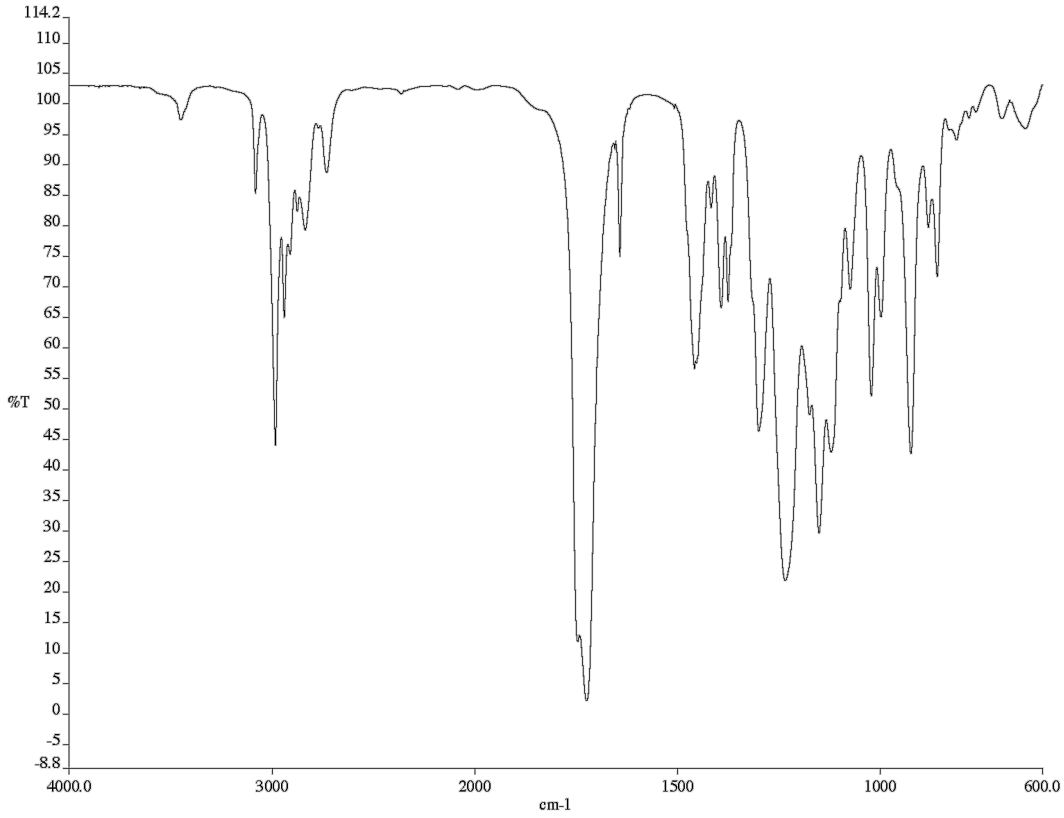


^{13}C NMR (126 MHz, $CDCl_3$) of compound **S8**.

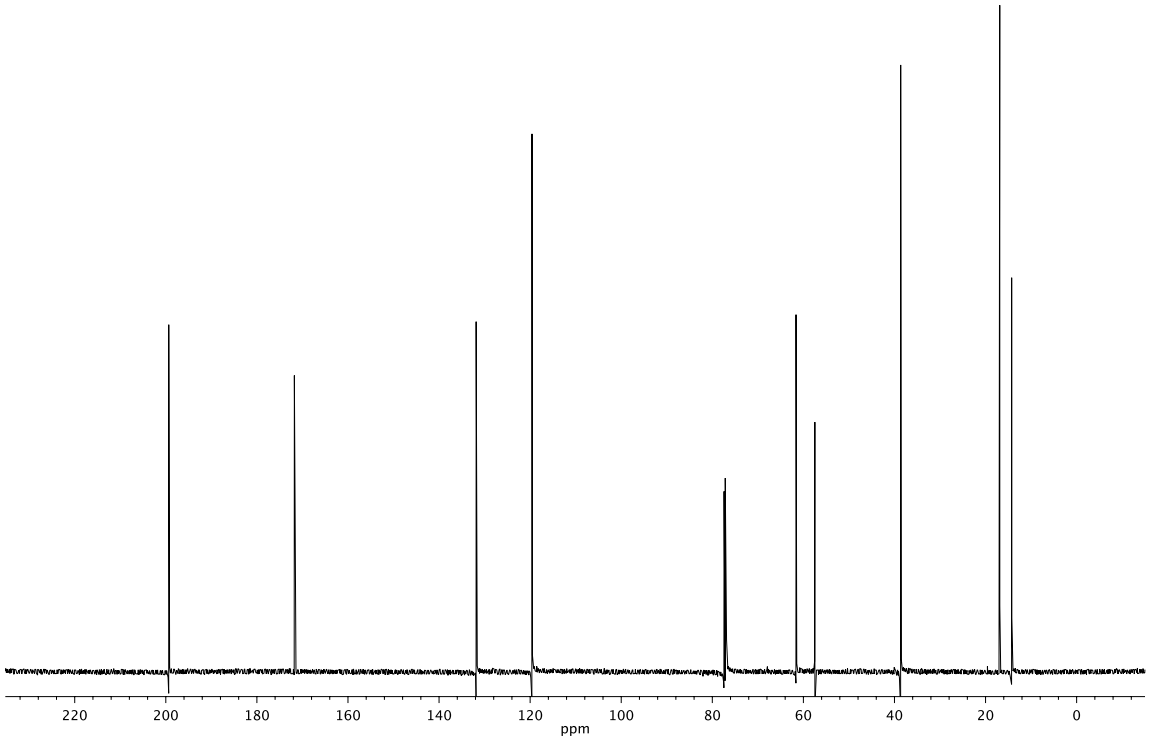


S9

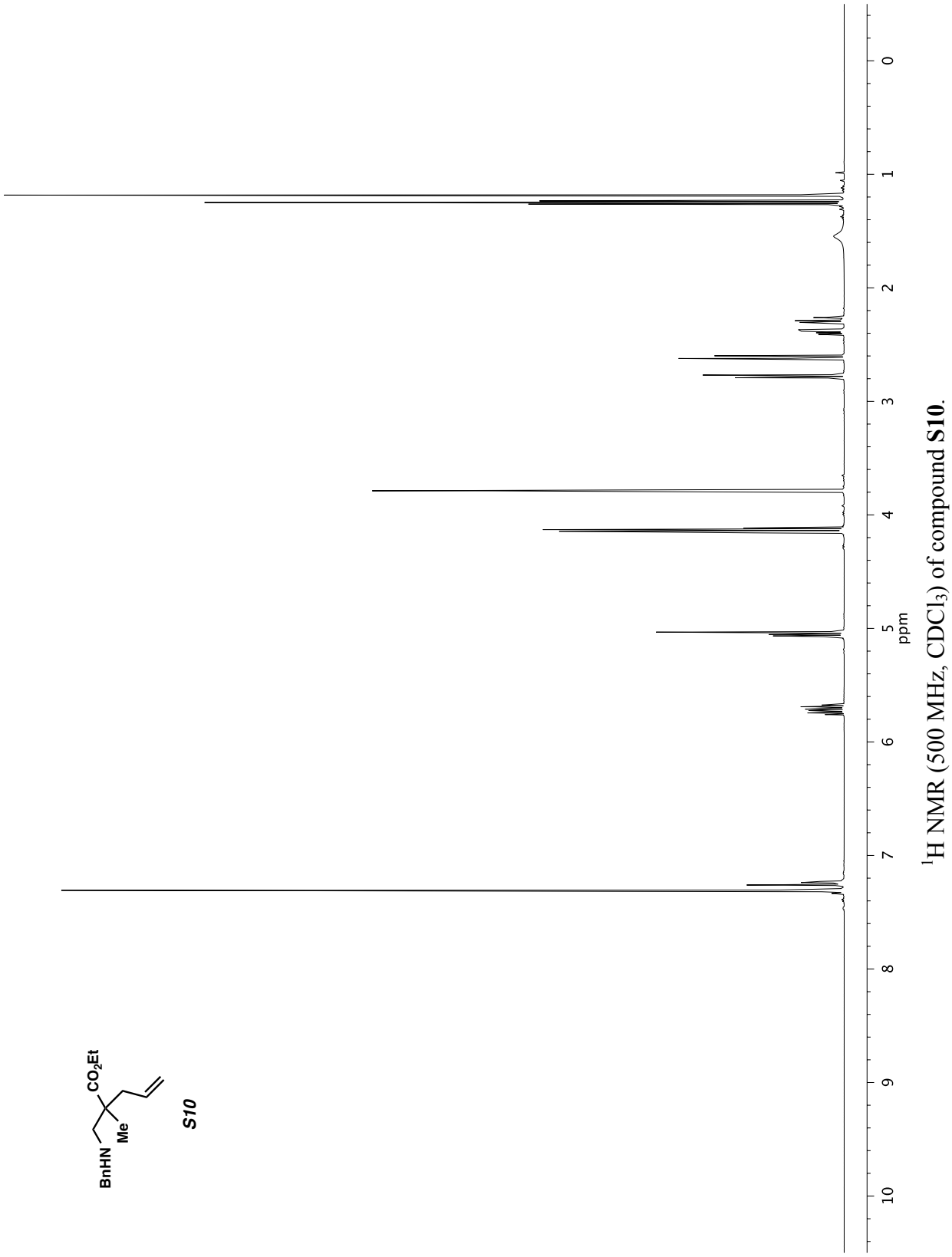
^{1}H NMR (500 MHz, $CDCl_3$) of compound **S9**.



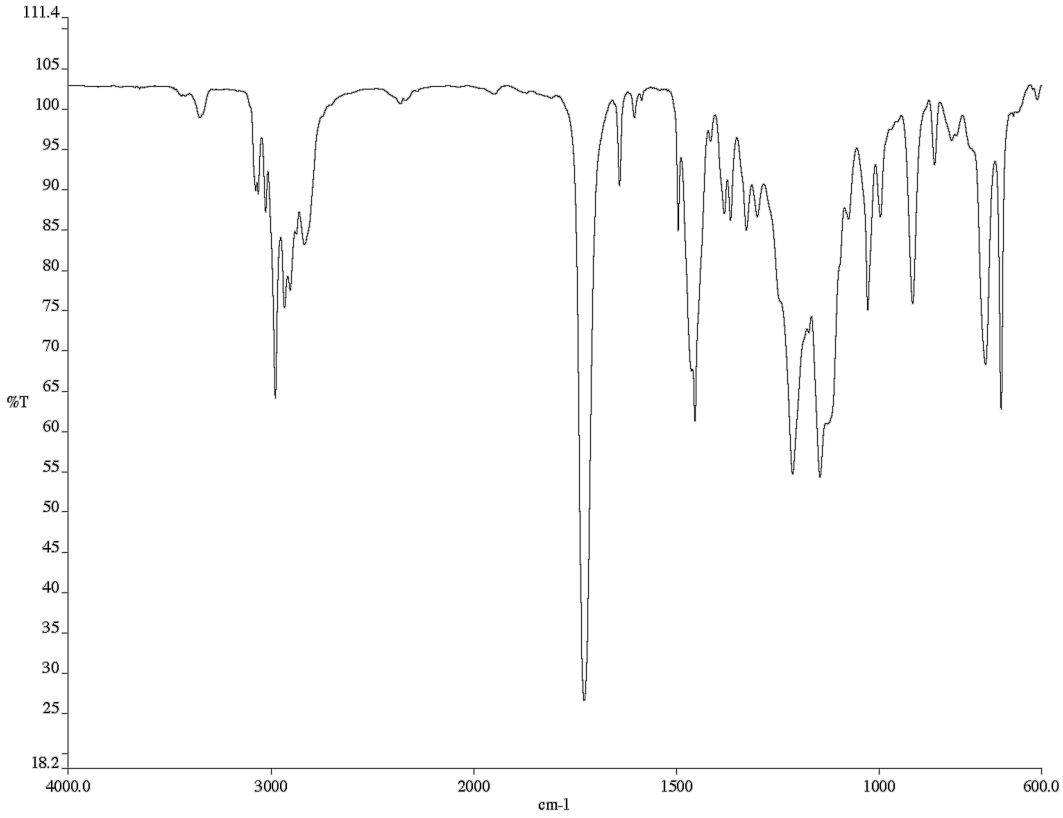
Infrared spectrum (Thin Film, NaCl) of compound **S9**.



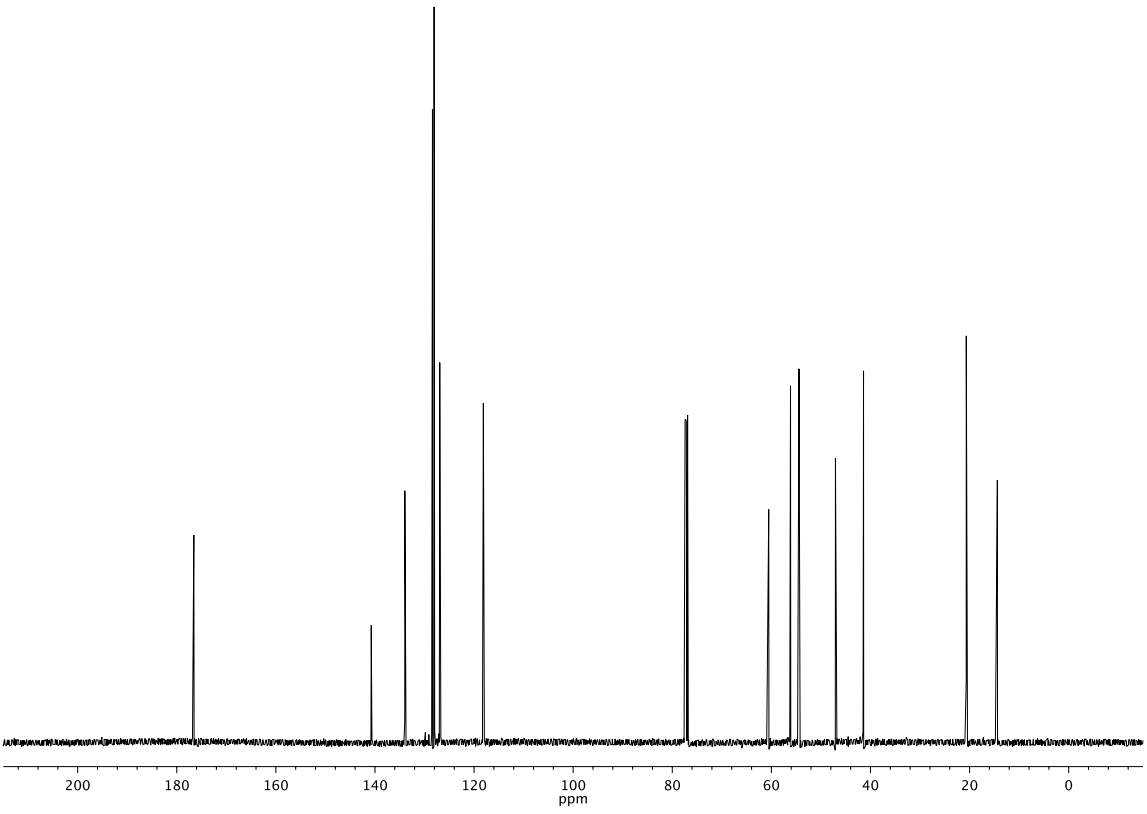
^{13}C NMR (126 MHz, $CDCl_3$) of compound **S9**.



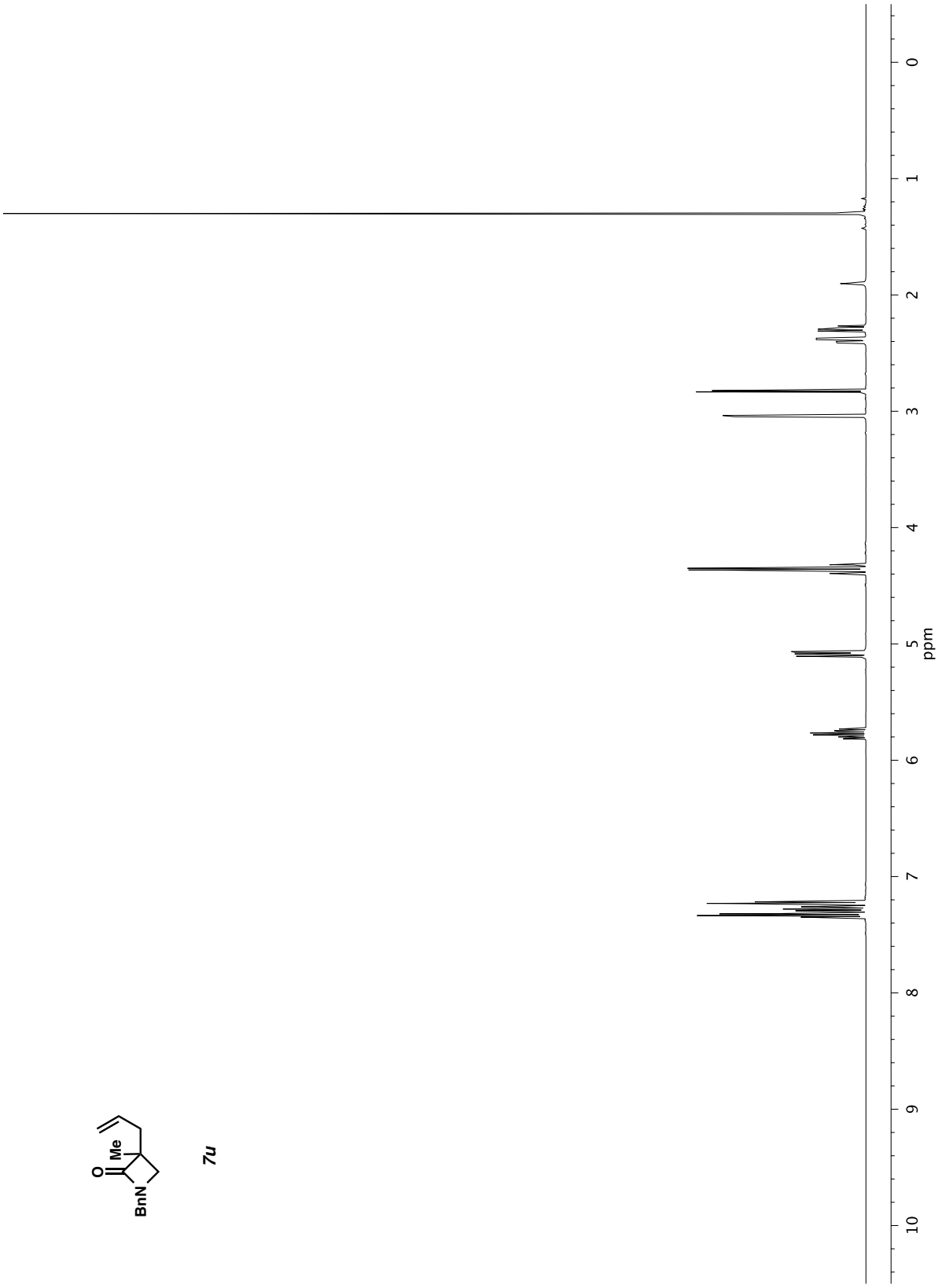
^{1}H NMR (500 MHz, $CDCl_3$) of compound **S10**.



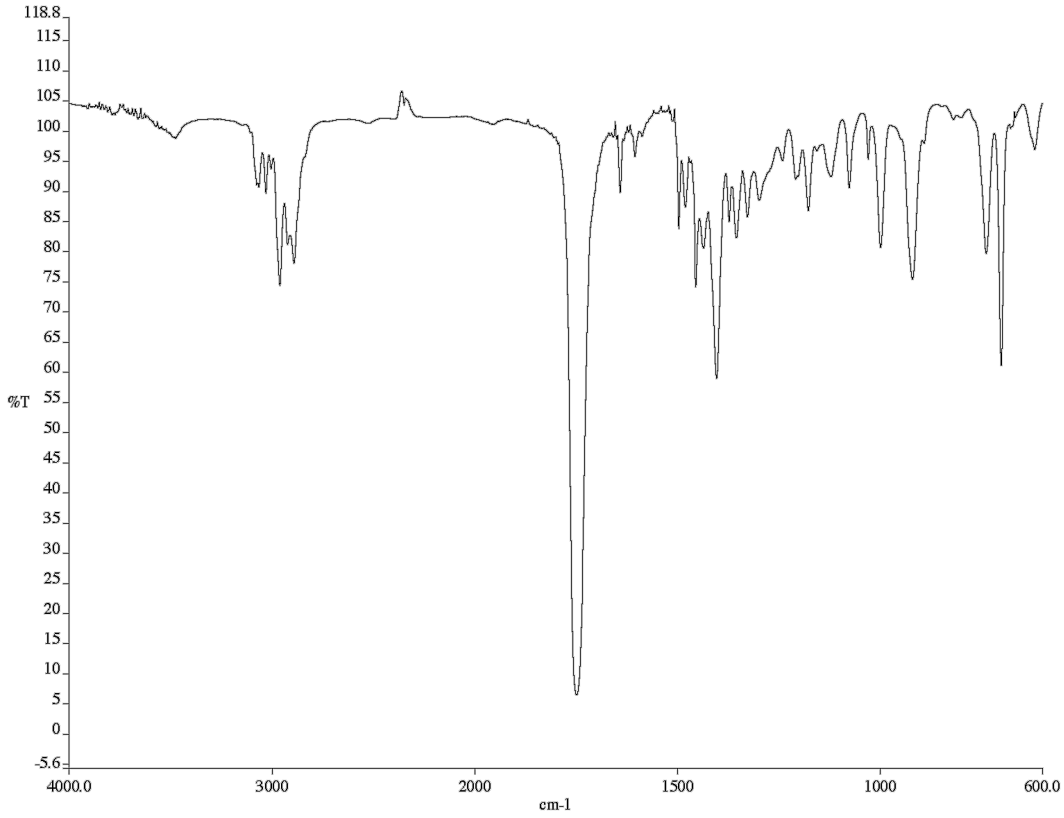
Infrared spectrum (Thin Film, NaCl) of compound **S10**.



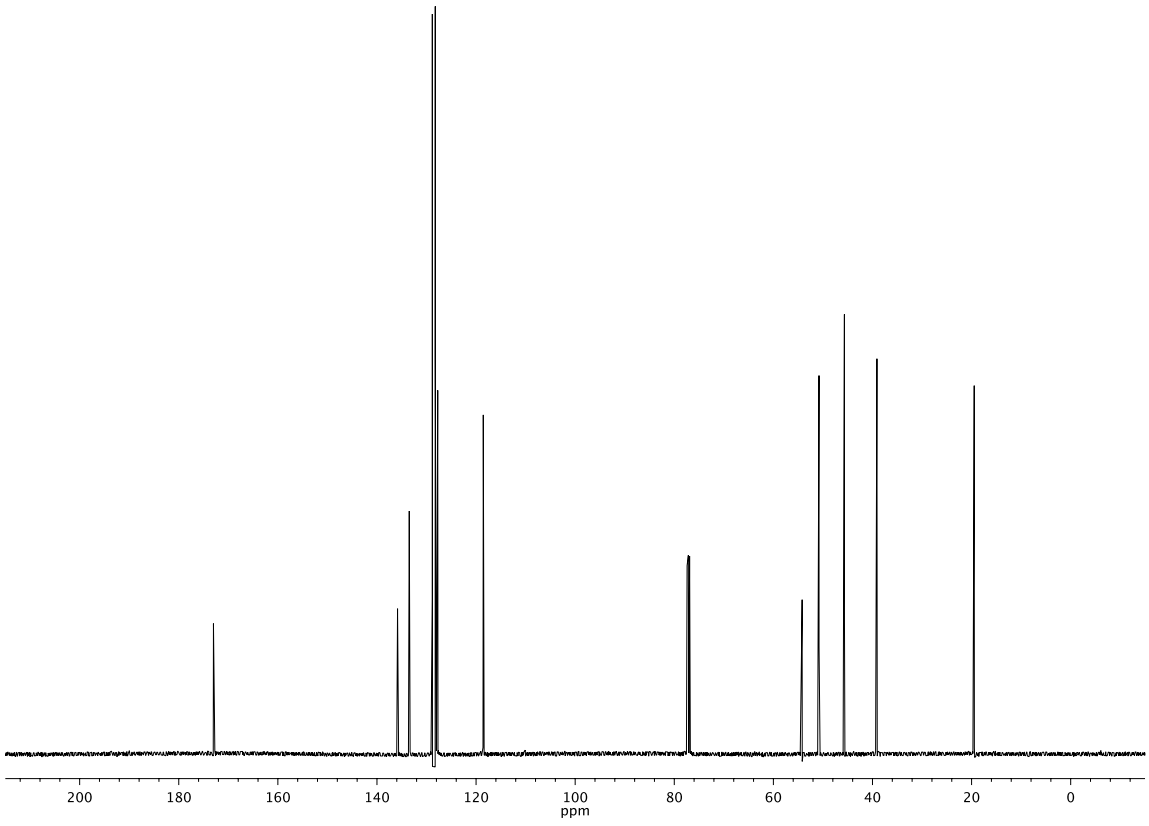
^{13}C NMR (126 MHz, $CDCl_3$) of compound **S10**.



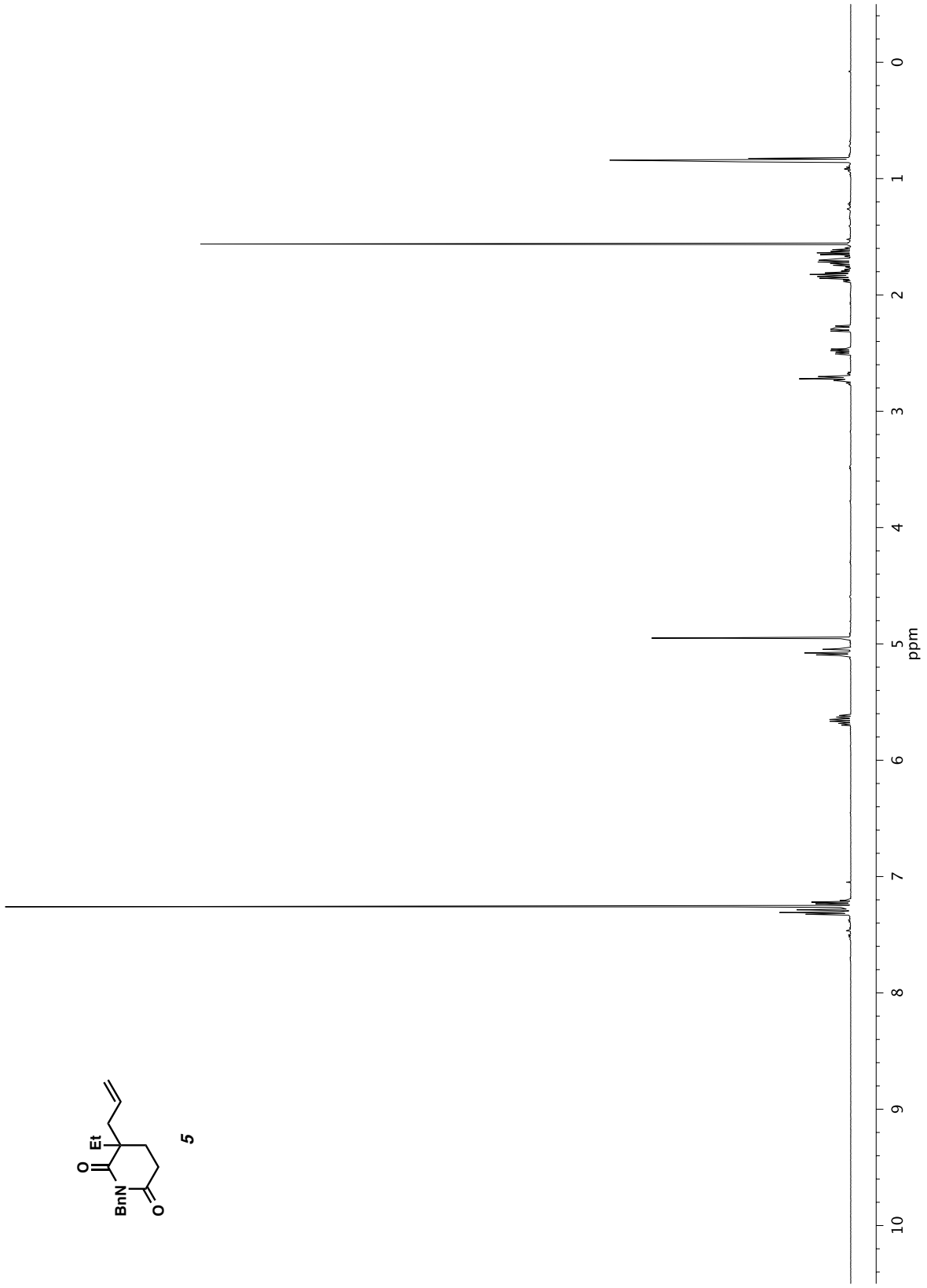
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7u**.



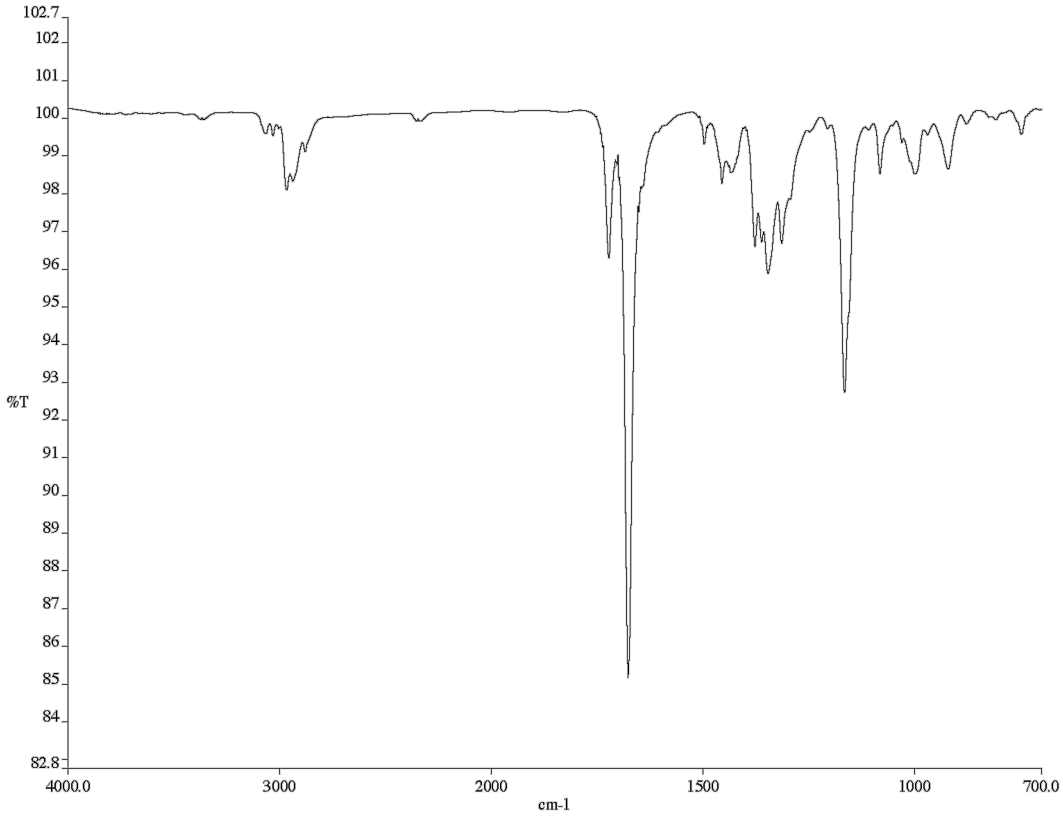
Infrared spectrum (Thin Film, NaCl) of compound **7u**.



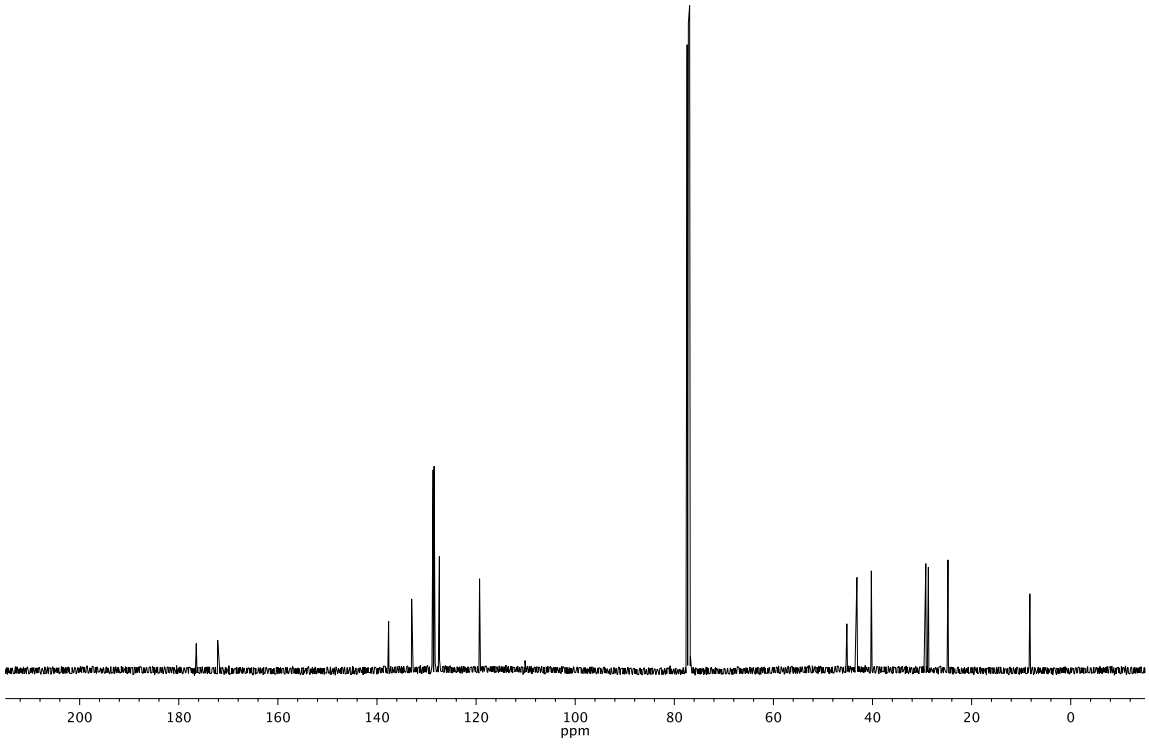
^{13}C NMR (126 MHz, $CDCl_3$) of compound **7u**.



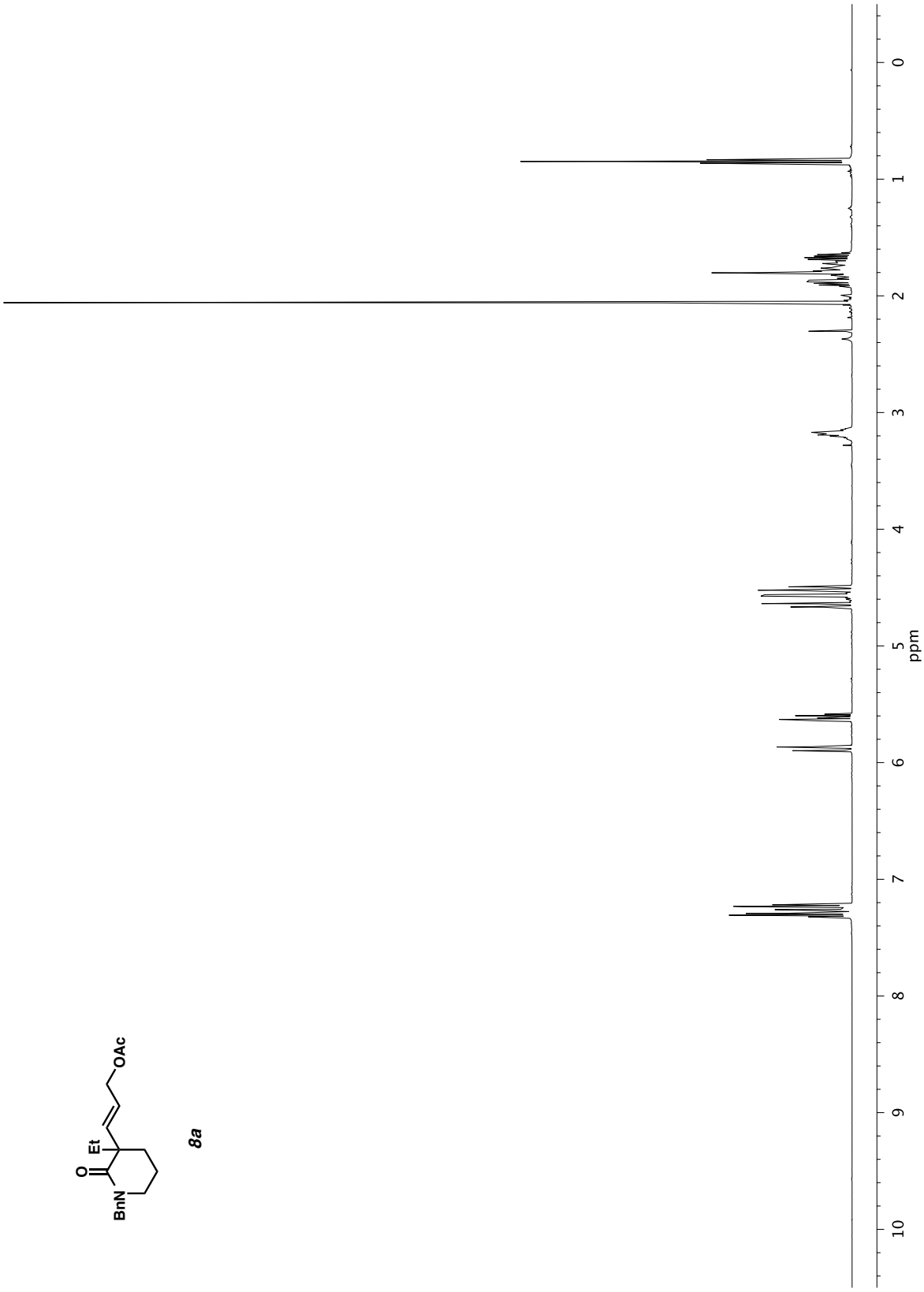
^{1}H NMR (500 MHz, $CDCl_3$) of compound **5**.



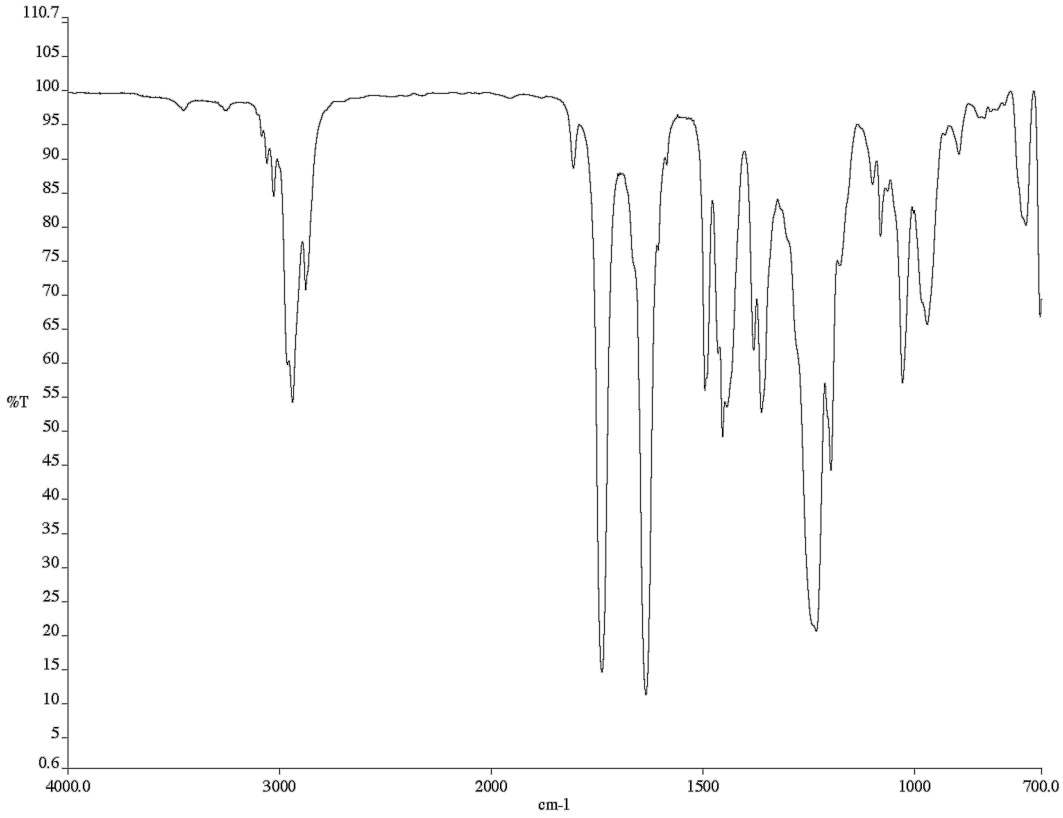
Infrared spectrum (Thin Film, NaCl) of compound **5**.



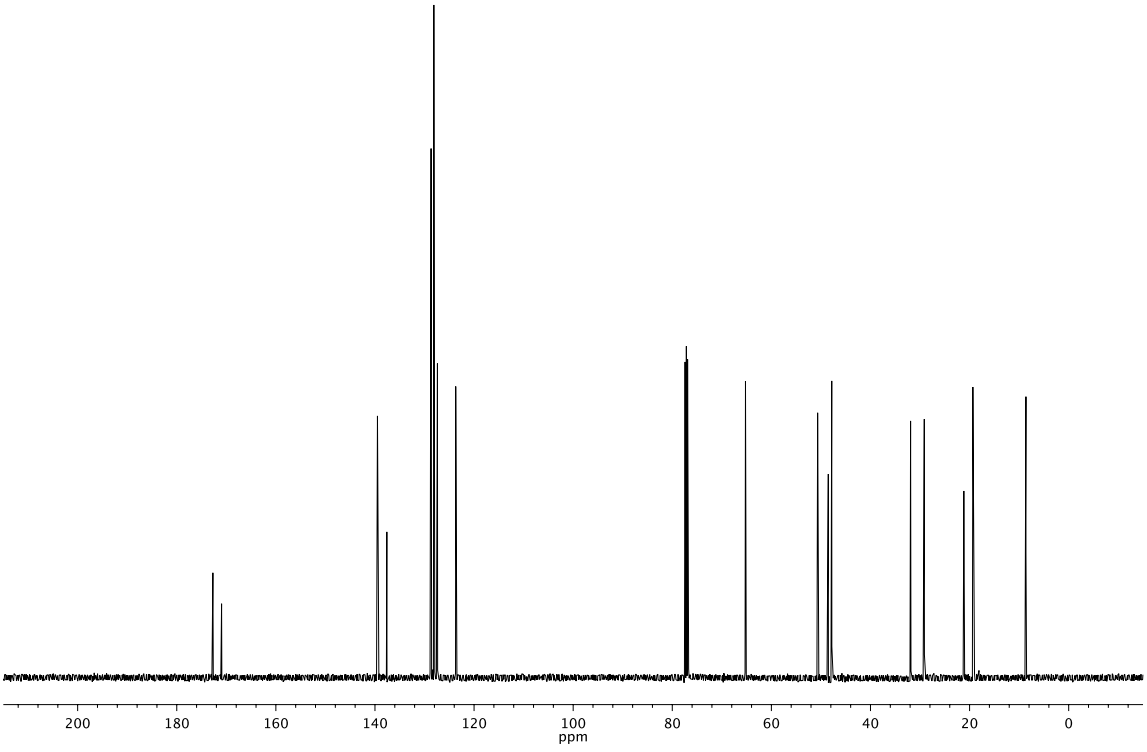
^{13}C NMR (126 MHz, $CDCl_3$) of compound **5**.



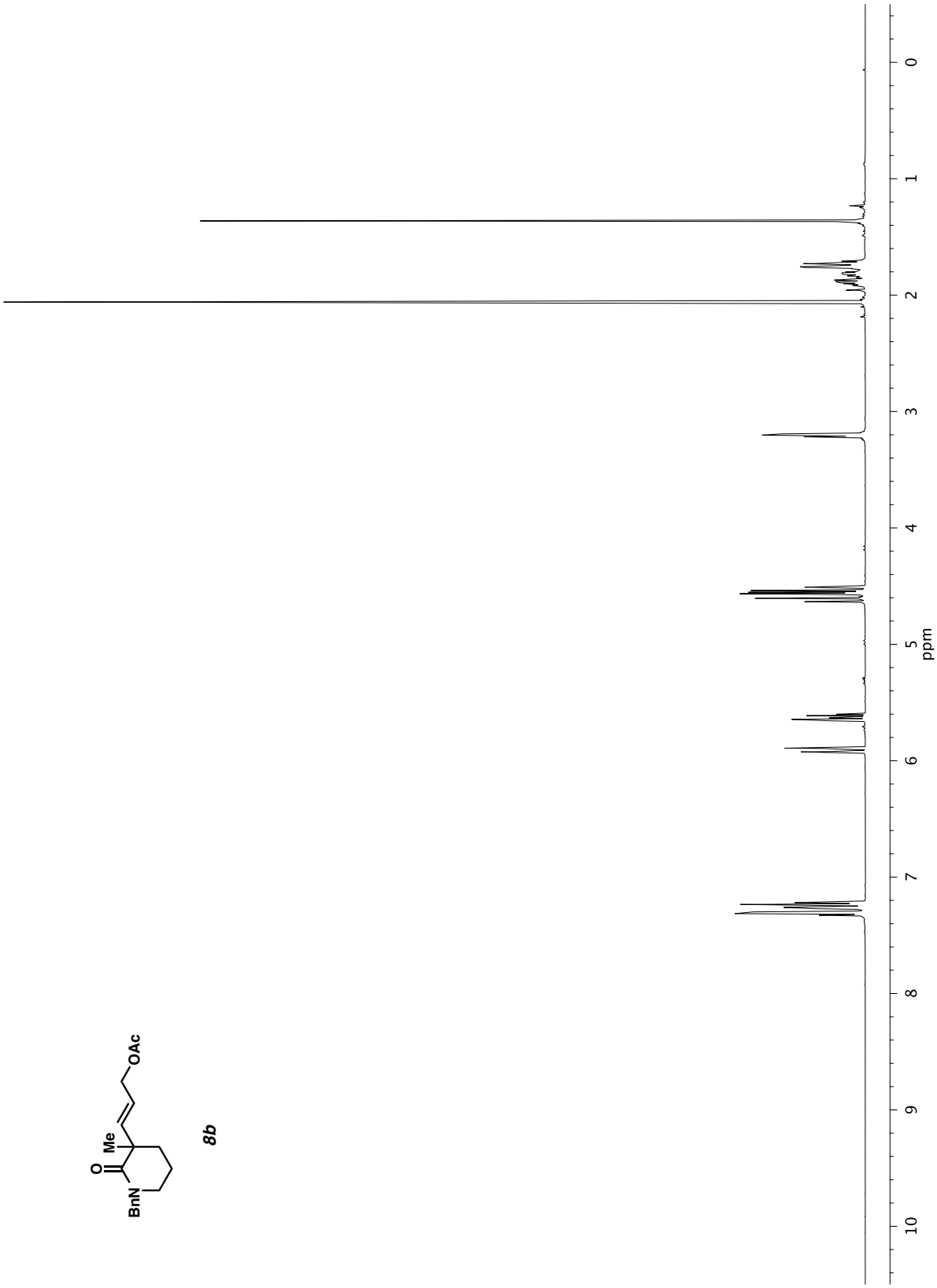
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8a**.



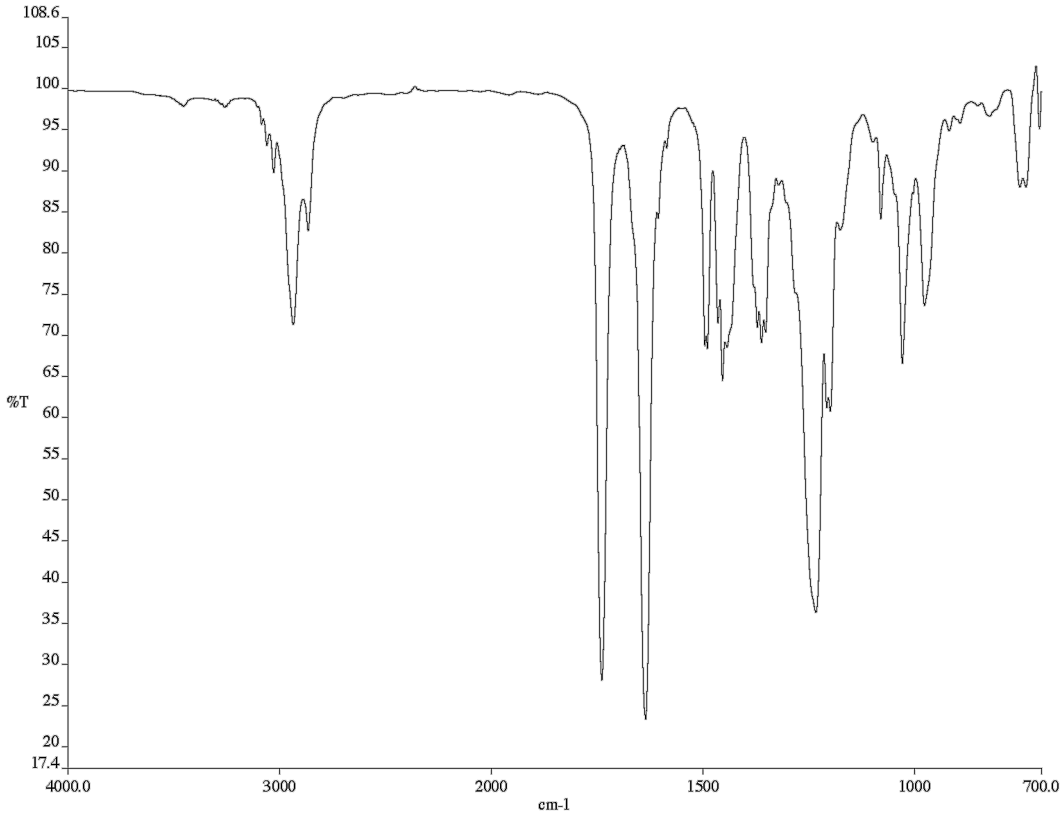
Infrared spectrum (Thin Film, NaCl) of compound **8a**.



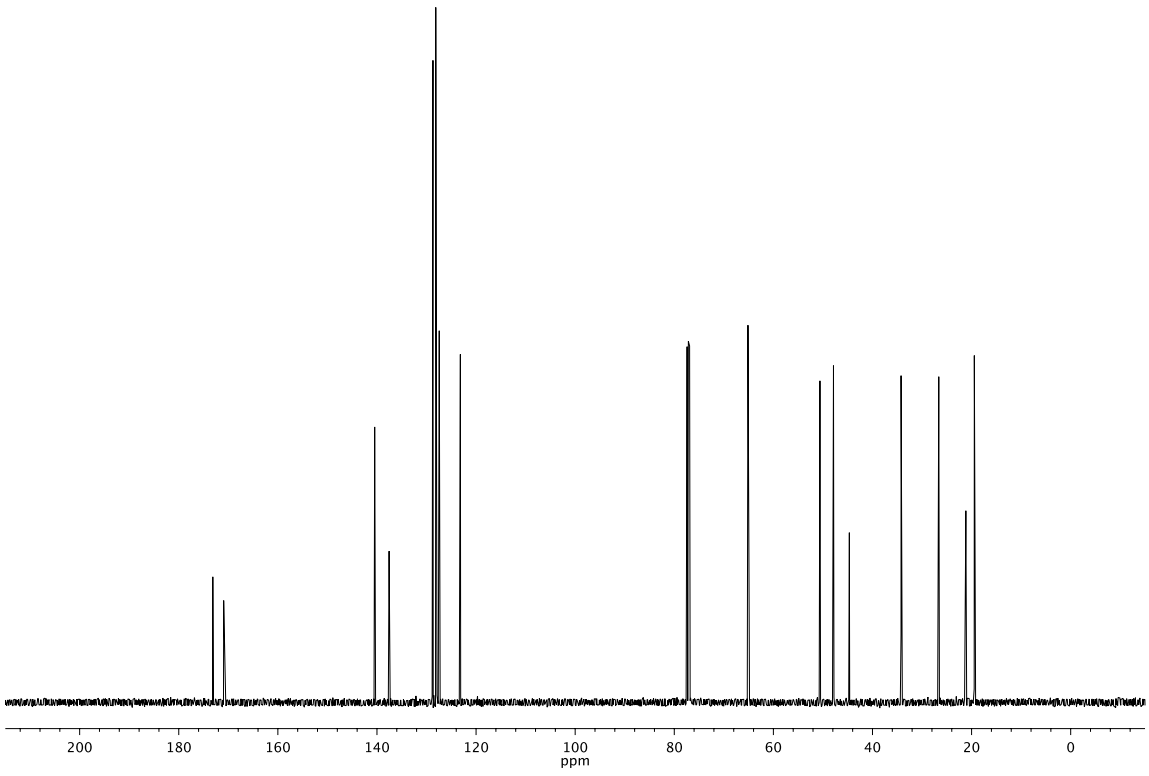
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8a**.



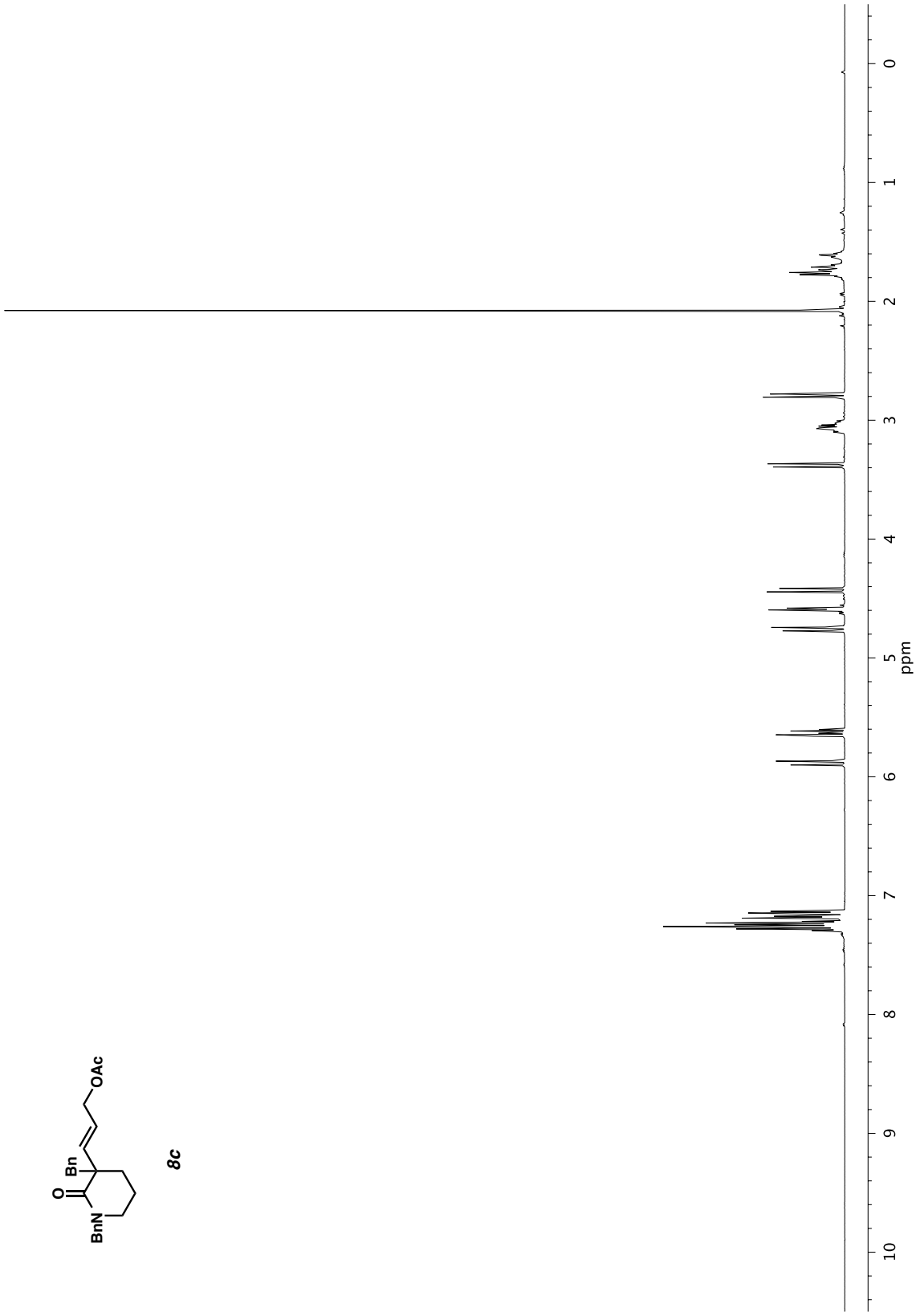
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8b**.



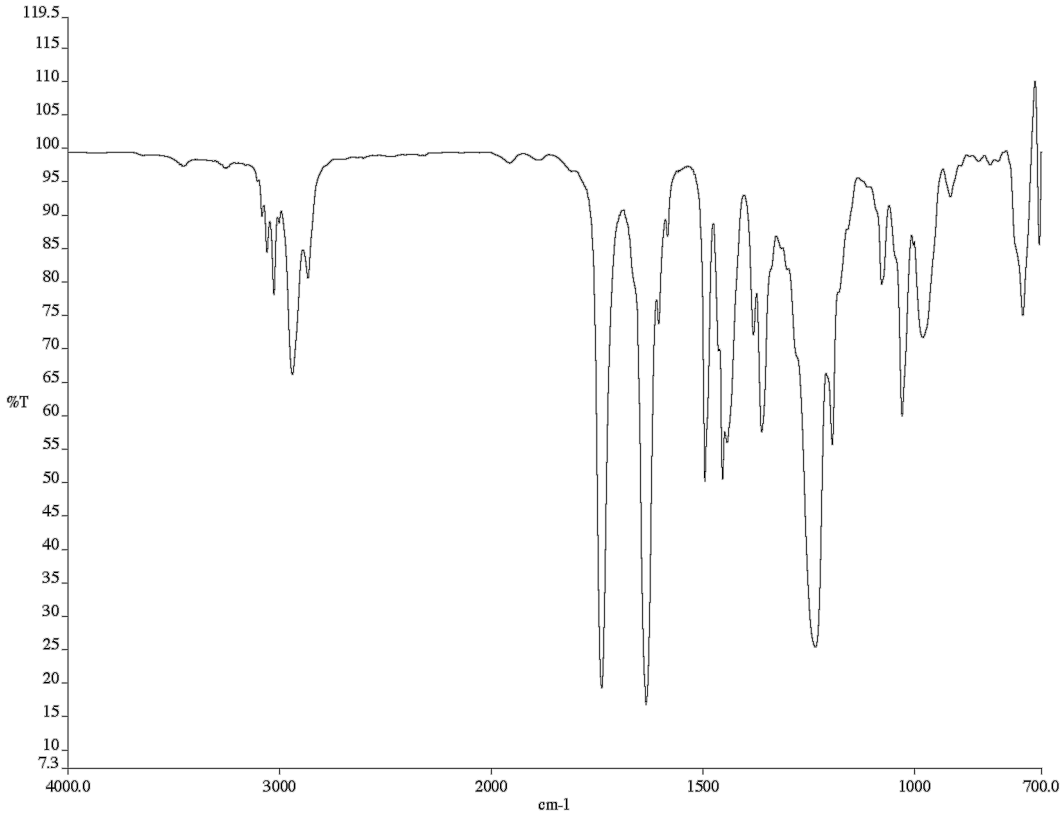
Infrared spectrum (Thin Film, NaCl) of compound **8b**.



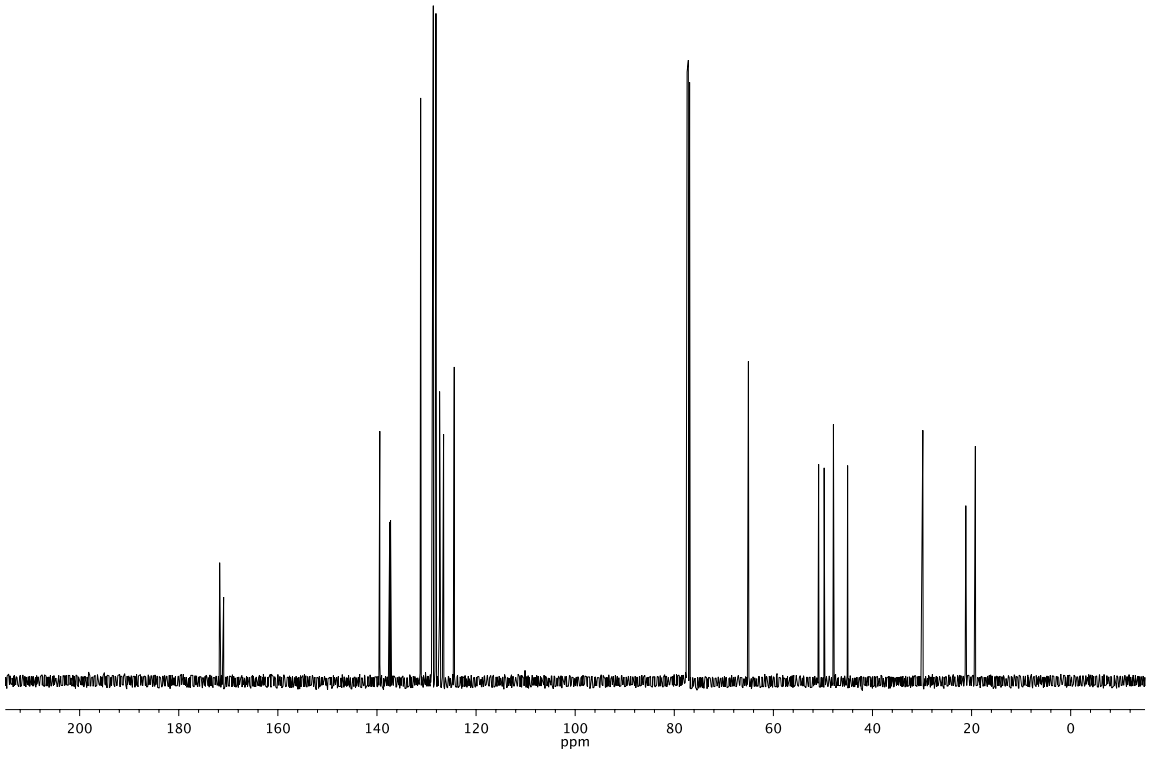
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8b**.



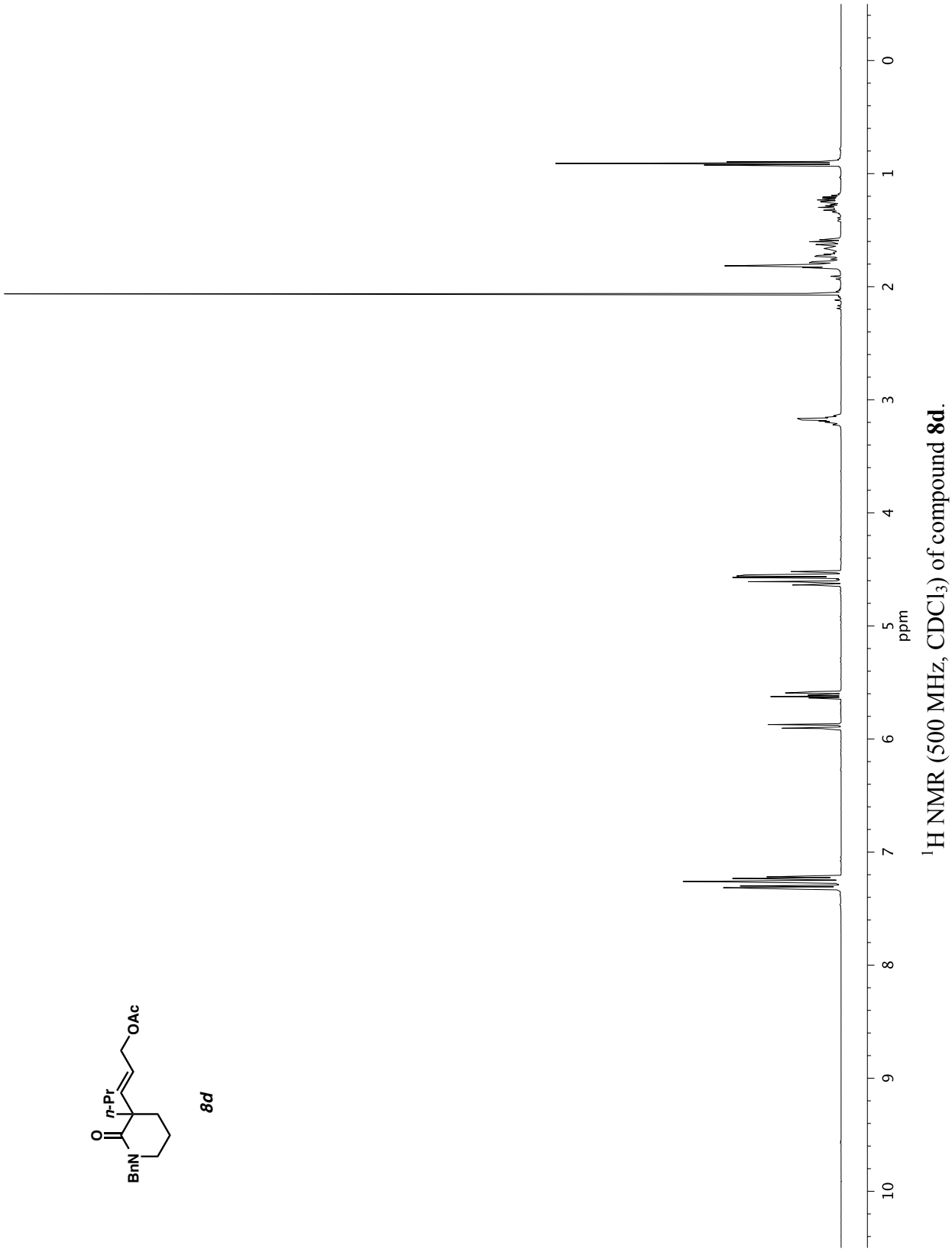
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8c**.



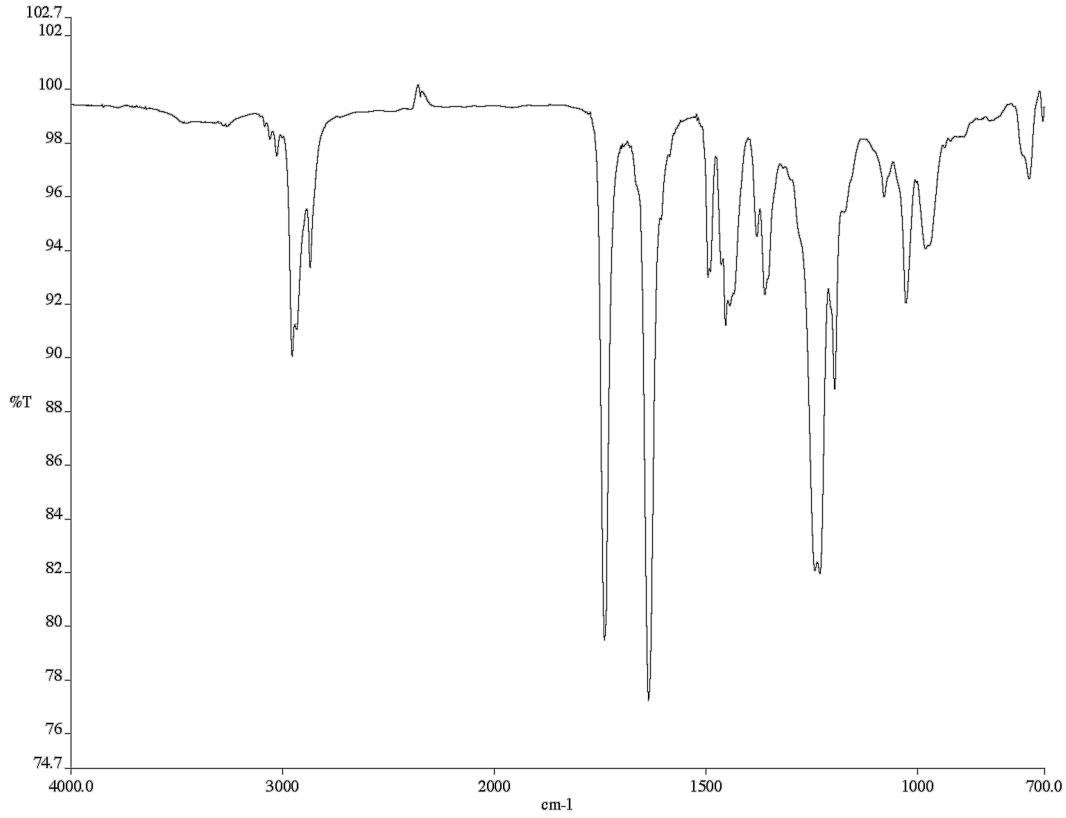
Infrared spectrum (Thin Film, NaCl) of compound **8c**.



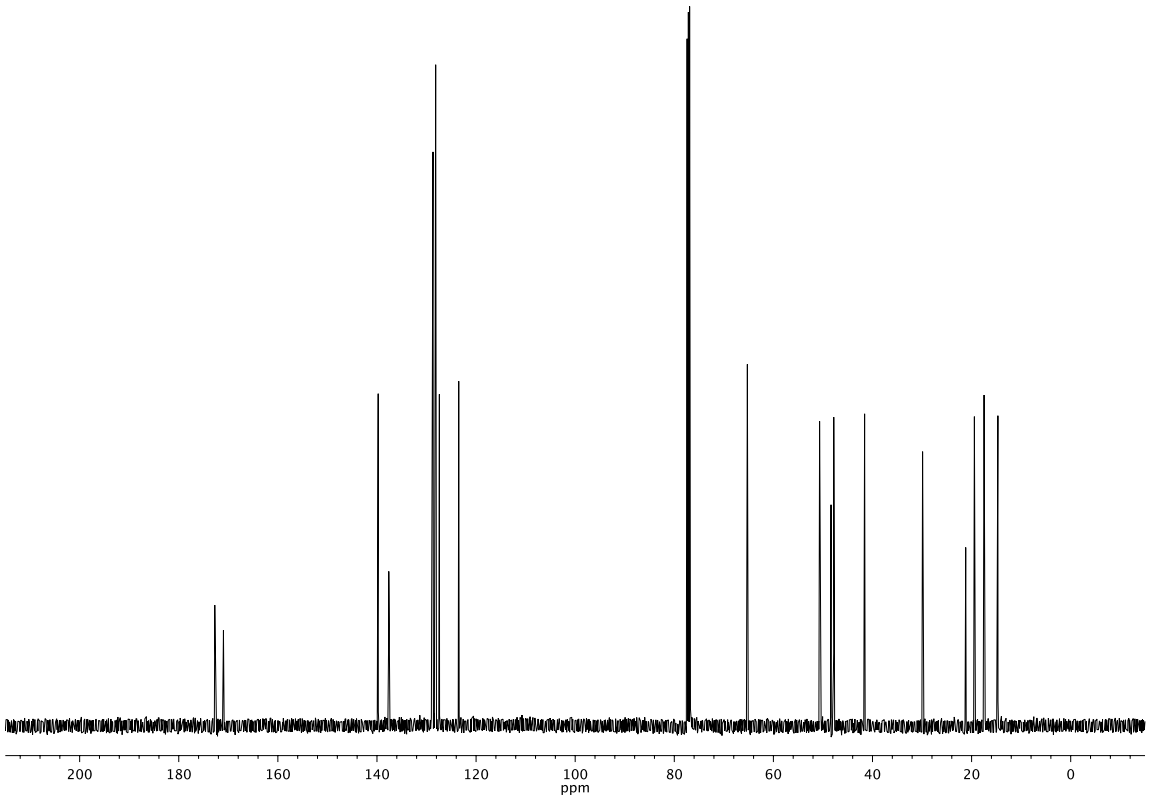
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8c**.



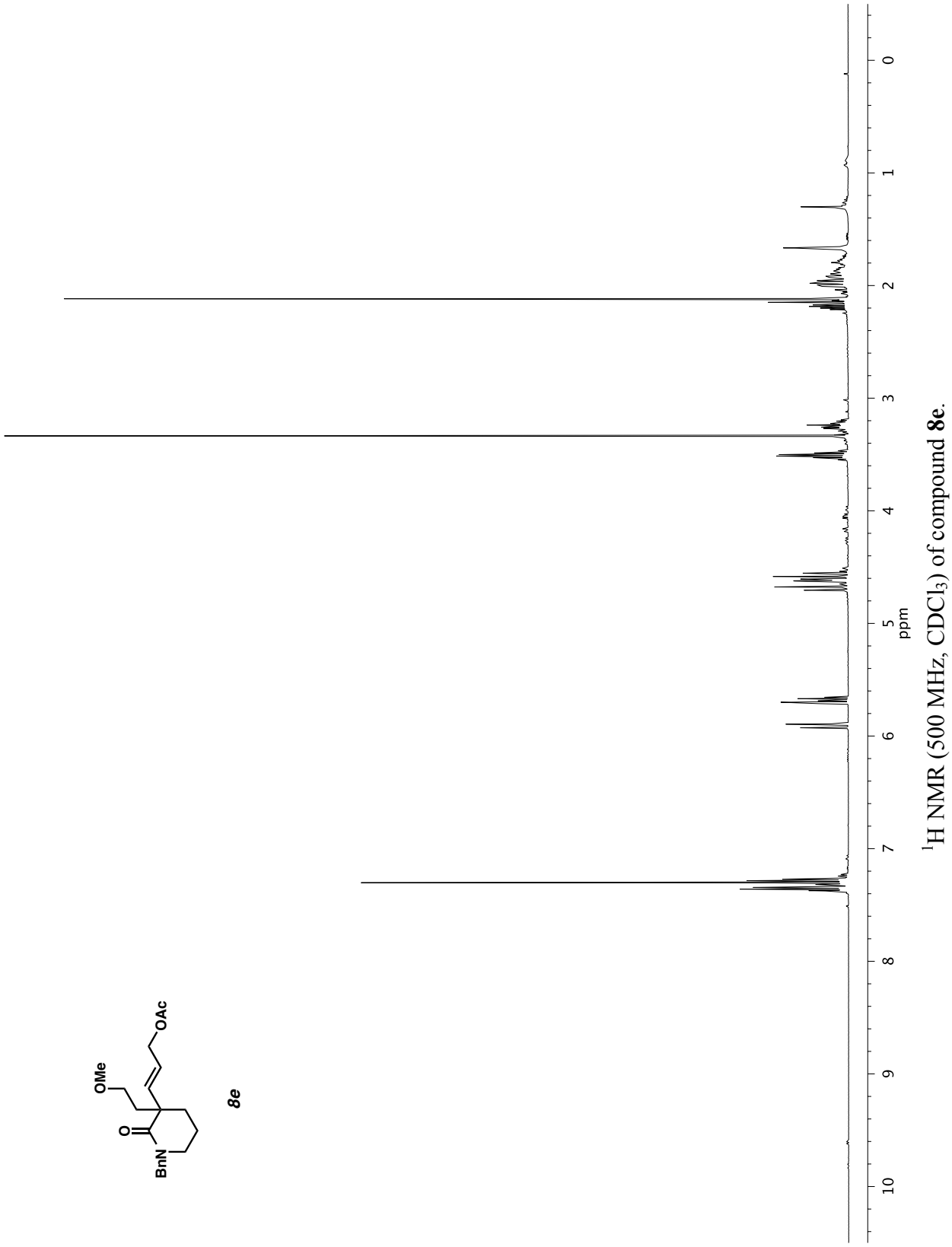
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8d**.



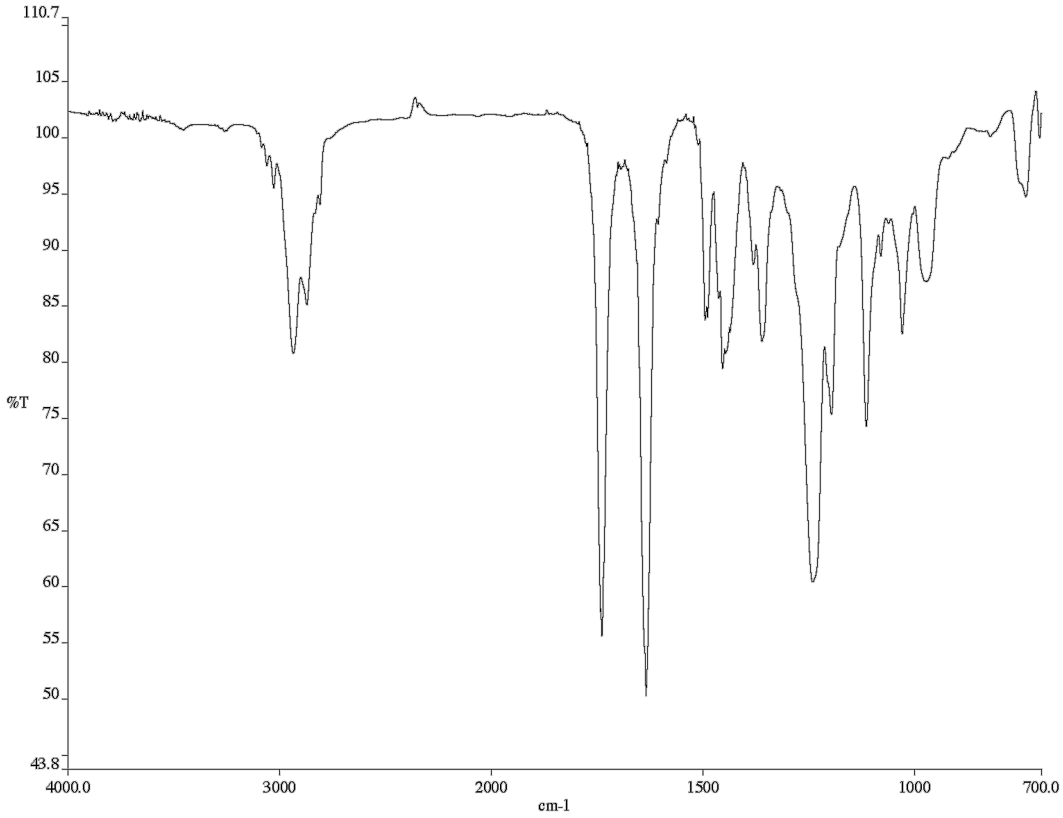
Infrared spectrum (Thin Film, NaCl) of compound **8d**.



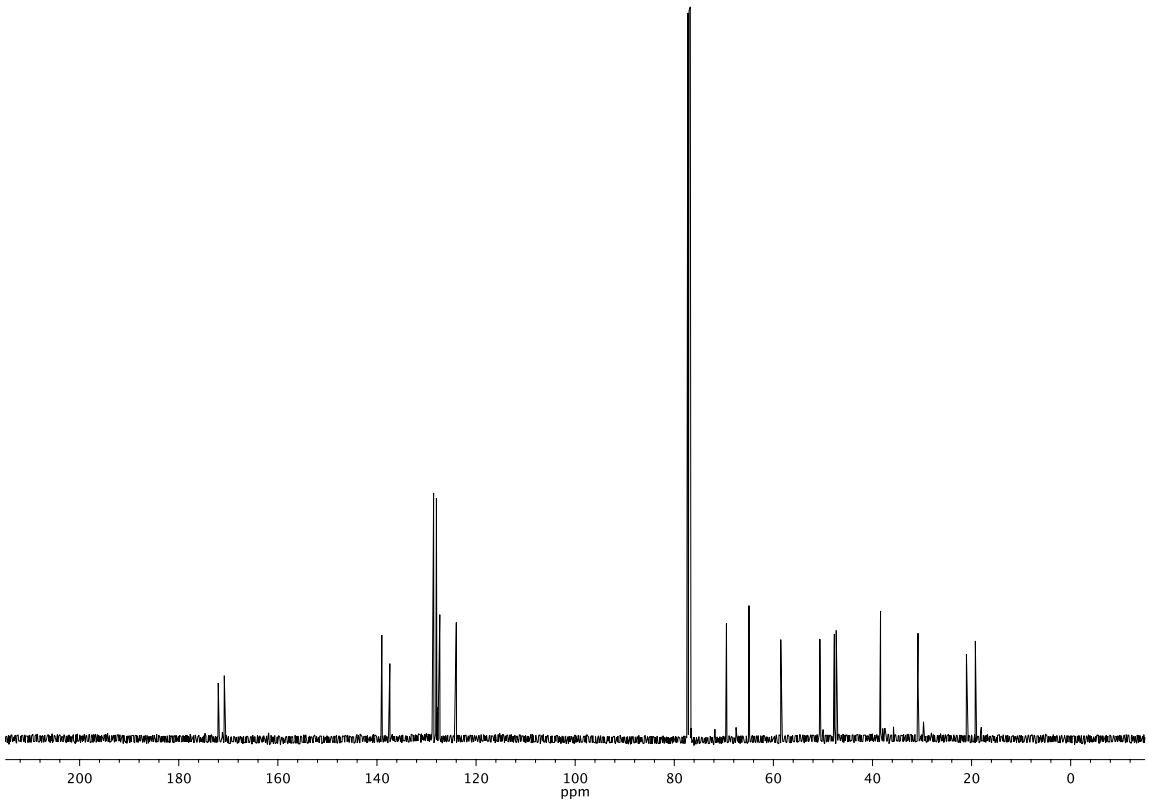
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8d**.



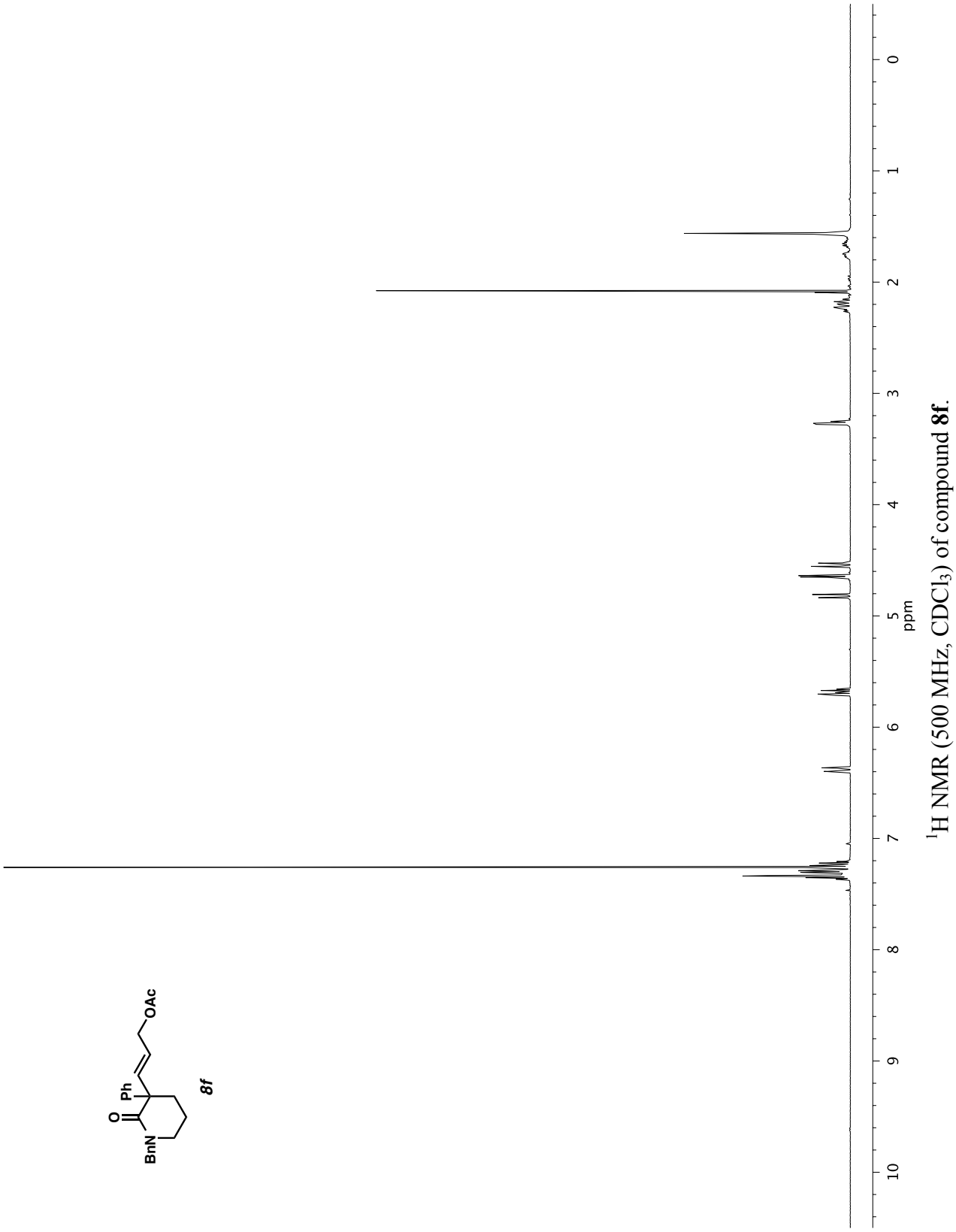
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8e**.



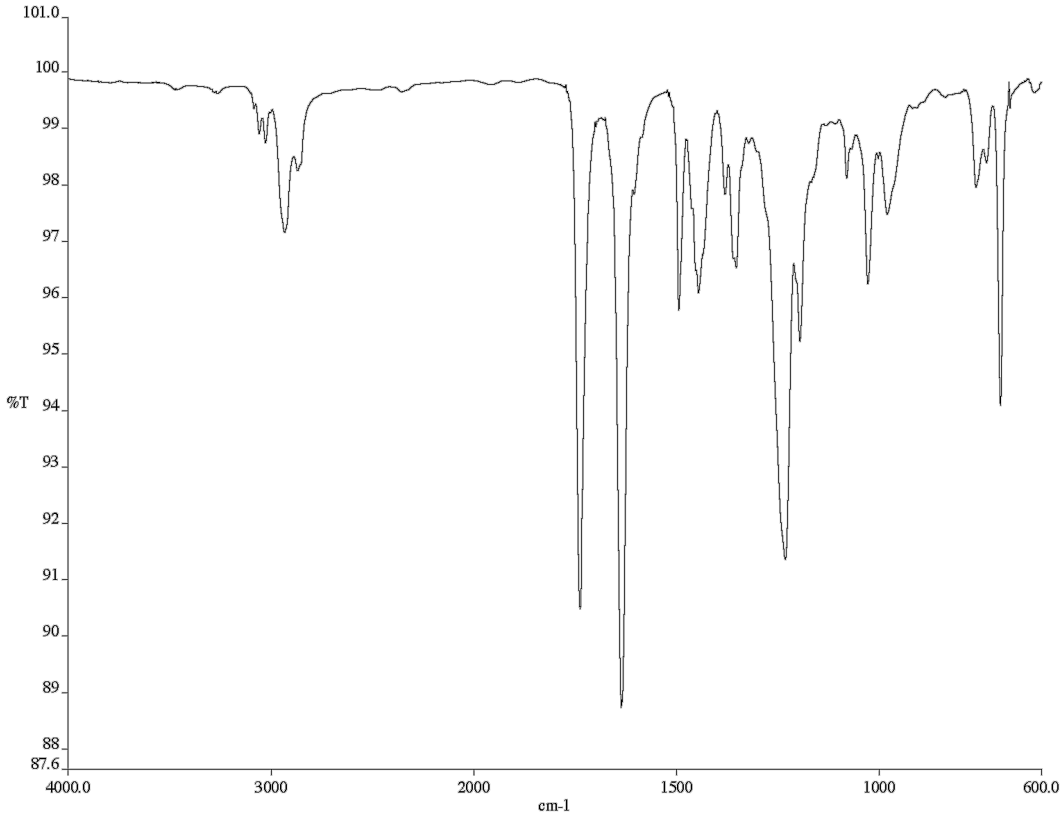
Infrared spectrum (Thin Film, NaCl) of compound **8e**.



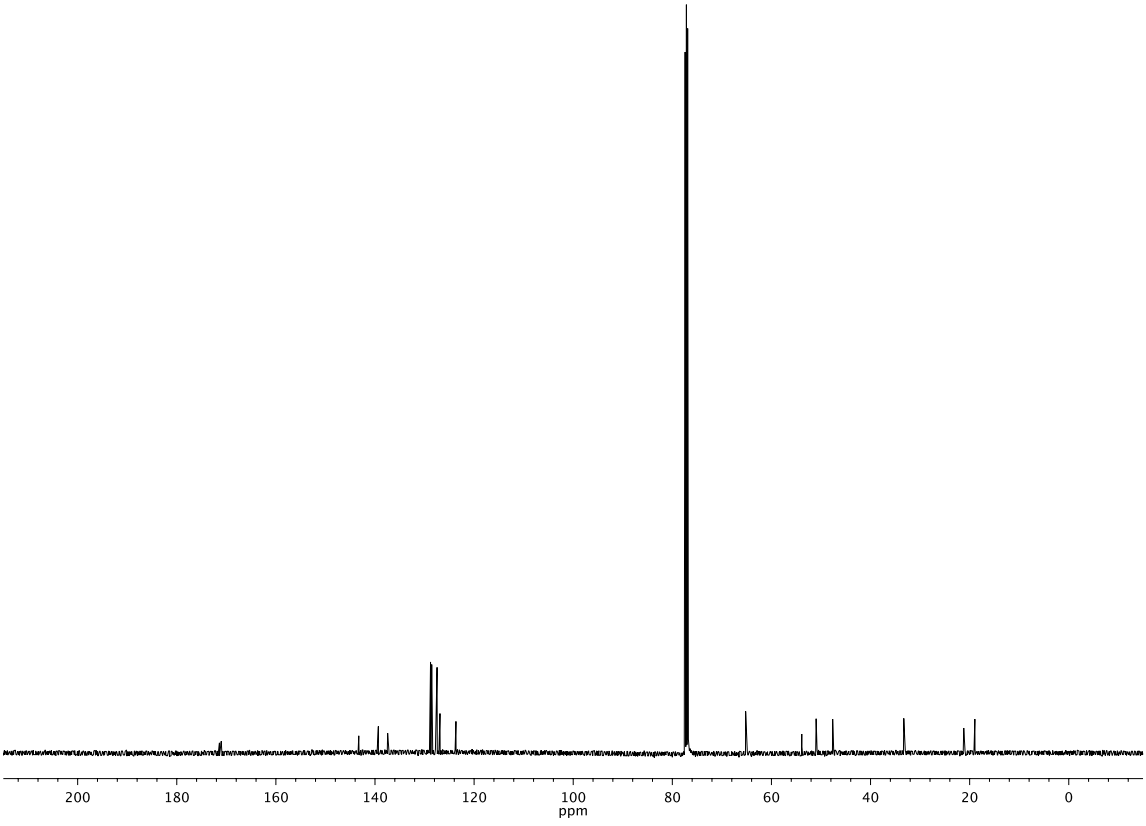
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8e**.



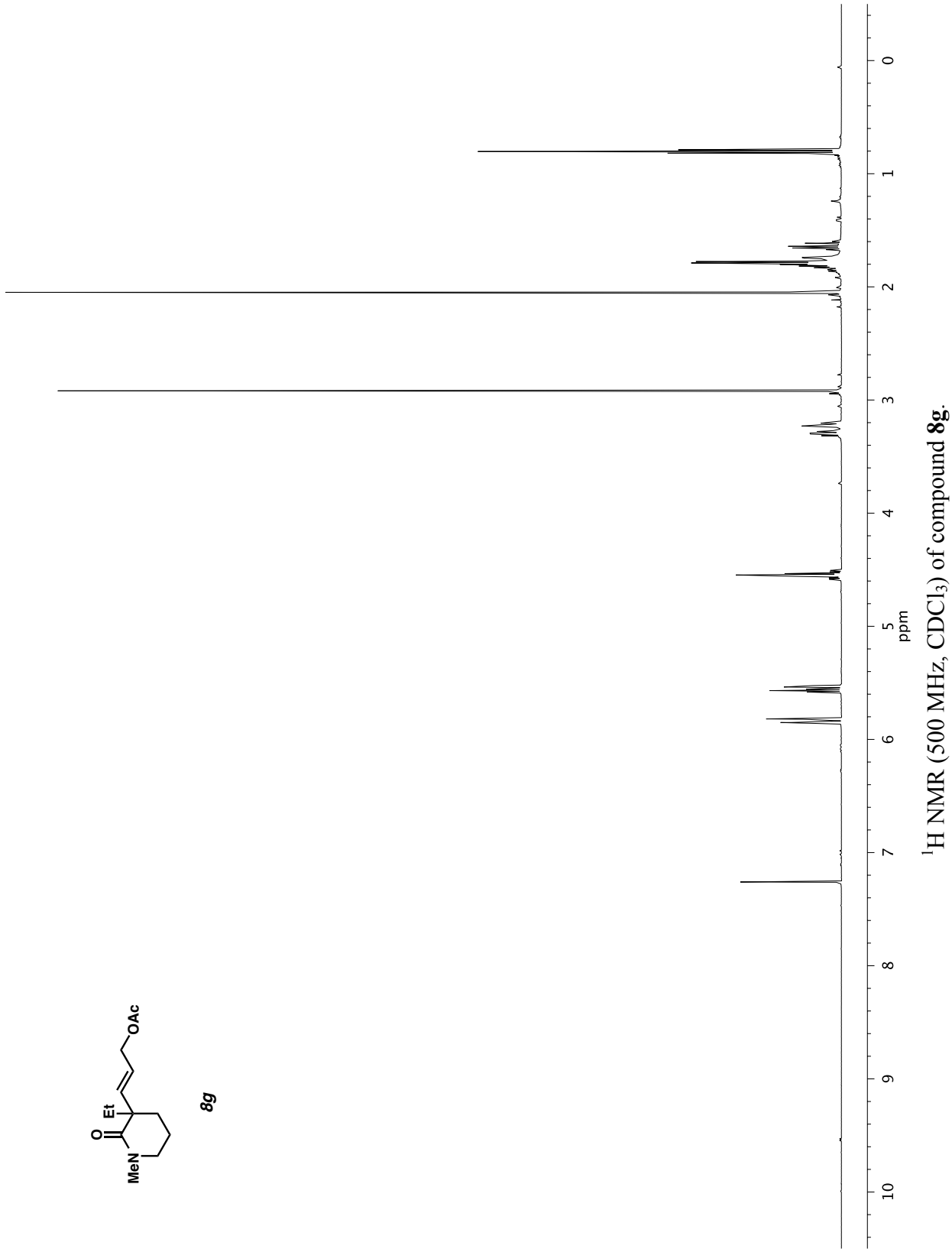
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8f**.



Infrared spectrum (Thin Film, NaCl) of compound **8f**.

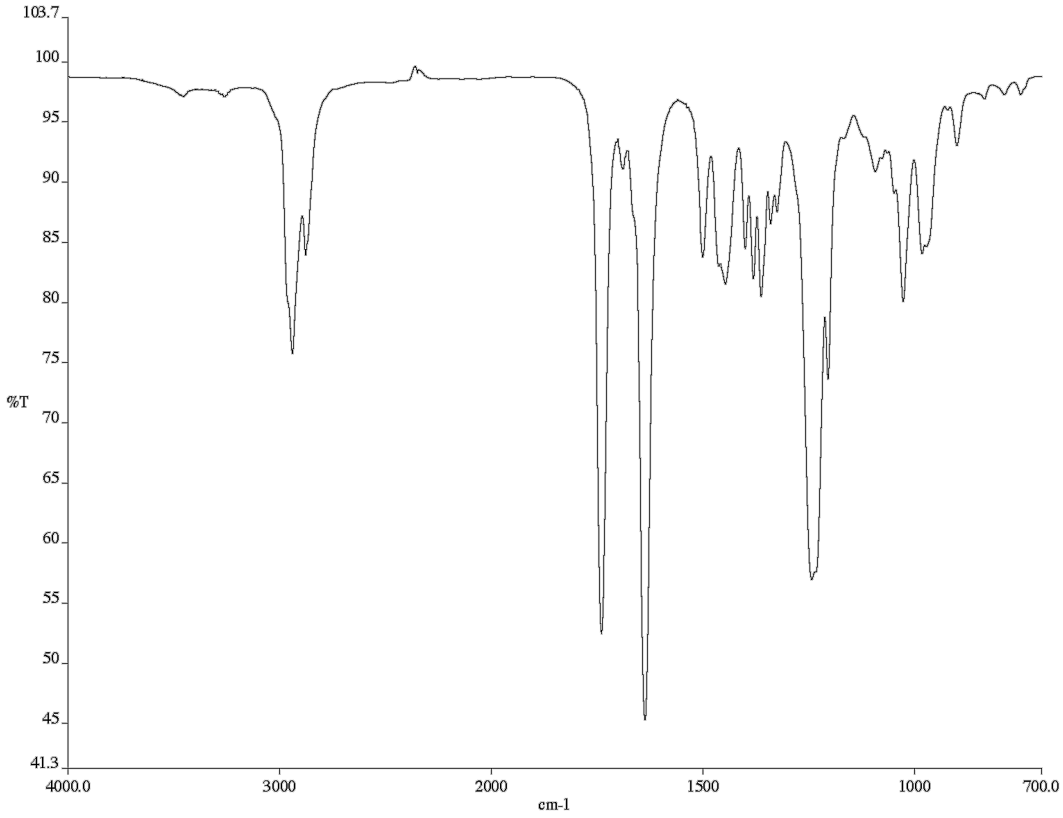


^{13}C NMR (126 MHz, $CDCl_3$) of compound **8f**.

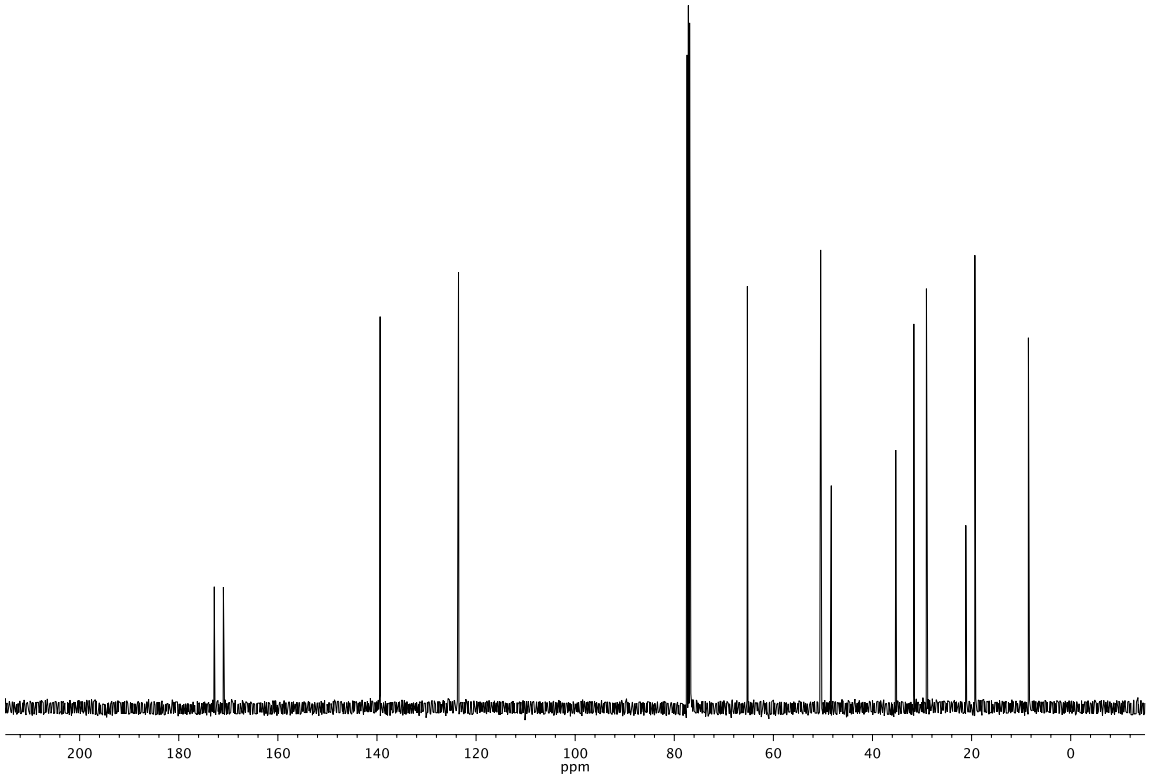


8g

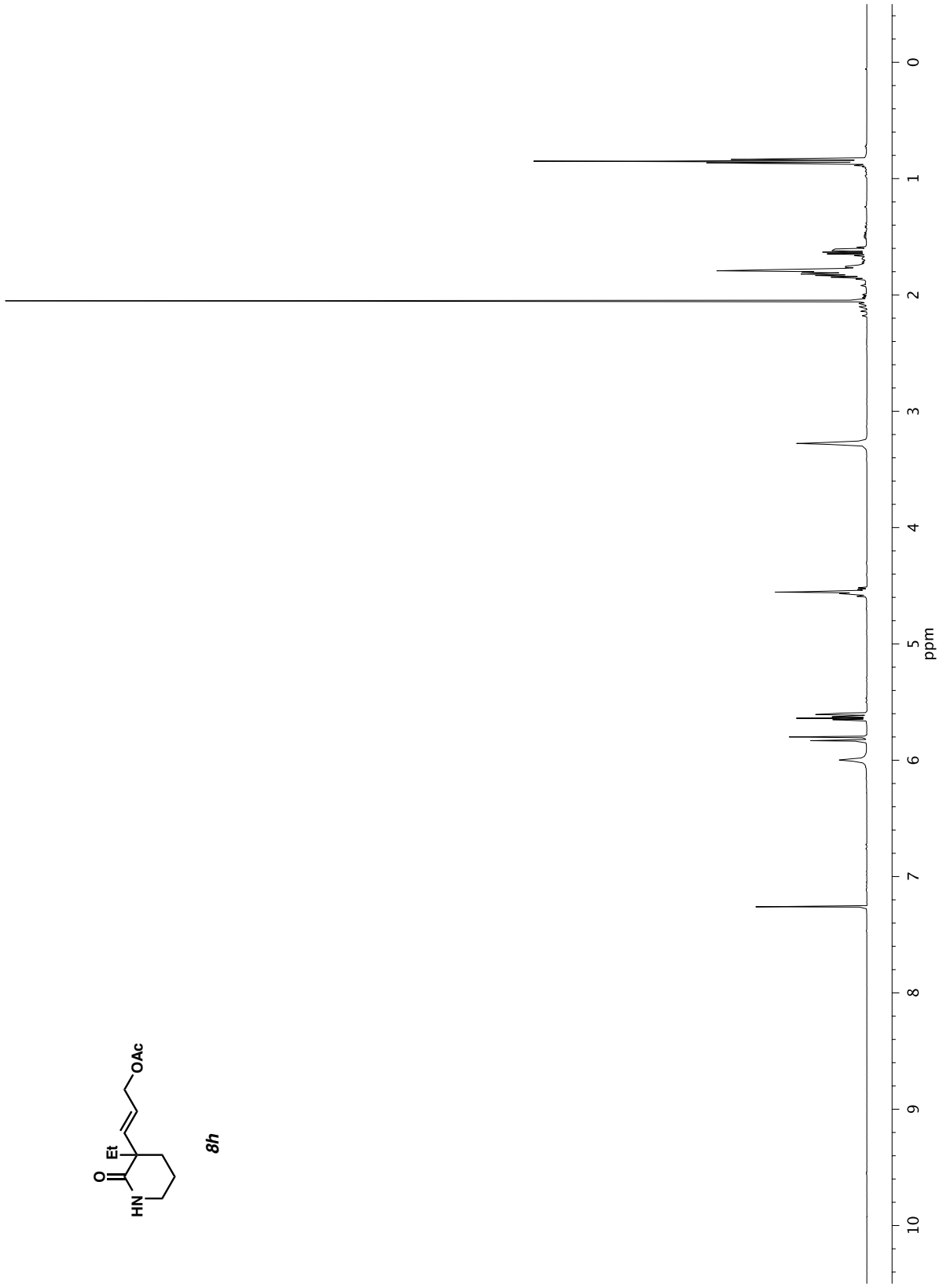
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8g**.



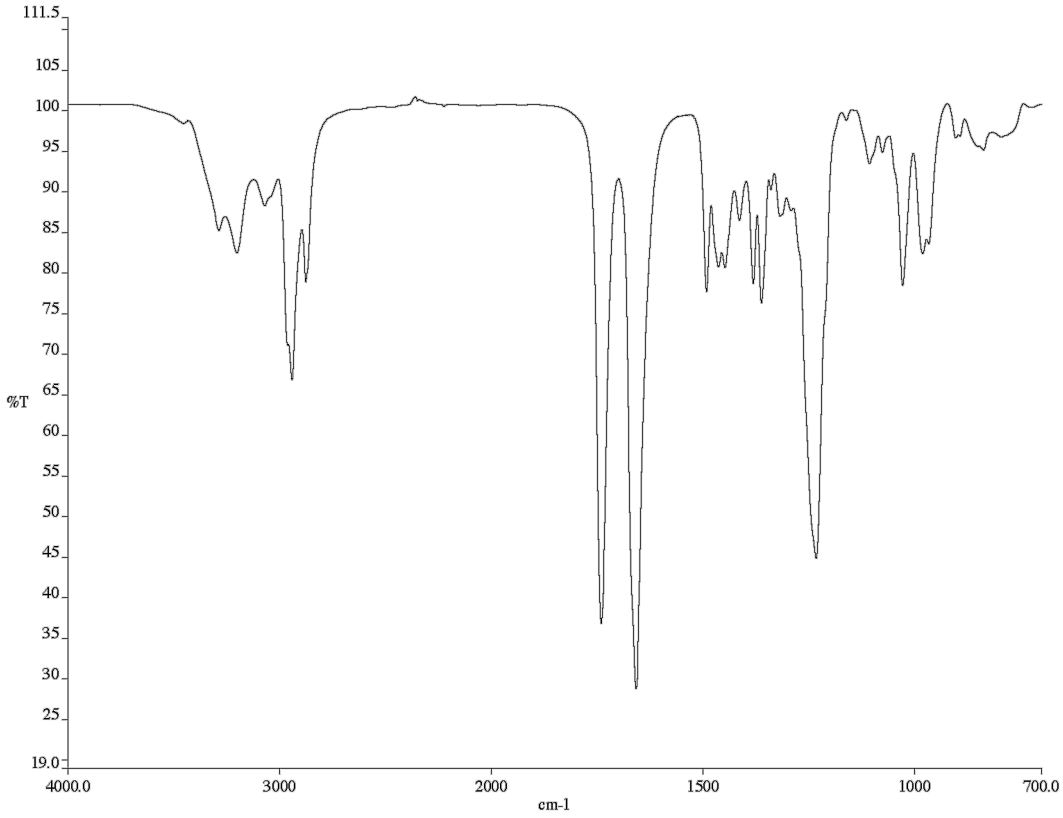
Infrared spectrum (Thin Film, NaCl) of compound **8g**.



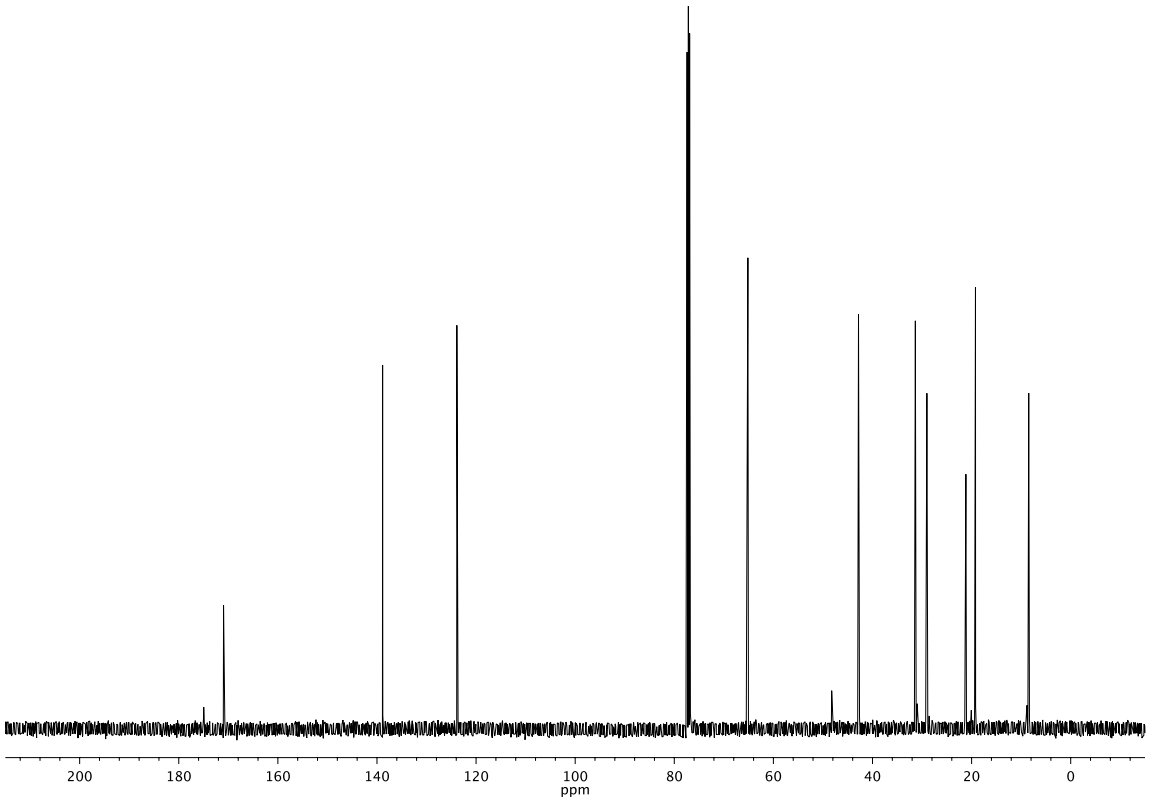
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8g**.



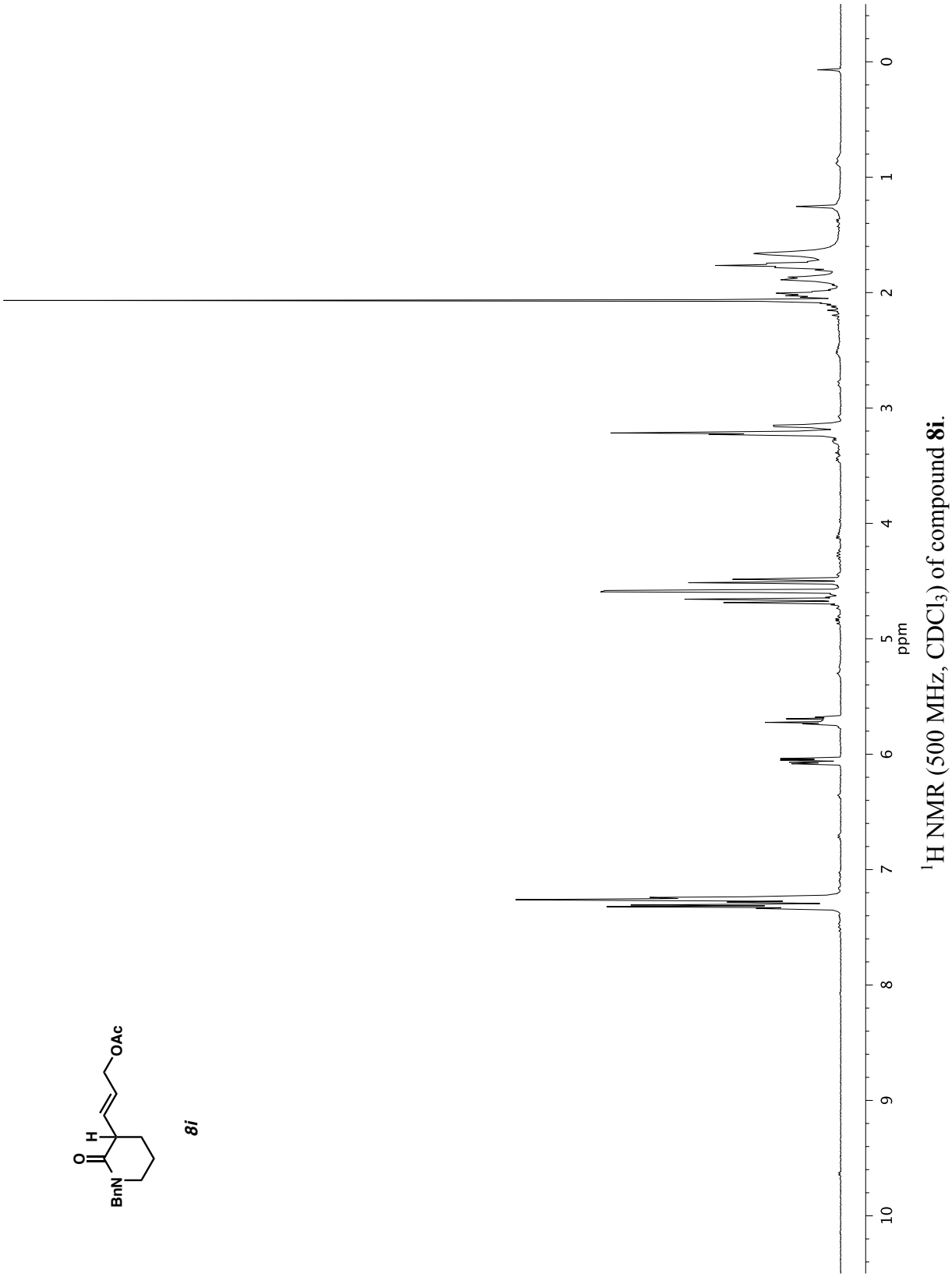
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8h**.



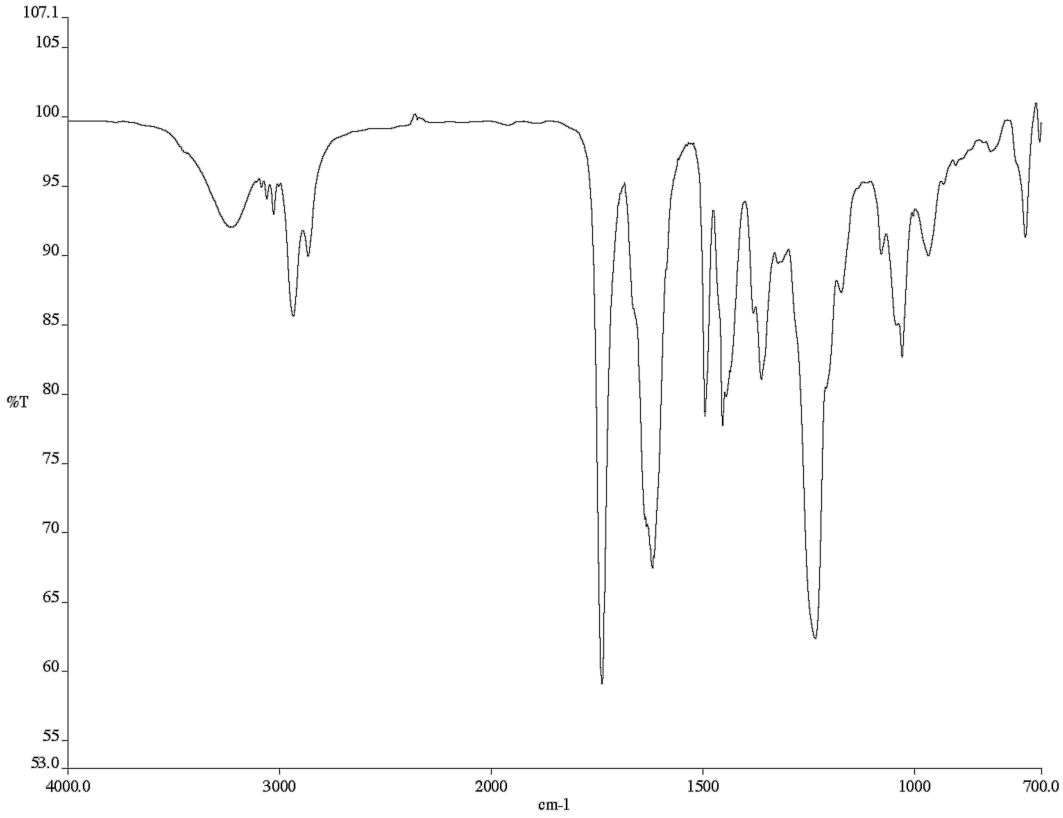
Infrared spectrum (Thin Film, NaCl) of compound **8h**.



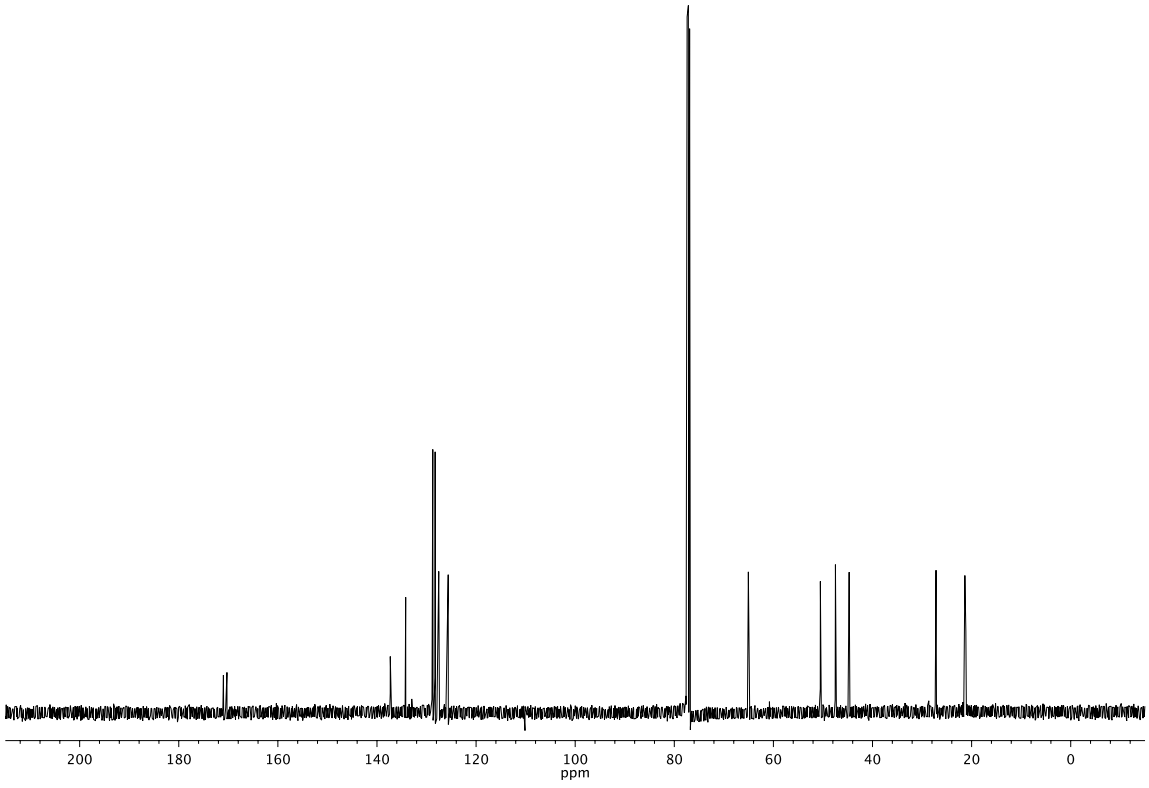
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8h**.



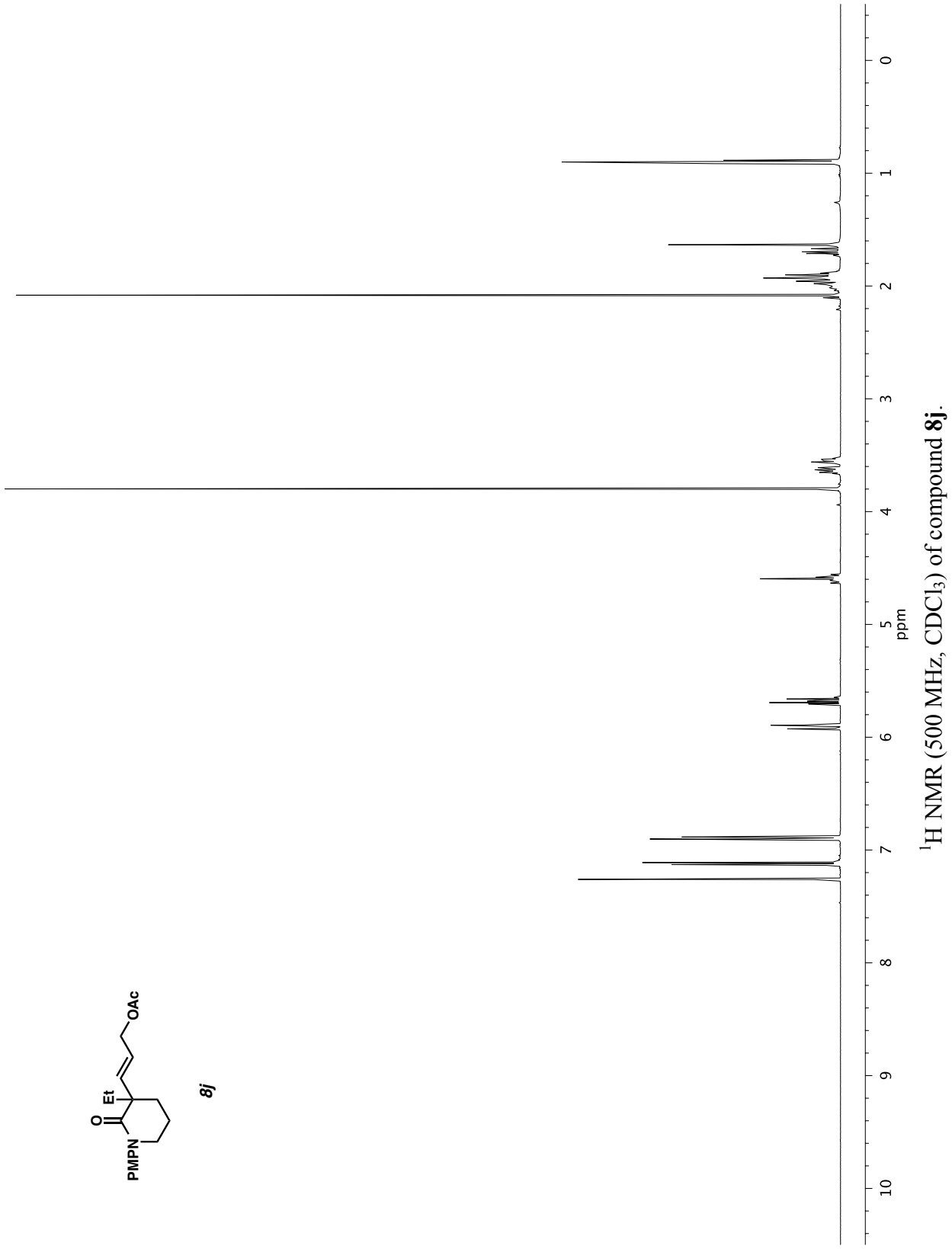
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8i**.



Infrared spectrum (Thin Film, NaCl) of compound **8i**.

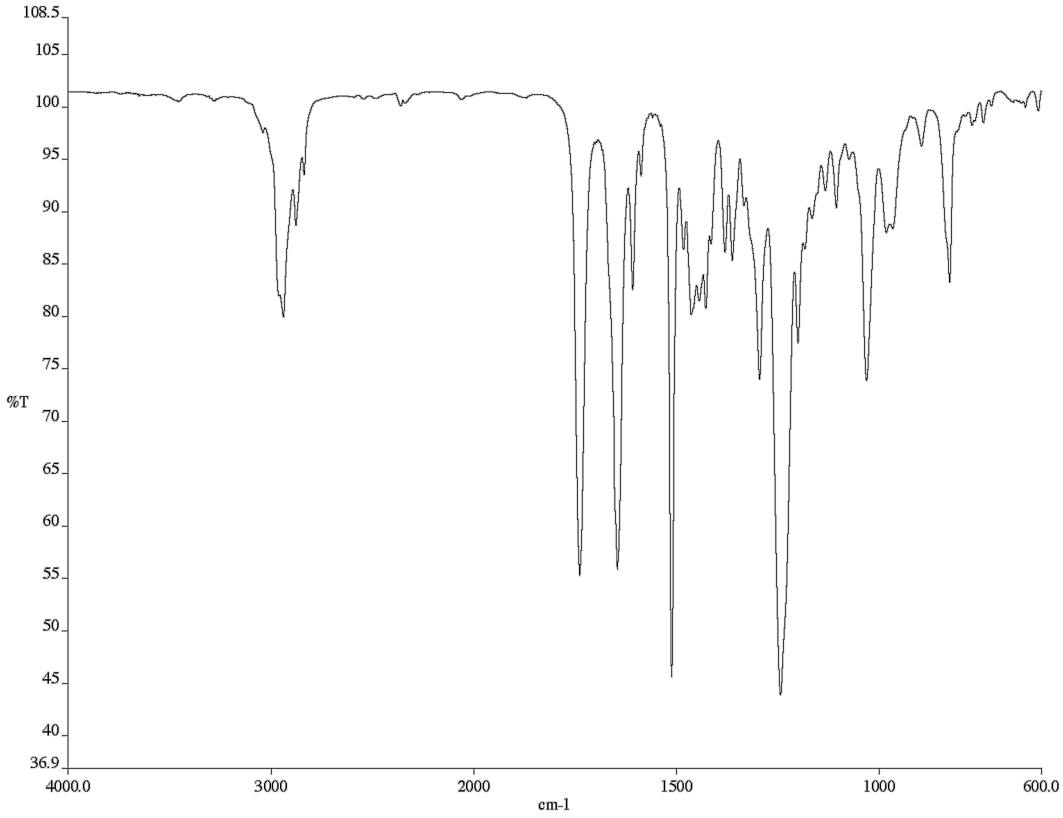


^{13}C NMR (126 MHz, $CDCl_3$) of compound **8i**.

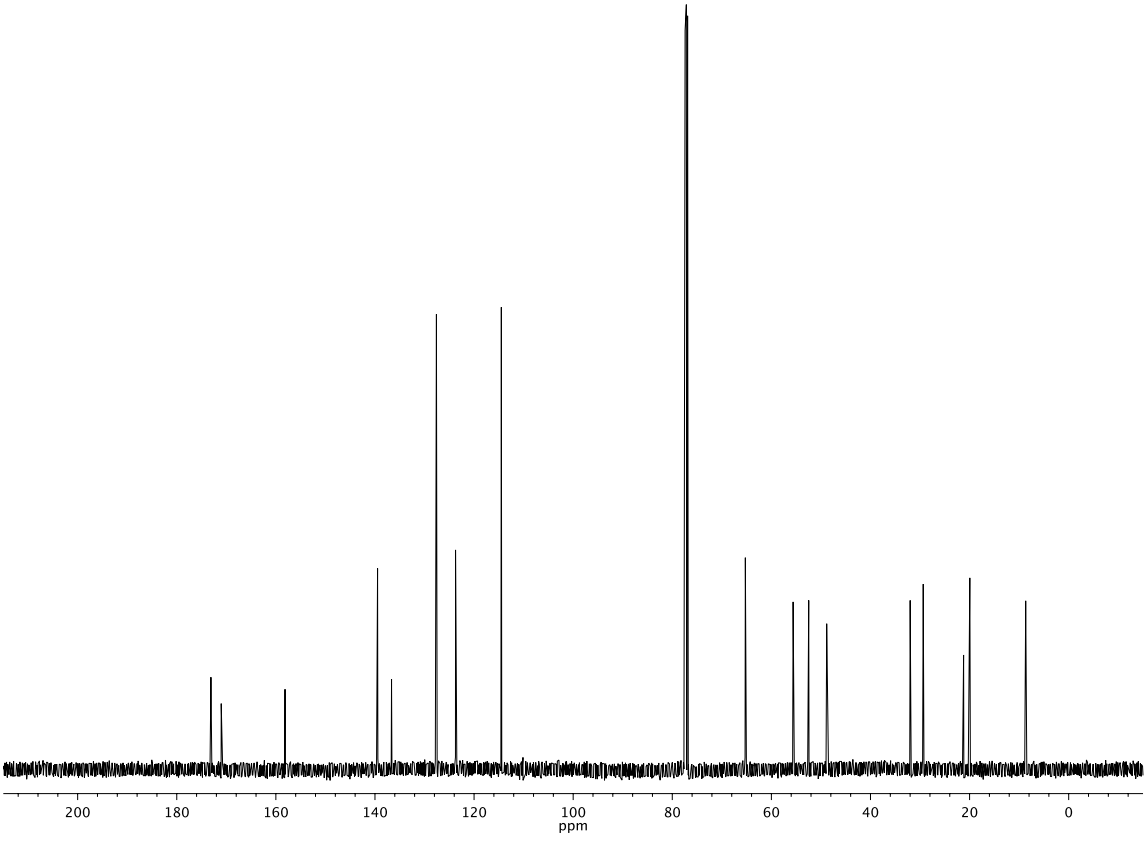


8j

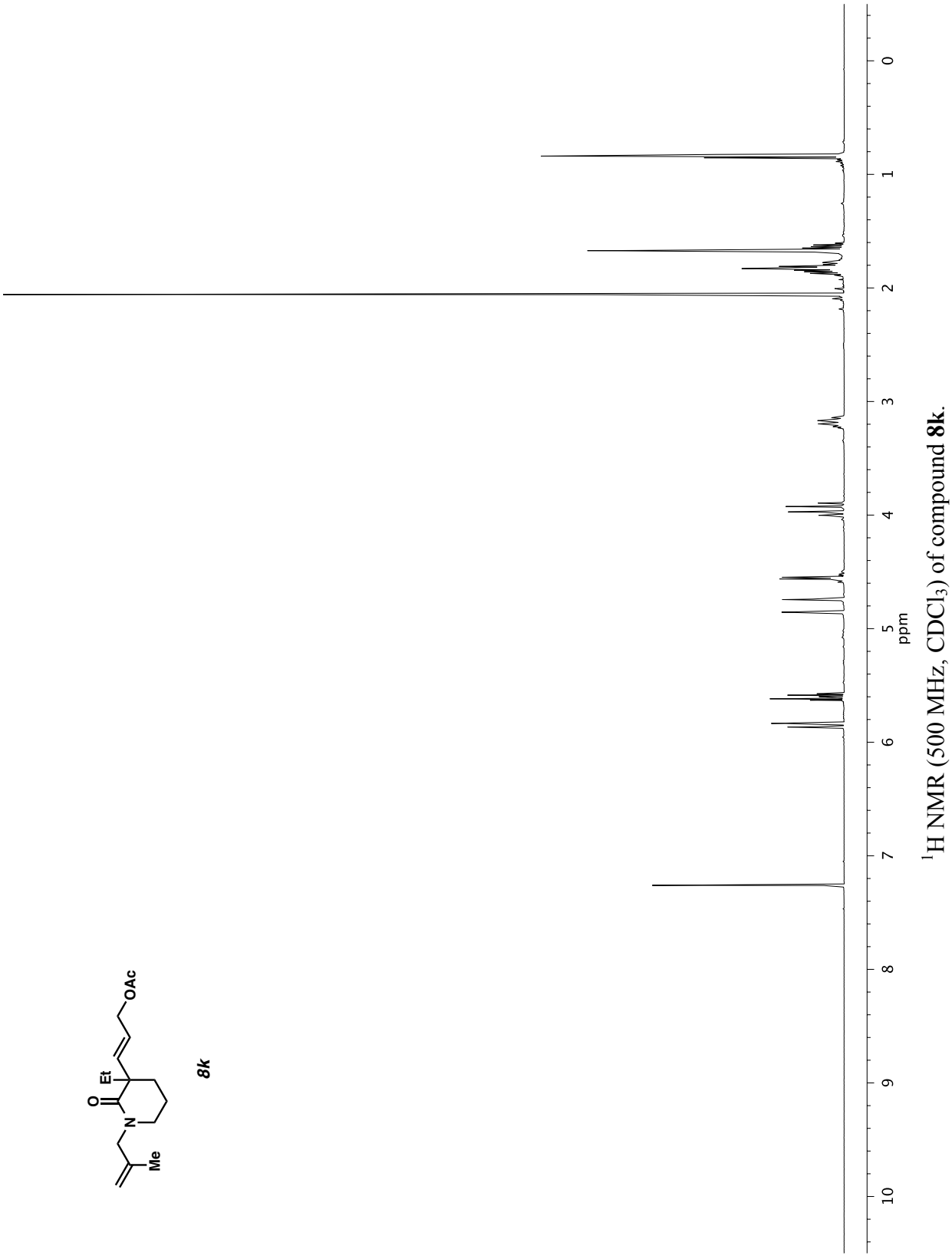
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8j**.



Infrared spectrum (Thin Film, NaCl) of compound **8j**.

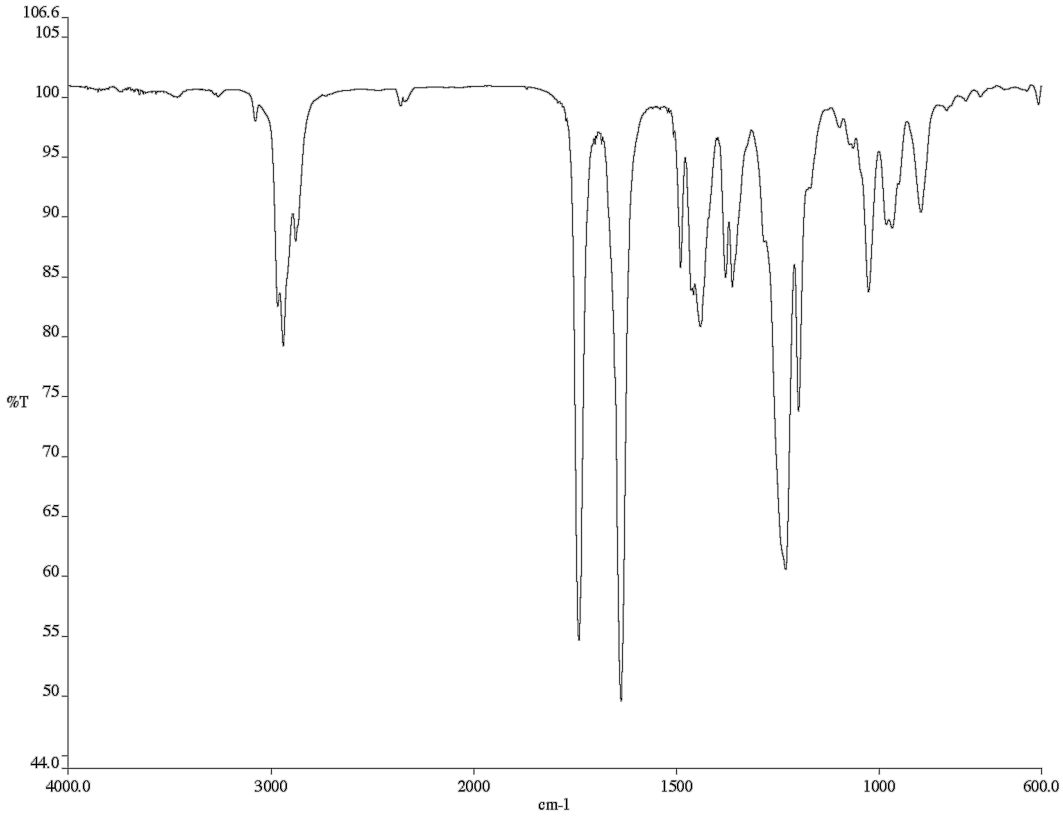


^{13}C NMR (126 MHz, $CDCl_3$) of compound **8j**.

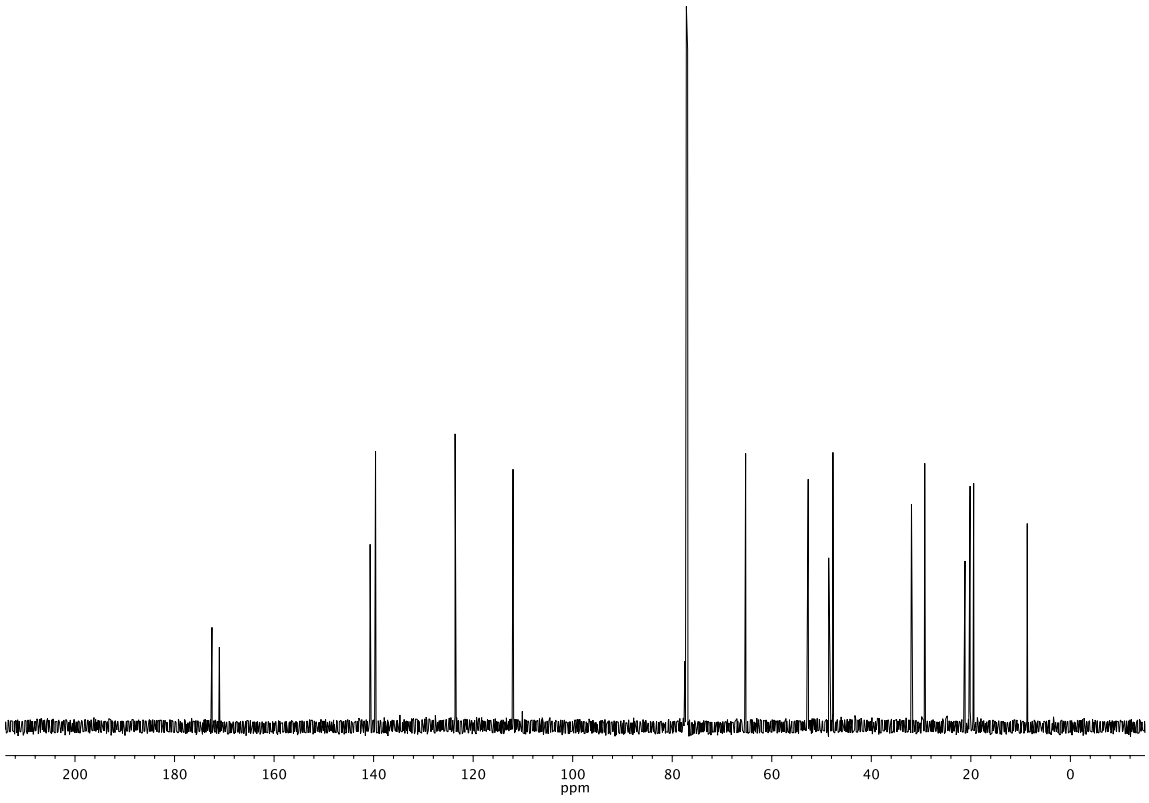


8k

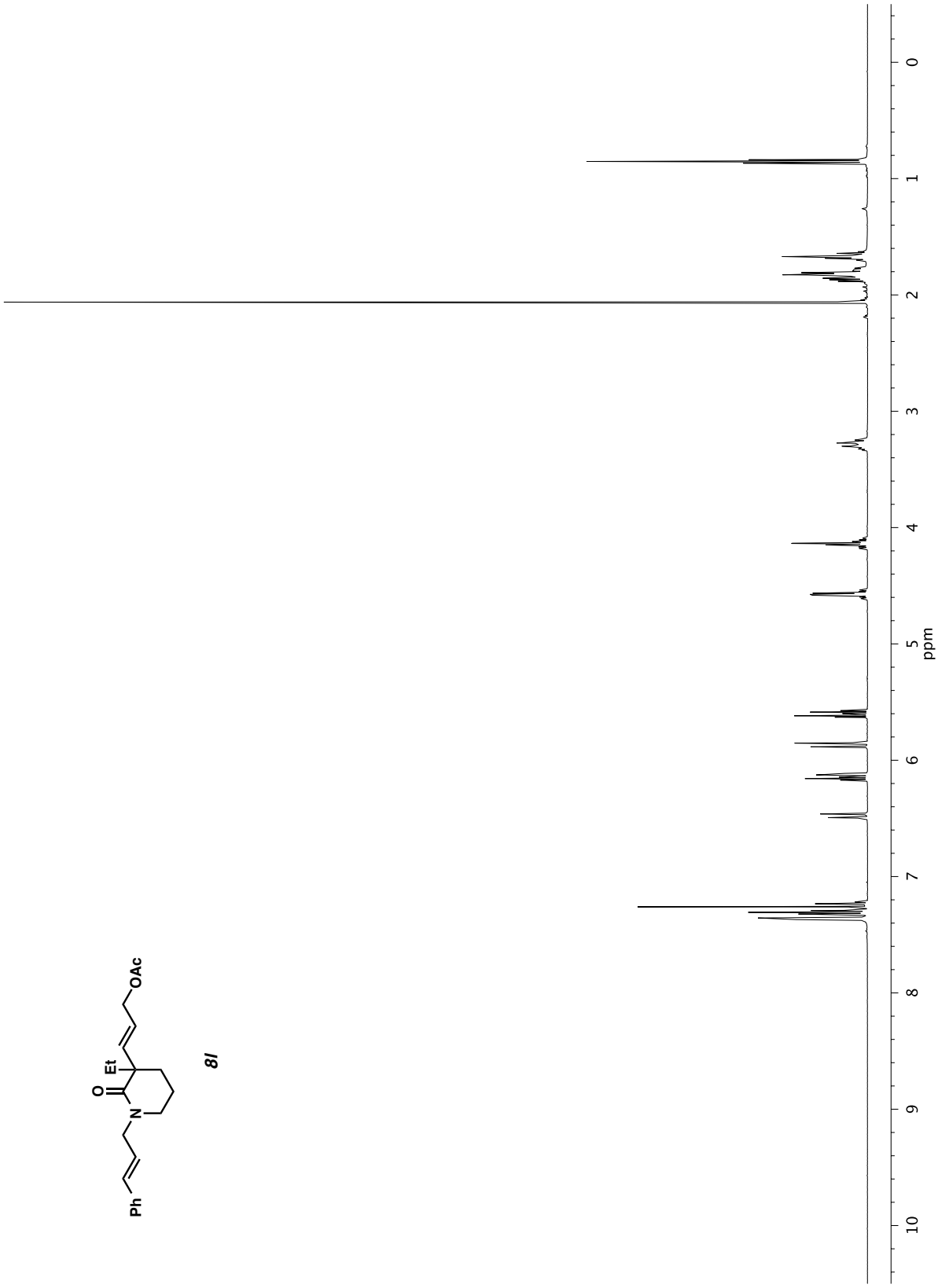
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8k**.



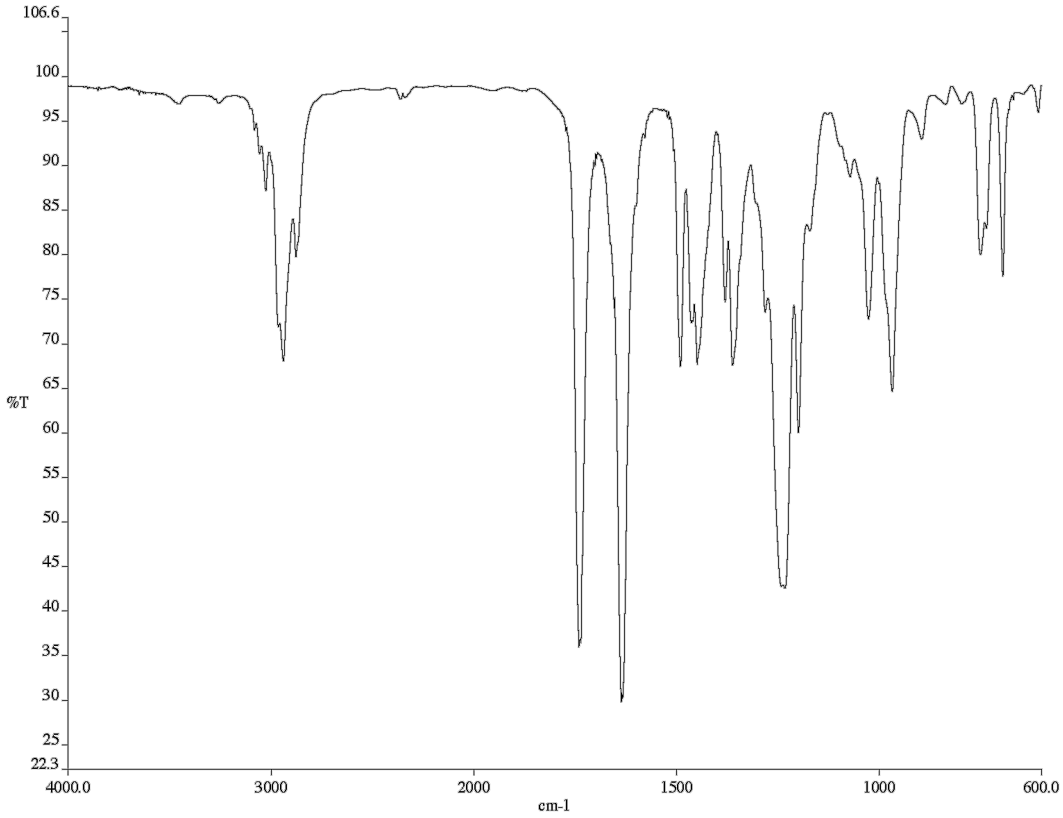
Infrared spectrum (Thin Film, NaCl) of compound **8k**.



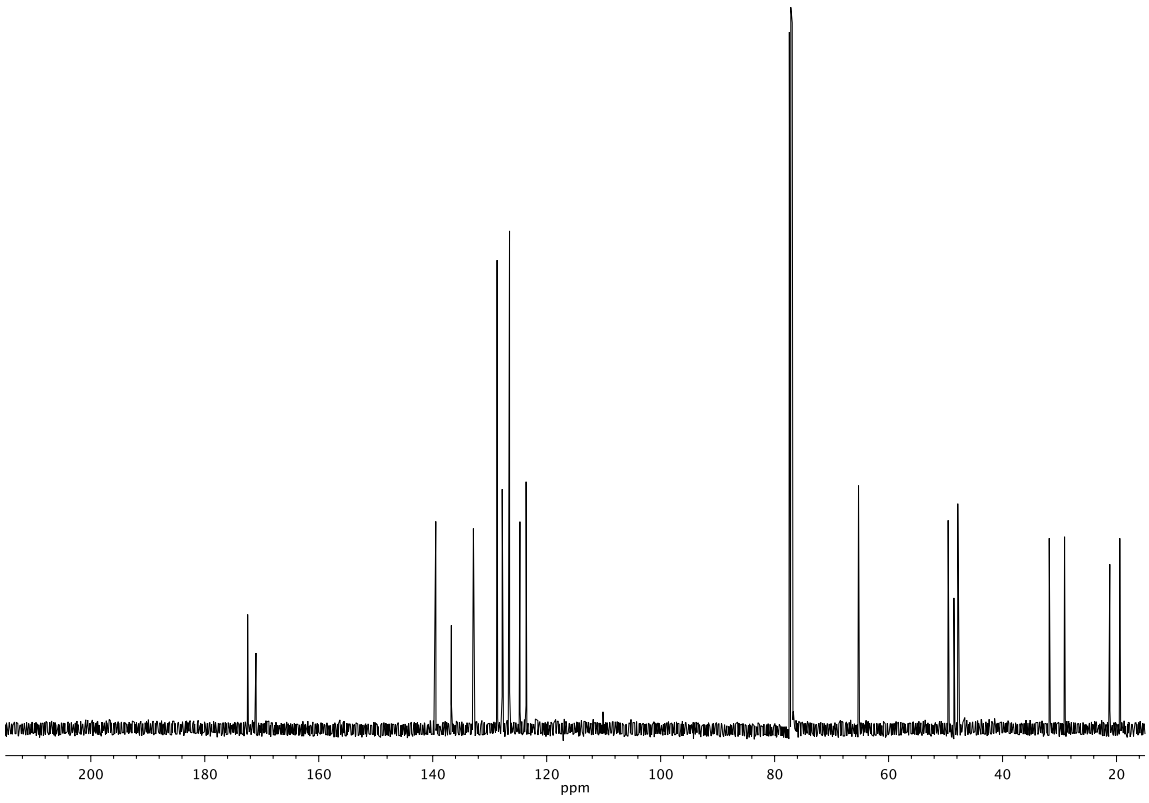
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8k**.



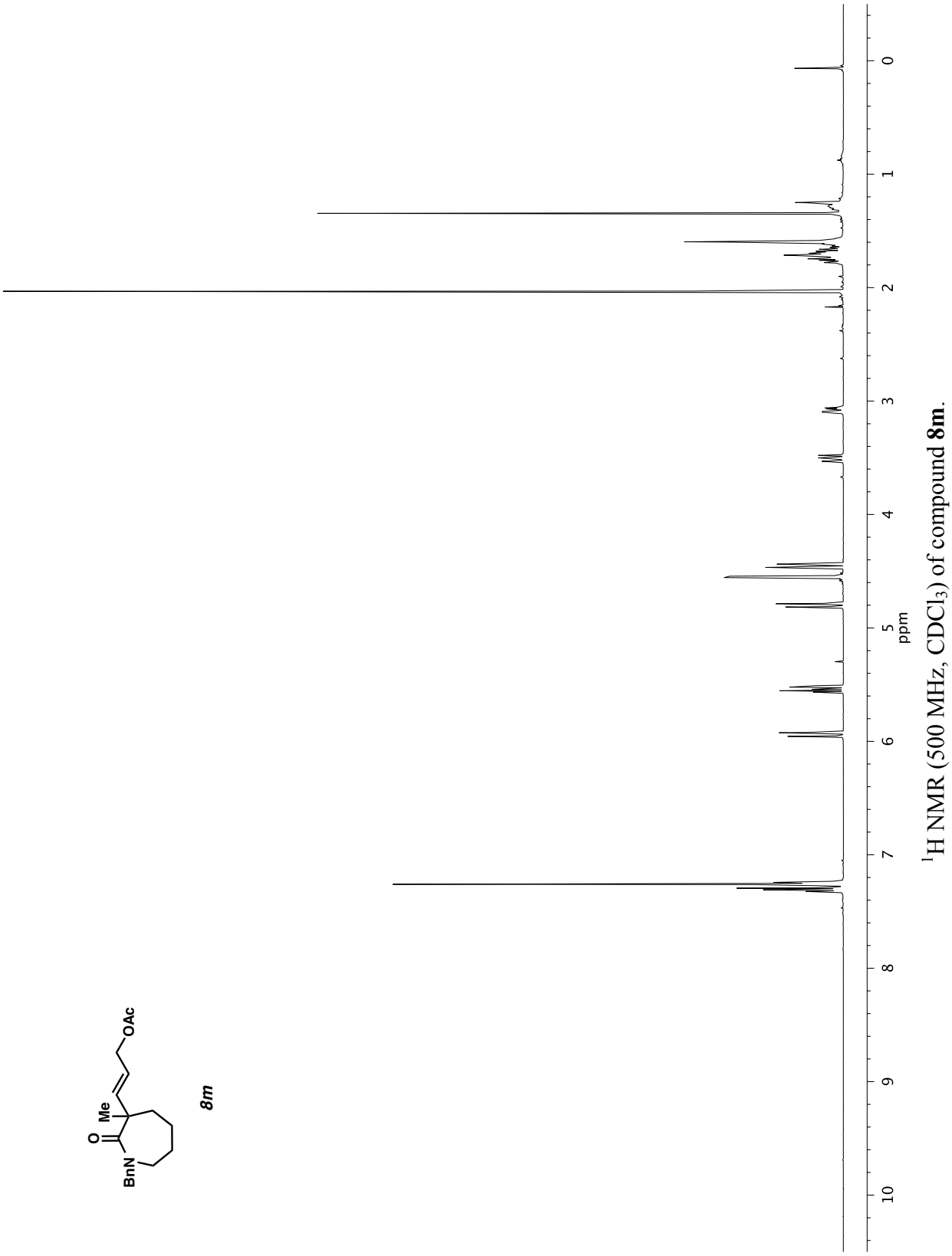
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8l**.



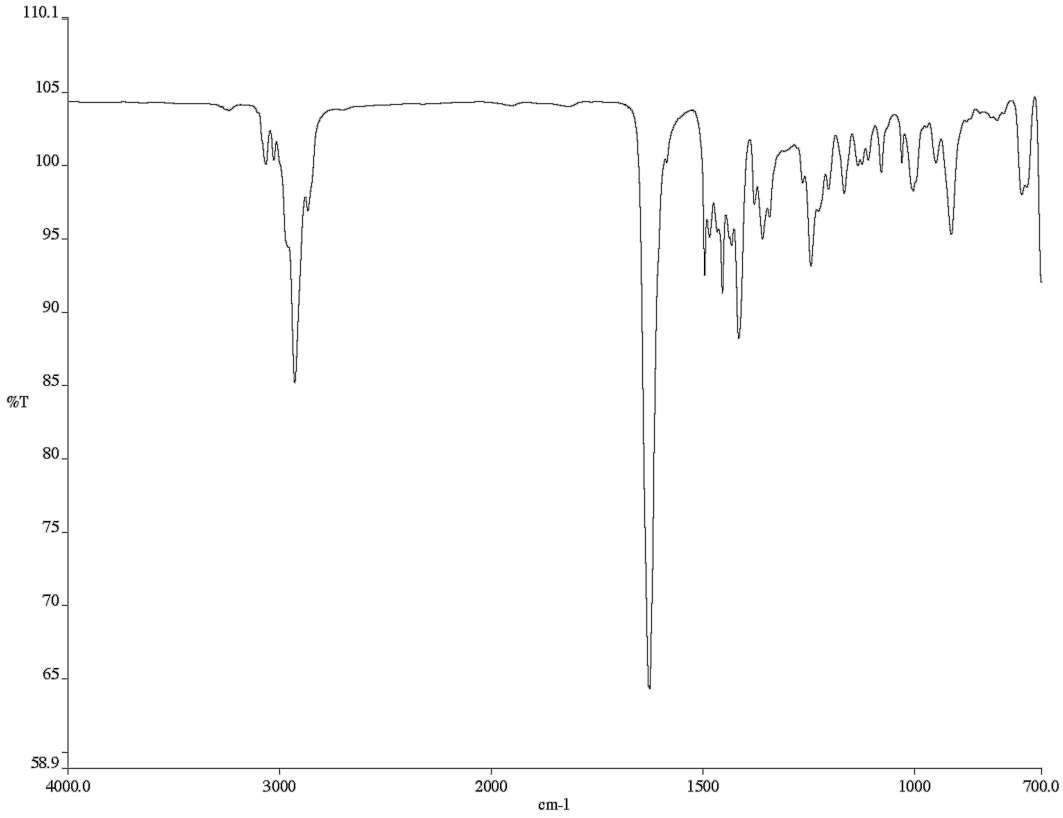
Infrared spectrum (Thin Film, NaCl) of compound **8l**.



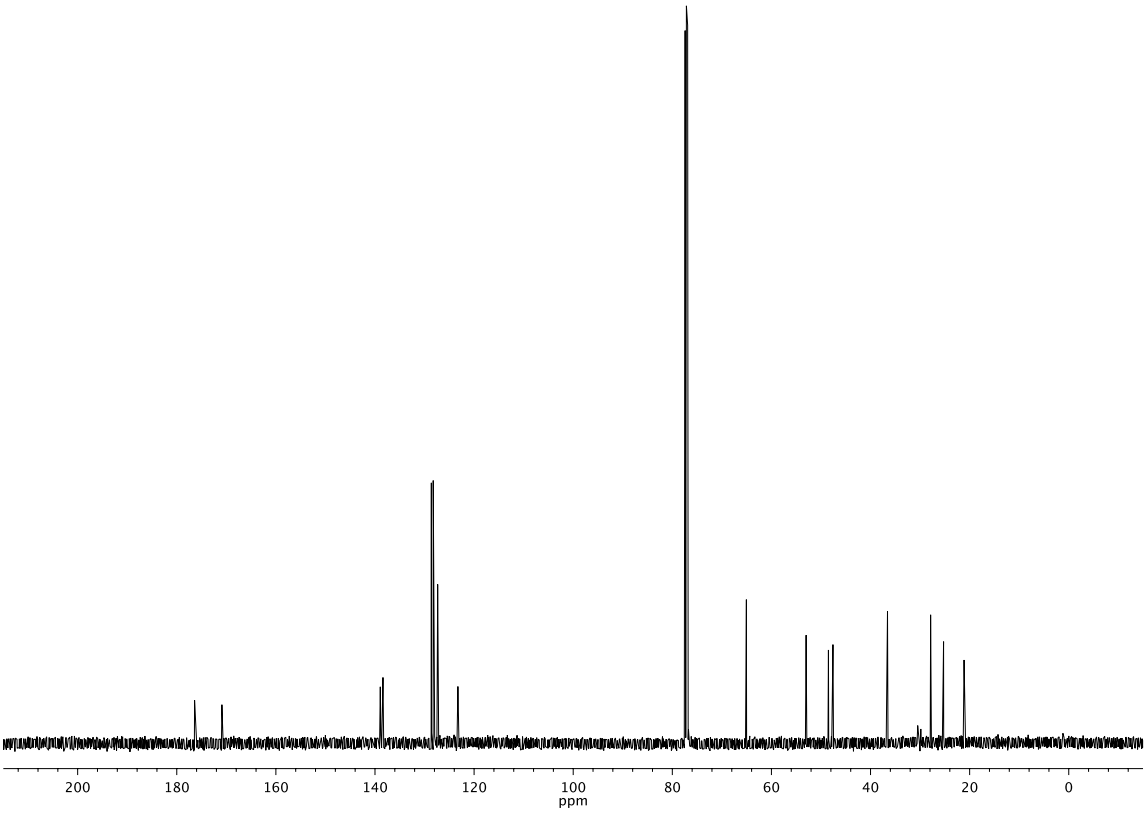
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8l**.



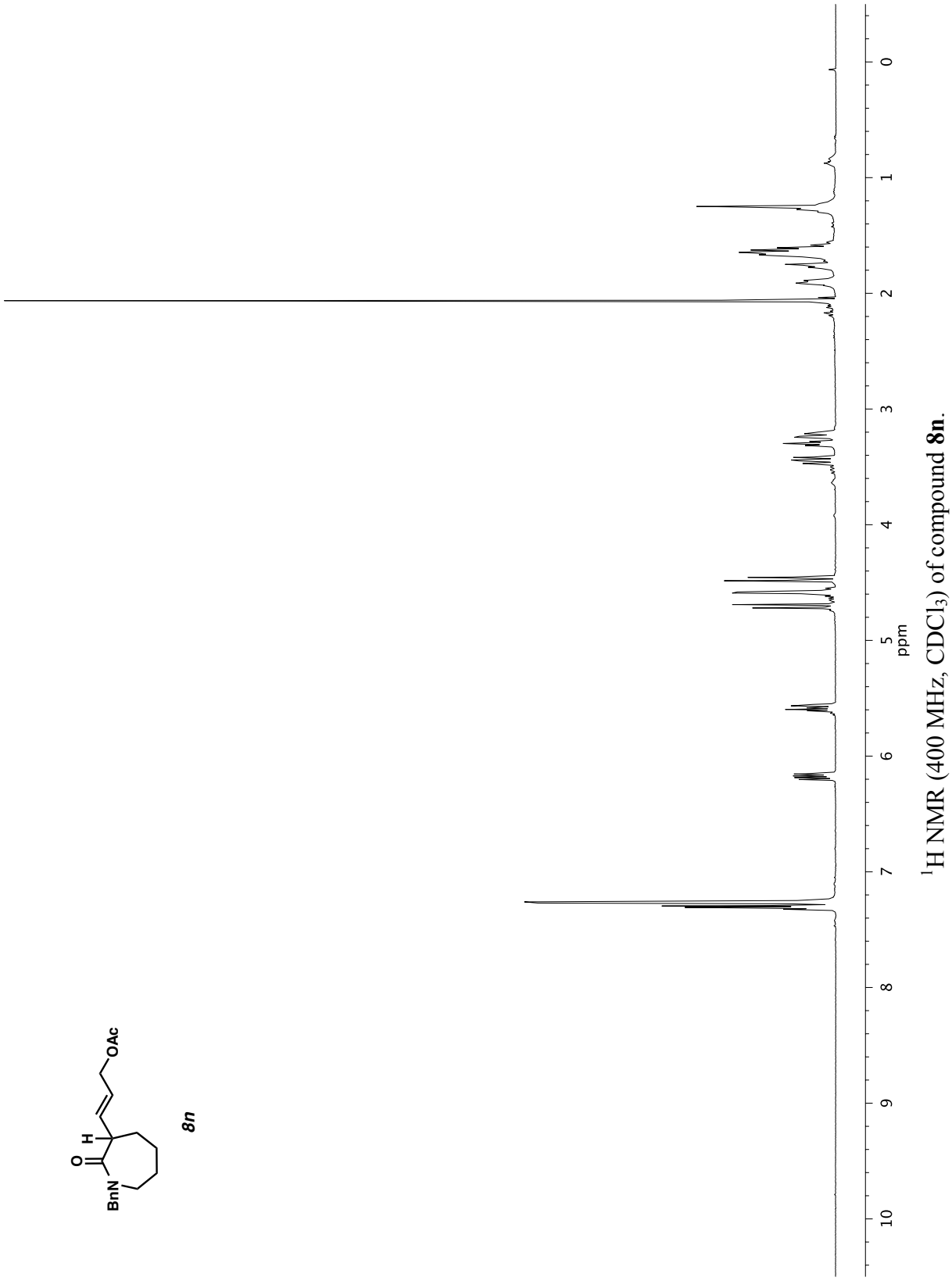
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8m**.



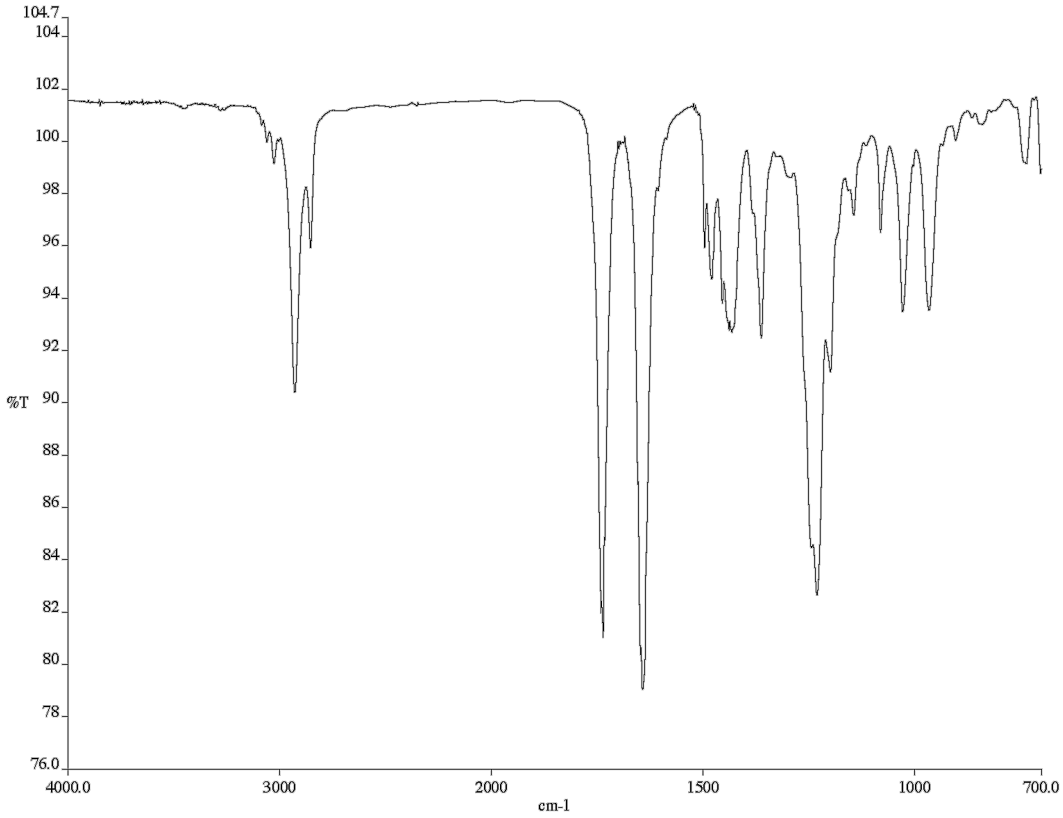
Infrared spectrum (Thin Film, NaCl) of compound **8m**.



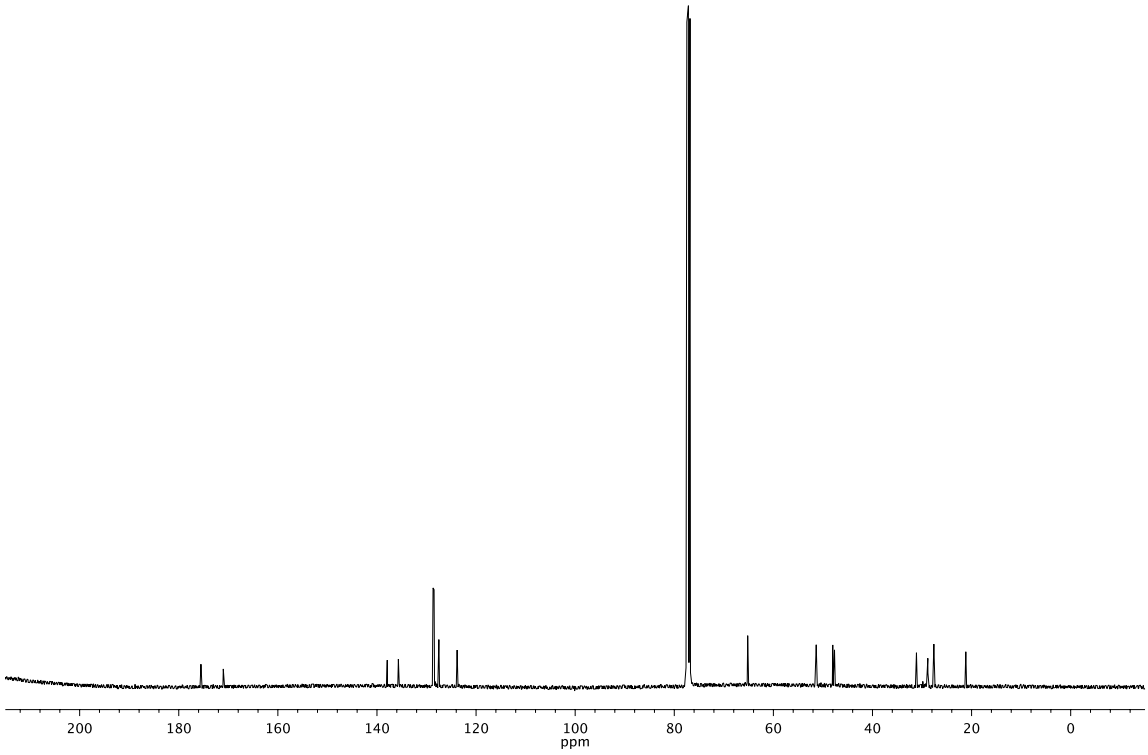
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8m**.



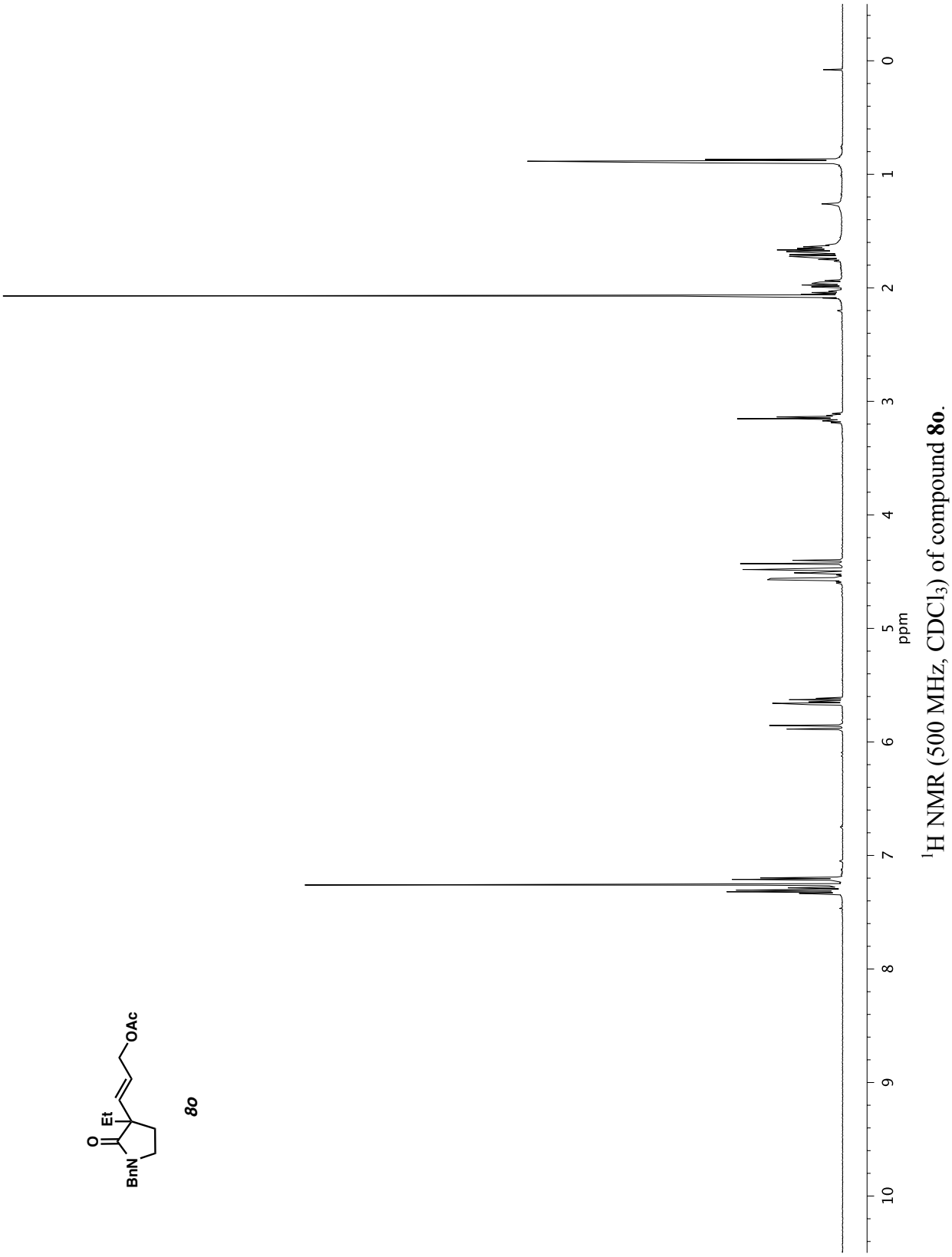
^{1}H NMR (400 MHz, $CDCl_3$) of compound **8n**.



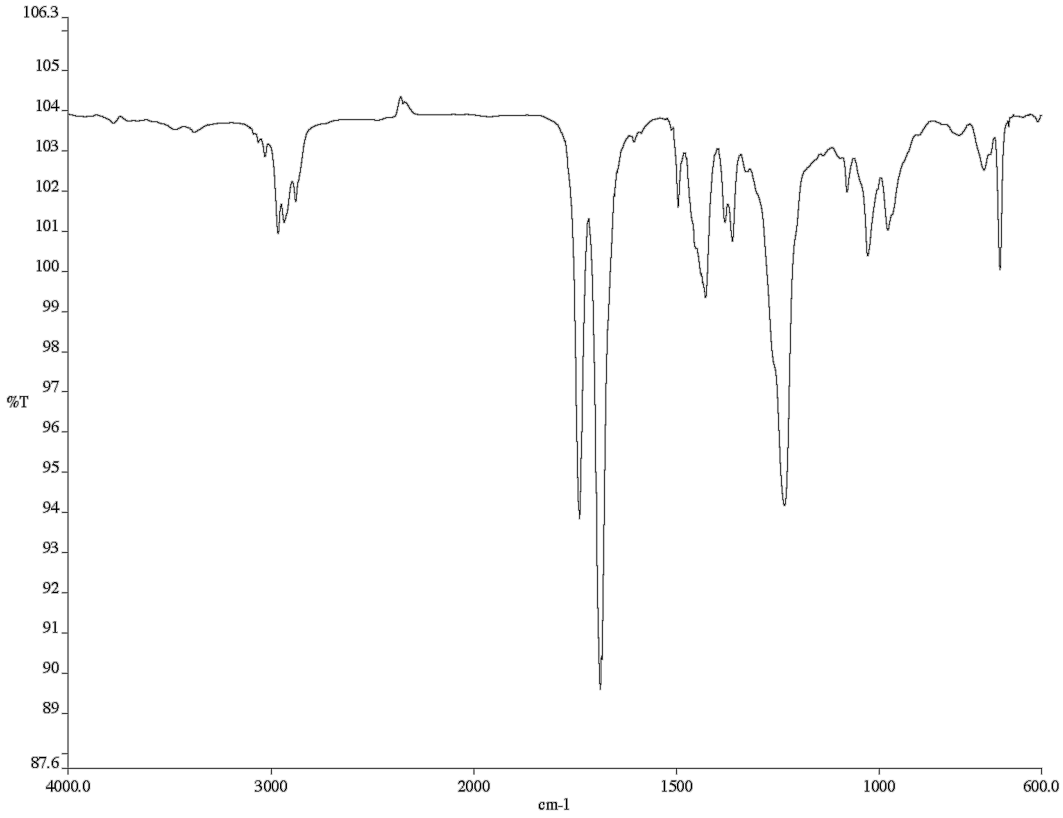
Infrared spectrum (Thin Film, NaCl) of compound **8n**.



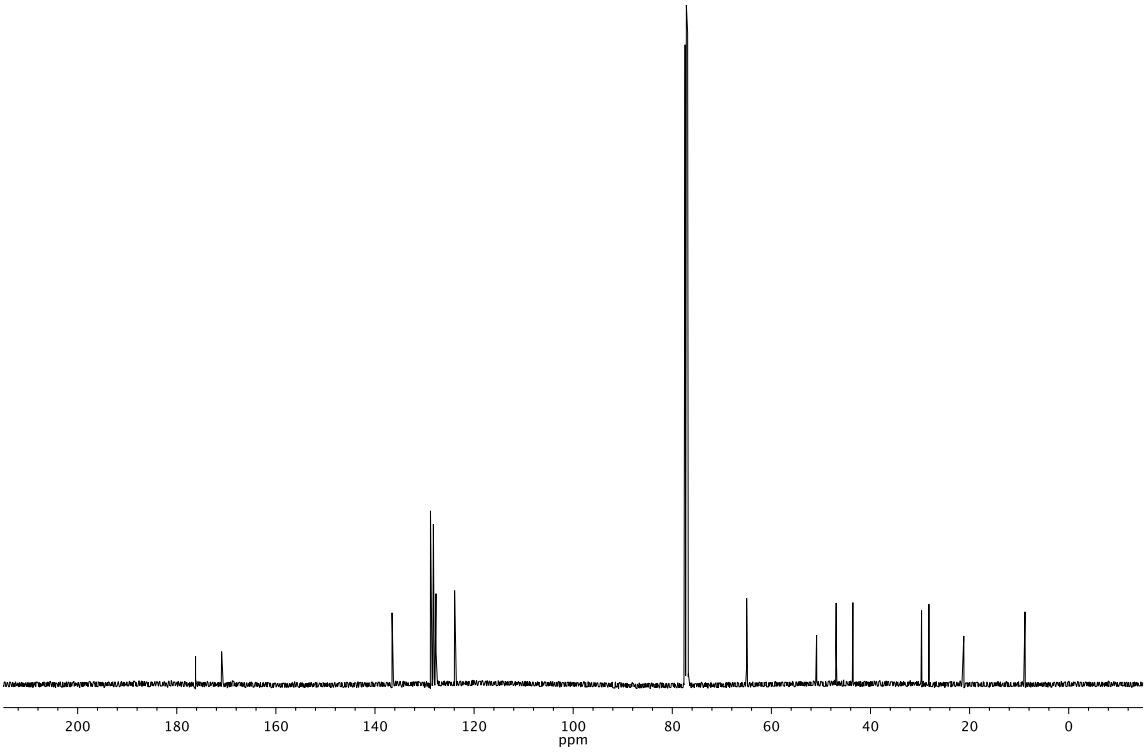
^{13}C NMR (101 MHz, $CDCl_3$) of compound **8n**.



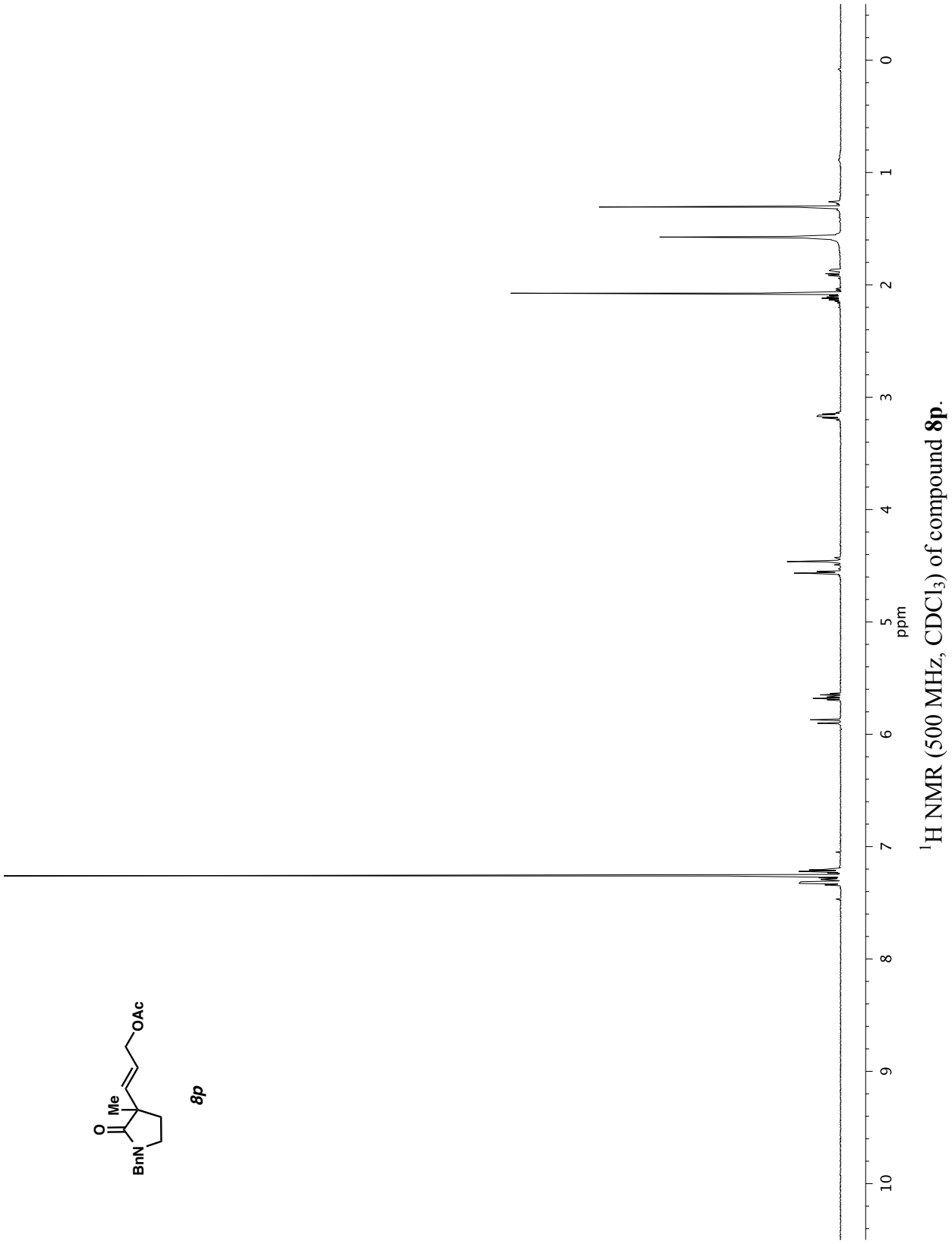
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8o**.



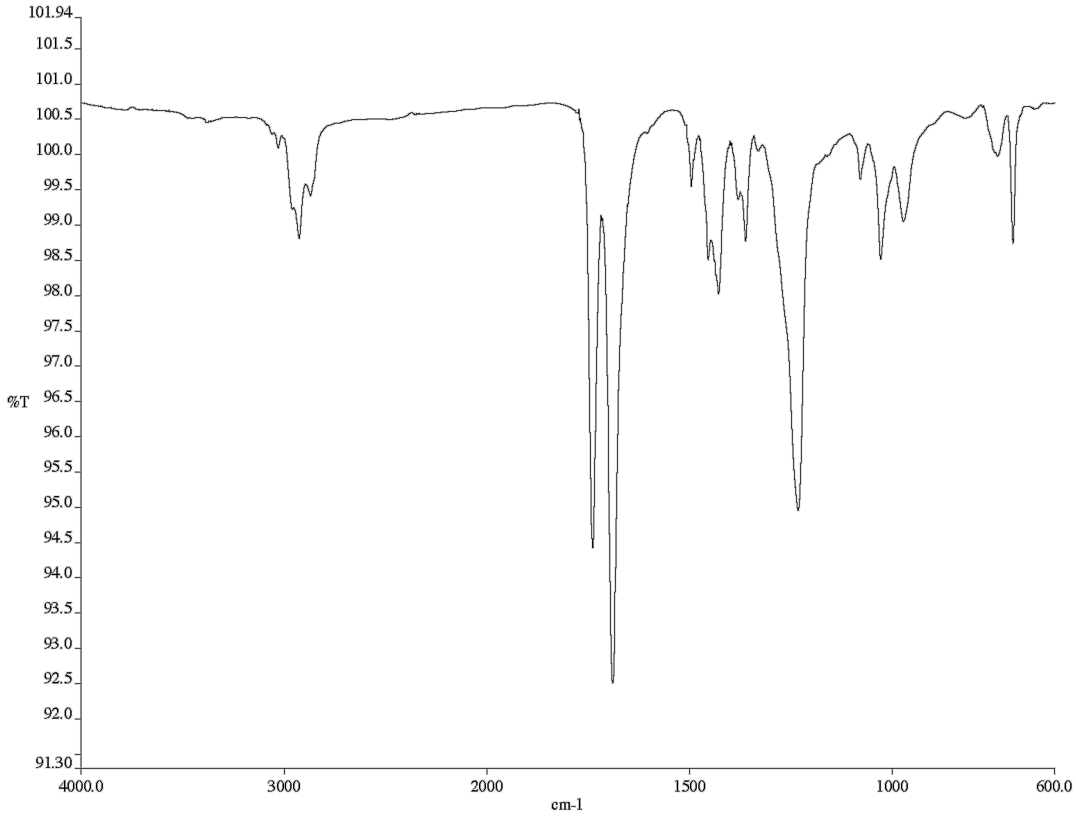
Infrared spectrum (Thin Film, NaCl) of compound **8o**.



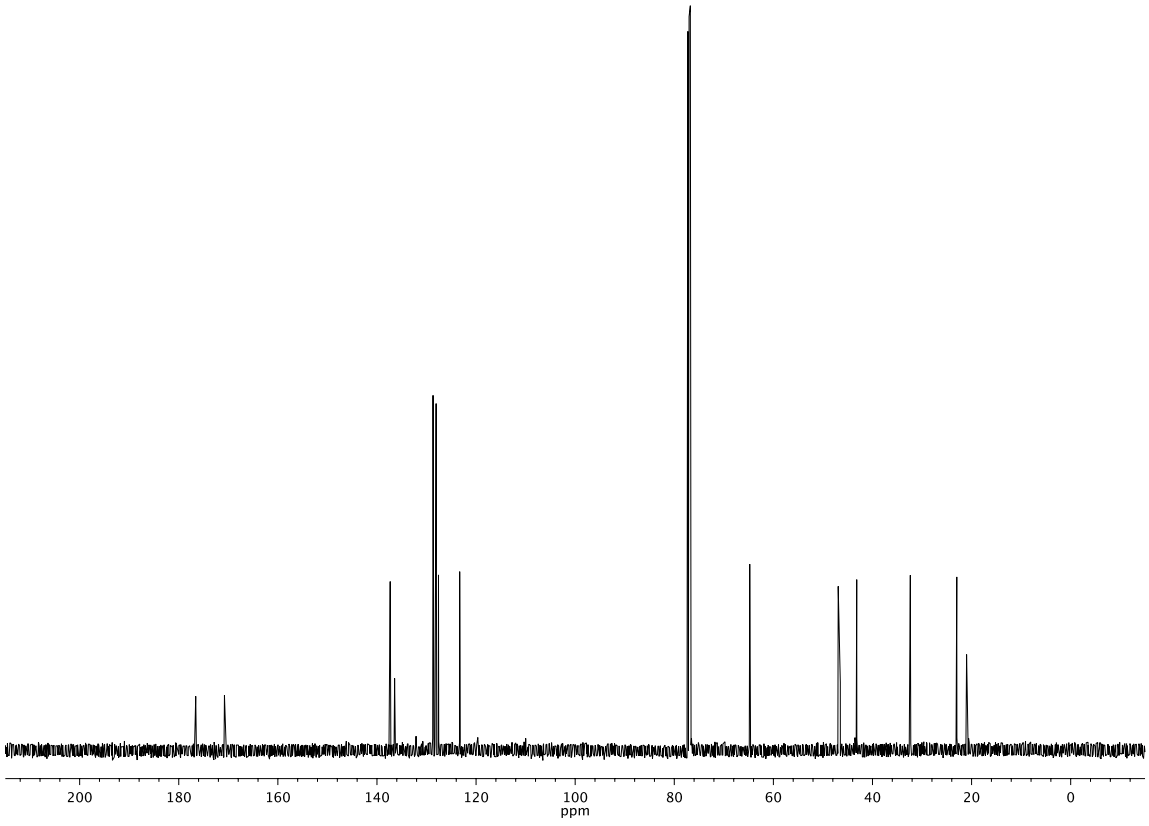
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8o**.



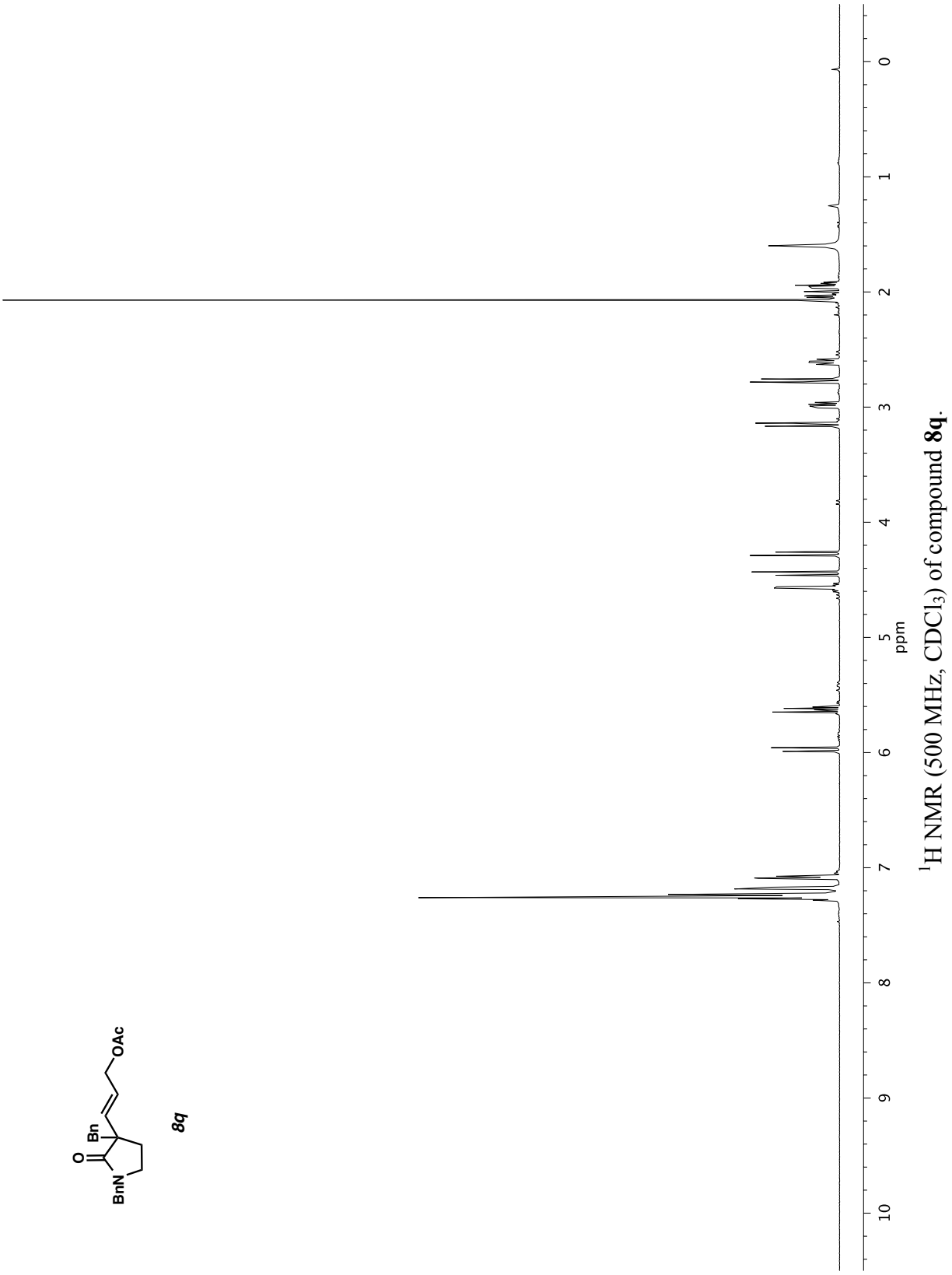
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8p**.



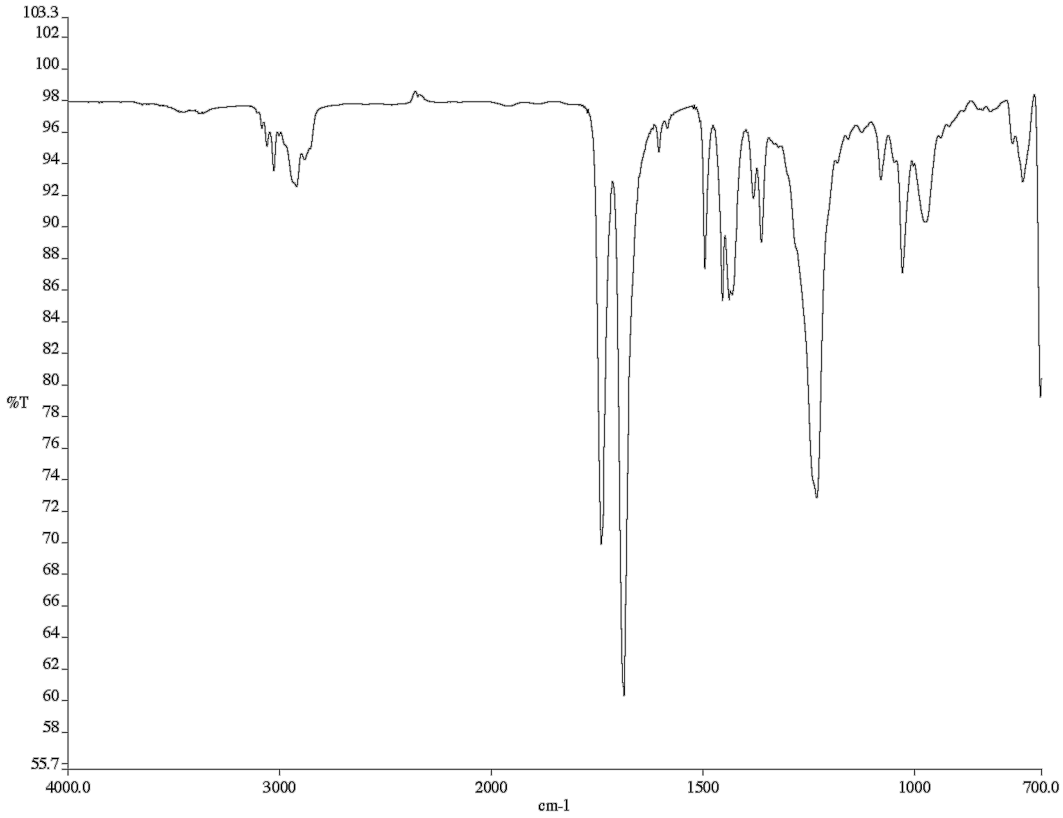
Infrared spectrum (Thin Film, NaCl) of compound **8p**.



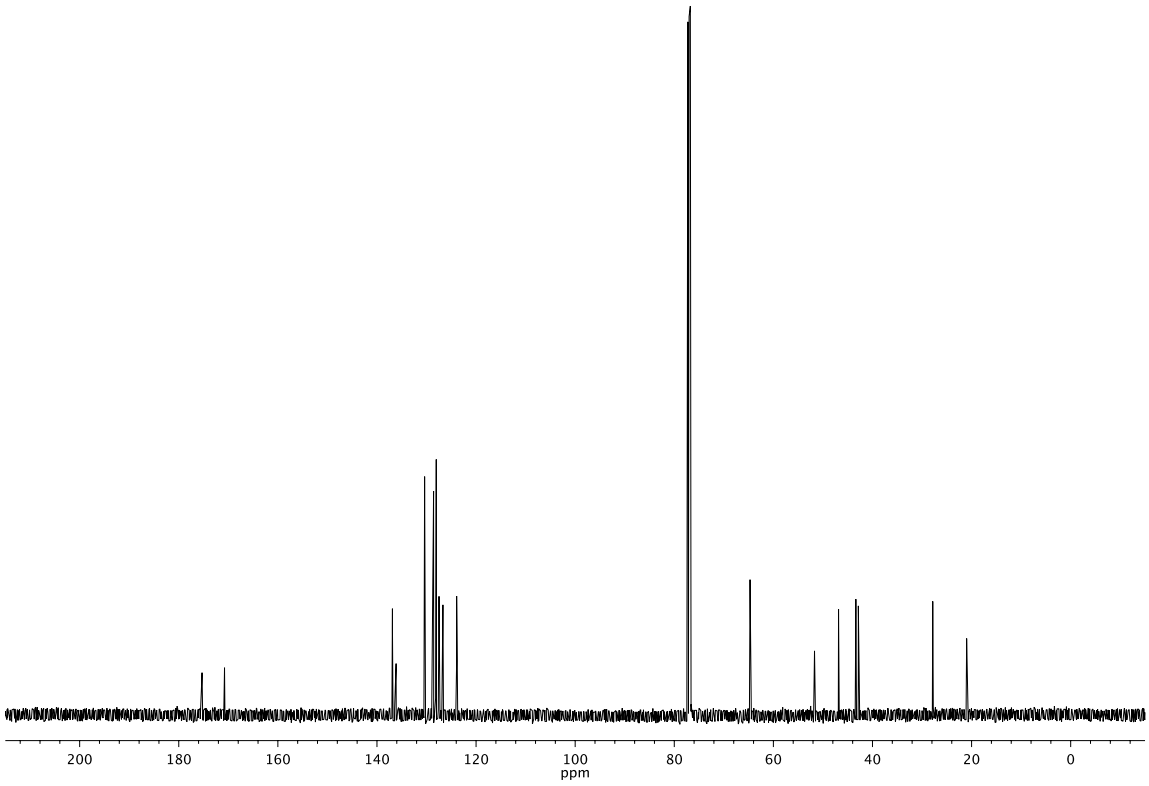
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8p**.



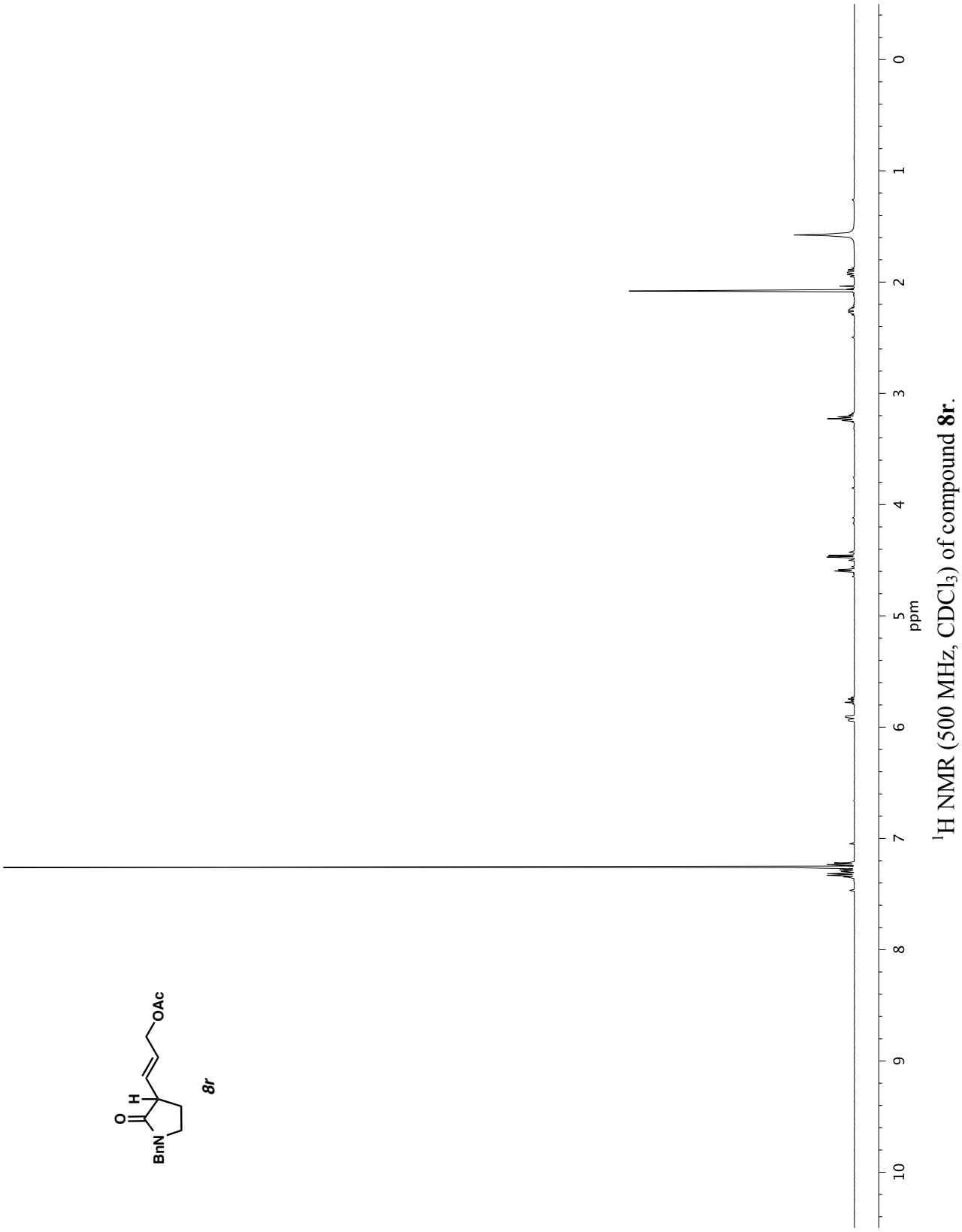
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8q**.



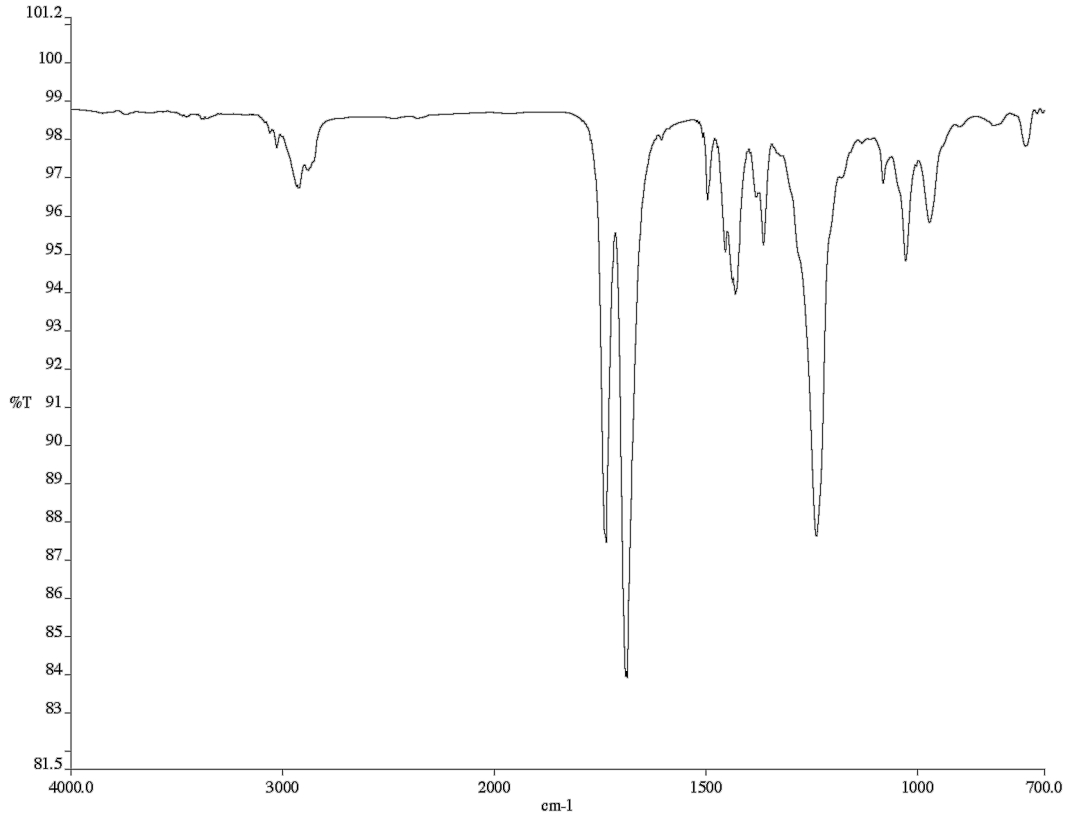
Infrared spectrum (Thin Film, NaCl) of compound **8q**.



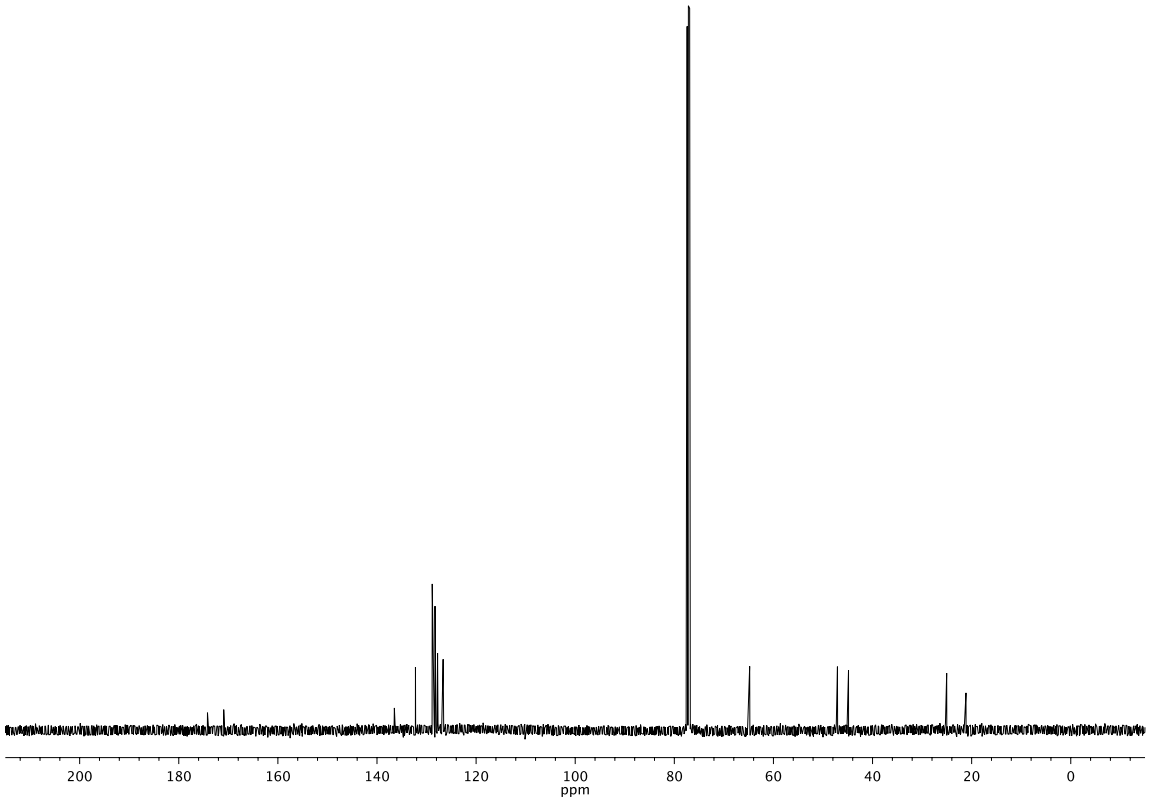
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8q**.



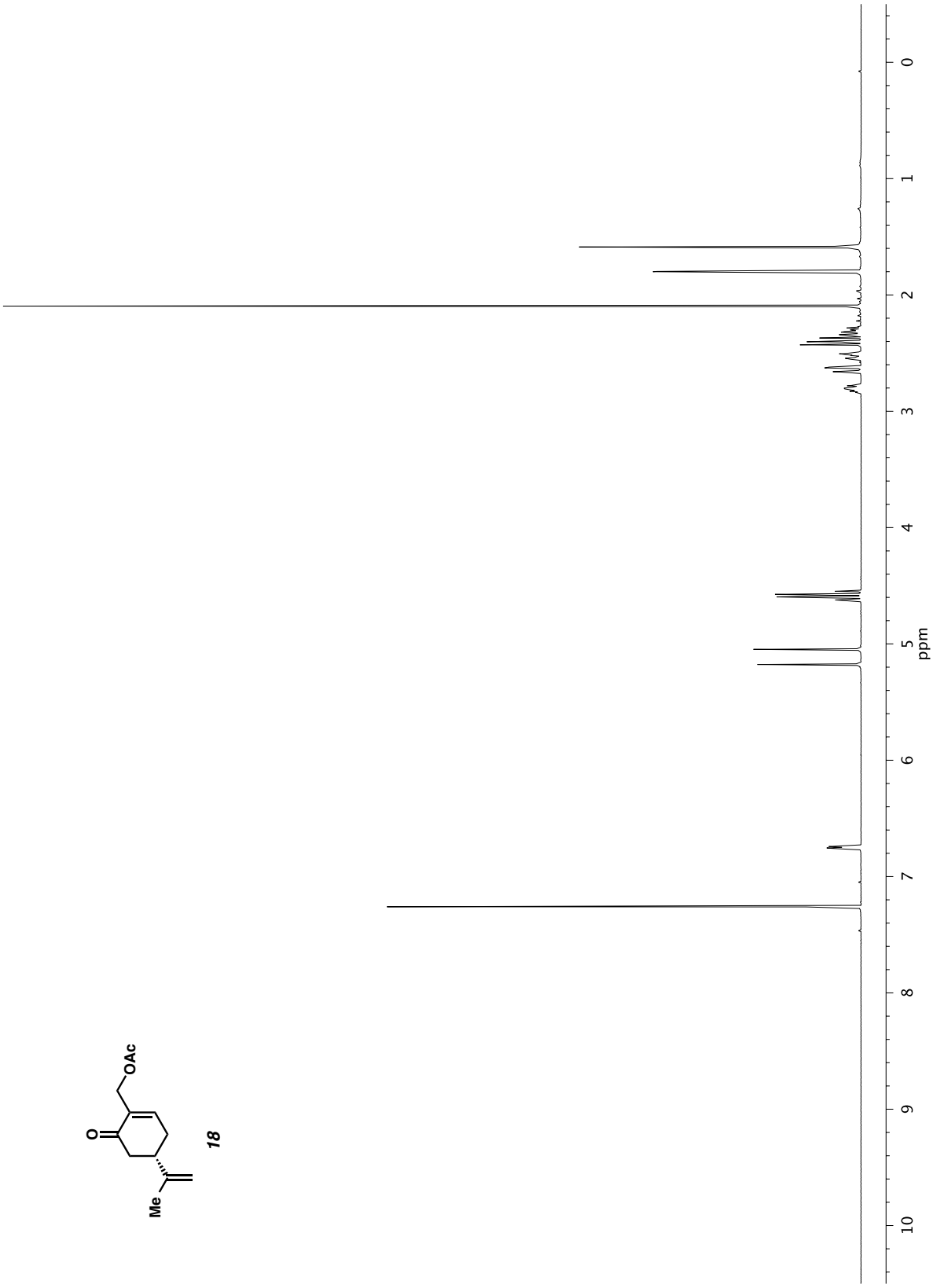
^{1}H NMR (500 MHz, $CDCl_3$) of compound **8r**.



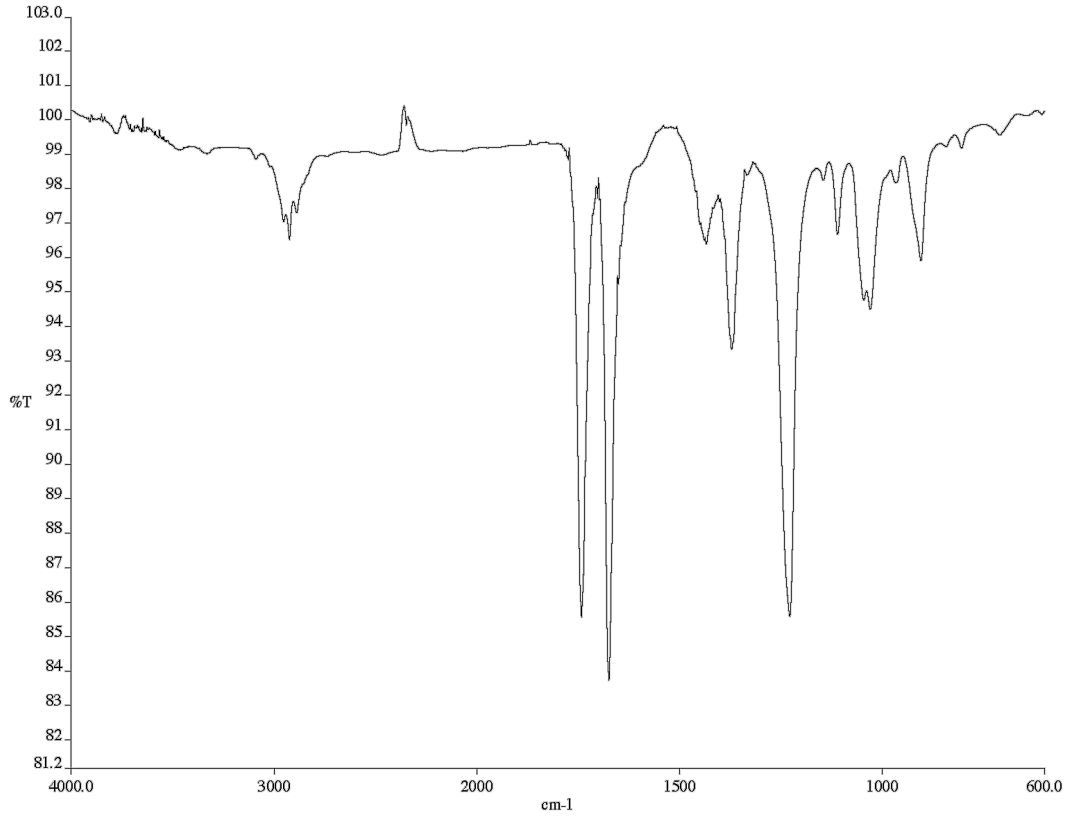
Infrared spectrum (Thin Film, NaCl) of compound **8r**.



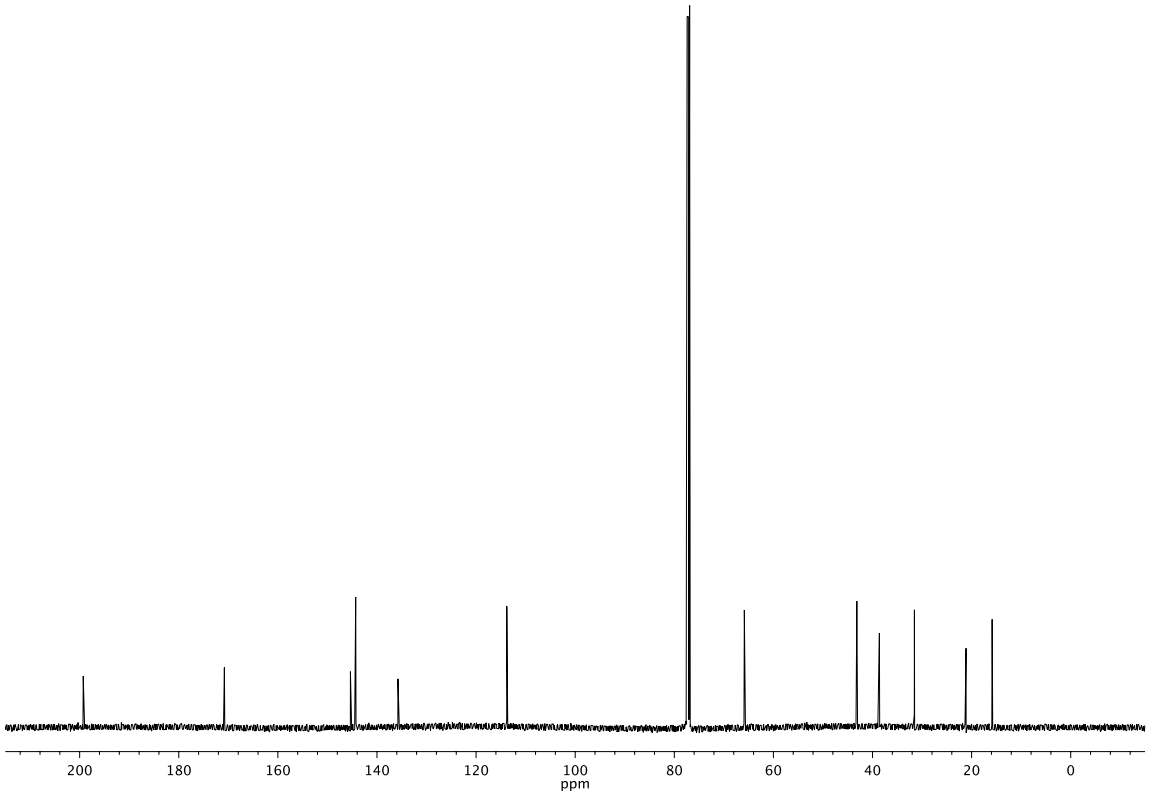
^{13}C NMR (126 MHz, $CDCl_3$) of compound **8r**.



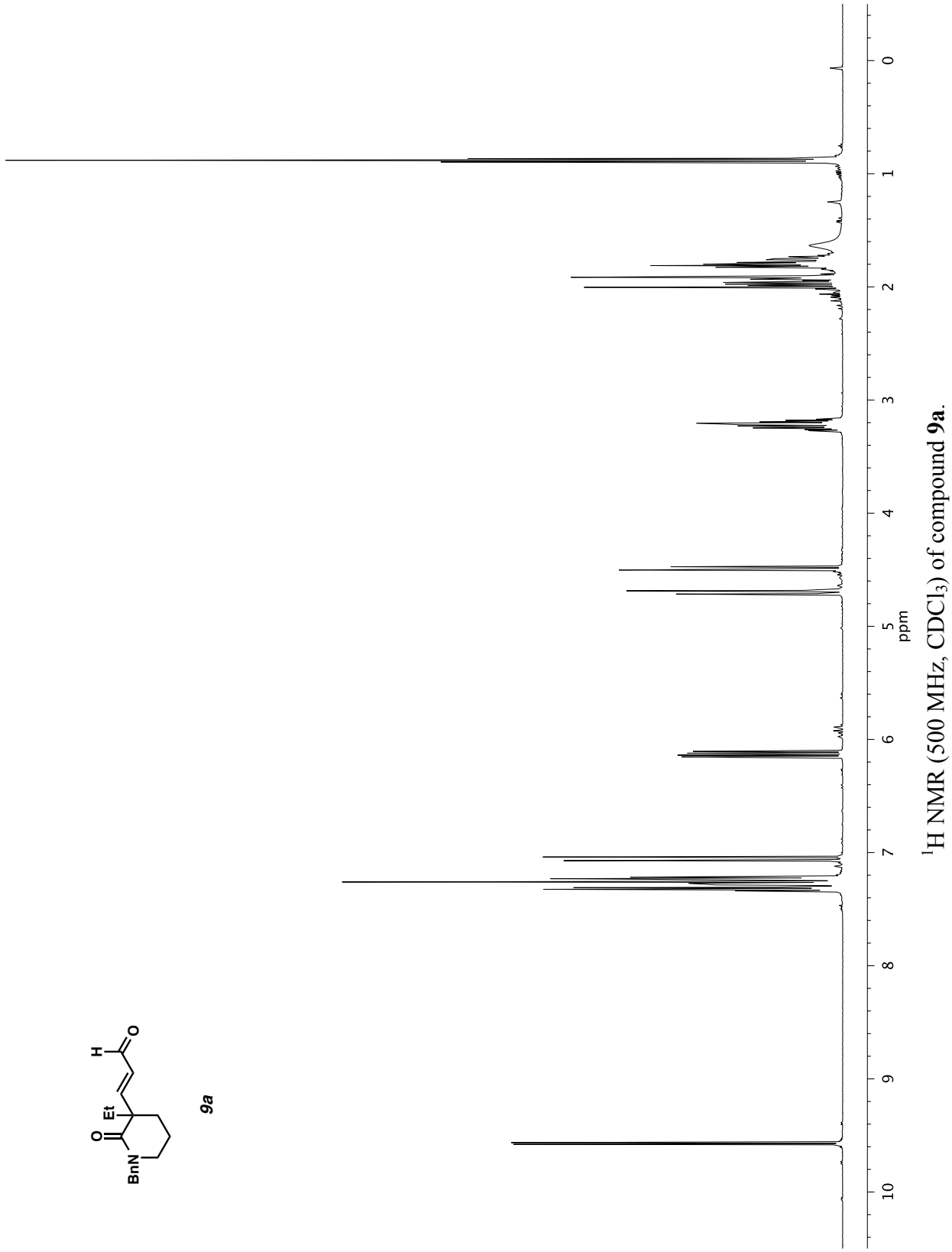
^{1}H NMR (500 MHz, $CDCl_3$) of compound **18**.



Infrared spectrum (Thin Film, NaCl) of compound **18**.

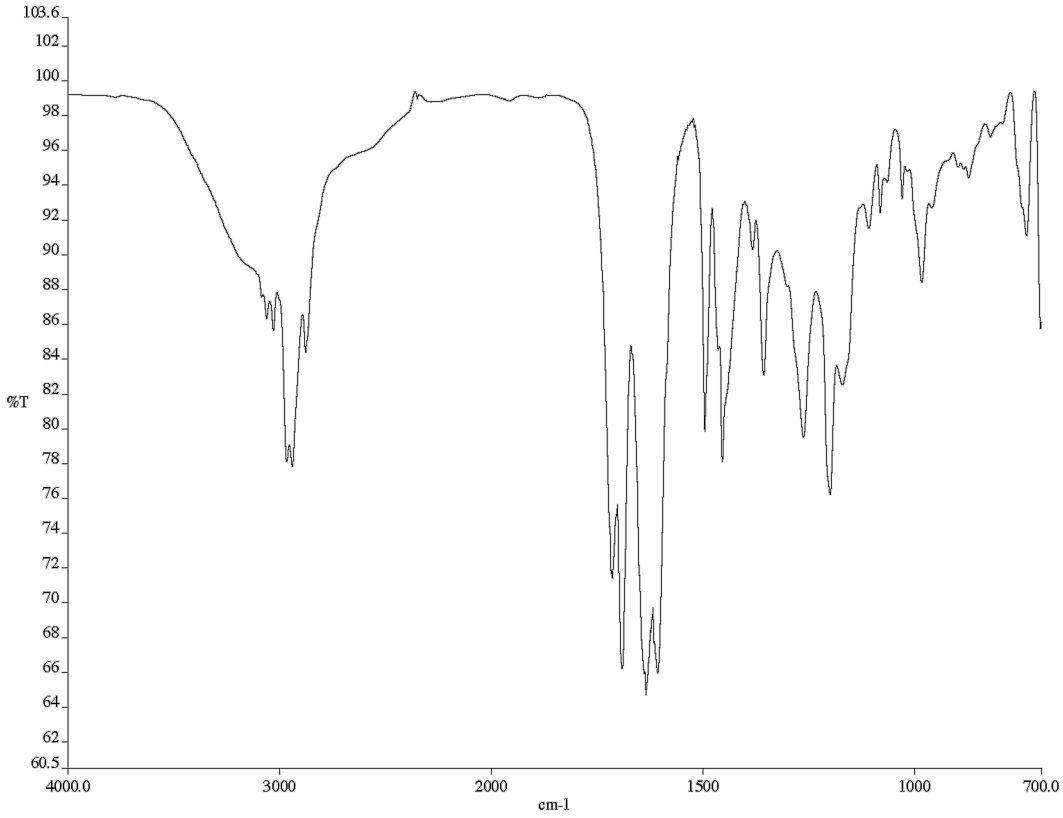


^{13}C NMR (126 MHz, $CDCl_3$) of compound **18**.

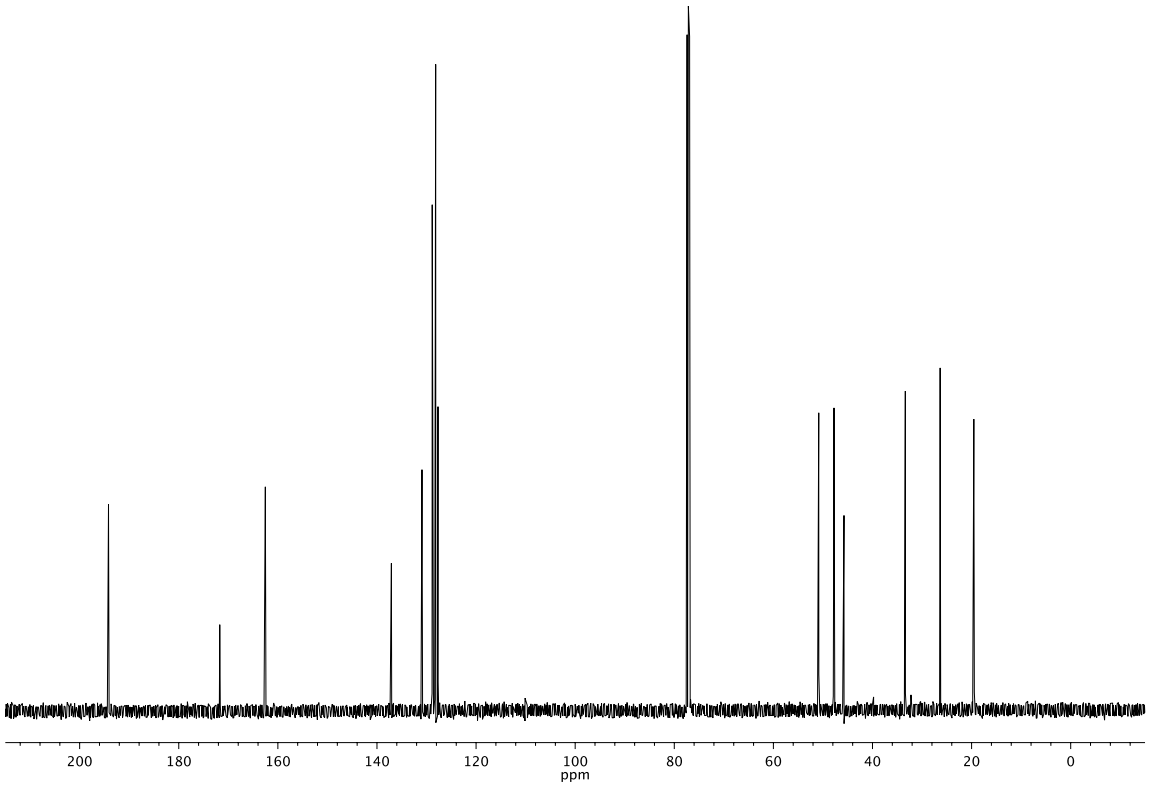


9a

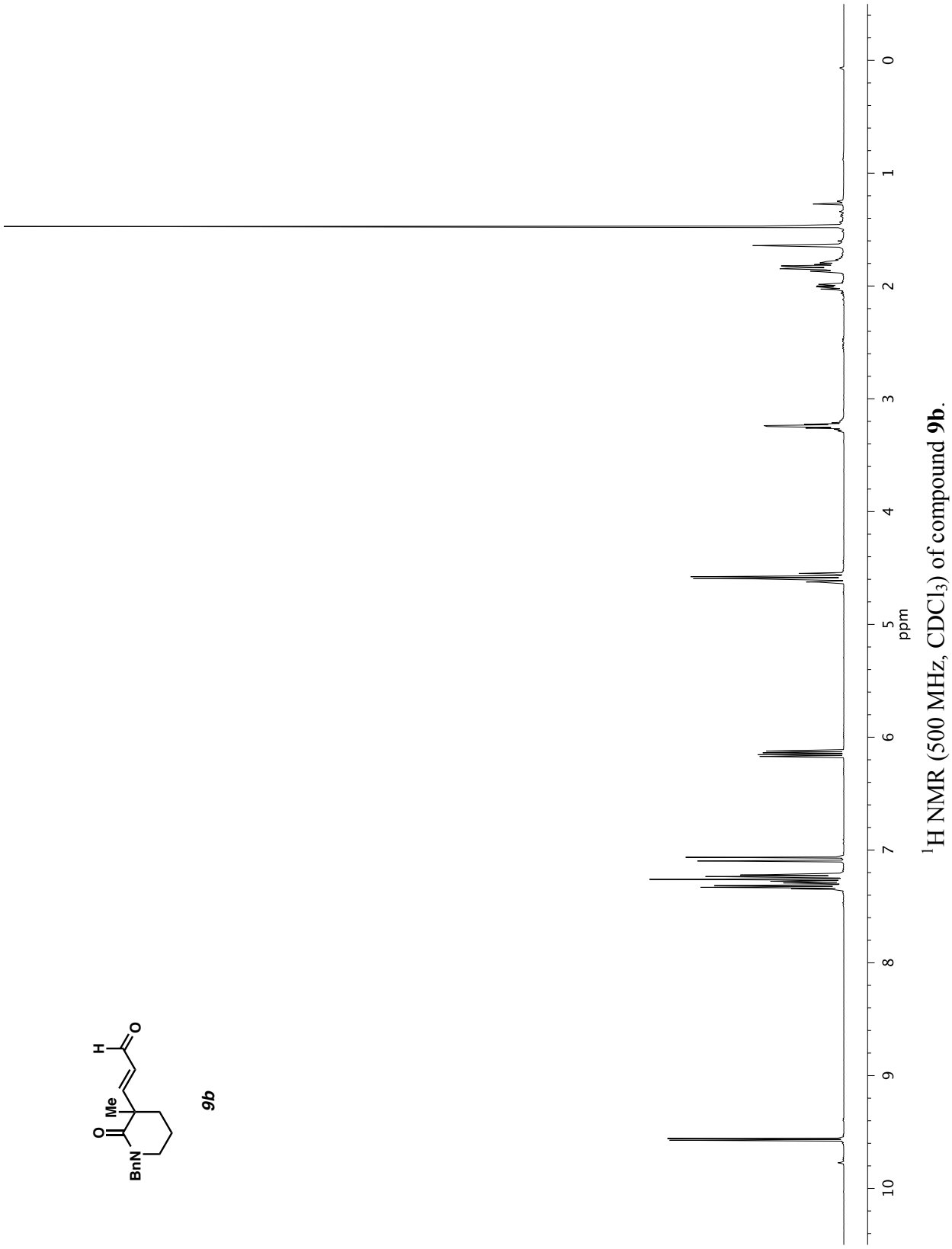
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9a**.



Infrared spectrum (Thin Film, NaCl) of compound **9a**.

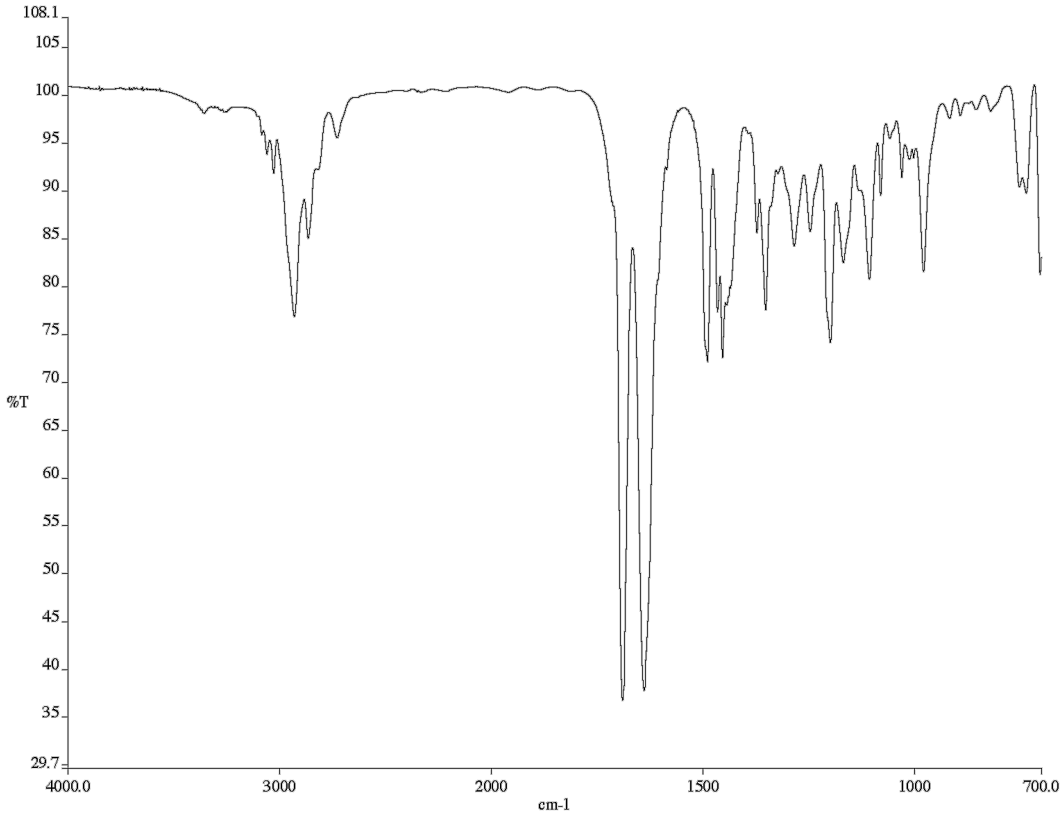


^{13}C NMR (126 MHz, $CDCl_3$) of compound **9a**.

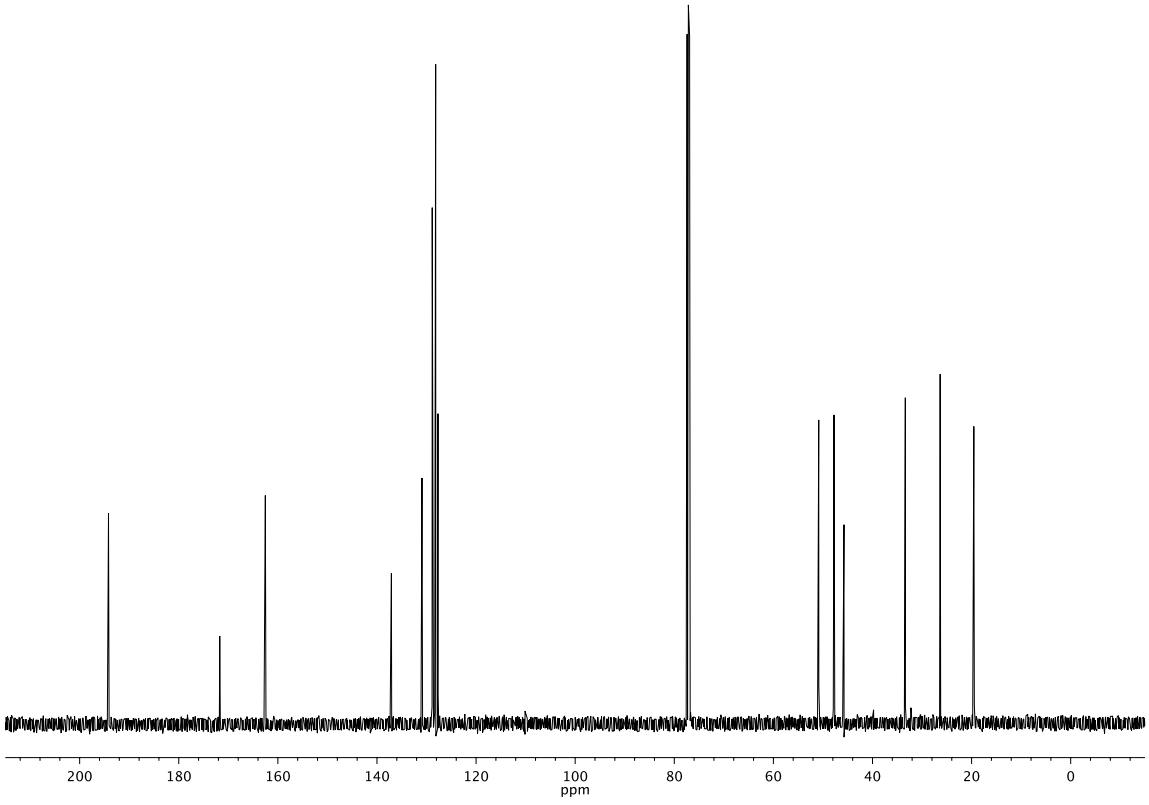


9b

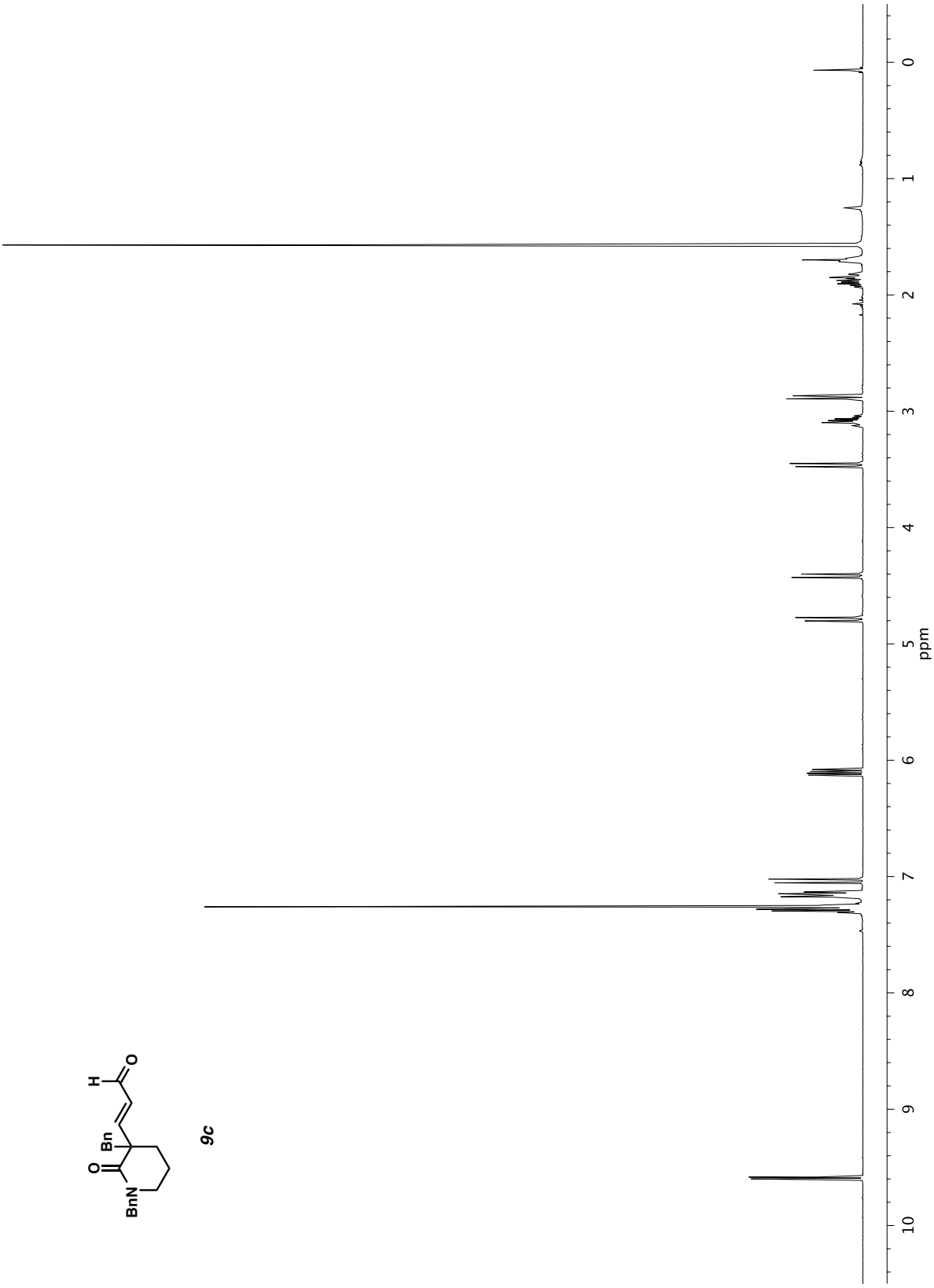
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9b**.



Infrared spectrum (Thin Film, NaCl) of compound **9b**.

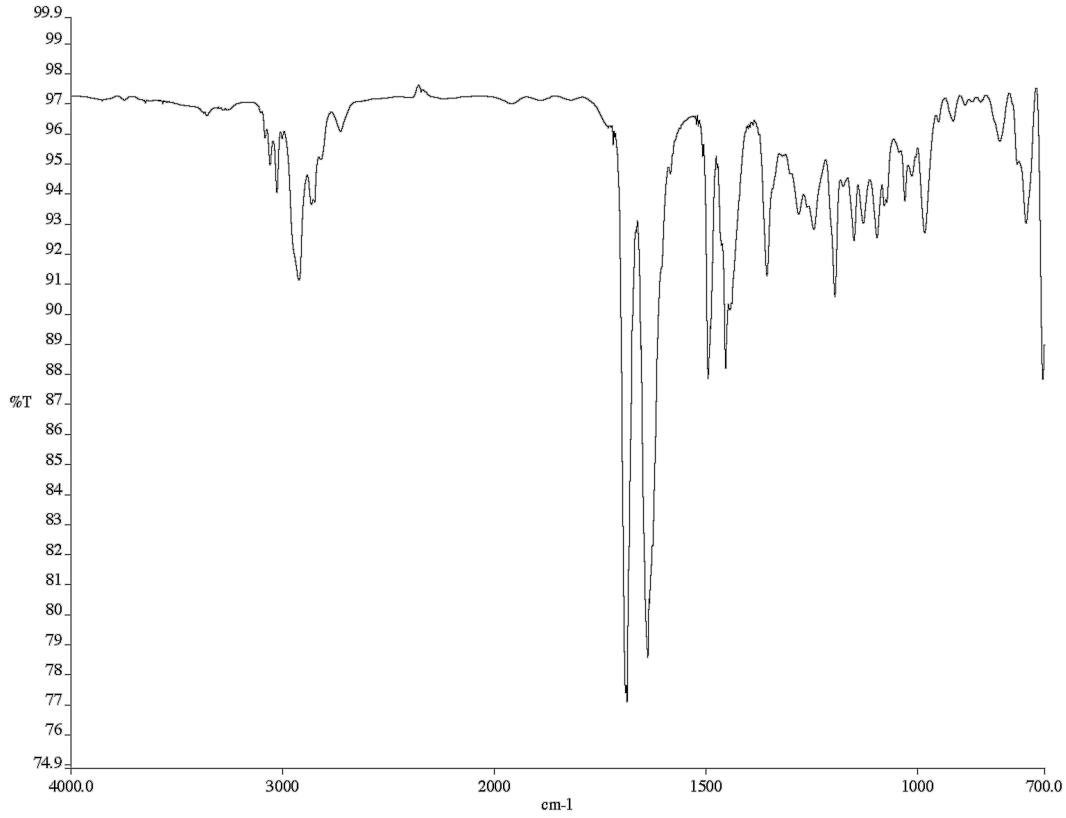


^{13}C NMR (126 MHz, $CDCl_3$) of compound **9b**.

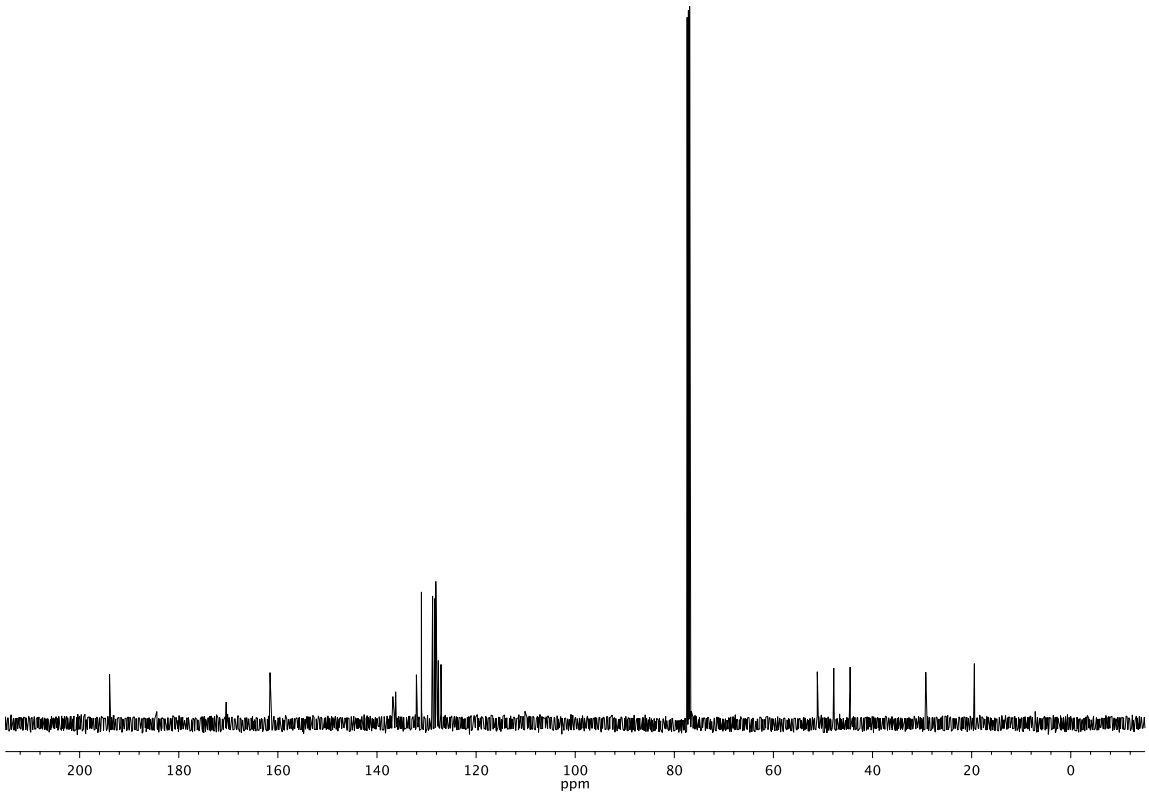


9c

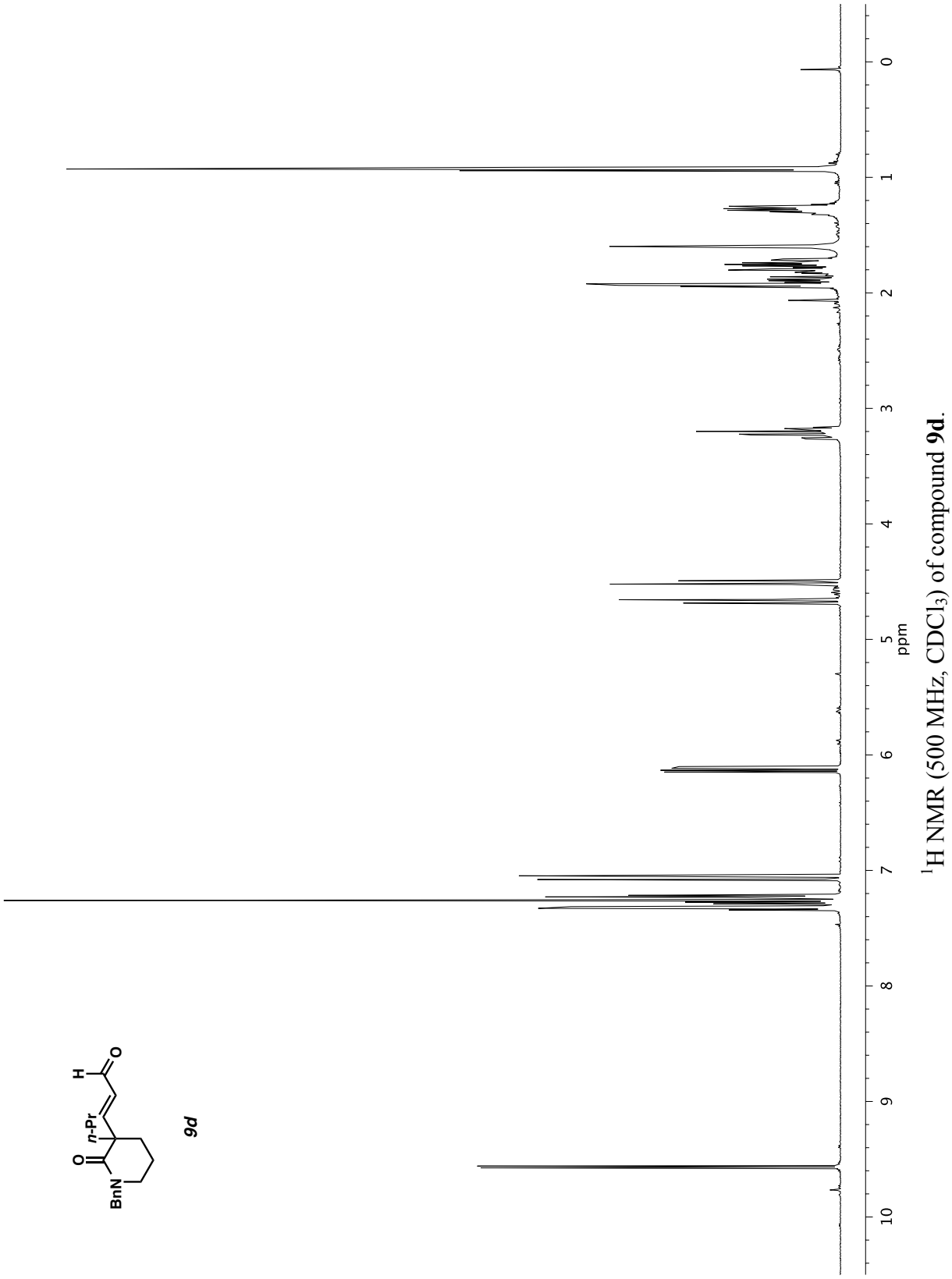
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9c**.



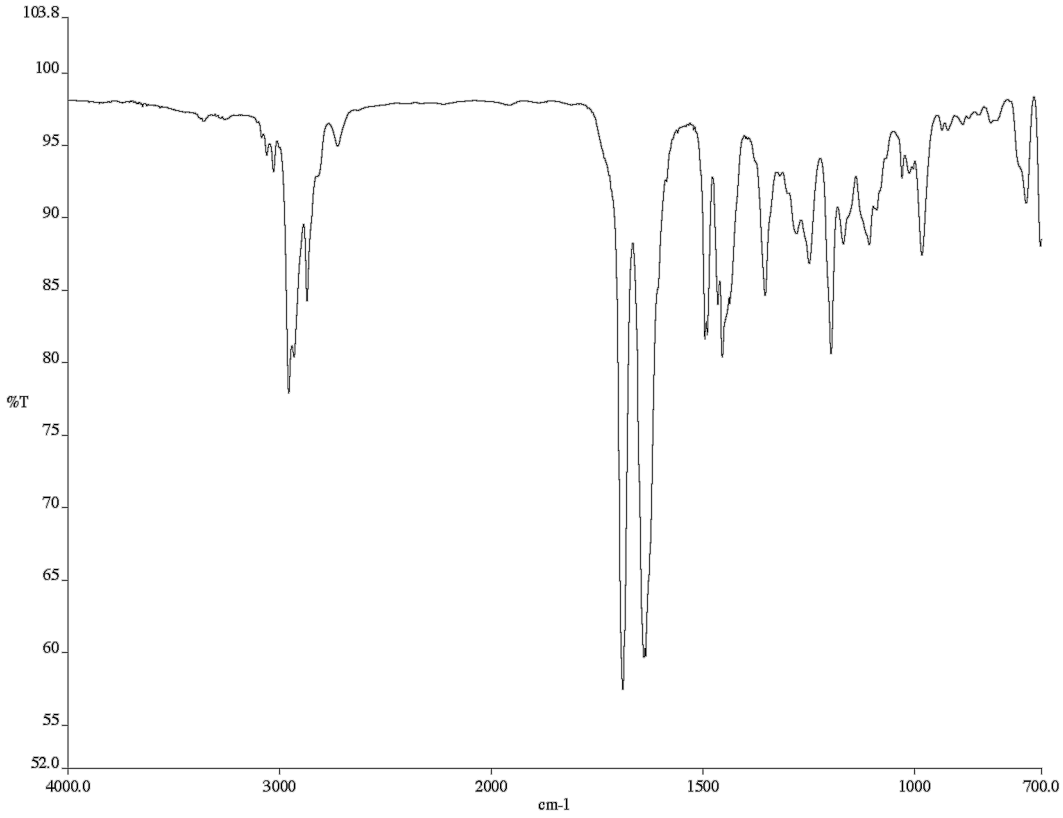
Infrared spectrum (Thin Film, NaCl) of compound **9c**.



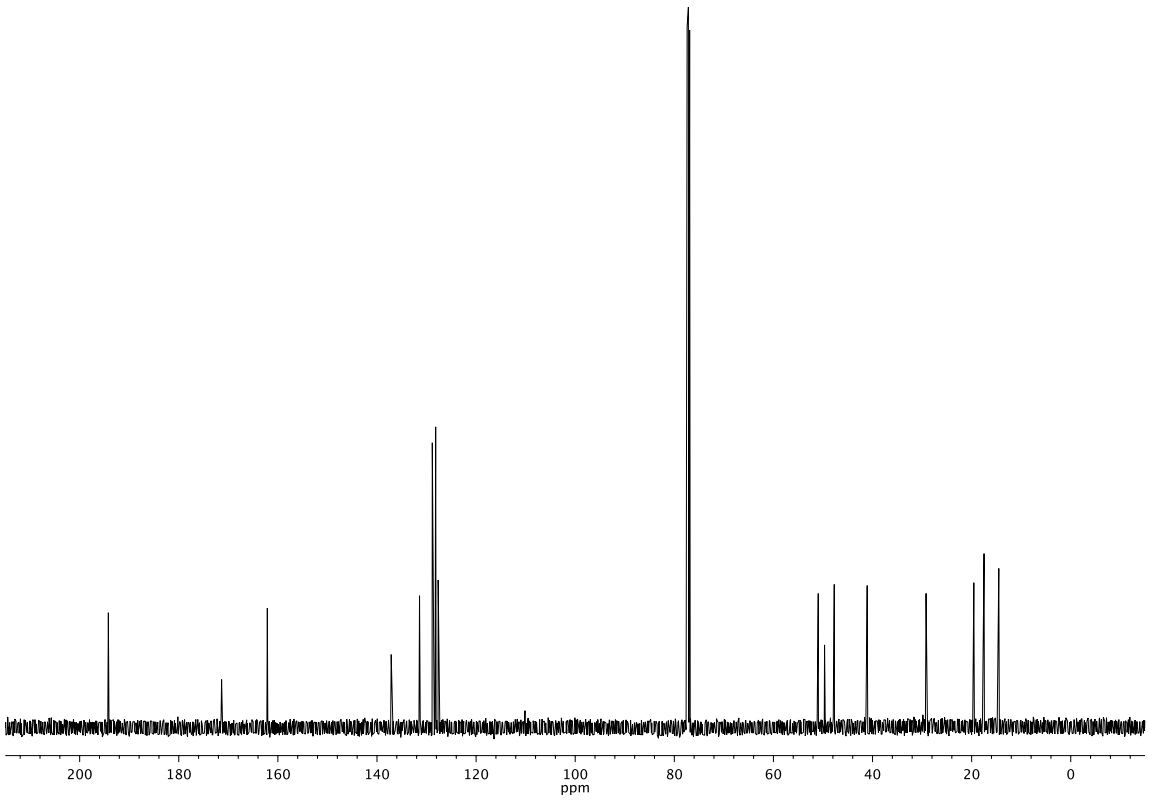
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9c**.



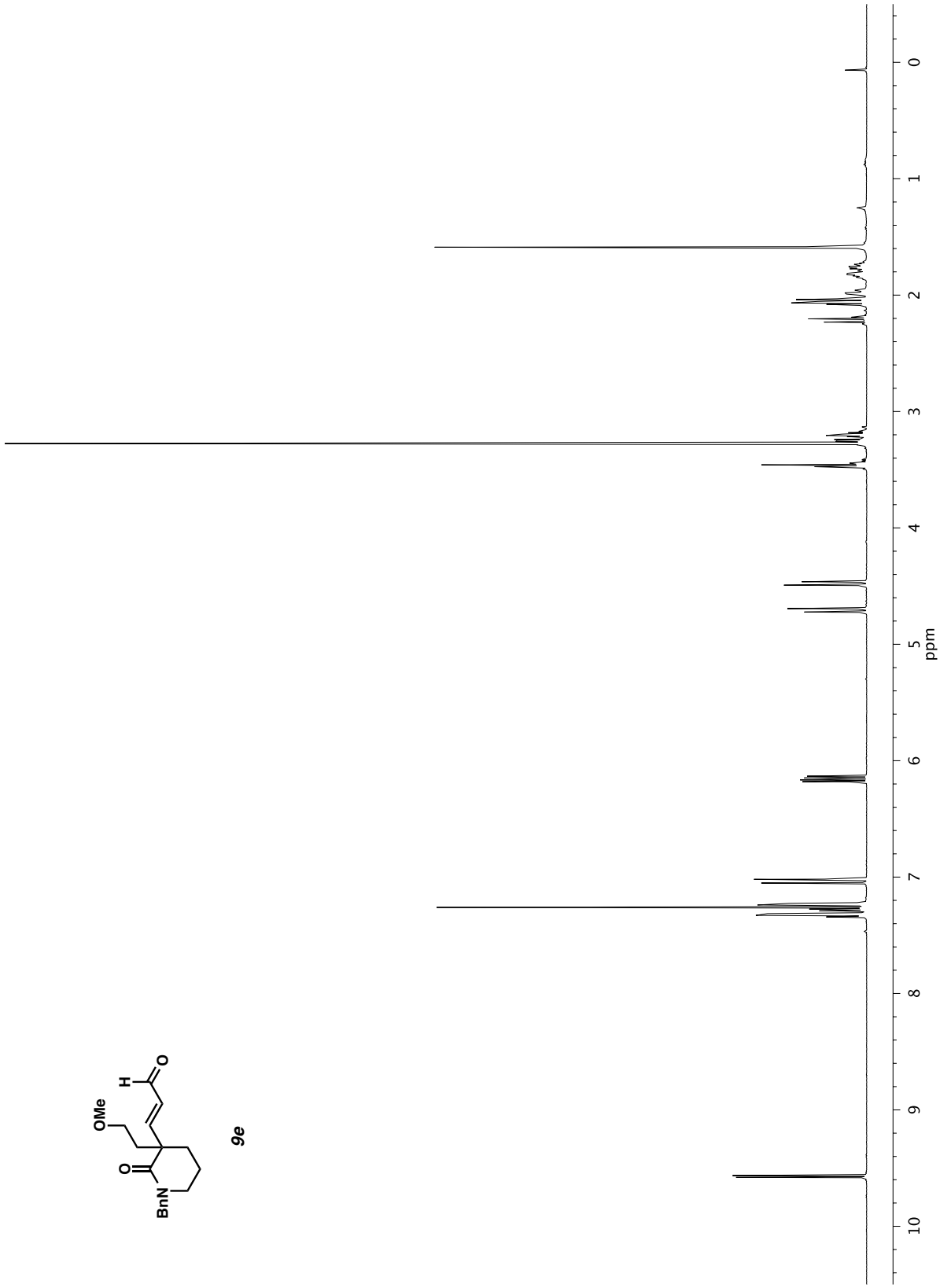
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9d**.



Infrared spectrum (Thin Film, NaCl) of compound **9d**.

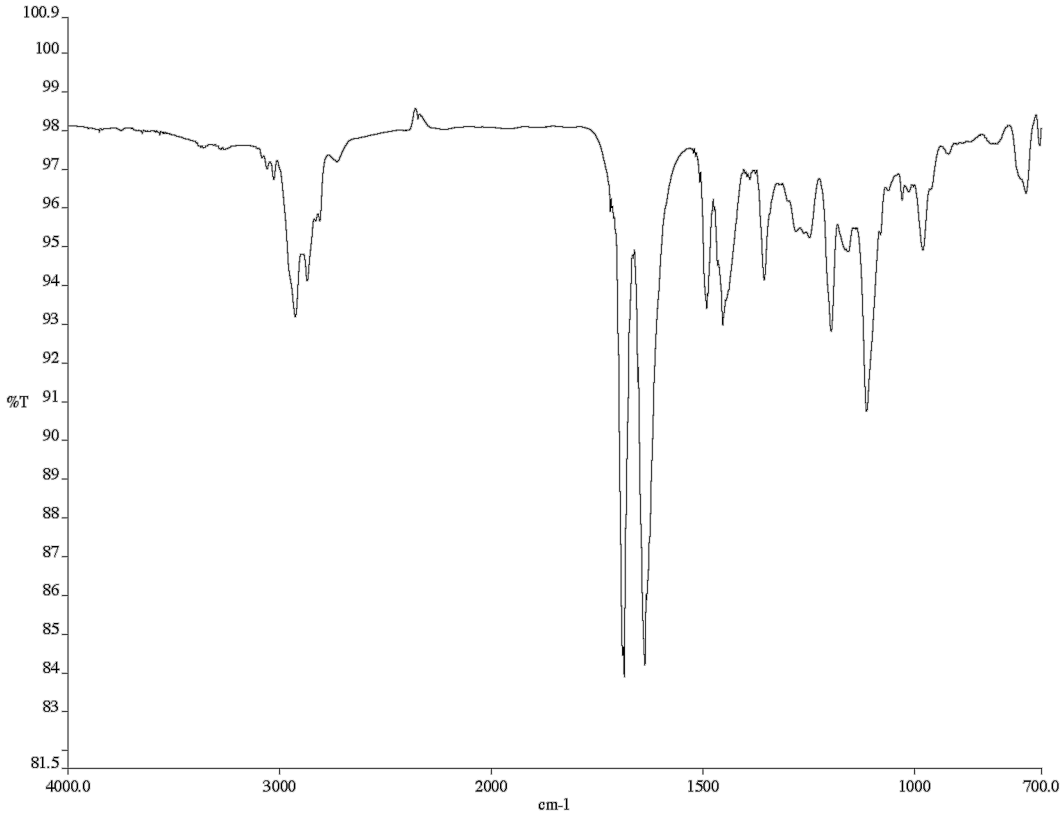


^{13}C NMR (126 MHz, $CDCl_3$) of compound **9d**.

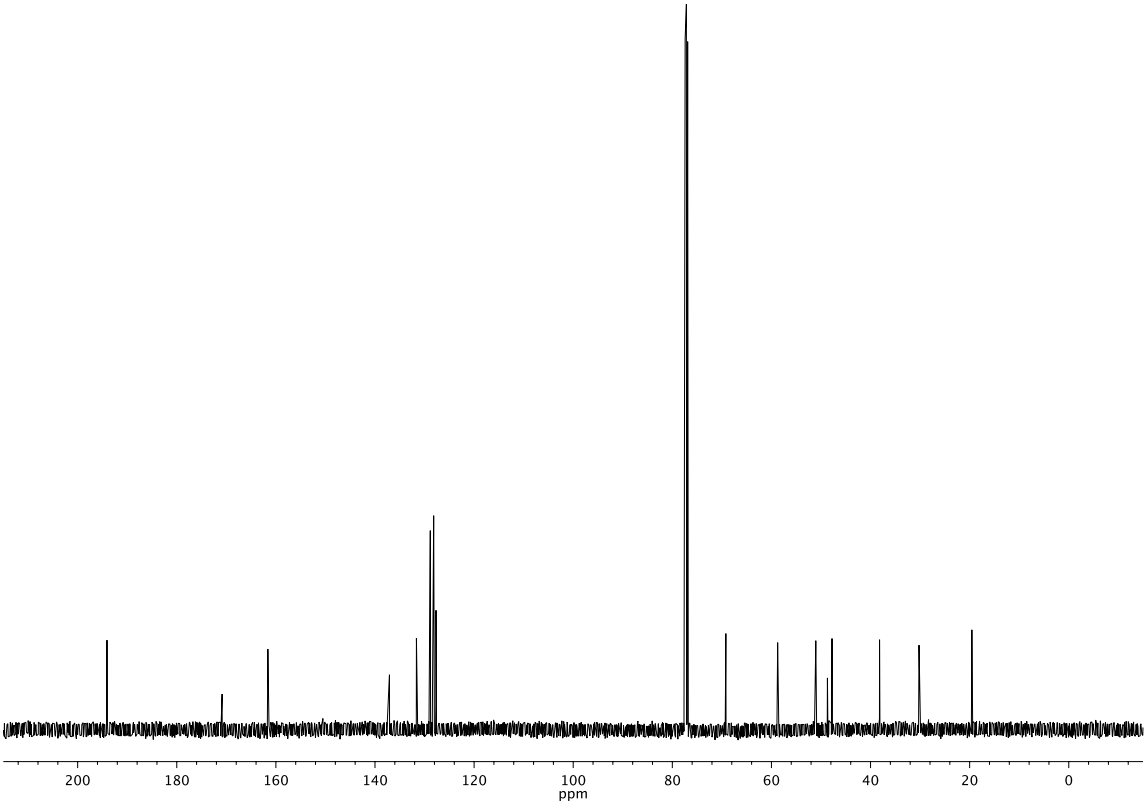


9e

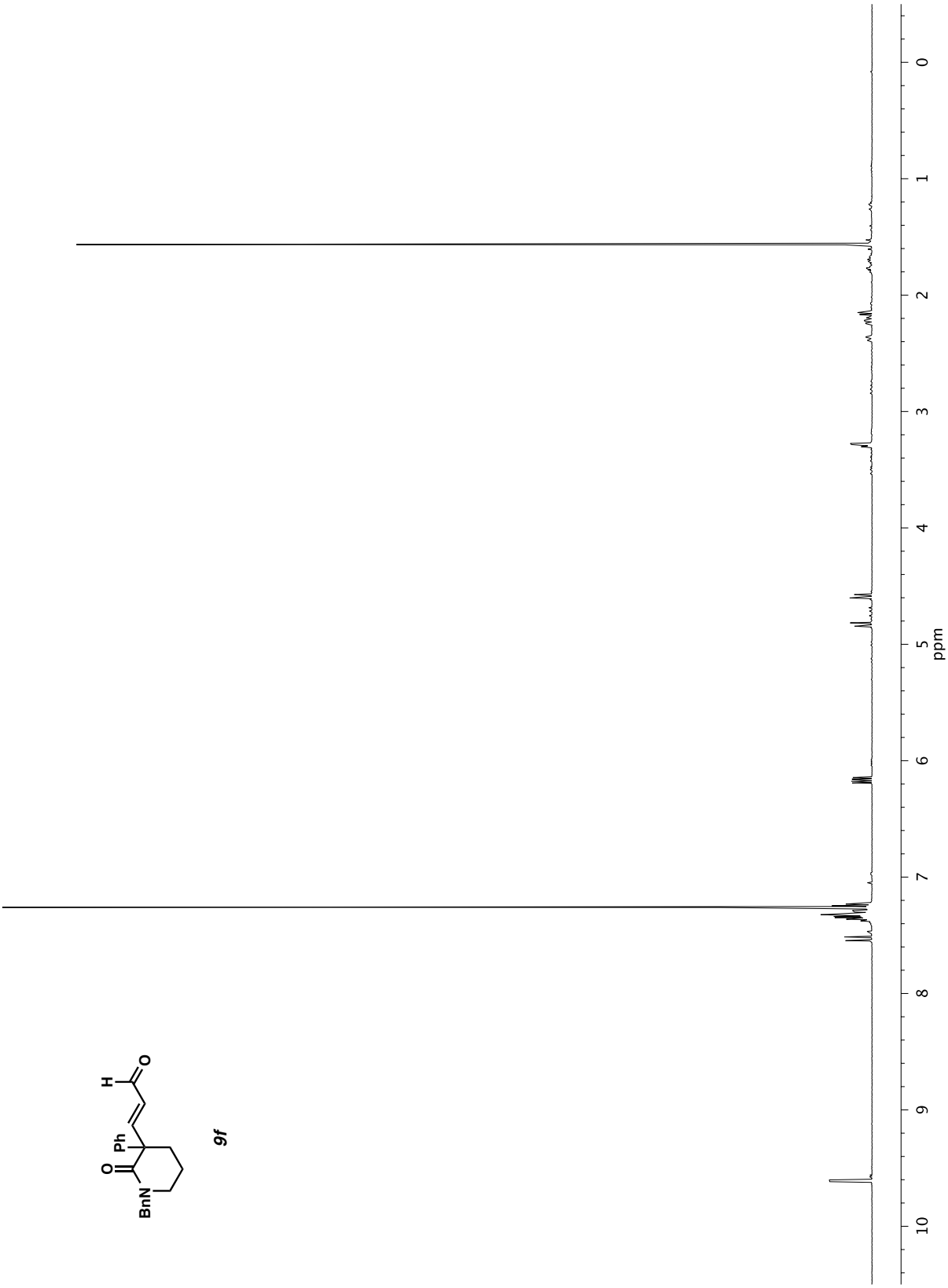
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9e**.



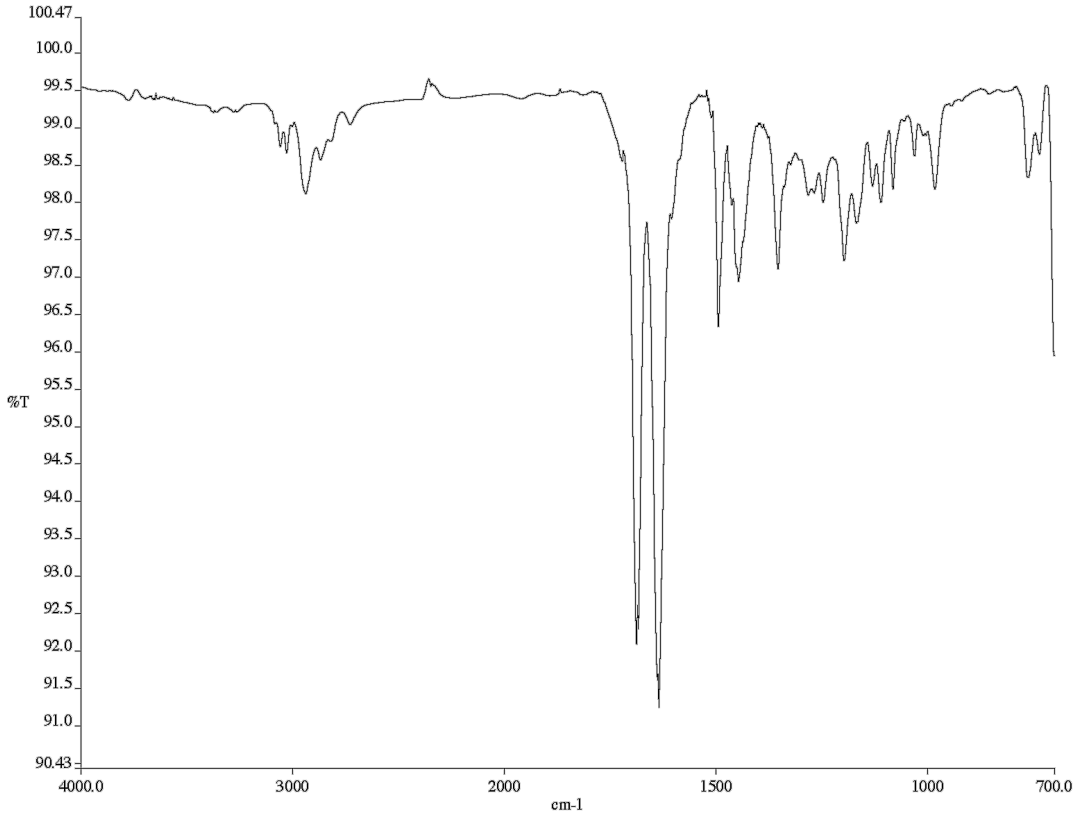
Infrared spectrum (Thin Film, NaCl) of compound **9e**.



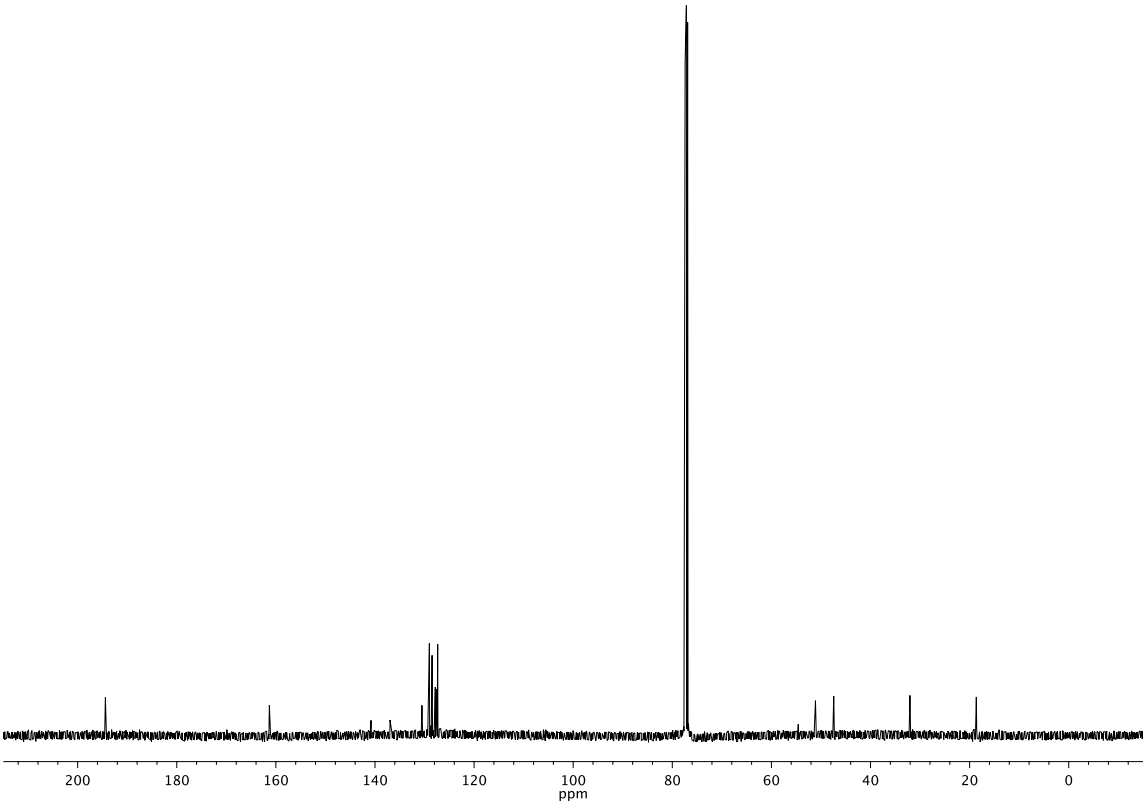
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9e**.



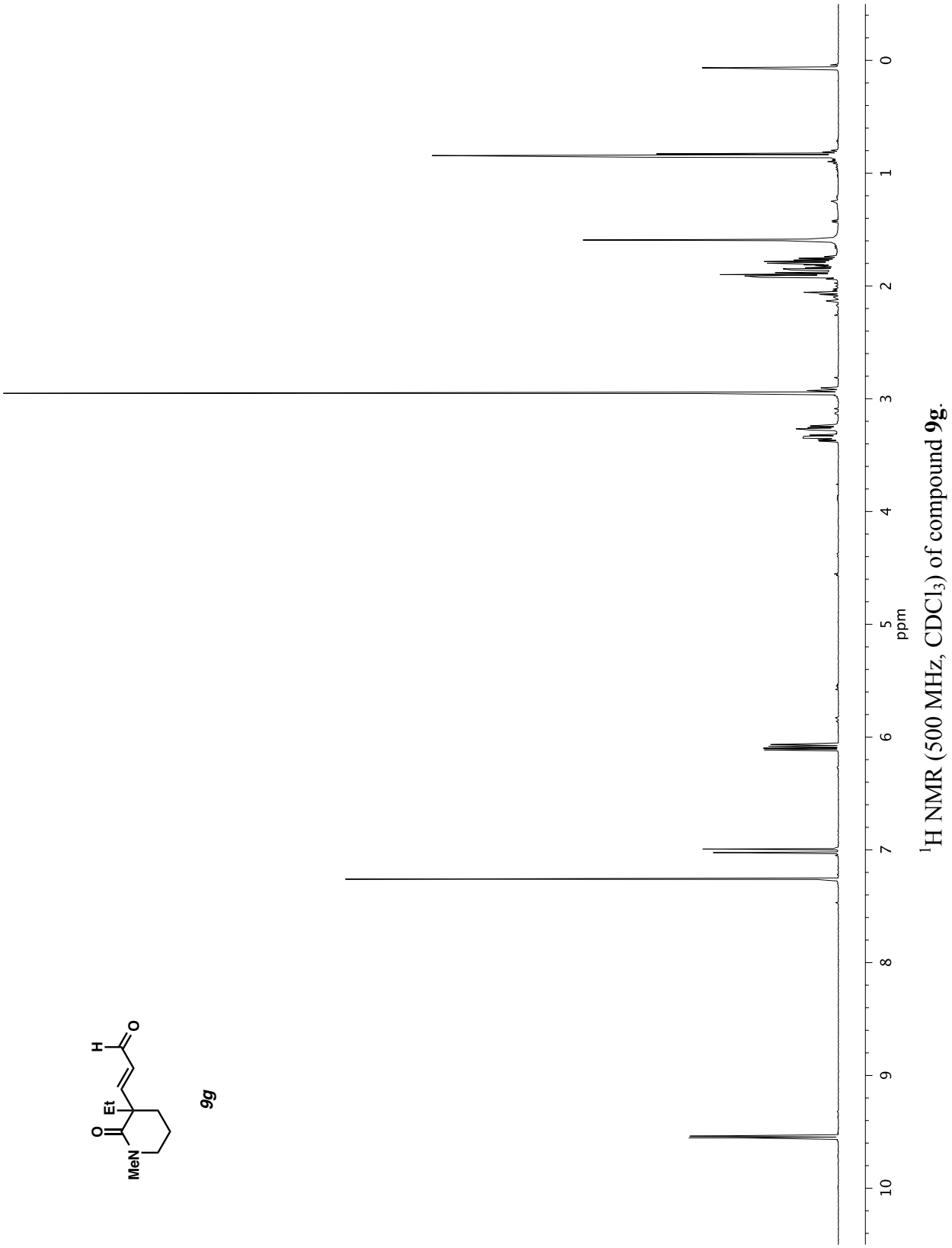
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9f**.



Infrared spectrum (Thin Film, NaCl) of compound **9f**.

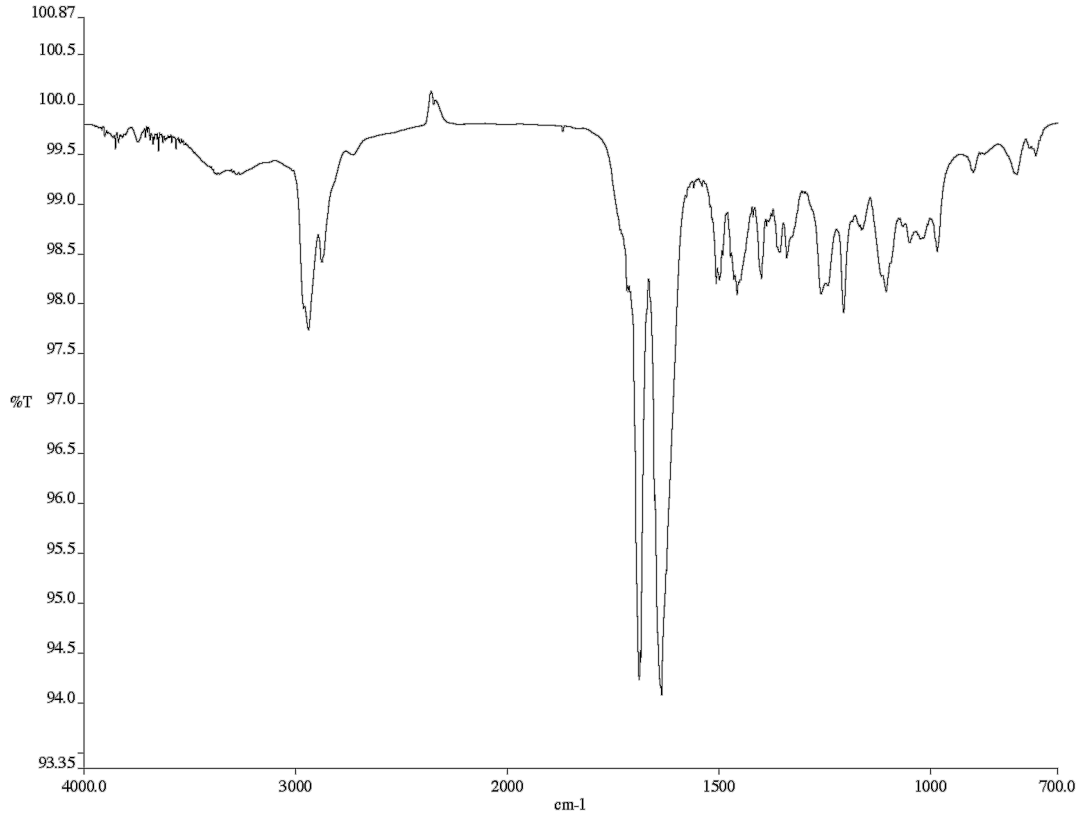


^{13}C NMR (126 MHz, $CDCl_3$) of compound **9f**.

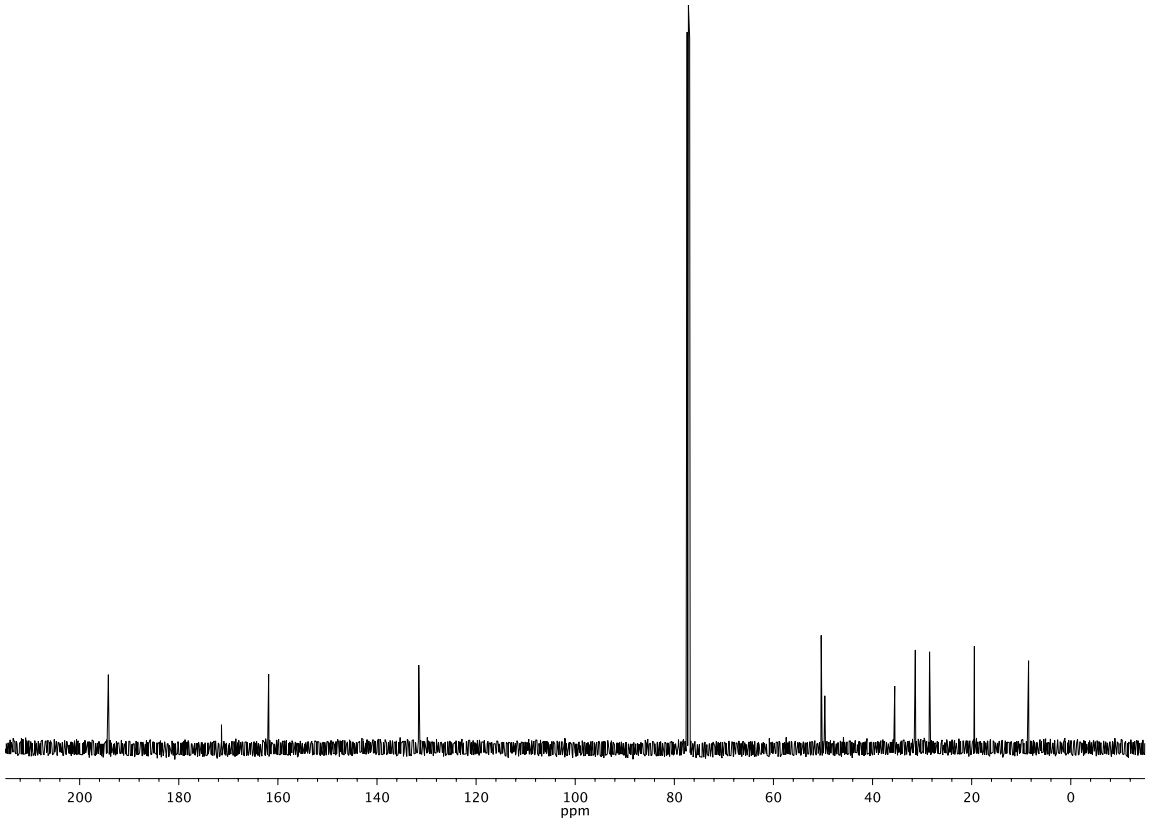


9g

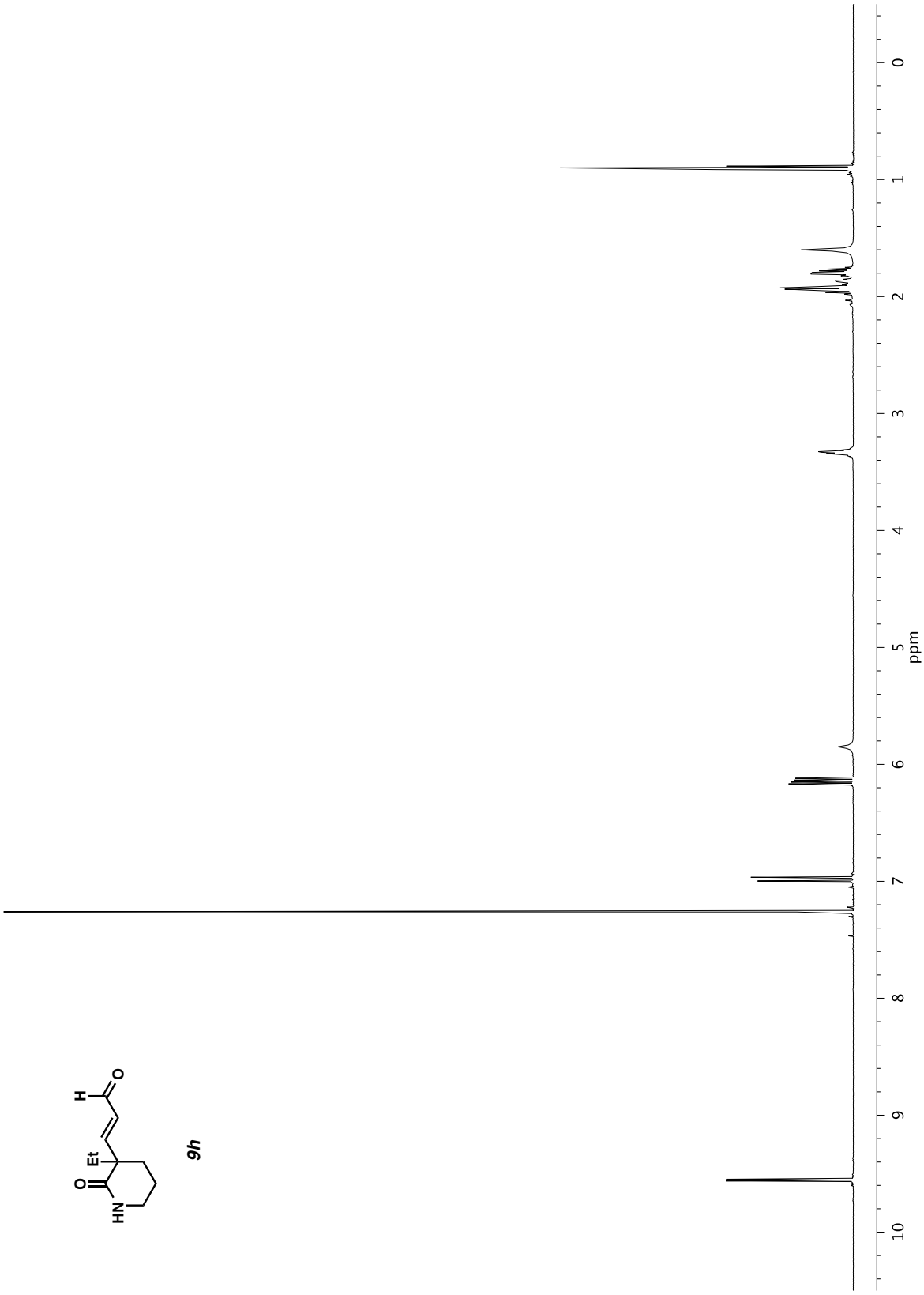
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9g**.



Infrared spectrum (Thin Film, NaCl) of compound **9g**.

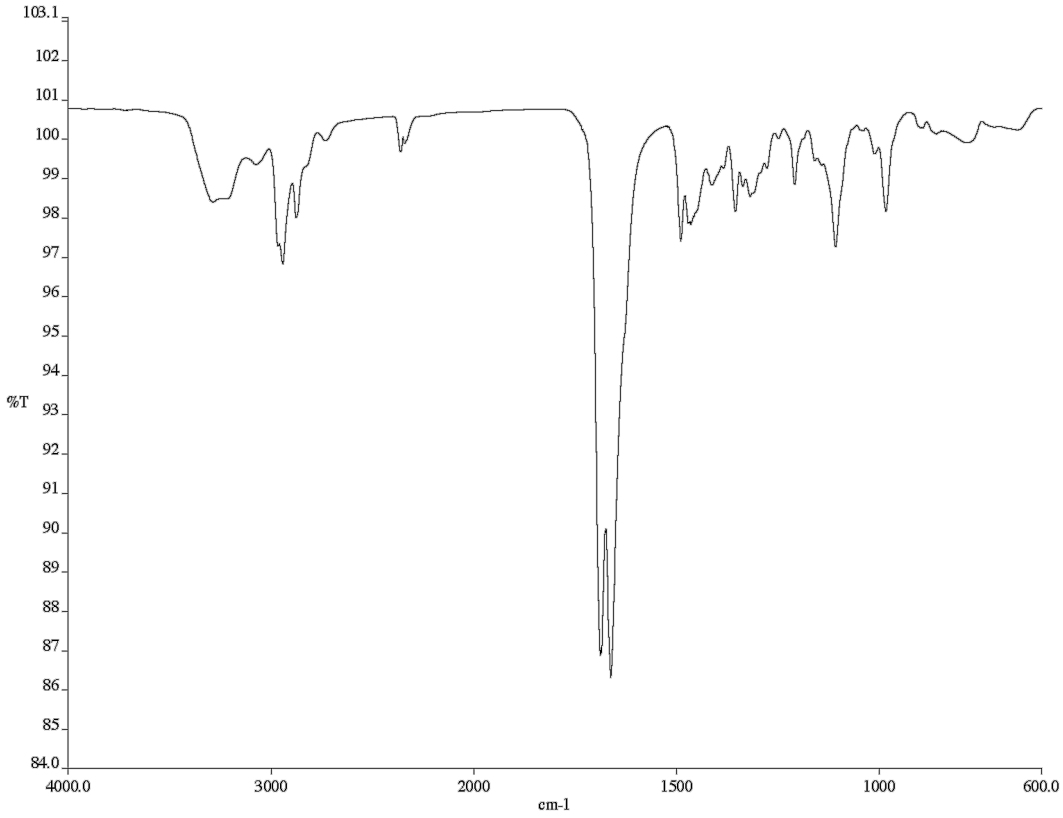


^{13}C NMR (126 MHz, $CDCl_3$) of compound **9g**.

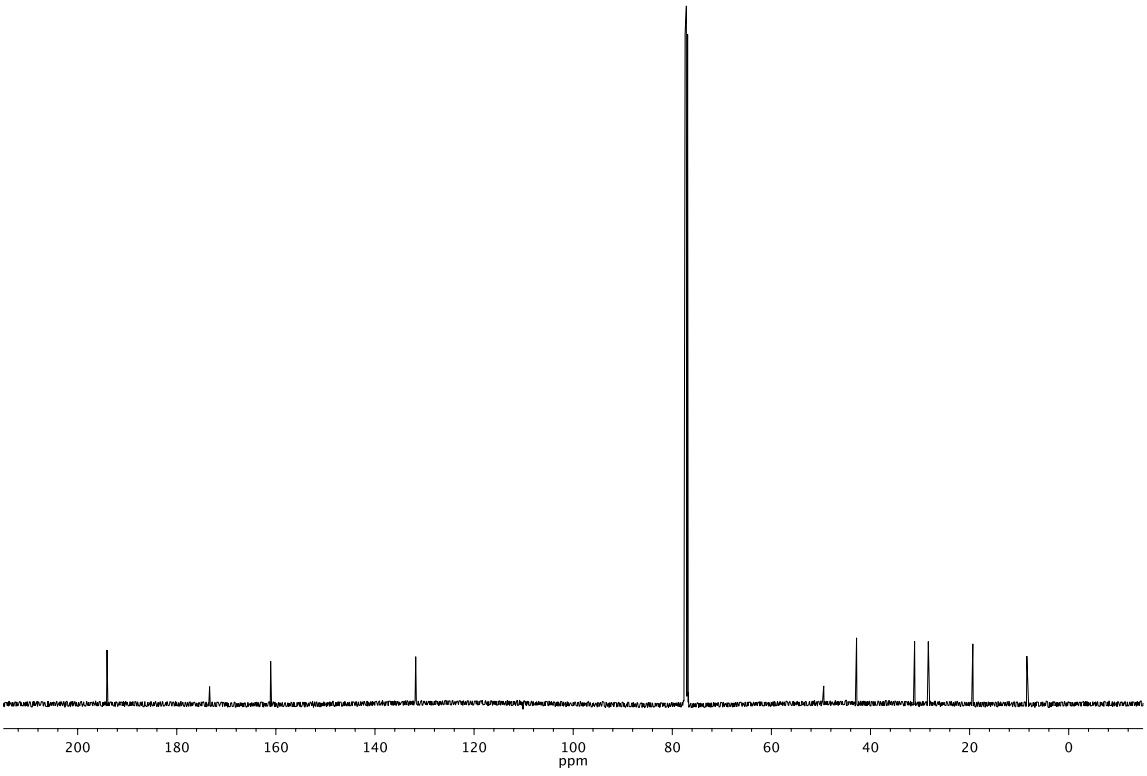


9h

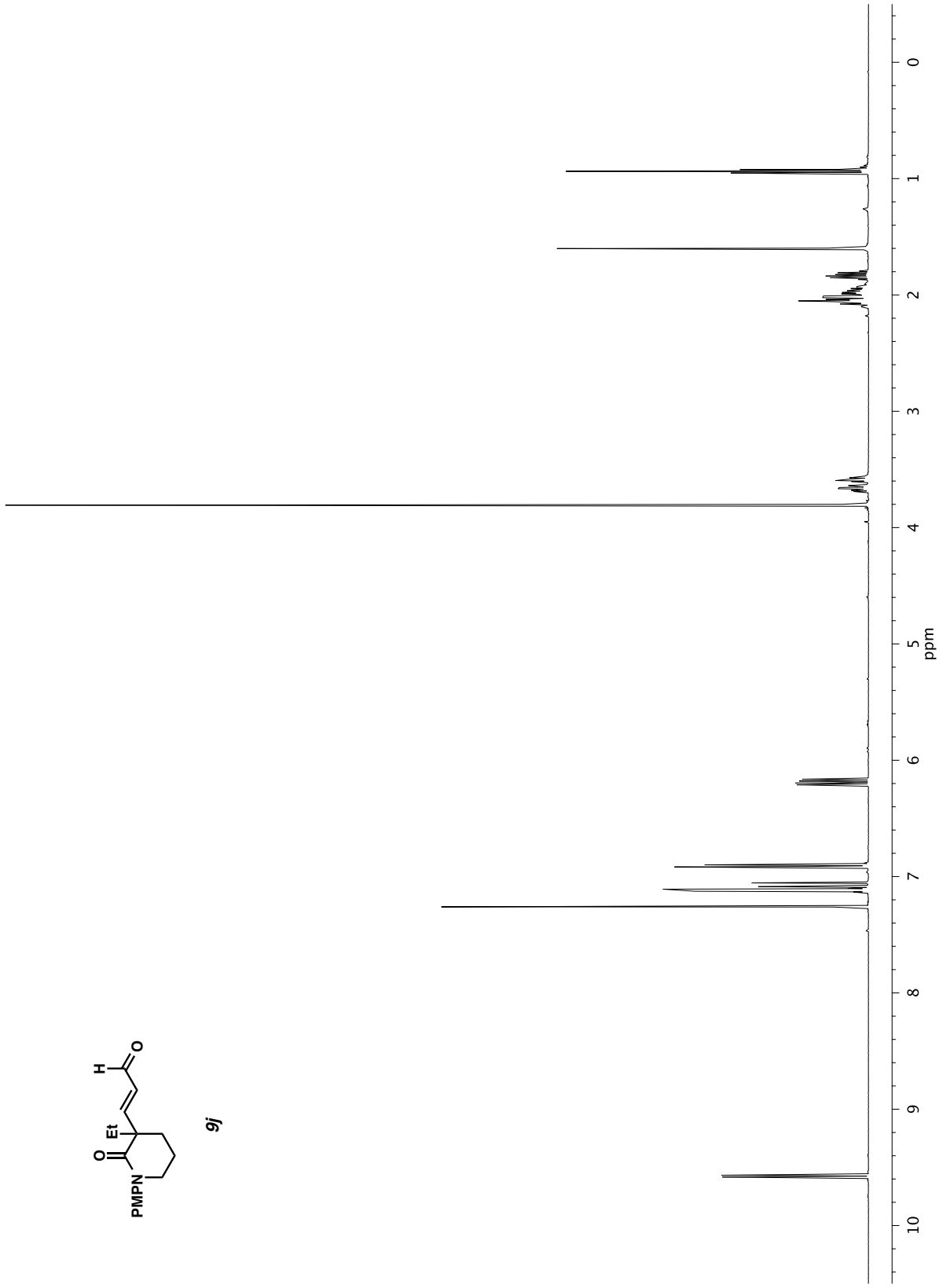
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9h**.



Infrared spectrum (Thin Film, NaCl) of compound **9h**.

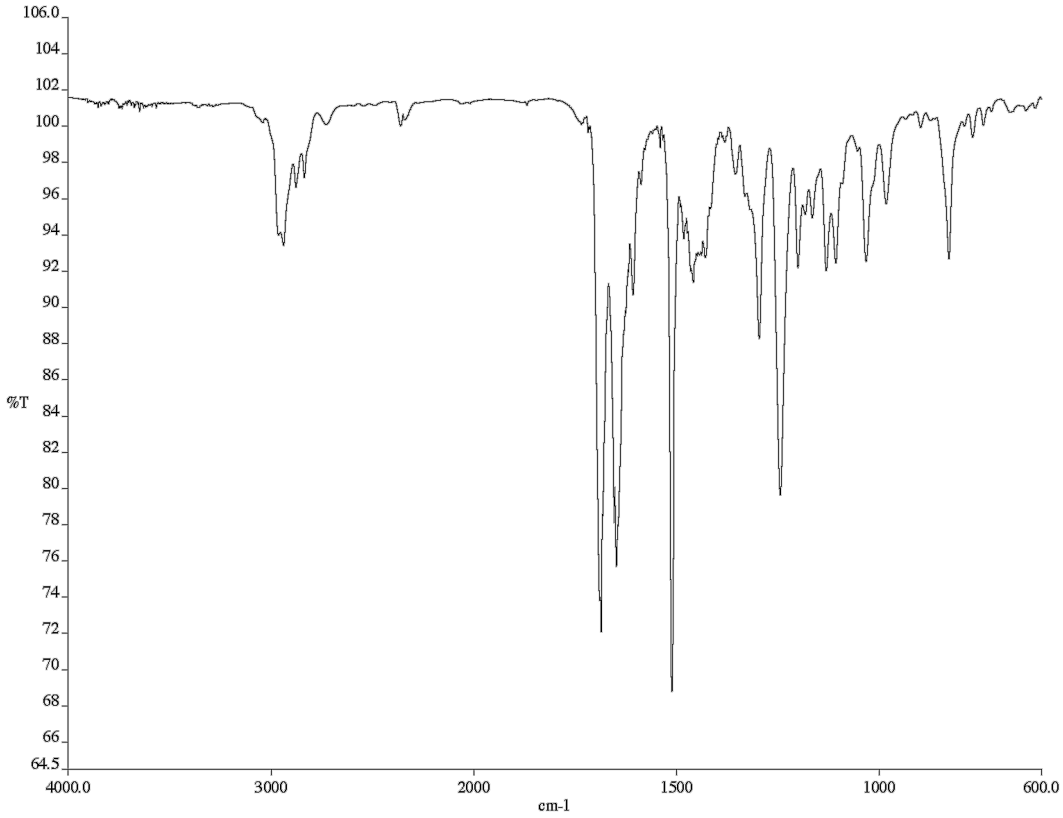


^{13}C NMR (126 MHz, $CDCl_3$) of compound **9h**.

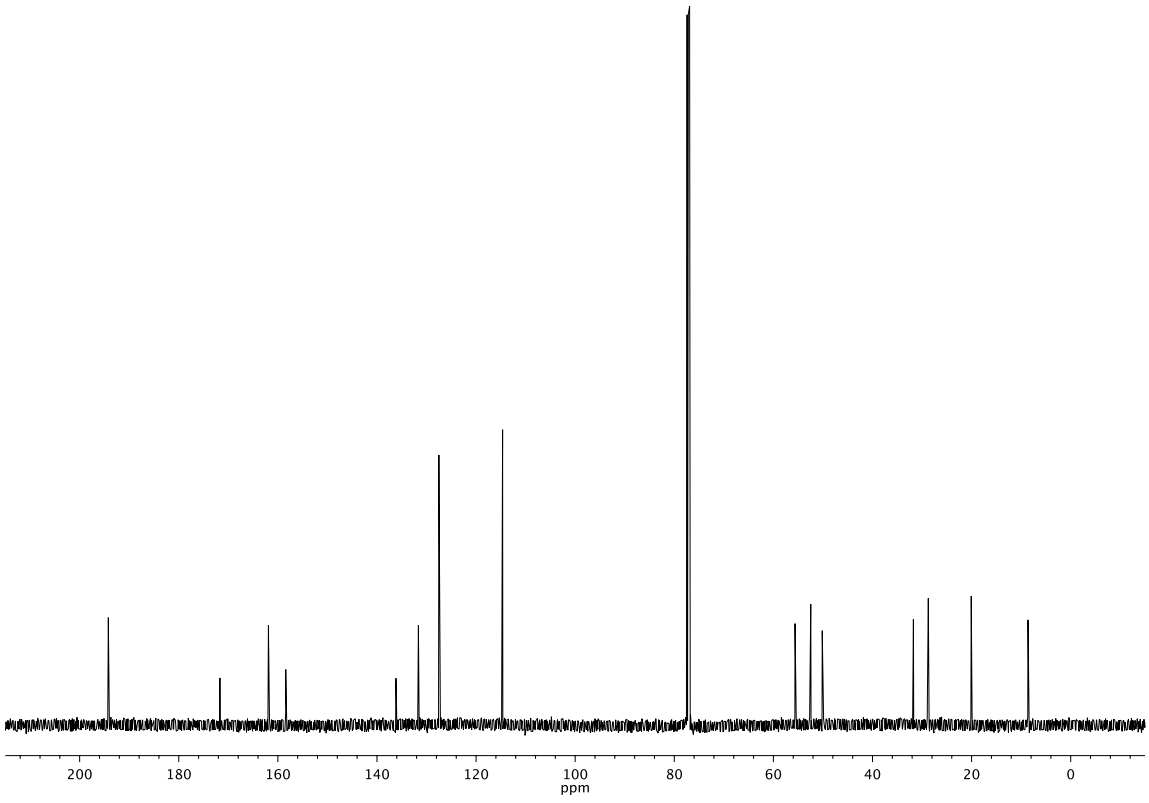


9j

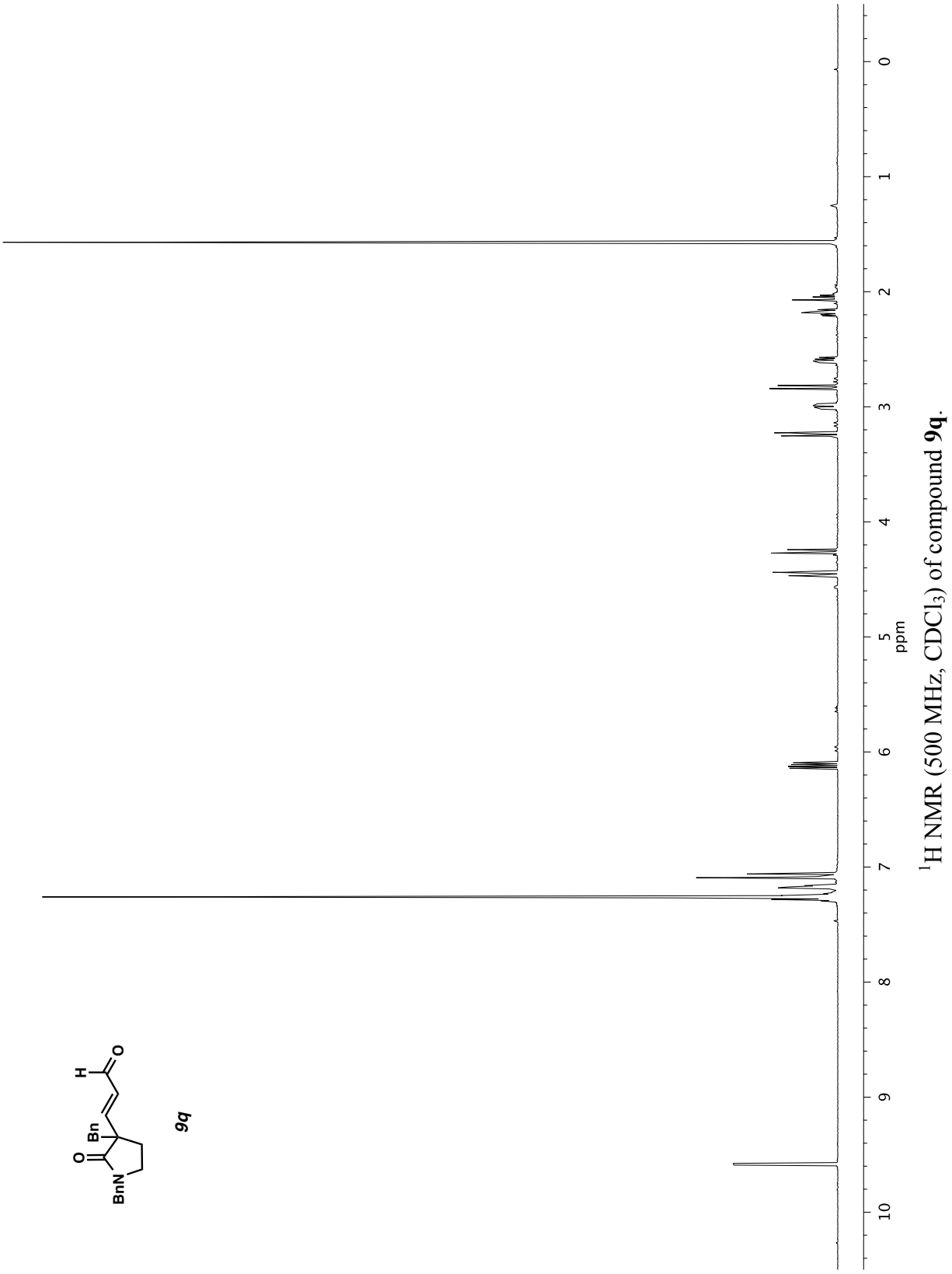
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9j**.



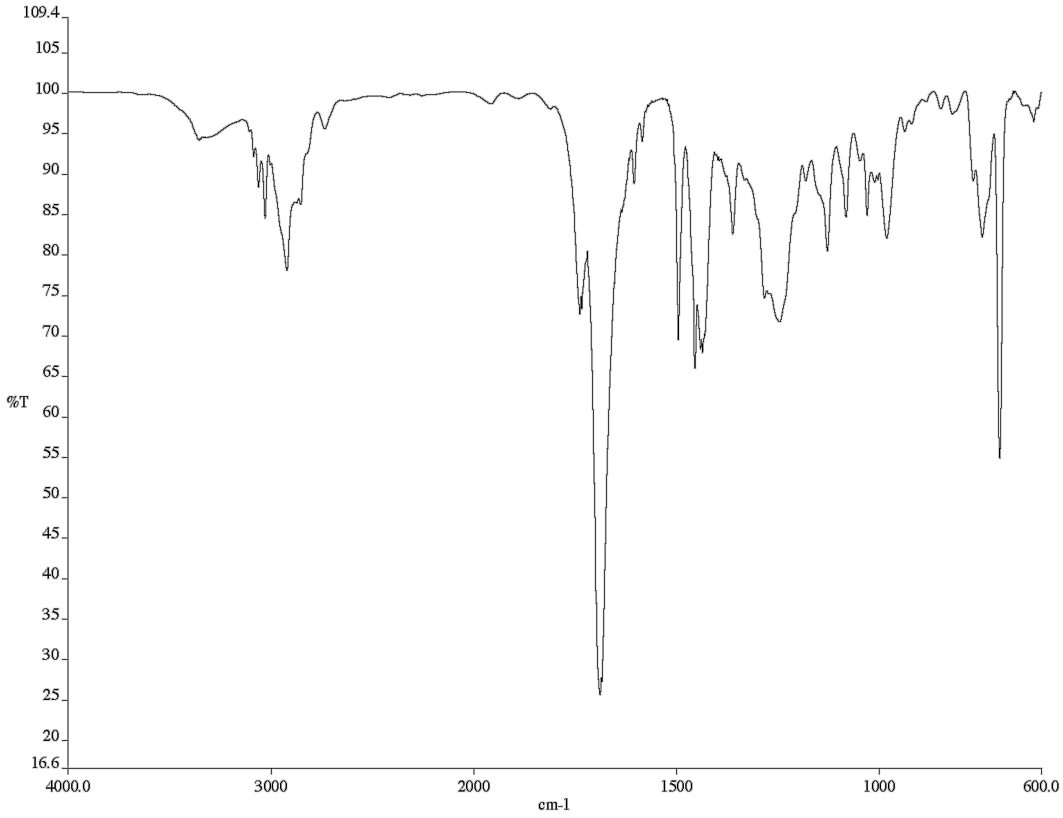
Infrared spectrum (Thin Film, NaCl) of compound **9j**.



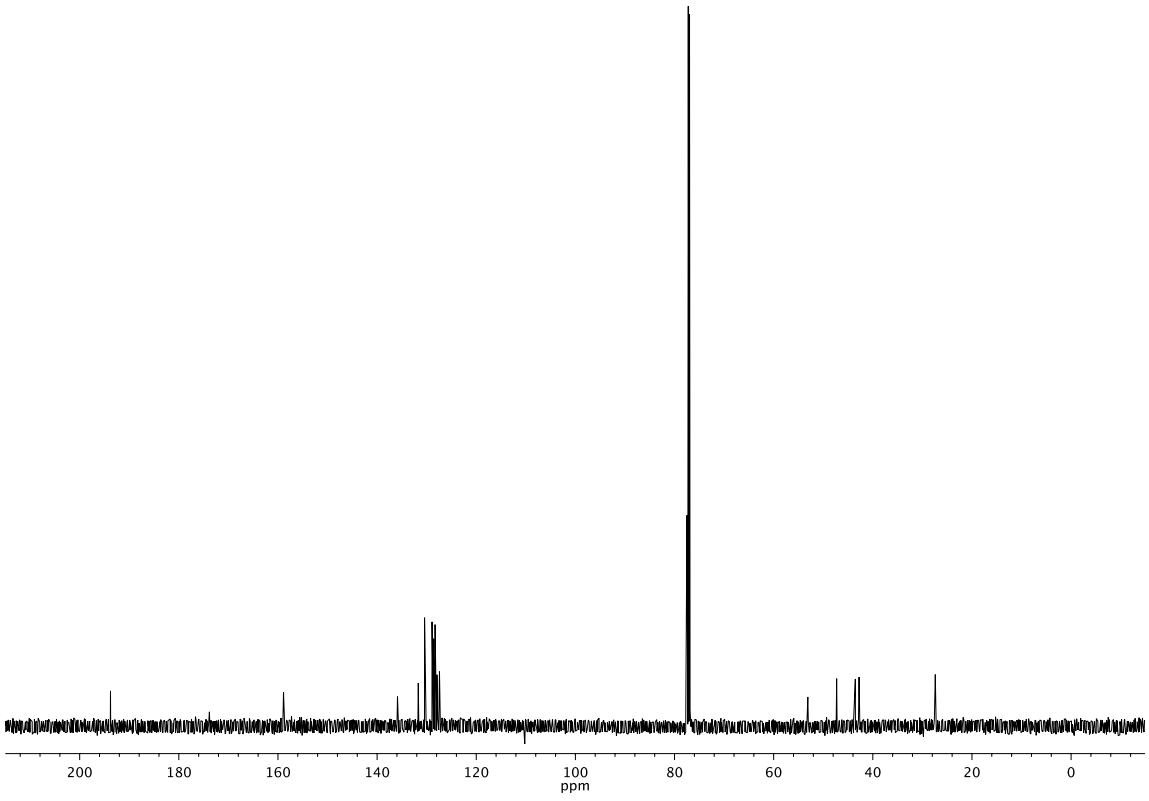
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9j**.



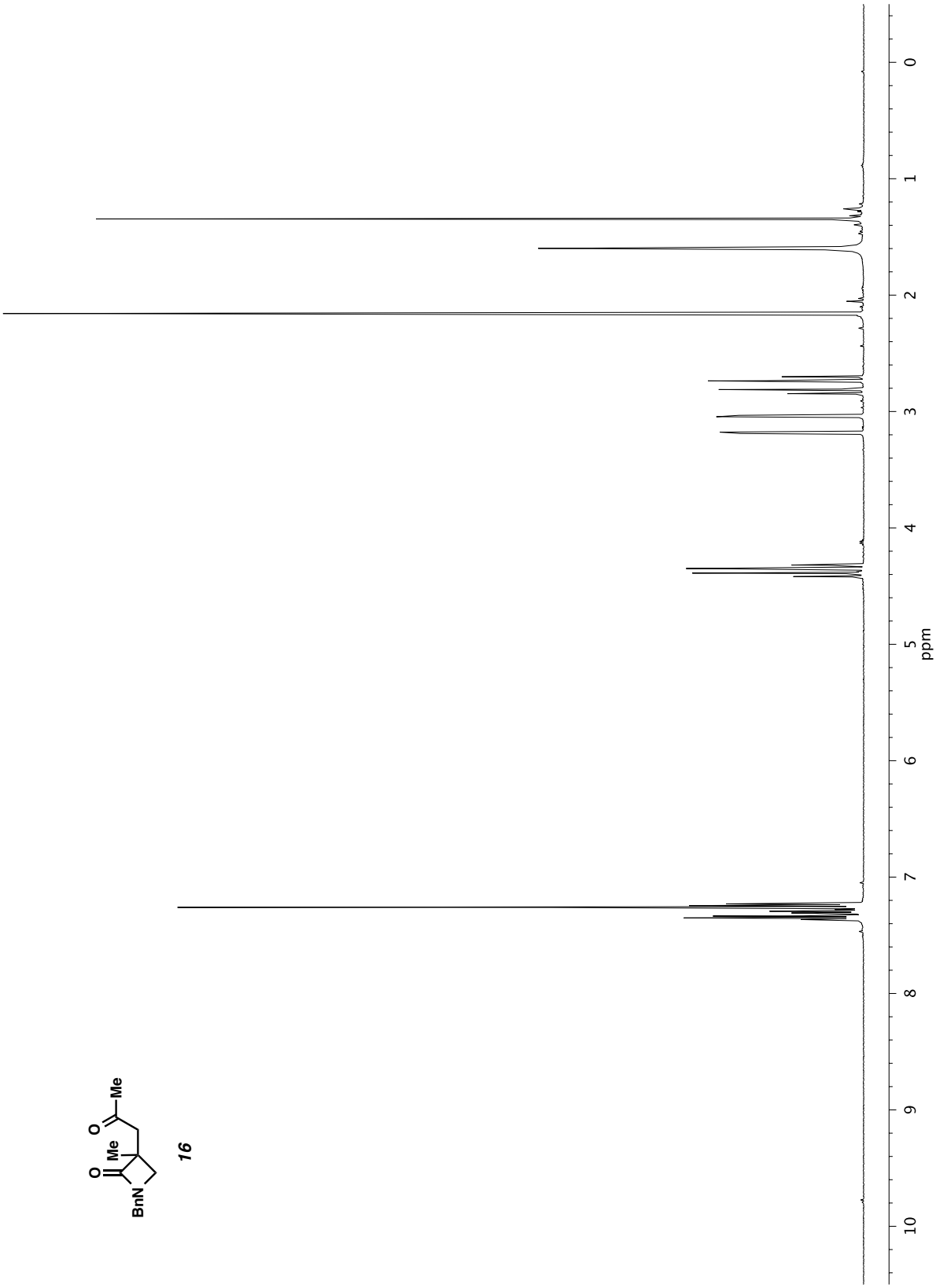
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9q**.



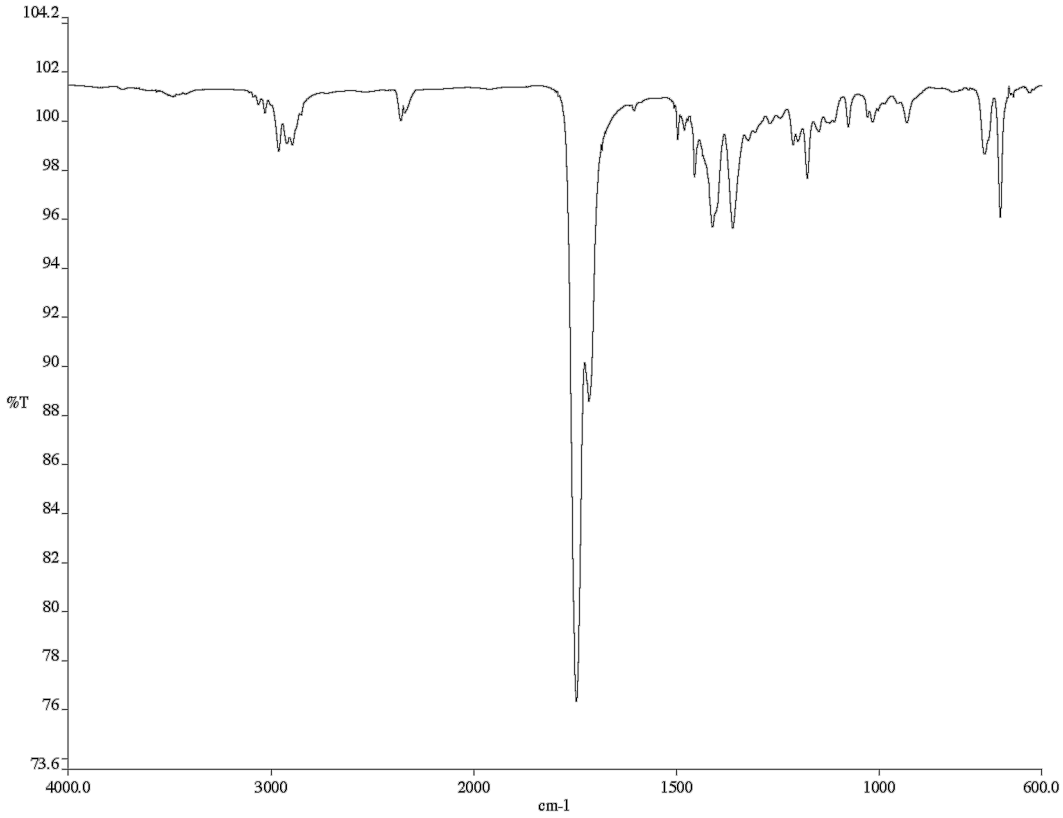
Infrared spectrum (Thin Film, NaCl) of compound **9q**.



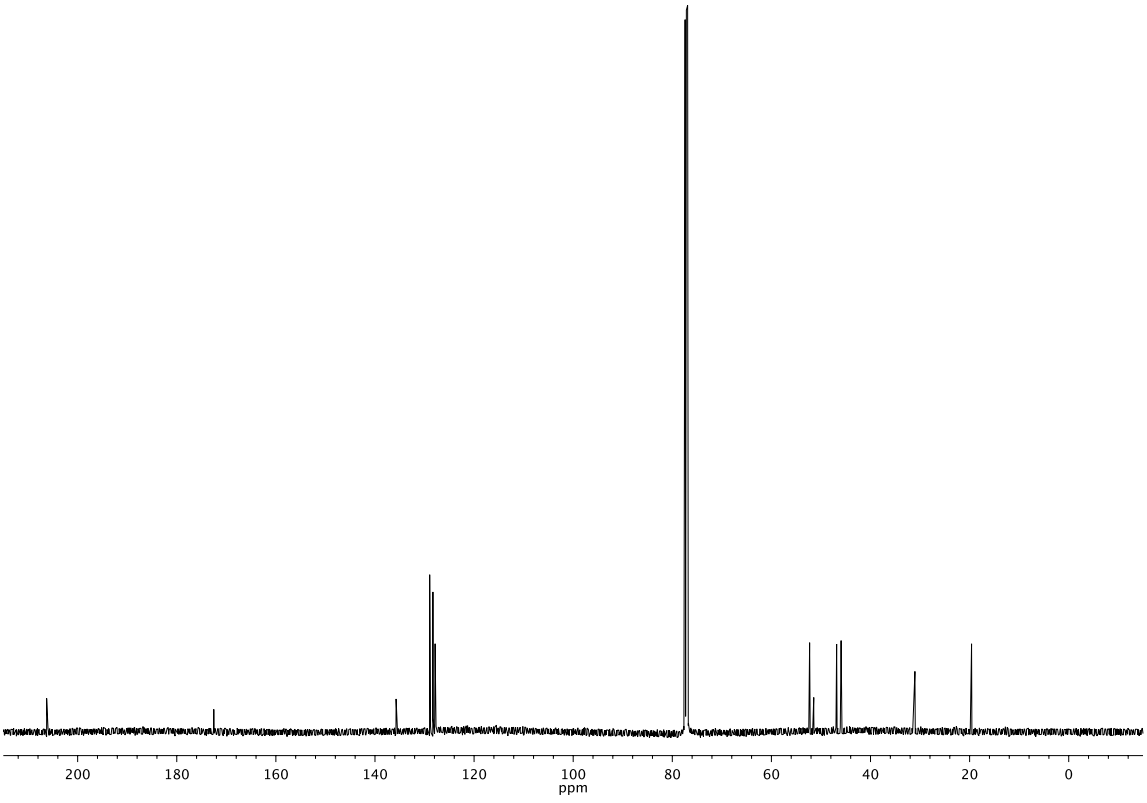
^{13}C NMR (126 MHz, $CDCl_3$) of compound **9q**.



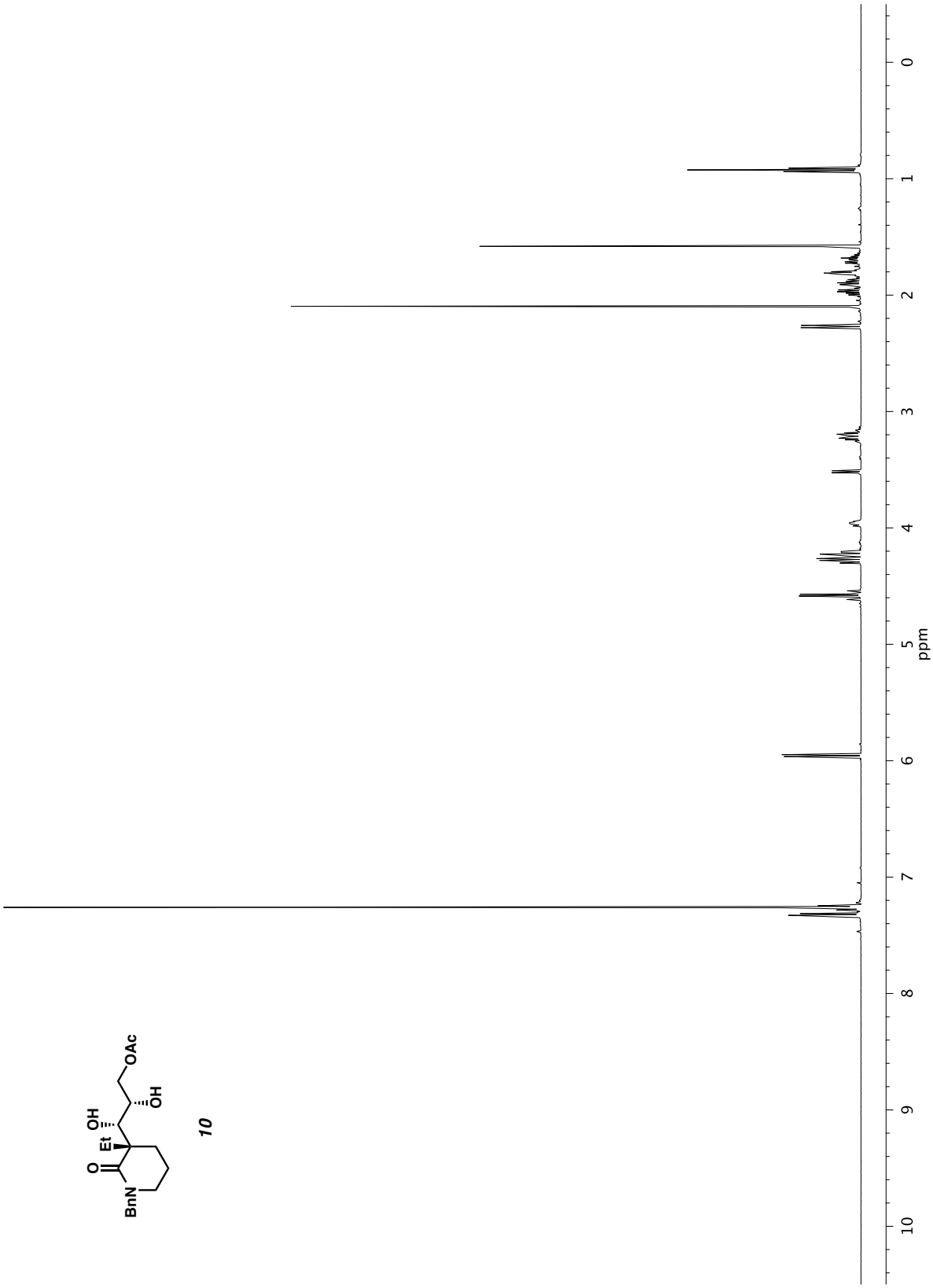
^{1}H NMR (500 MHz, $CDCl_3$) of compound **16**.



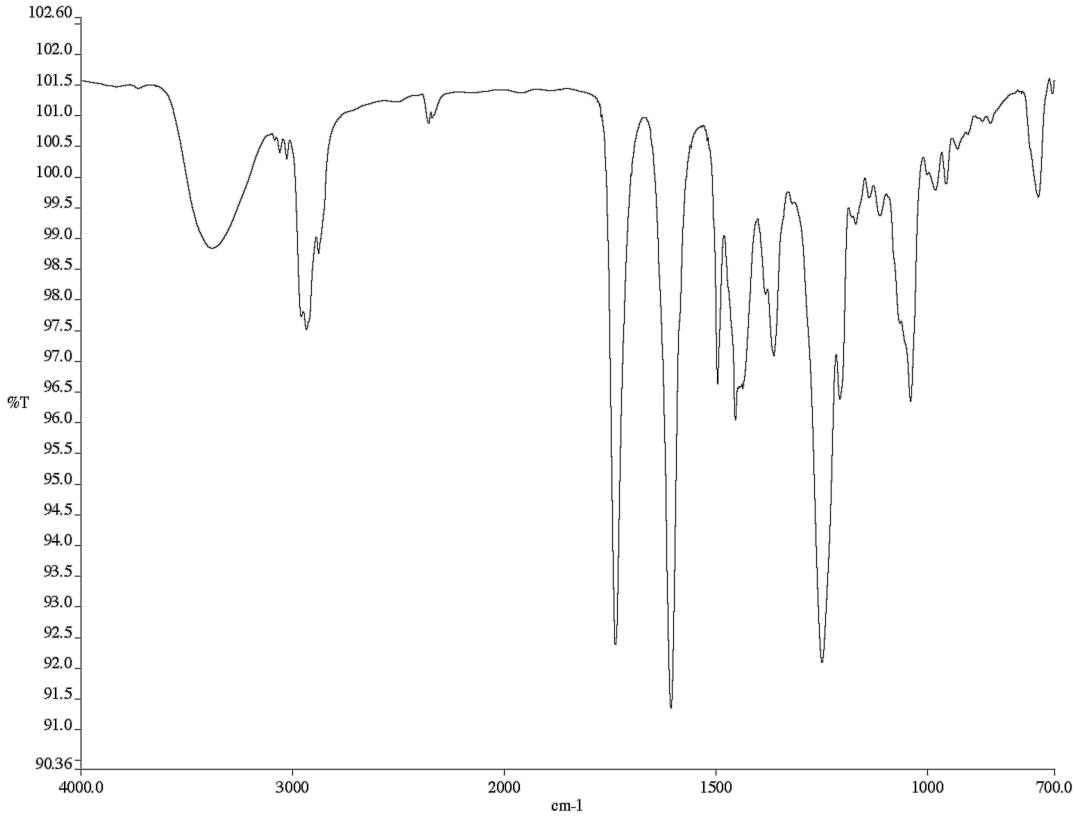
Infrared spectrum (Thin Film, NaCl) of compound **16**.



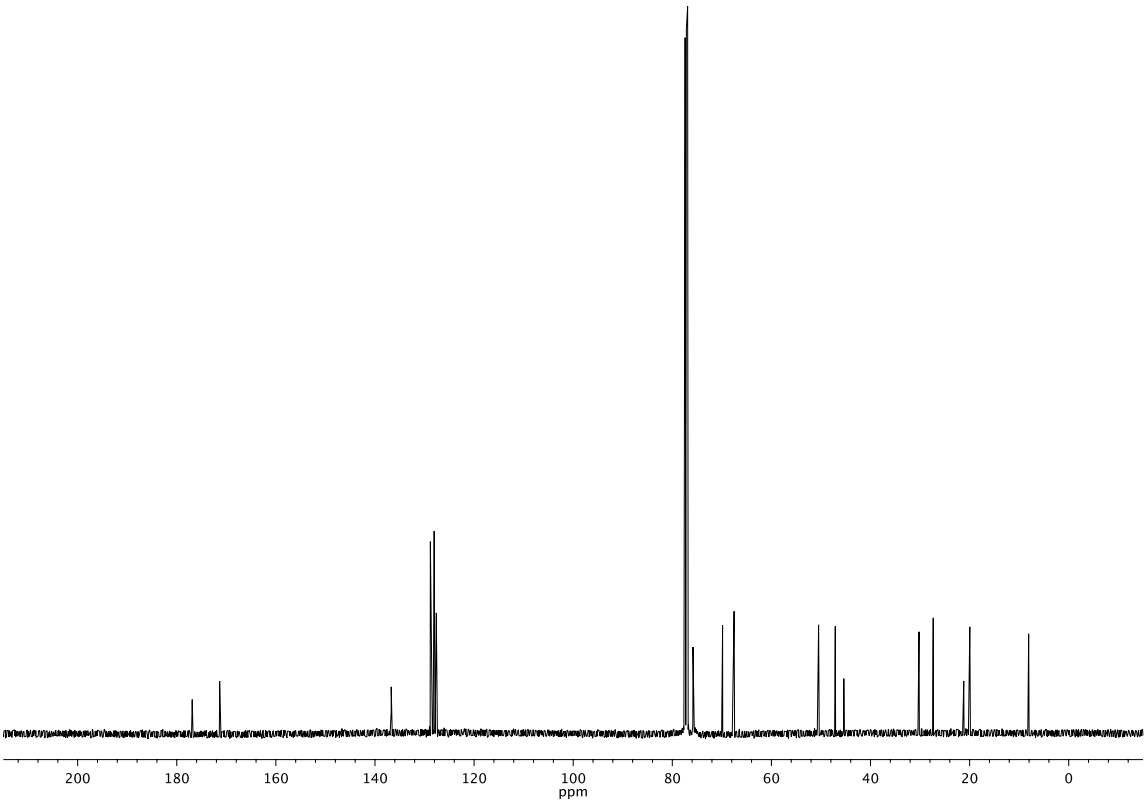
^{13}C NMR (126 MHz, $CDCl_3$) of compound **16**.



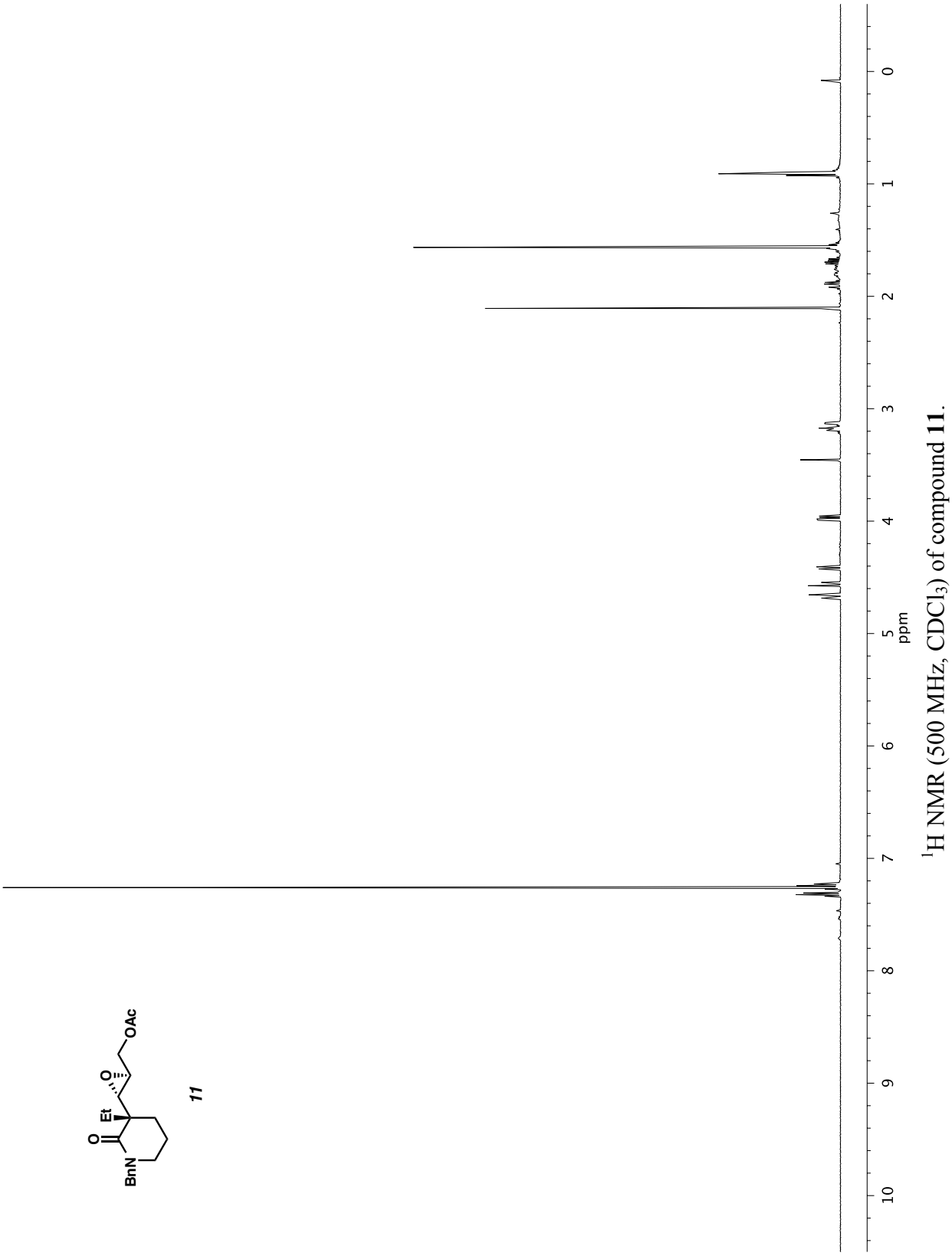
^{1}H NMR (500 MHz, $CDCl_3$) of compound **10**.



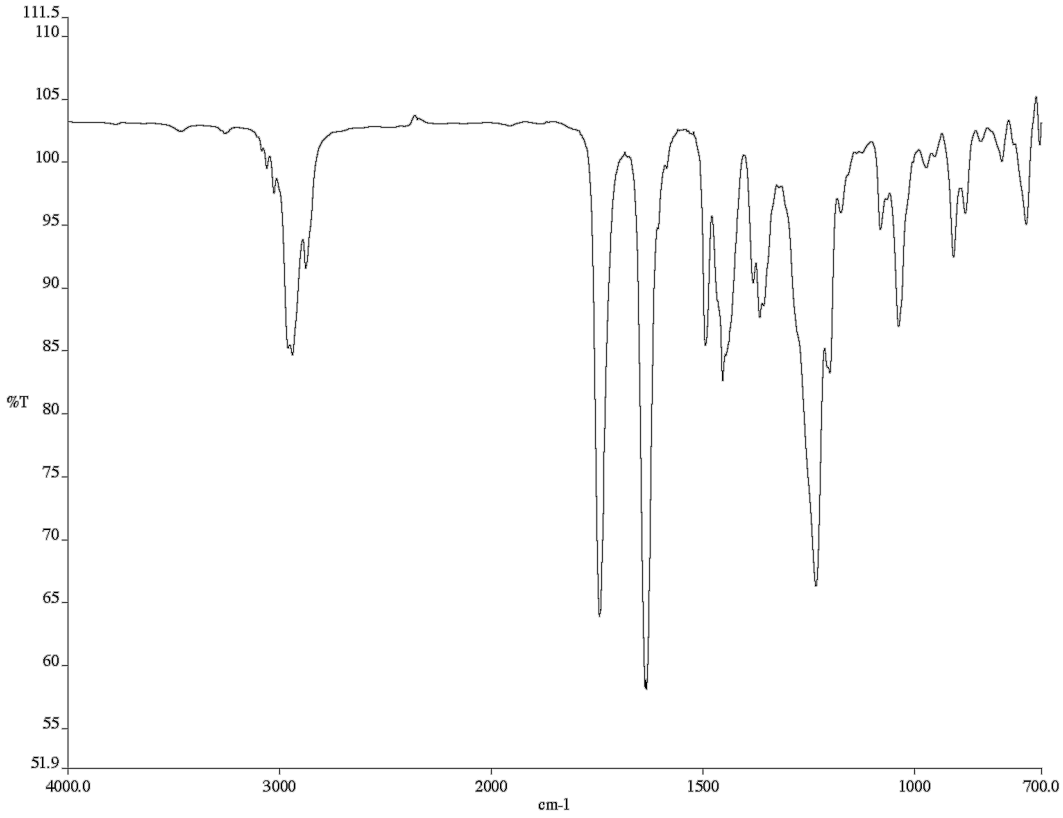
Infrared spectrum (Thin Film, NaCl) of compound **10**.



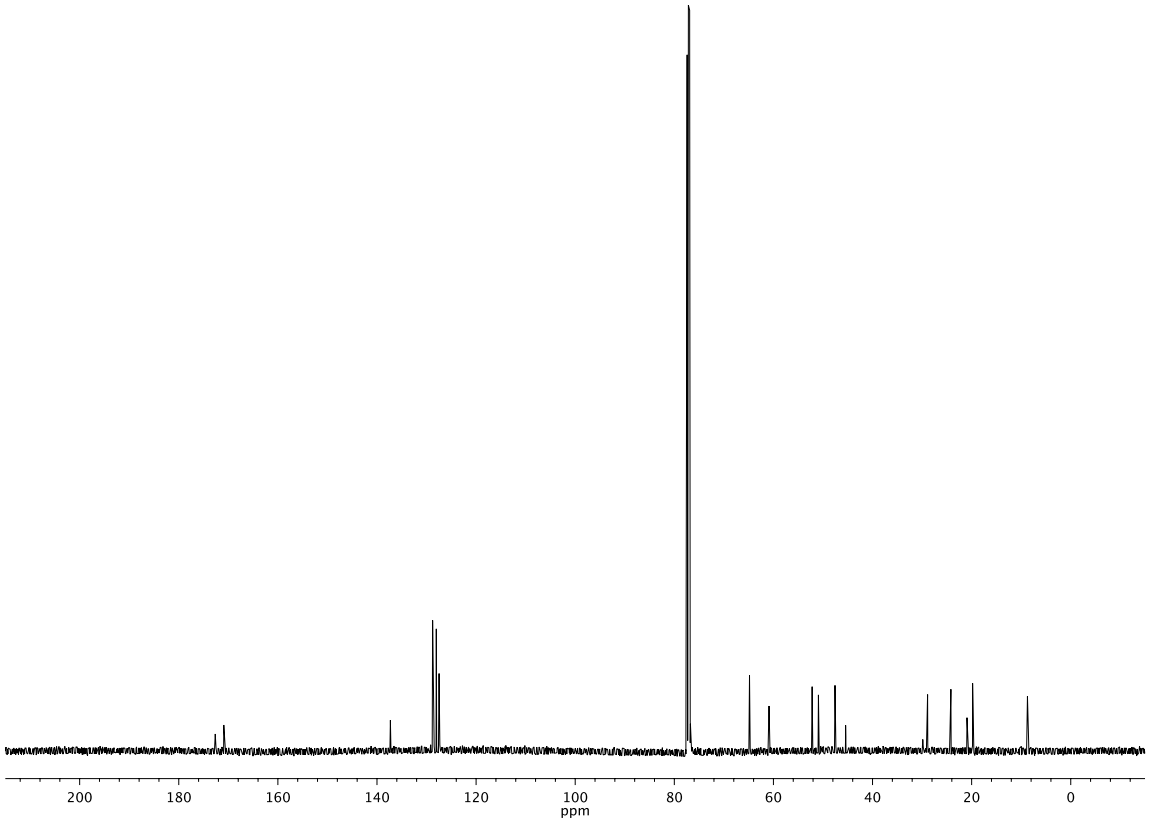
^{13}C NMR (126 MHz, $CDCl_3$) of compound **10**.



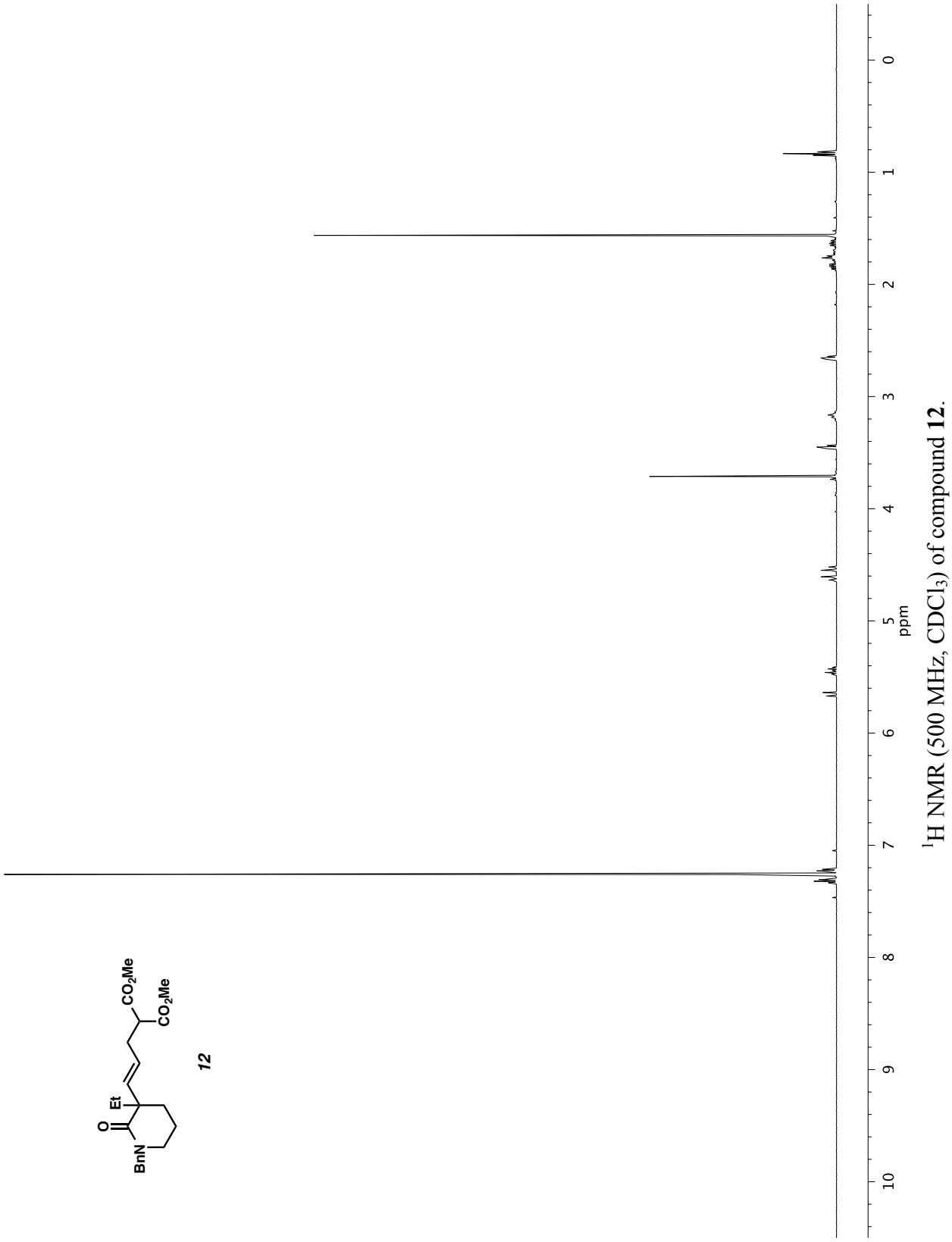
^{1}H NMR (500 MHz, $CDCl_3$) of compound **11**.



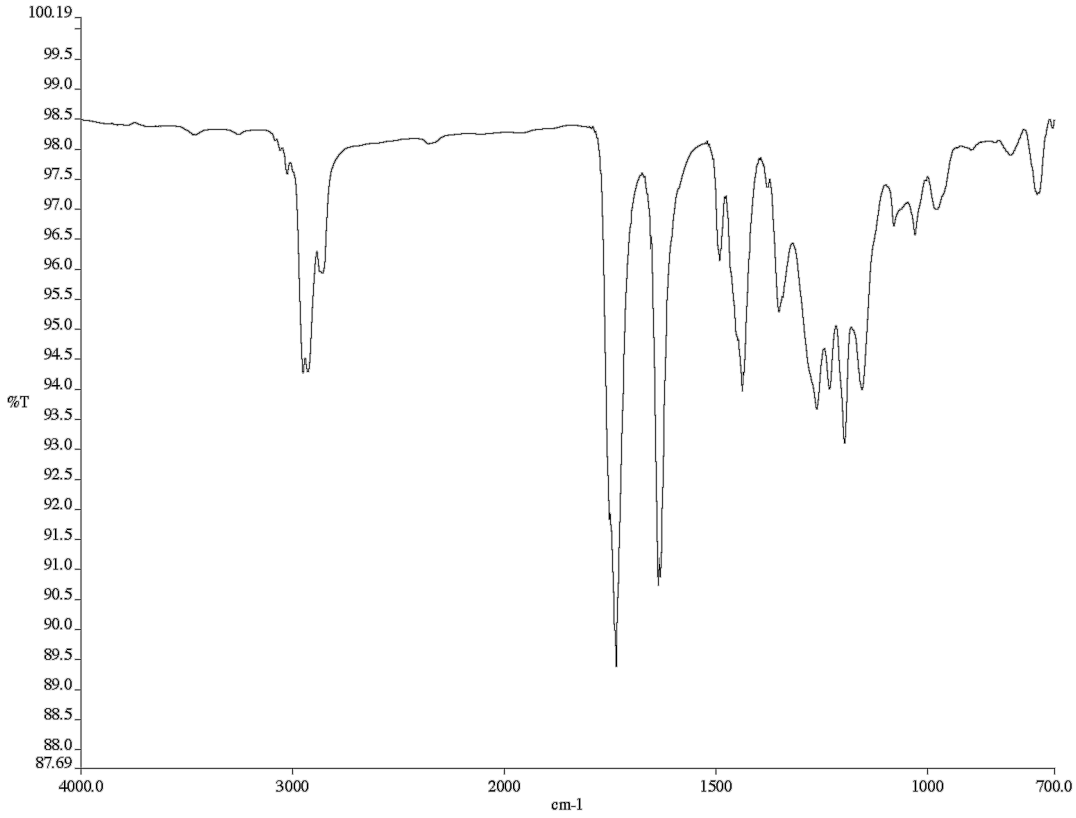
Infrared spectrum (Thin Film, NaCl) of compound **11**.



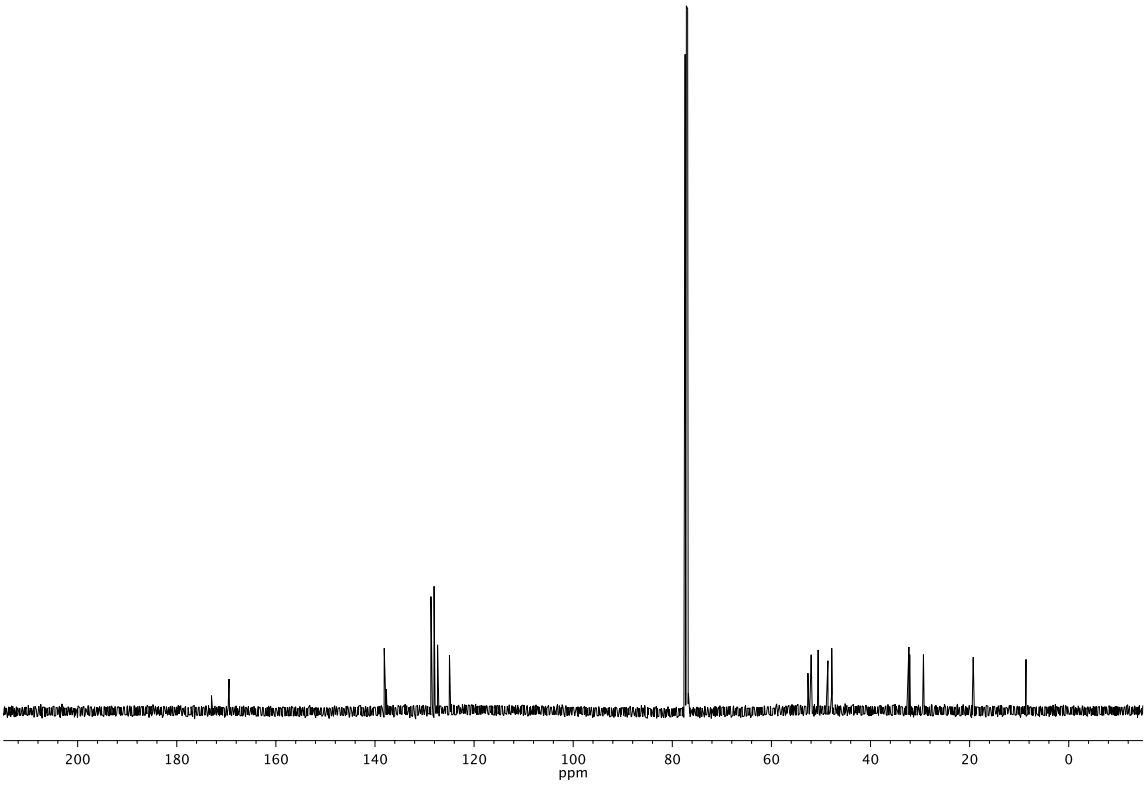
^{13}C NMR (126 MHz, $CDCl_3$) of compound **11**.



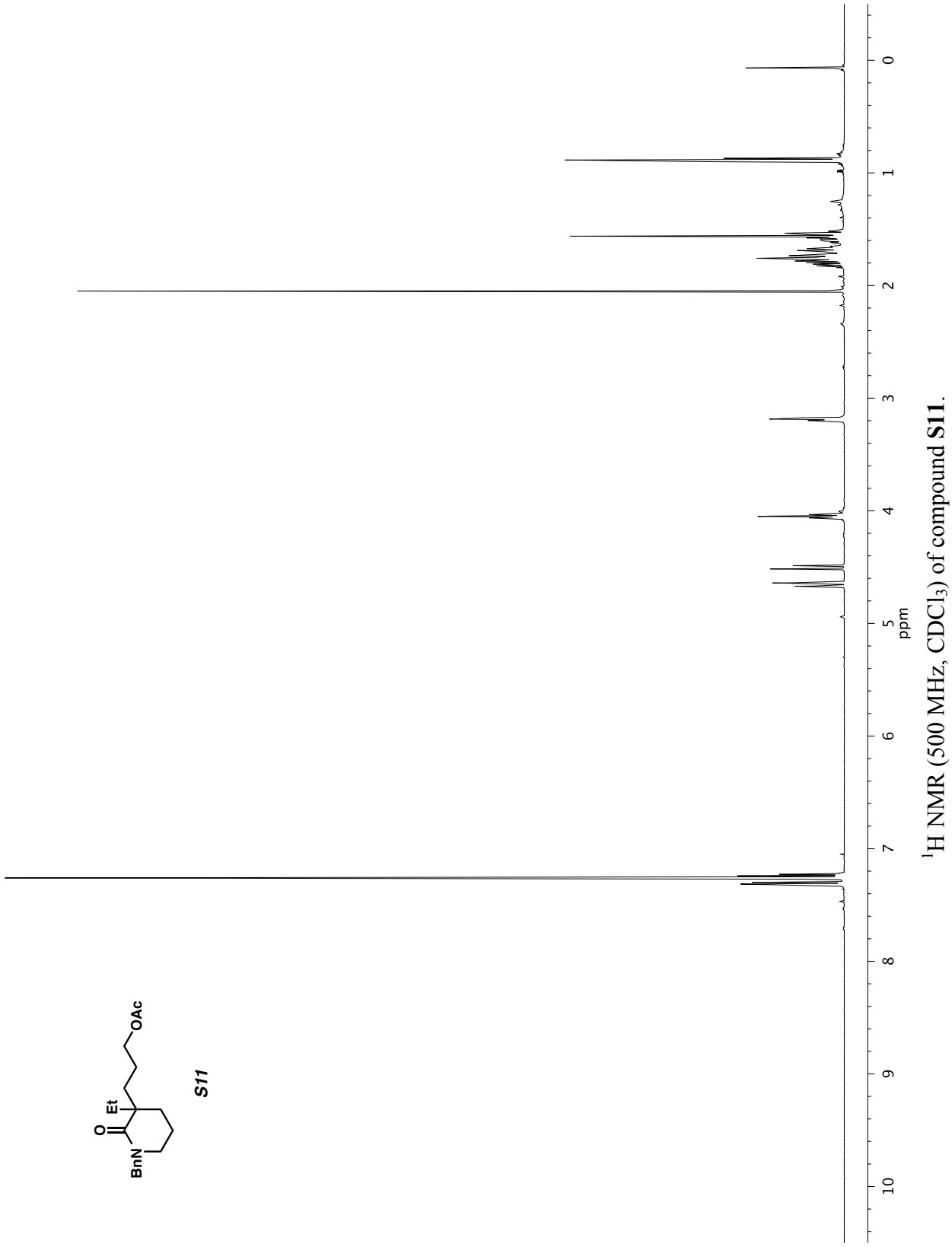
^{1}H NMR (500 MHz, $CDCl_3$) of compound **12**.



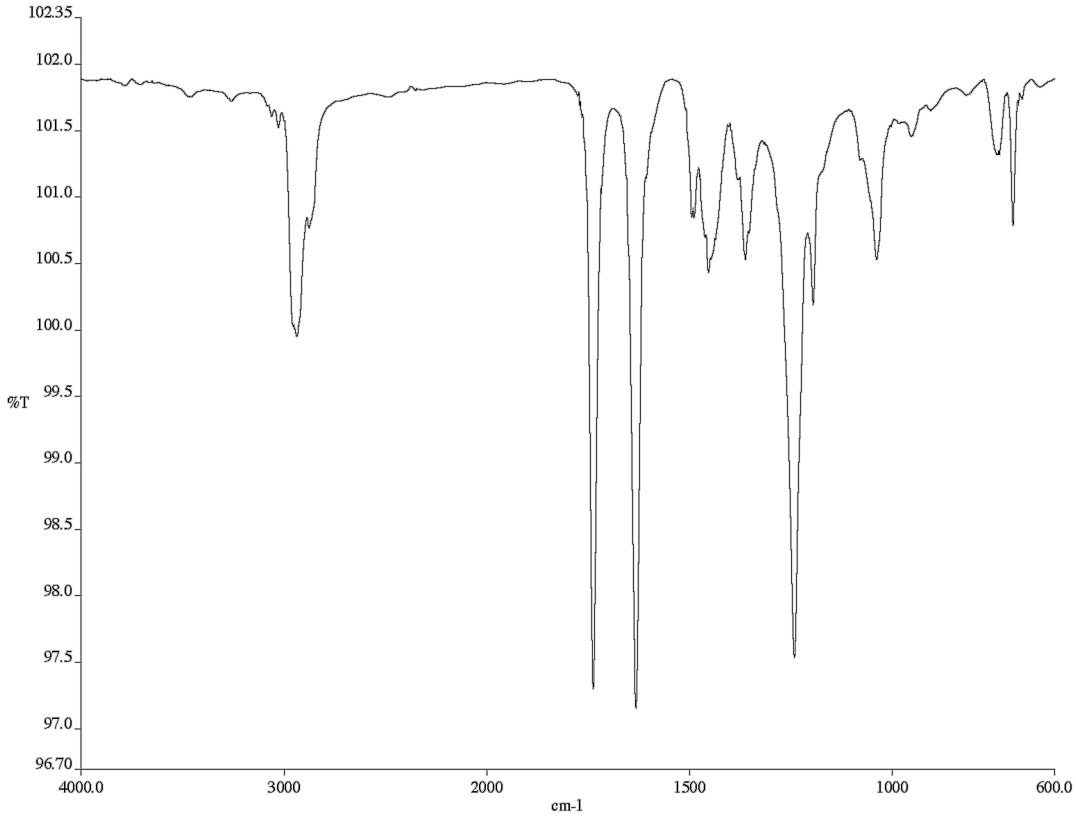
Infrared spectrum (Thin Film, NaCl) of compound **12**.



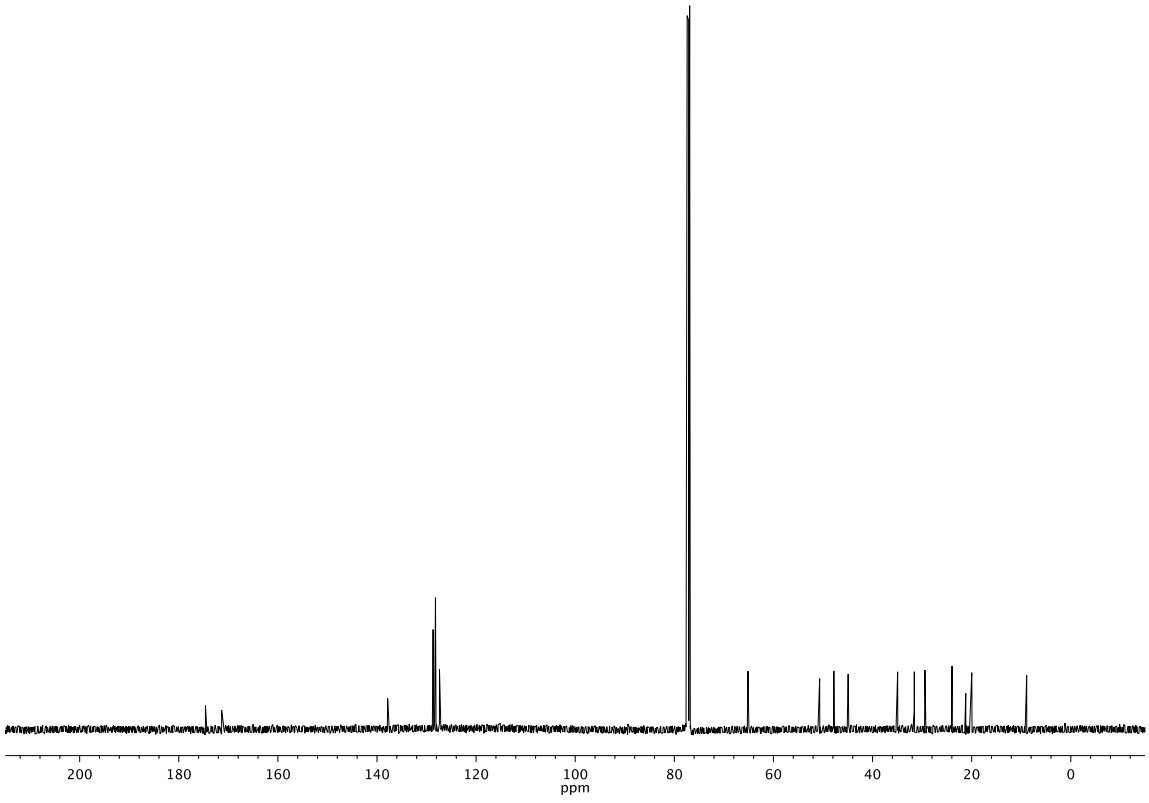
^{13}C NMR (126 MHz, $CDCl_3$) of compound **12**.



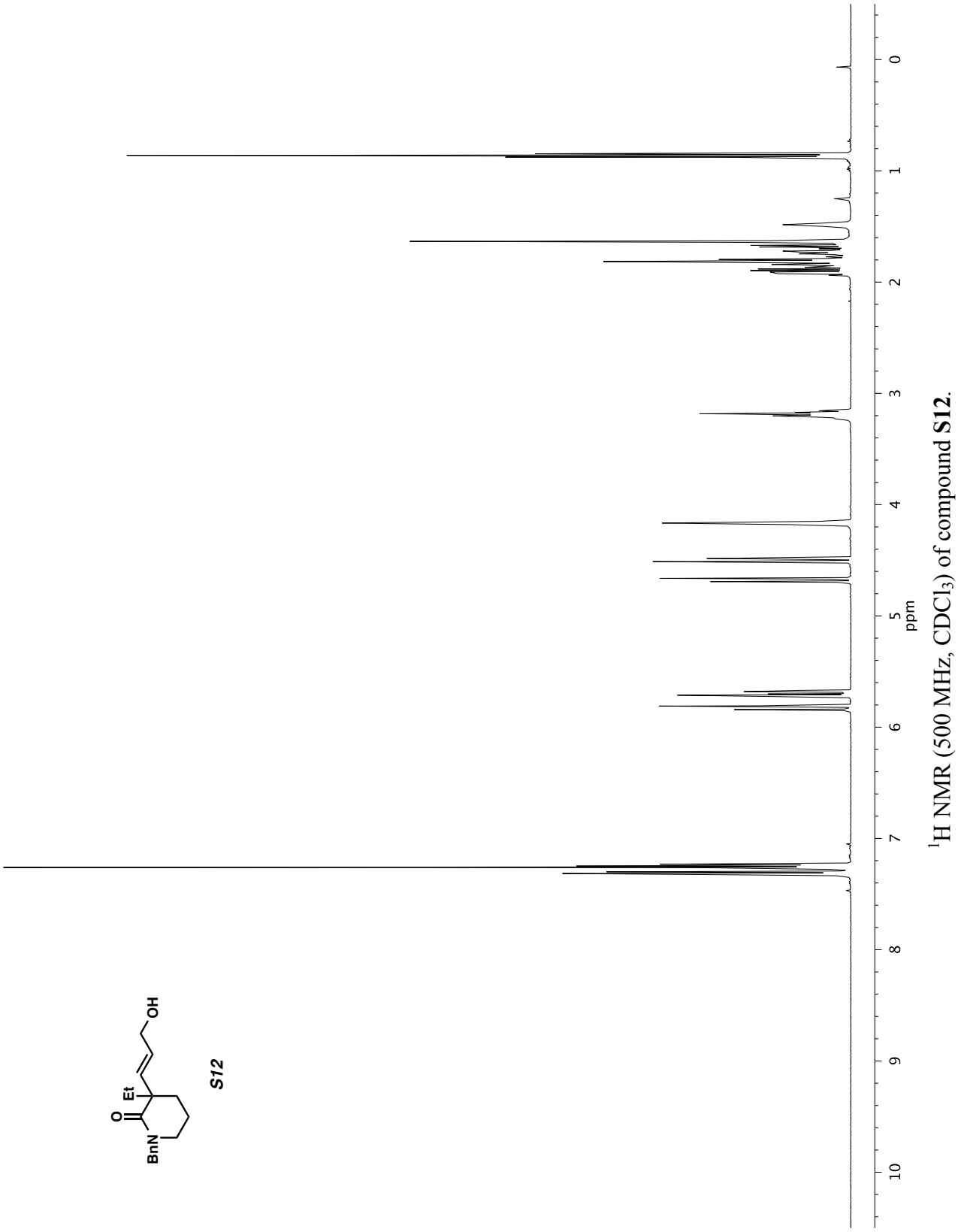
^{1}H NMR (500 MHz, $CDCl_3$) of compound **S11**.



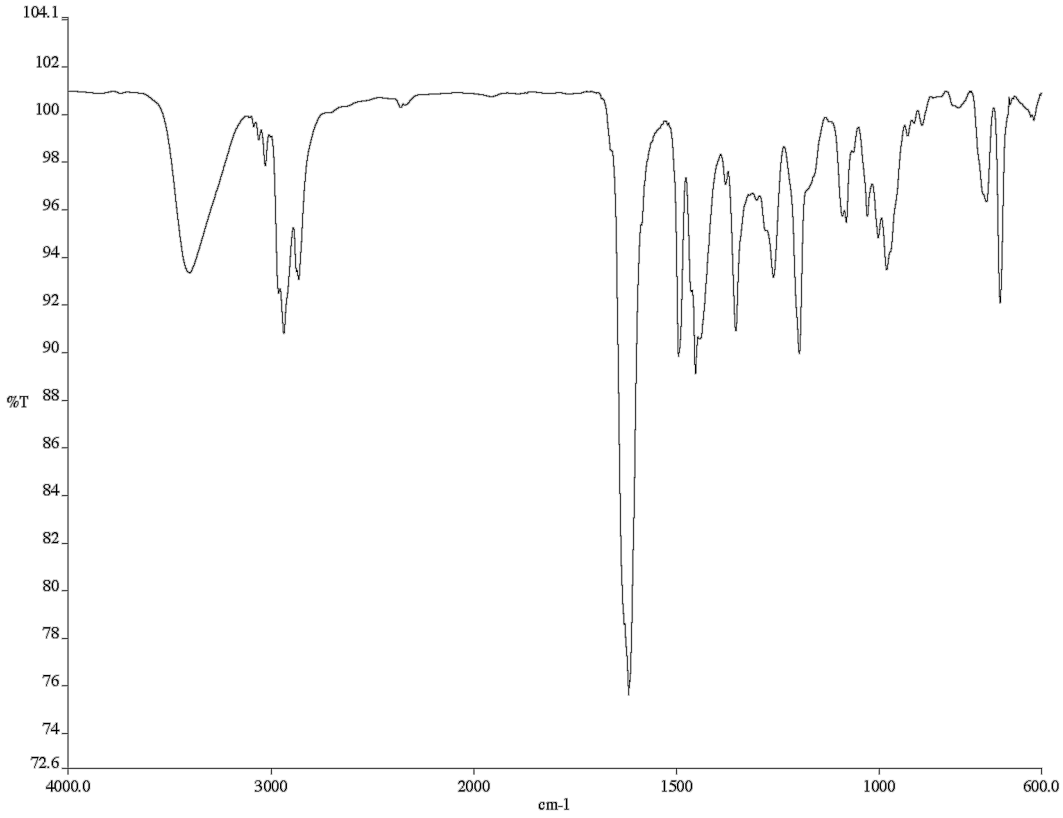
Infrared spectrum (Thin Film, NaCl) of compound **S11**.



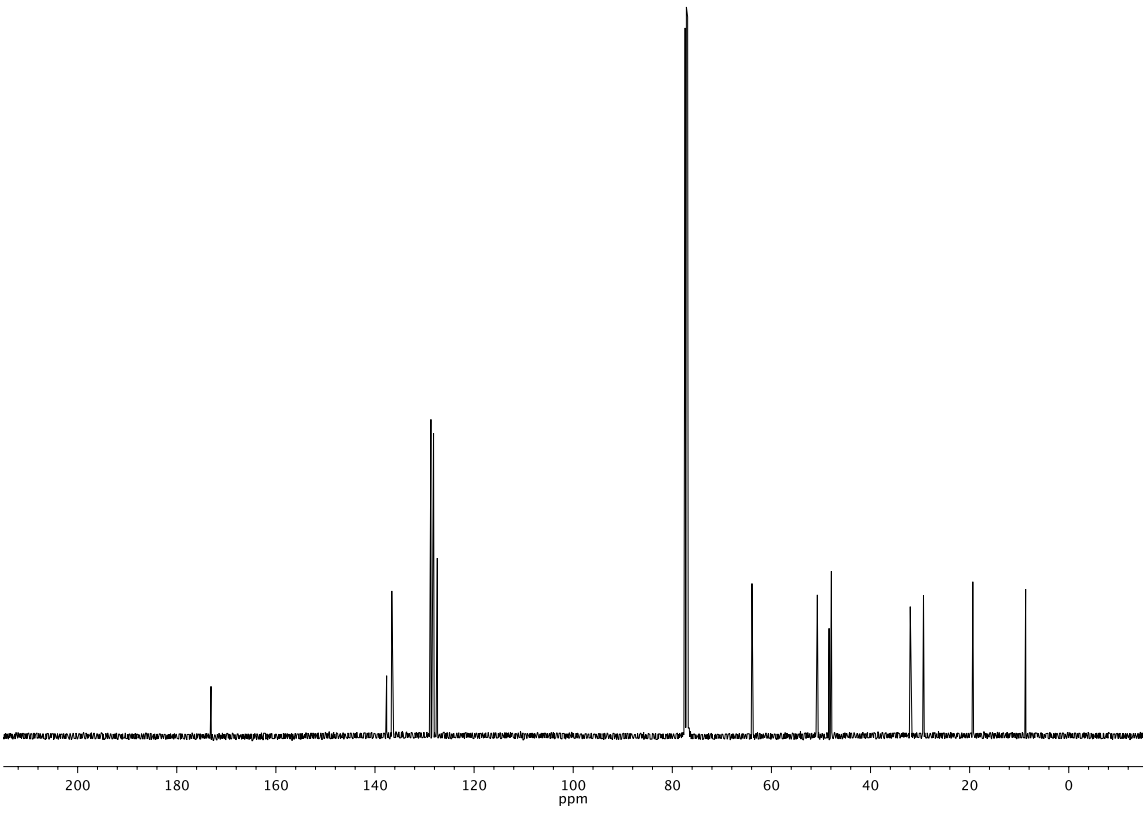
^{13}C NMR (126 MHz, $CDCl_3$) of compound **S11**.



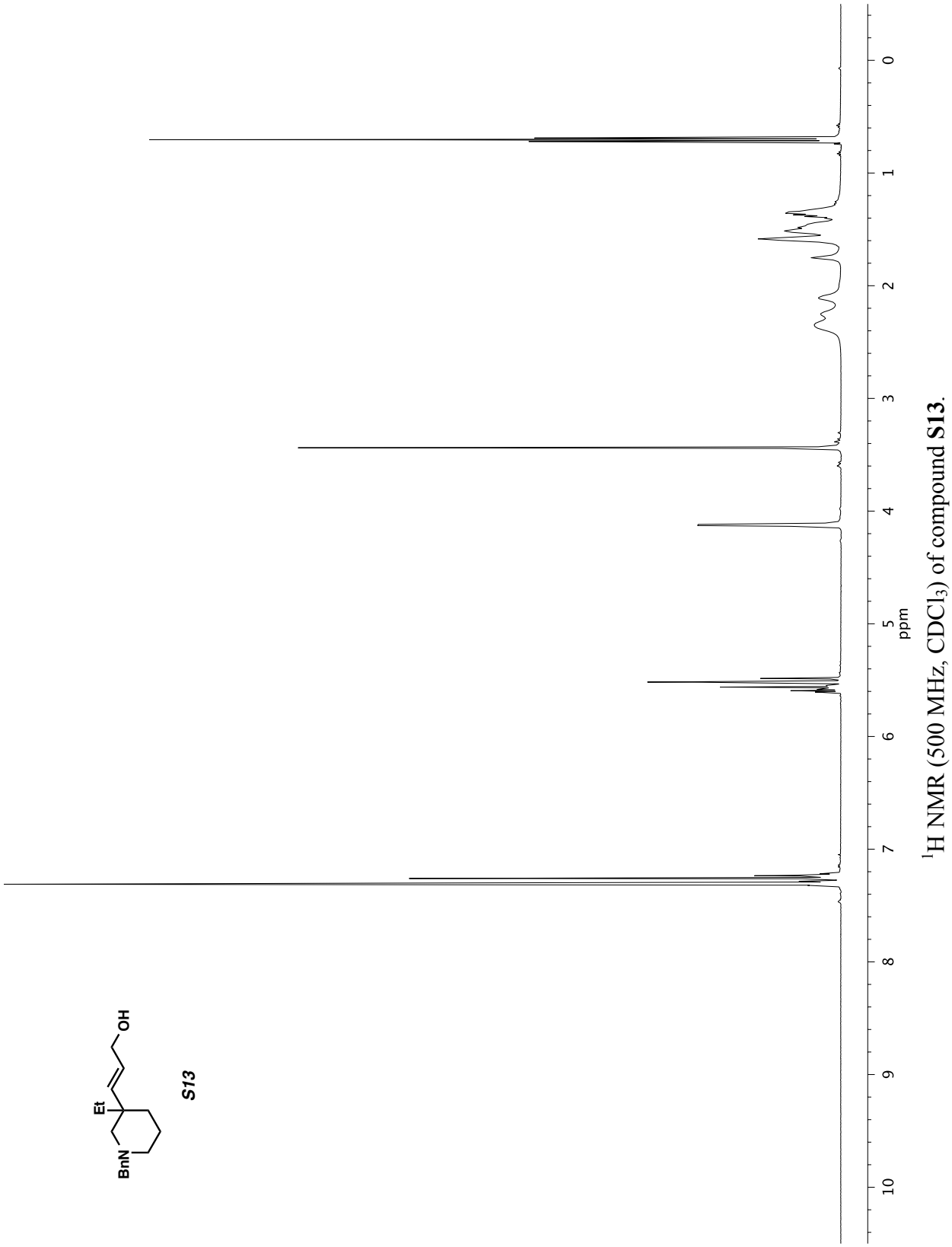
^{1}H NMR (500 MHz, $CDCl_3$) of compound **S12**.



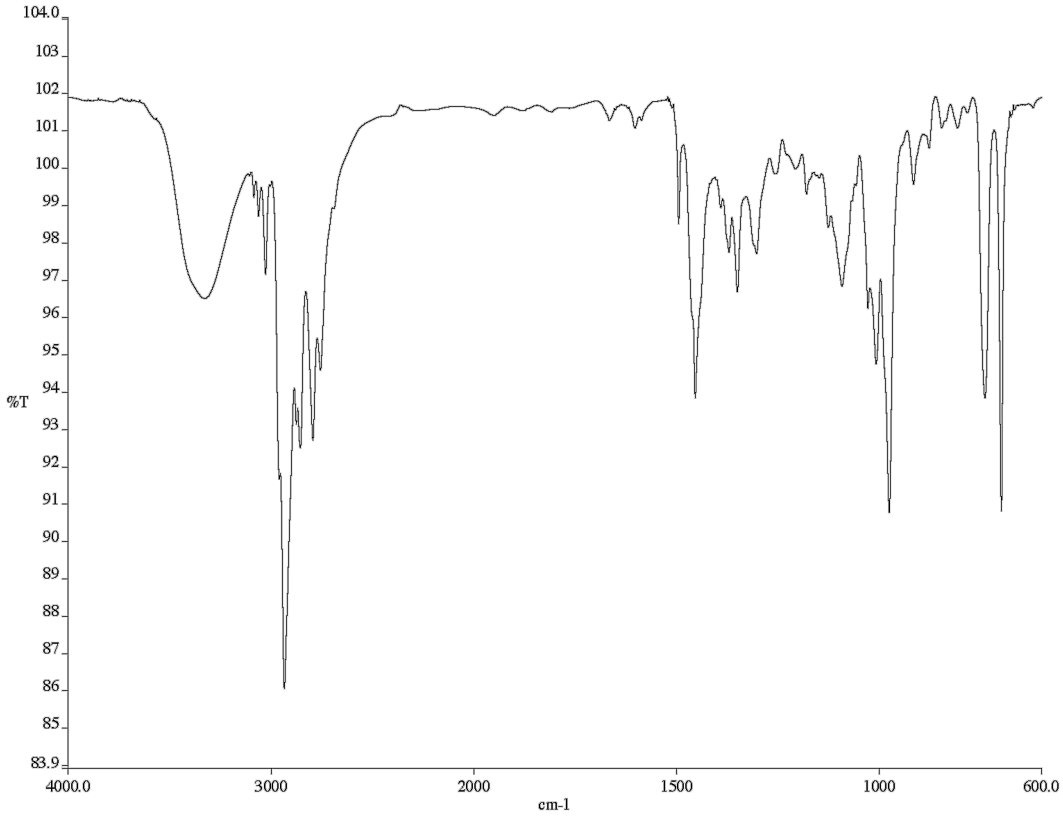
Infrared spectrum (Thin Film, NaCl) of compound **S12**.



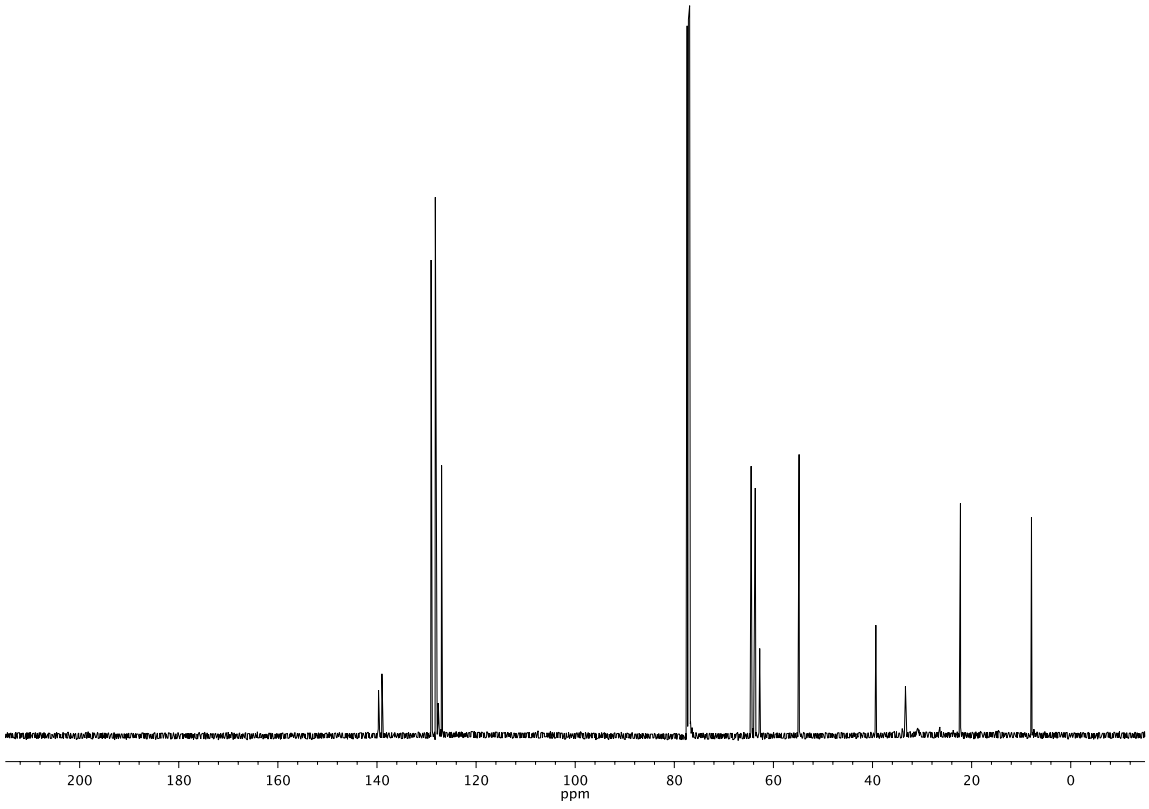
^{13}C NMR (126 MHz, $CDCl_3$) of compound **S12**.



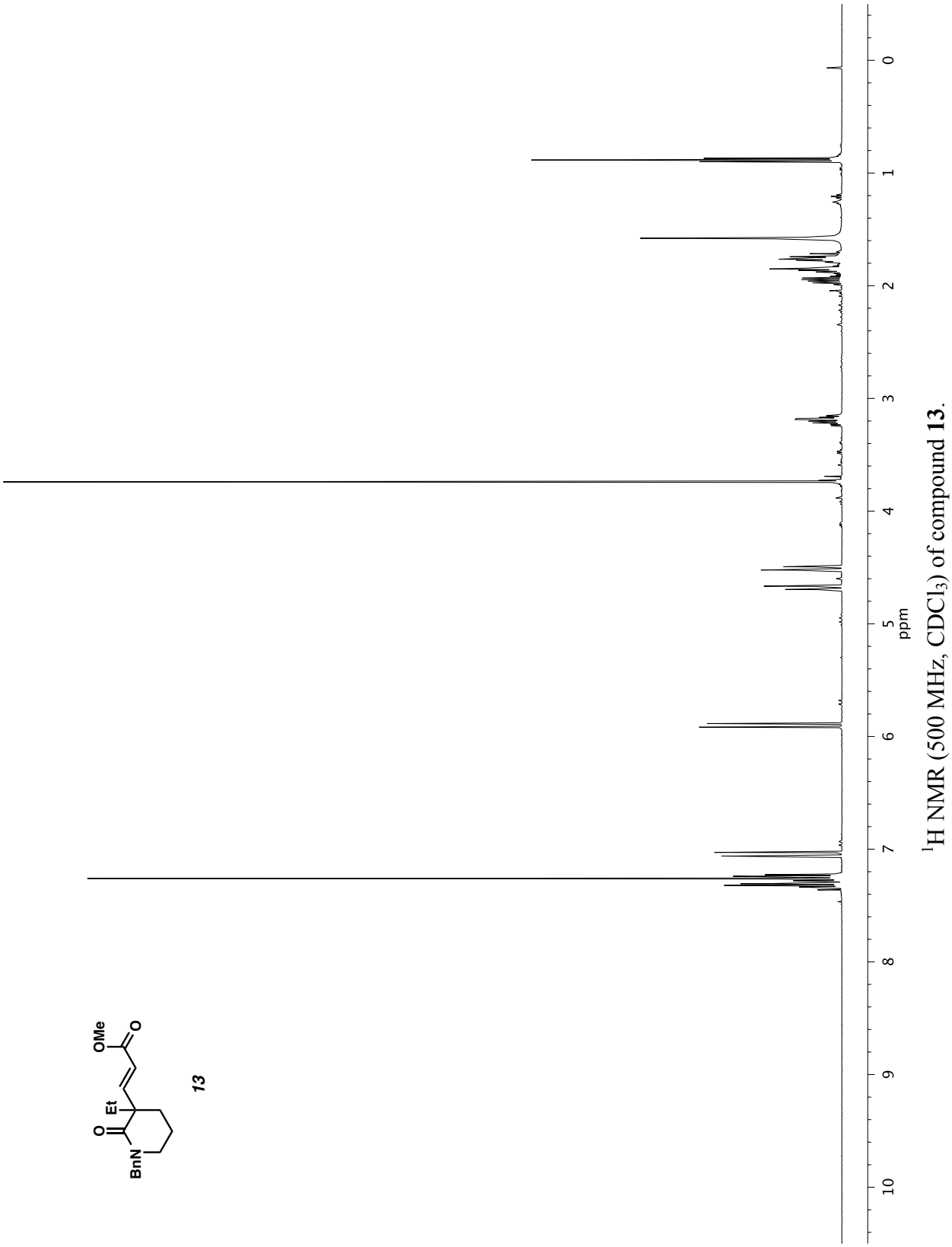
^{1}H NMR (500 MHz, $CDCl_3$) of compound **S13**.



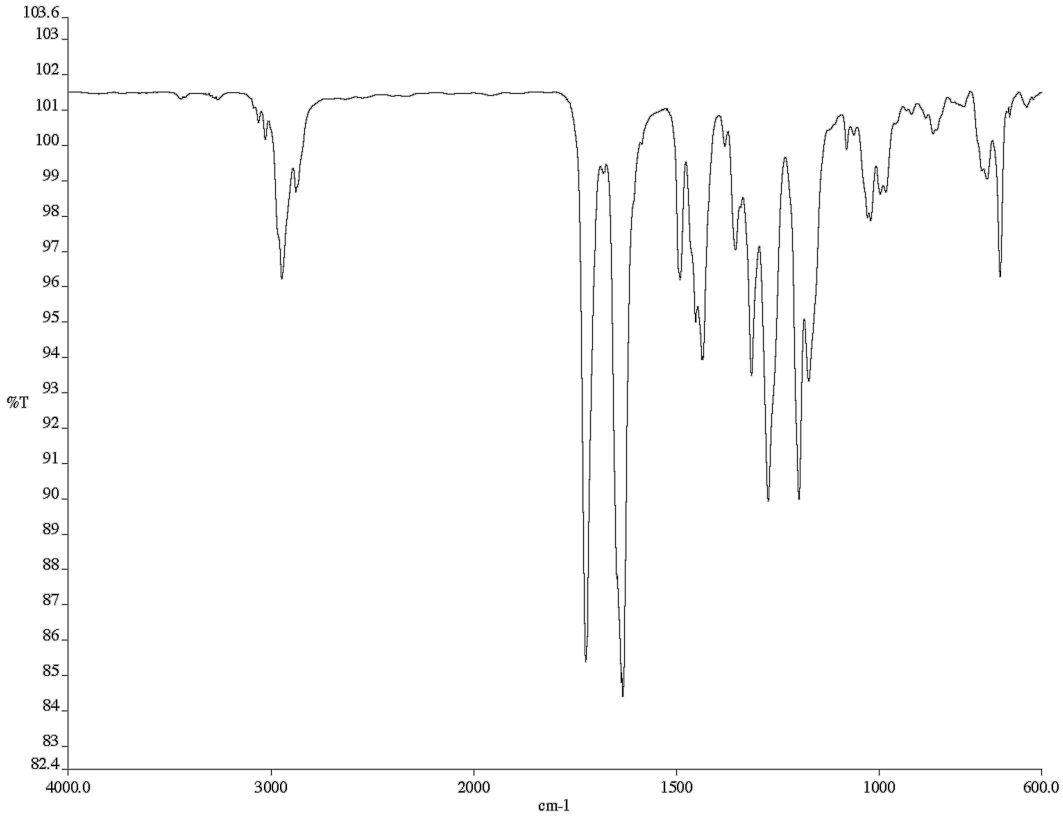
Infrared spectrum (Thin Film, NaCl) of compound **S13**.



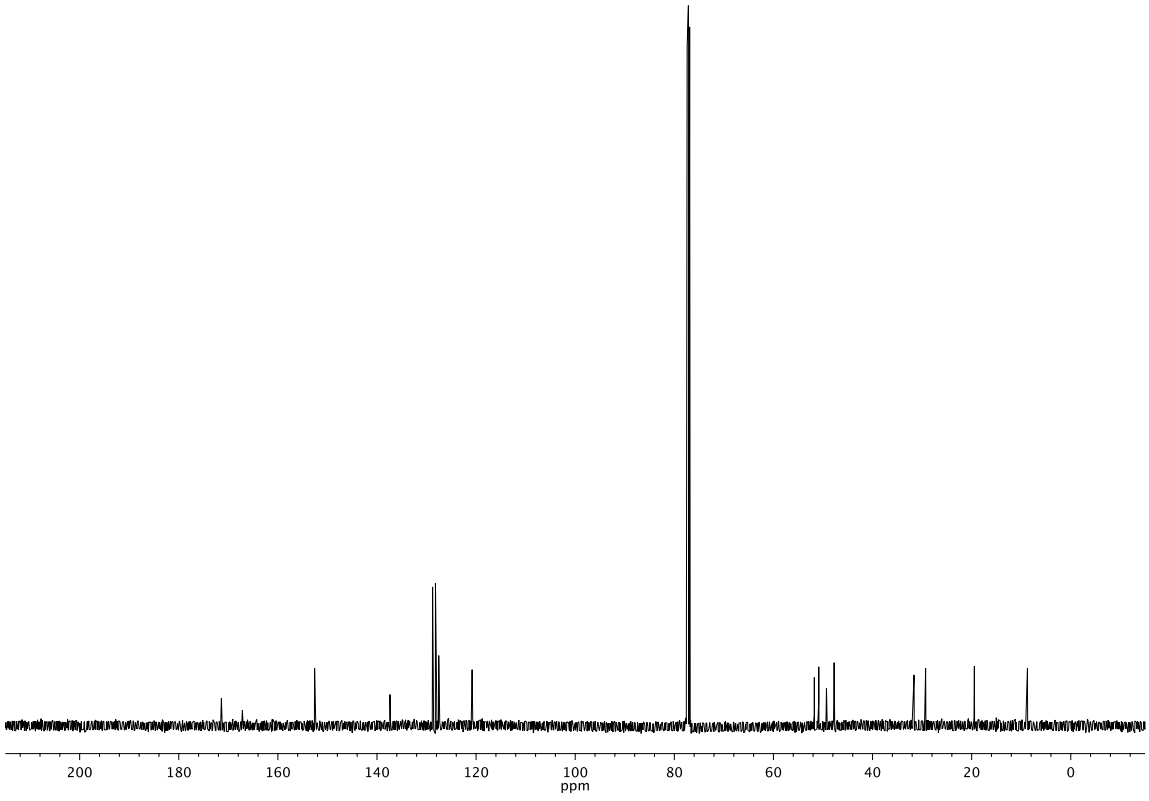
^{13}C NMR (126 MHz, $CDCl_3$) of compound **S13**.



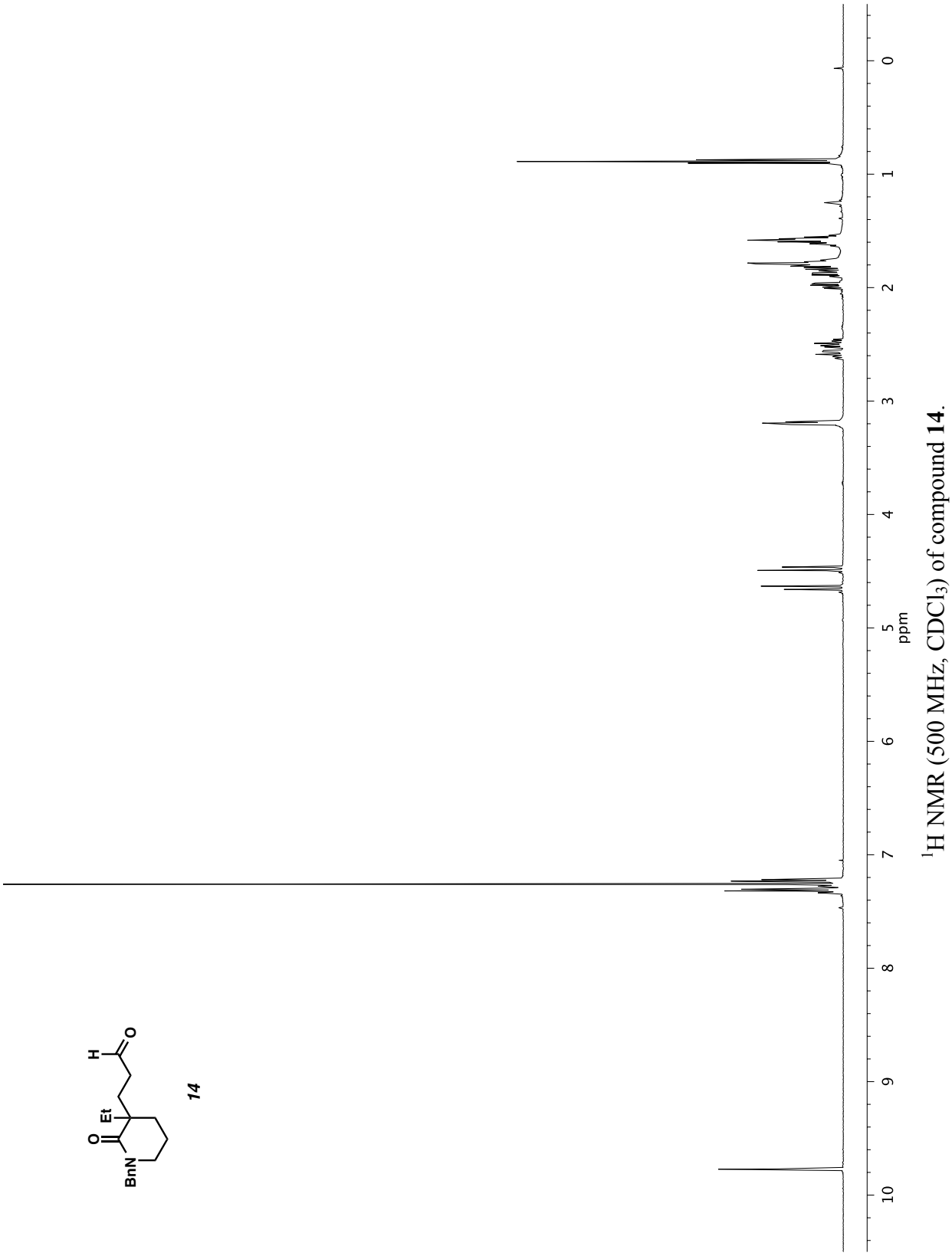
^{1}H NMR (500 MHz, $CDCl_3$) of compound **13**.



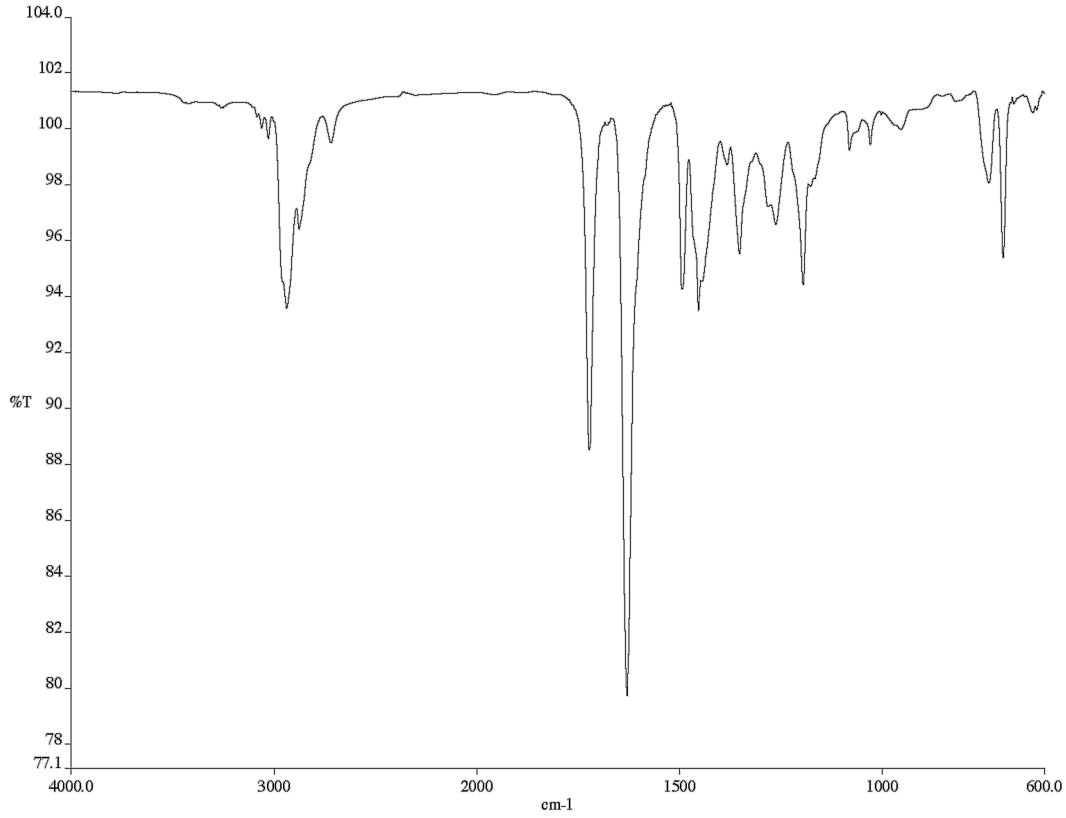
Infrared spectrum (Thin Film, NaCl) of compound **13**.



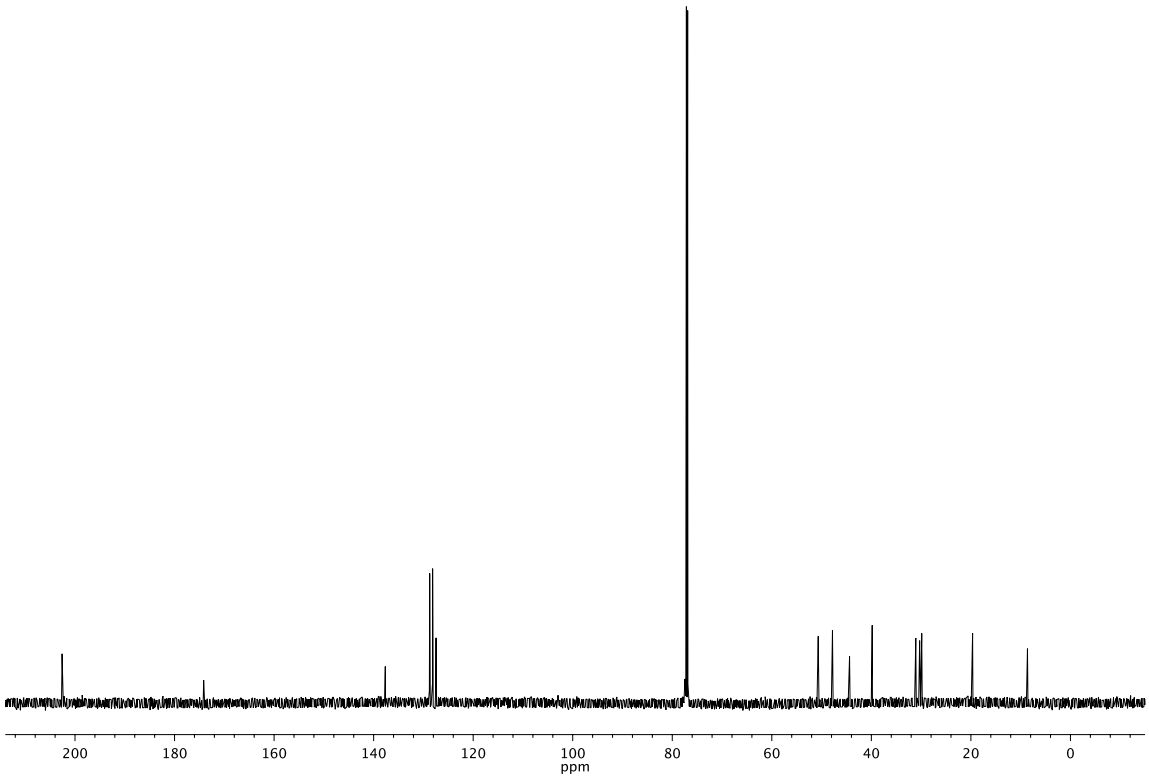
^{13}C NMR (126 MHz, $CDCl_3$) of compound **13**.



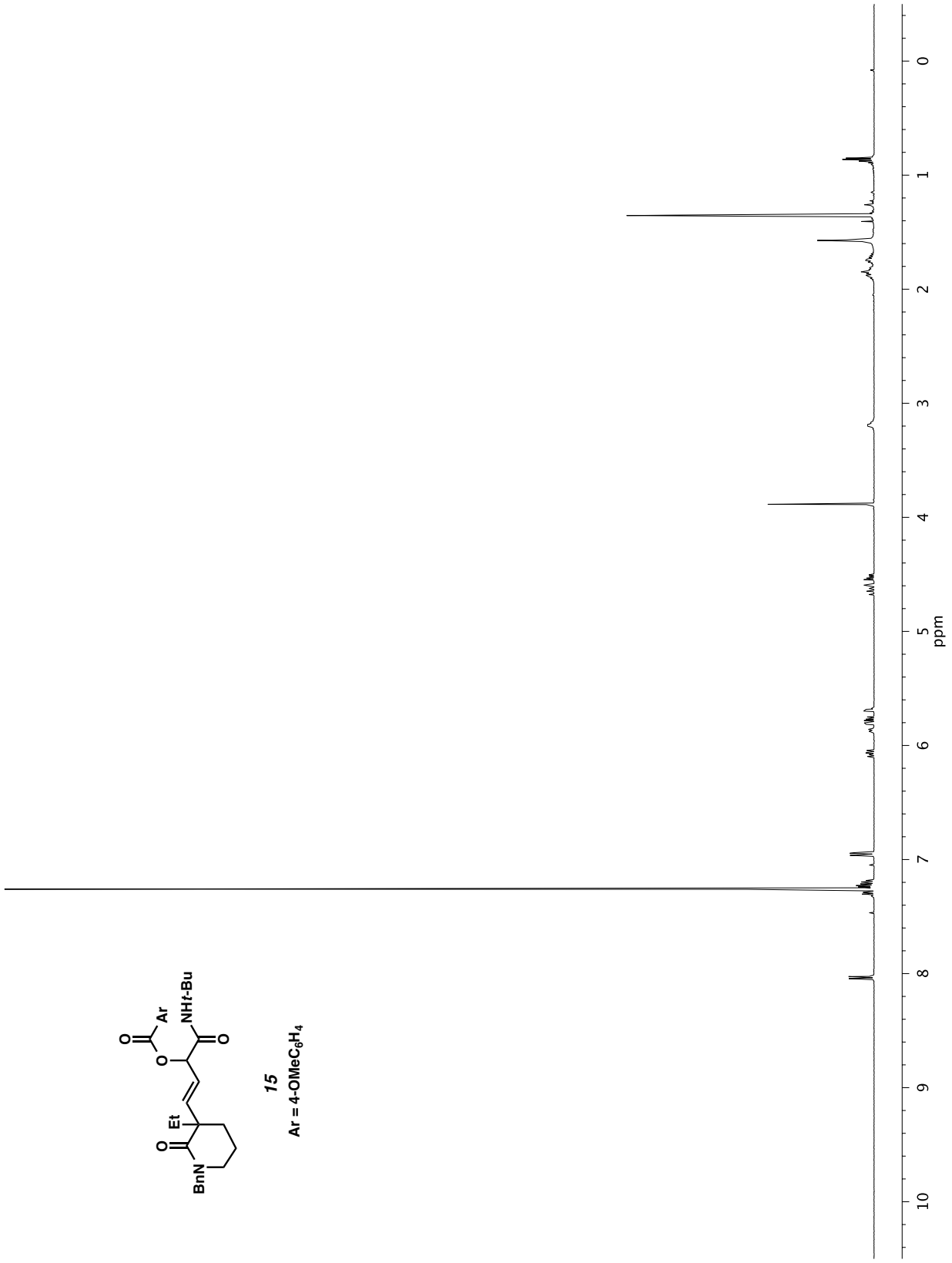
^{1}H NMR (500 MHz, $CDCl_3$) of compound **14**.



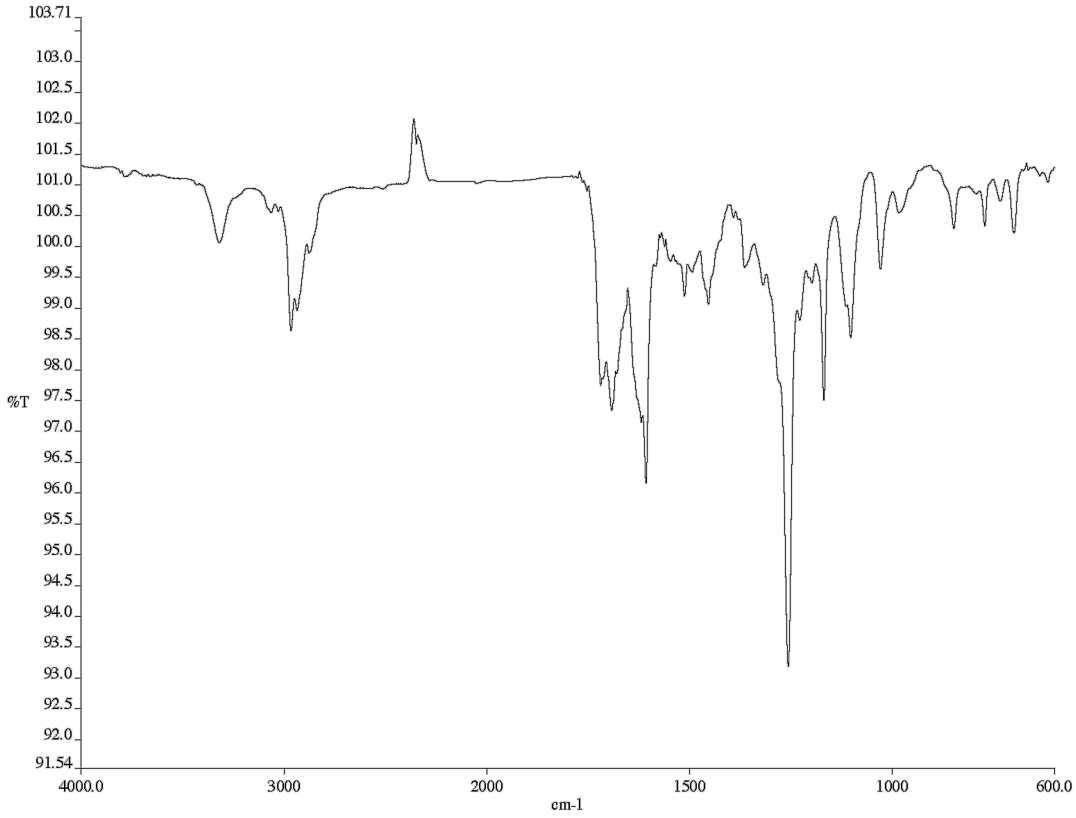
Infrared spectrum (Thin Film, NaCl) of compound **14**.



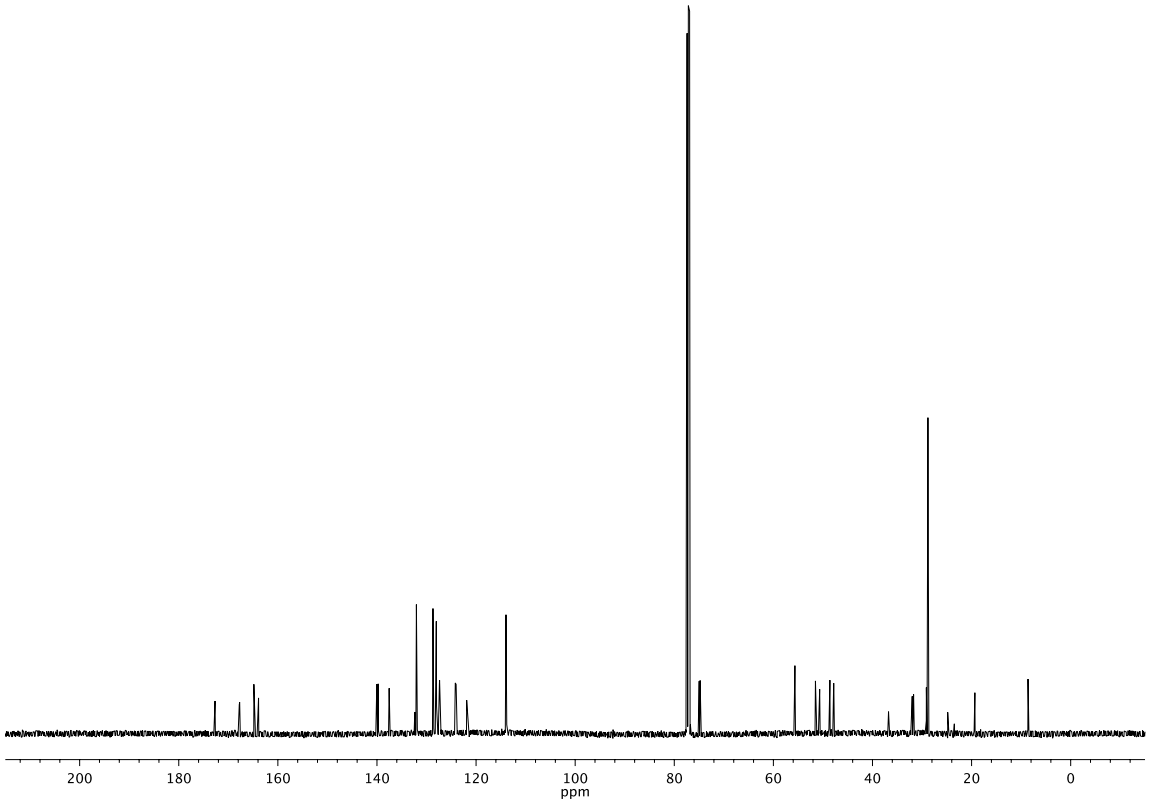
^{13}C NMR (126 MHz, $CDCl_3$) of compound **14**.



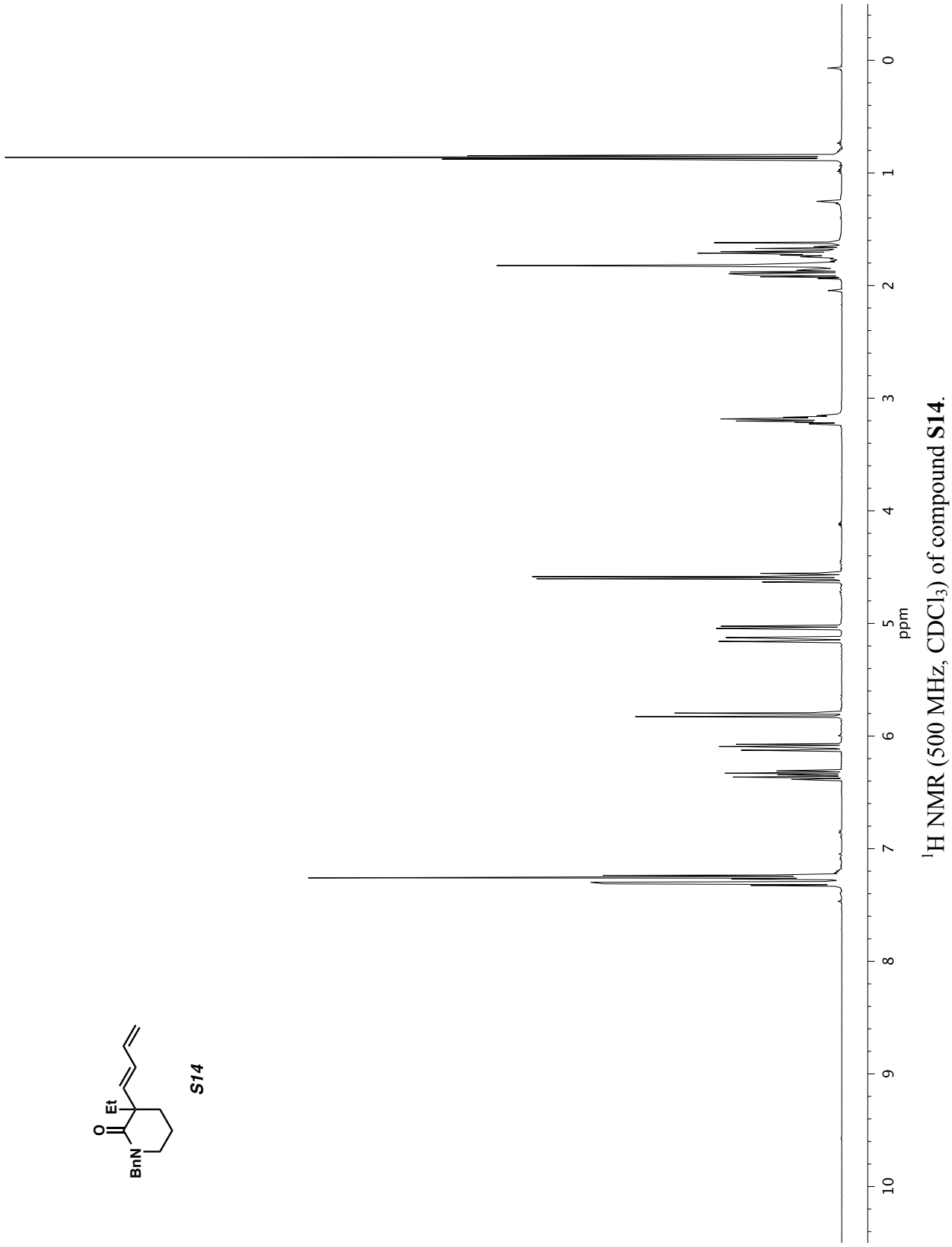
^{1}H NMR (500 MHz, $CDCl_3$) of compound **15**.



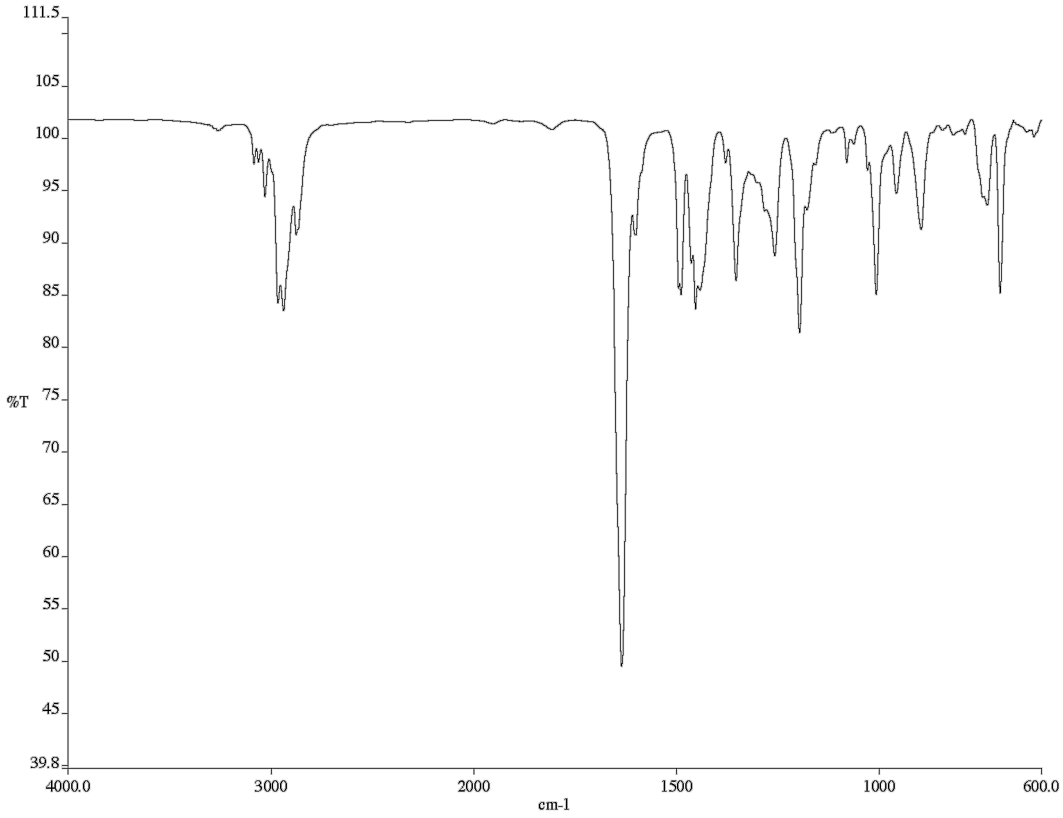
Infrared spectrum (Thin Film, NaCl) of compound **15**.



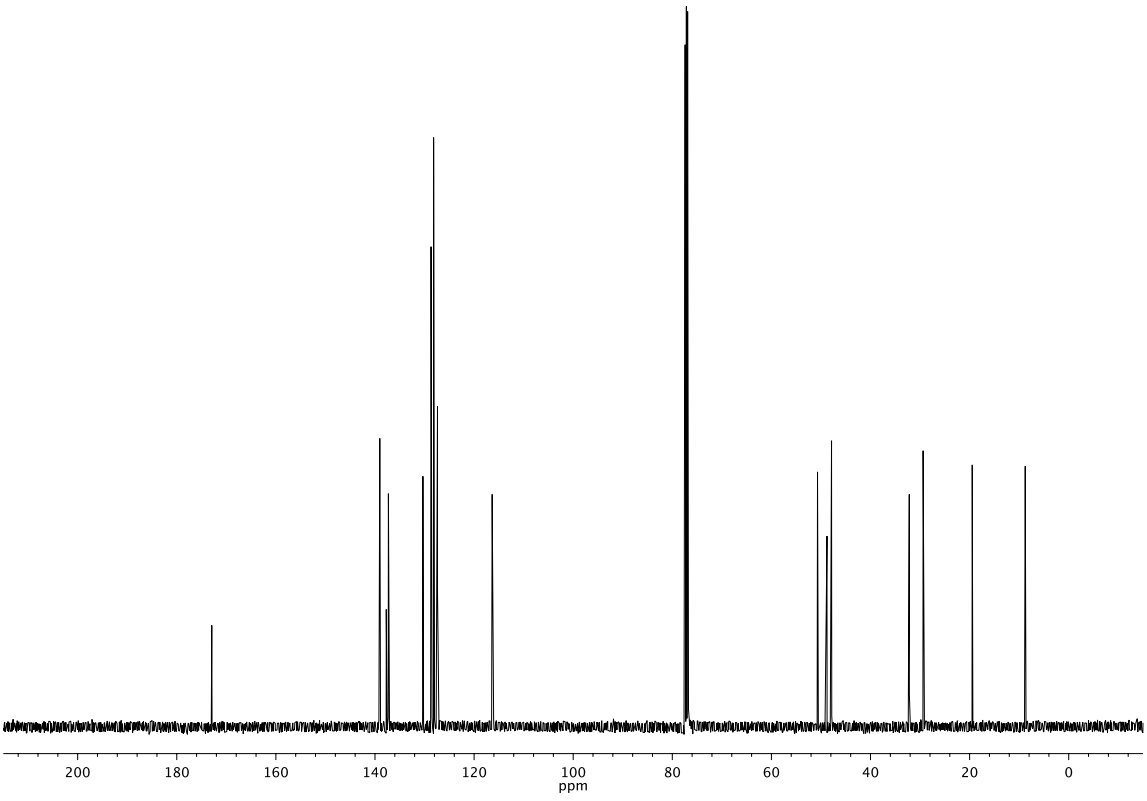
^{13}C NMR (126 MHz, $CDCl_3$) of compound **15**.



^{1}H NMR (500 MHz, $CDCl_3$) of compound **S14**.

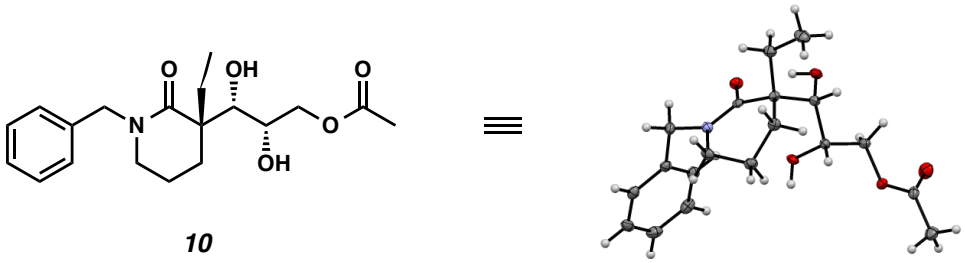


Infrared spectrum (Thin Film, NaCl) of compound **S14**.



^{13}C NMR (126 MHz, $CDCl_3$) of compound **S14**.

Crystallography Data for 3-(1-benzyl-3-ethyl-2-oxopiperidin-3-yl)-2,3-dihydroxypropyl acetate (10)



10

Low-temperature diffraction data (ϕ-and ω-scans) were collected on a Bruker AXS D8 VENTURE KAPPA diffractometer coupled to a PHOTON 100 CMOS detector with Cu K_α radiation (λ = 1.54178 Å) from an IμS micro-source for the structure of compound **10**. The structure was solved by direct methods using SHELXS and refined against F^2 on all data by full-matrix least squares with SHELXL-2014 using established refinement techniques. 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).

Compound **10** crystallizes in the orthorhombic space group $P2_12_12_1$ with one molecule in the asymmetric unit. The coordinates for the hydrogen atoms bound to O2 and O3 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).

Table 1. Crystal data and structure refinement for compound **10**.

CCDC deposition number	1057691	
Empirical formula	C19 H27 N O5	
Formula weight	349.41	
Temperature	100(2) K	
Wavelength	1.54178 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 7.8598(4) Å	a= 90°.
	b = 11.0342(6) Å	b= 90°.
	c = 20.5656(13) Å	g = 90°.
Volume	1783.58(17) Å^3	
Z	4	
Density (calculated)	1.301 Mg/m^3	
Absorption coefficient	0.767 mm^{-1}	
F(000)	752	

Crystal size	0.150 x 0.100 x 0.100 mm^3
Theta range for data collection	4.299 to 74.529°.
Index ranges	-9<=h<=9, -8<=k<=13, -25<=l<=25
Reflections collected	12461
Independent reflections	3592 [R(int) = 0.0553]
Completeness to theta = 67.679°	99.9 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7538 and 0.6907
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	3592 / 2 / 234
Goodness-of-fit on F^2	1.056
Final R indices [I>2sigma(I)]	R1 = 0.0368, wR2 = 0.0729
R indices (all data)	R1 = 0.0470, wR2 = 0.0765
Absolute structure parameter	0.00(14)
Extinction coefficient	n/a
Largest diff. peak and hole	0.182 and -0.201 $e.Å^{-3}$

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

	x	y	z	U(eq)
N(1)	3370(3)	3133(2)	986(1)	16(1)
C(13)	1612(3)	3420(2)	809(1)	18(1)
C(21)	831(3)	4438(2)	1206(1)	16(1)
C(22)	282(3)	5492(2)	901(1)	18(1)
C(23)	-554(3)	6393(2)	1254(1)	21(1)
C(24)	-825(3)	6248(2)	1914(1)	23(1)
C(25)	-244(3)	5205(2)	2224(1)	22(1)
C(26)	579(3)	4304(2)	1873(1)	19(1)
C(1)	3702(3)	2140(2)	1342(1)	14(1)
O(1)	2533(2)	1498(1)	1558(1)	17(1)
C(2)	5551(3)	1718(2)	1435(1)	13(1)
C(6)	5875(3)	1416(2)	2158(1)	14(1)
O(2)	4694(2)	530(1)	2395(1)	16(1)
C(7)	5905(3)	2505(2)	2618(1)	14(1)
O(3)	4348(2)	3153(2)	2569(1)	17(1)
C(8)	6201(3)	2075(2)	3309(1)	17(1)
O(4)	6995(2)	3075(1)	3653(1)	17(1)
O(5)	6468(3)	2166(2)	4609(1)	26(1)
C(9)	7090(3)	2982(2)	4303(1)	18(1)
C(10)	8103(4)	4004(2)	4588(1)	23(1)
C(11)	5664(3)	524(2)	1031(1)	18(1)
C(12)	7406(4)	-94(2)	1031(2)	25(1)
C(3)	6887(3)	2629(2)	1183(1)	16(1)
C(4)	6245(3)	3928(2)	1163(1)	19(1)
C(5)	4663(3)	3988(2)	751(1)	18(1)

Table 3. Bond lengths [Å] and angles [°] for compound **10**.

N(1)-C(1)	1.343(3)
N(1)-C(13)	1.464(3)
N(1)-C(5)	1.469(3)
C(13)-C(21)	1.519(3)
C(13)-H(13A)	0.9900
C(13)-H(13B)	0.9900
C(21)-C(22)	1.390(3)
C(21)-C(26)	1.394(4)
C(22)-C(23)	1.395(4)
C(22)-H(22)	0.9500
C(23)-C(24)	1.384(4)
C(23)-H(23)	0.9500
C(24)-C(25)	1.392(4)
C(24)-H(24)	0.9500
C(25)-C(26)	1.388(4)
C(25)-H(25)	0.9500
C(26)-H(26)	0.9500
C(1)-O(1)	1.241(3)
C(1)-C(2)	1.539(3)
C(2)-C(3)	1.543(3)
C(2)-C(6)	1.544(3)
C(2)-C(11)	1.560(3)
C(6)-O(2)	1.434(3)
C(6)-C(7)	1.530(3)
C(6)-H(6)	1.0000
O(2)-H(2O)	0.83(2)
C(7)-O(3)	1.421(3)
C(7)-C(8)	1.517(3)
C(7)-H(7)	1.0000
O(3)-H(3O)	0.83(2)
C(8)-O(4)	1.452(3)
C(8)-H(8A)	0.9900
C(8)-H(8B)	0.9900
O(4)-C(9)	1.344(3)

O(5)-C(9)	1.203(3)
C(9)-C(10)	1.499(4)
C(10)-H(10A)	0.9800
C(10)-H(10B)	0.9800
C(10)-H(10C)	0.9800
C(11)-C(12)	1.529(4)
C(11)-H(11A)	0.9900
C(11)-H(11B)	0.9900
C(12)-H(12A)	0.9800
C(12)-H(12B)	0.9800
C(12)-H(12C)	0.9800
C(3)-C(4)	1.521(3)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-C(5)	1.505(4)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900

C(1)-N(1)-C(13)	119.7(2)
C(1)-N(1)-C(5)	124.7(2)
C(13)-N(1)-C(5)	115.59(19)
N(1)-C(13)-C(21)	114.0(2)
N(1)-C(13)-H(13A)	108.8
C(21)-C(13)-H(13A)	108.8
N(1)-C(13)-H(13B)	108.8
C(21)-C(13)-H(13B)	108.8
H(13A)-C(13)-H(13B)	107.6
C(22)-C(21)-C(26)	119.3(2)
C(22)-C(21)-C(13)	120.0(2)
C(26)-C(21)-C(13)	120.6(2)
C(21)-C(22)-C(23)	120.6(3)
C(21)-C(22)-H(22)	119.7
C(23)-C(22)-H(22)	119.7
C(24)-C(23)-C(22)	120.0(2)

C(24)-C(23)-H(23)	120.0
C(22)-C(23)-H(23)	120.0
C(23)-C(24)-C(25)	119.6(2)
C(23)-C(24)-H(24)	120.2
C(25)-C(24)-H(24)	120.2
C(26)-C(25)-C(24)	120.5(3)
C(26)-C(25)-H(25)	119.7
C(24)-C(25)-H(25)	119.7
C(25)-C(26)-C(21)	120.1(2)
C(25)-C(26)-H(26)	120.0
C(21)-C(26)-H(26)	120.0
O(1)-C(1)-N(1)	121.1(2)
O(1)-C(1)-C(2)	118.8(2)
N(1)-C(1)-C(2)	119.9(2)
C(1)-C(2)-C(3)	113.80(19)
C(1)-C(2)-C(6)	109.93(19)
C(3)-C(2)-C(6)	110.59(19)
C(1)-C(2)-C(11)	104.10(18)
C(3)-C(2)-C(11)	109.40(19)
C(6)-C(2)-C(11)	108.73(19)
O(2)-C(6)-C(7)	109.6(2)
O(2)-C(6)-C(2)	111.61(19)
C(7)-C(6)-C(2)	115.36(18)
O(2)-C(6)-H(6)	106.6
C(7)-C(6)-H(6)	106.6
C(2)-C(6)-H(6)	106.6
C(6)-O(2)-H(2O)	104(2)
O(3)-C(7)-C(8)	110.8(2)
O(3)-C(7)-C(6)	109.76(19)
C(8)-C(7)-C(6)	109.65(18)
O(3)-C(7)-H(7)	108.9
C(8)-C(7)-H(7)	108.9
C(6)-C(7)-H(7)	108.9
C(7)-O(3)-H(3O)	109(2)
O(4)-C(8)-C(7)	106.53(18)
O(4)-C(8)-H(8A)	110.4

C(7)-C(8)-H(8A)	110.4
O(4)-C(8)-H(8B)	110.4
C(7)-C(8)-H(8B)	110.4
H(8A)-C(8)-H(8B)	108.6
C(9)-O(4)-C(8)	116.82(19)
O(5)-C(9)-O(4)	123.7(2)
O(5)-C(9)-C(10)	125.1(2)
O(4)-C(9)-C(10)	111.1(2)
C(9)-C(10)-H(10A)	109.5
C(9)-C(10)-H(10B)	109.5
H(10A)-C(10)-H(10B)	109.5
C(9)-C(10)-H(10C)	109.5
H(10A)-C(10)-H(10C)	109.5
H(10B)-C(10)-H(10C)	109.5
C(12)-C(11)-C(2)	115.3(2)
C(12)-C(11)-H(11A)	108.4
C(2)-C(11)-H(11A)	108.4
C(12)-C(11)-H(11B)	108.4
C(2)-C(11)-H(11B)	108.4
H(11A)-C(11)-H(11B)	107.5
C(11)-C(12)-H(12A)	109.5
C(11)-C(12)-H(12B)	109.5
H(12A)-C(12)-H(12B)	109.5
C(11)-C(12)-H(12C)	109.5
H(12A)-C(12)-H(12C)	109.5
H(12B)-C(12)-H(12C)	109.5
C(4)-C(3)-C(2)	113.4(2)
C(4)-C(3)-H(3A)	108.9
C(2)-C(3)-H(3A)	108.9
C(4)-C(3)-H(3B)	108.9
C(2)-C(3)-H(3B)	108.9
H(3A)-C(3)-H(3B)	107.7
C(5)-C(4)-C(3)	109.3(2)
C(5)-C(4)-H(4A)	109.8
C(3)-C(4)-H(4A)	109.8
C(5)-C(4)-H(4B)	109.8

C(3)-C(4)-H(4B)	109.8
H(4A)-C(4)-H(4B)	108.3
N(1)-C(5)-C(4)	111.0(2)
N(1)-C(5)-H(5A)	109.4
C(4)-C(5)-H(5A)	109.4
N(1)-C(5)-H(5B)	109.4
C(4)-C(5)-H(5B)	109.4
H(5A)-C(5)-H(5B)	108.0

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for compound **10**. 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)	15(1)	16(1)	2(1)	-1(1)	0(1)
C(13)	19(1)	20(1)	16(1)	-1(1)	-5(1)	3(1)
C(21)	12(1)	16(1)	21(1)	-2(1)	-2(1)	-2(1)
C(22)	15(1)	21(1)	19(1)	0(1)	-1(1)	-4(1)
C(23)	18(1)	14(1)	31(2)	1(1)	-2(1)	-1(1)
C(24)	18(1)	21(1)	31(2)	-9(1)	3(1)	-2(1)
C(25)	18(1)	31(1)	18(2)	-4(1)	1(1)	-5(1)
C(26)	17(1)	21(1)	20(1)	2(1)	-1(1)	-2(1)
C(1)	17(1)	13(1)	11(1)	-4(1)	-1(1)	-1(1)
O(1)	14(1)	17(1)	21(1)	0(1)	2(1)	-3(1)
C(2)	11(1)	14(1)	14(1)	-1(1)	1(1)	-1(1)
C(6)	12(1)	11(1)	17(1)	0(1)	1(1)	0(1)
O(2)	20(1)	11(1)	19(1)	2(1)	1(1)	-2(1)
C(7)	14(1)	12(1)	16(1)	0(1)	-1(1)	1(1)
O(3)	18(1)	10(1)	22(1)	-1(1)	-1(1)	3(1)
C(8)	22(1)	11(1)	17(1)	-2(1)	-2(1)	0(1)
O(4)	22(1)	15(1)	14(1)	-1(1)	-4(1)	-1(1)
O(5)	30(1)	31(1)	18(1)	3(1)	2(1)	-5(1)
C(9)	17(1)	21(1)	15(1)	-1(1)	-2(1)	4(1)
C(10)	22(1)	25(1)	21(1)	-6(1)	-2(1)	2(1)
C(11)	20(1)	16(1)	18(1)	-1(1)	2(1)	0(1)
C(12)	29(2)	20(1)	27(2)	-4(1)	5(1)	6(1)
C(3)	14(1)	18(1)	17(1)	1(1)	2(1)	-2(1)
C(4)	20(1)	16(1)	20(1)	1(1)	1(1)	-4(1)
C(5)	22(1)	16(1)	18(1)	3(1)	3(1)	-1(1)

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

	x	y	z	U(eq)
H(13A)	908	2683	862	22
H(13B)	1579	3649	343	22
H(22)	477	5599	449	22
H(23)	-936	7107	1040	25
H(24)	-1403	6857	2155	28
H(25)	-414	5109	2678	27
H(26)	972	3595	2089	23
H(6)	7029	1037	2181	16
H(2O)	3780(30)	710(30)	2213(14)	25
H(7)	6860	3054	2489	17
H(3O)	4550(40)	3884(19)	2621(15)	25
H(8A)	5108	1855	3517	20
H(8B)	6954	1356	3312	20
H(10A)	7558	4284	4989	34
H(10B)	8156	4674	4275	34
H(10C)	9258	3723	4685	34
H(11A)	4815	-56	1203	22
H(11B)	5347	708	576	22
H(12A)	8281	495	905	38
H(12B)	7400	-766	719	38
H(12C)	7654	-405	1467	38
H(3A)	7903	2591	1467	20
H(3B)	7241	2385	740	20
H(4A)	5988	4211	1609	22
H(4B)	7132	4463	977	22
H(5A)	4197	4821	763	22
H(5B)	4954	3793	295	22

Table 6. Torsion angles [°] for compound **10**.

C(1)-N(1)-C(13)-C(21)	103.5(3)
C(5)-N(1)-C(13)-C(21)	-76.4(3)
N(1)-C(13)-C(21)-C(22)	119.0(2)
N(1)-C(13)-C(21)-C(26)	-64.2(3)
C(26)-C(21)-C(22)-C(23)	-1.7(4)
C(13)-C(21)-C(22)-C(23)	175.1(2)
C(21)-C(22)-C(23)-C(24)	0.7(4)
C(22)-C(23)-C(24)-C(25)	0.6(4)
C(23)-C(24)-C(25)-C(26)	-1.0(4)
C(24)-C(25)-C(26)-C(21)	-0.1(4)
C(22)-C(21)-C(26)-C(25)	1.4(4)
C(13)-C(21)-C(26)-C(25)	-175.4(2)
C(13)-N(1)-C(1)-O(1)	-4.4(3)
C(5)-N(1)-C(1)-O(1)	175.6(2)
C(13)-N(1)-C(1)-C(2)	169.9(2)
C(5)-N(1)-C(1)-C(2)	-10.1(3)
O(1)-C(1)-C(2)-C(3)	-176.6(2)
N(1)-C(1)-C(2)-C(3)	9.0(3)
O(1)-C(1)-C(2)-C(6)	-51.9(3)
N(1)-C(1)-C(2)-C(6)	133.7(2)
O(1)-C(1)-C(2)-C(11)	64.4(3)
N(1)-C(1)-C(2)-C(11)	-110.0(2)
C(1)-C(2)-C(6)-O(2)	56.0(2)
C(3)-C(2)-C(6)-O(2)	-177.47(19)
C(11)-C(2)-C(6)-O(2)	-57.3(2)
C(1)-C(2)-C(6)-C(7)	-69.9(2)
C(3)-C(2)-C(6)-C(7)	56.6(3)
C(11)-C(2)-C(6)-C(7)	176.78(19)
O(2)-C(6)-C(7)-O(3)	-70.0(2)
C(2)-C(6)-C(7)-O(3)	57.0(3)
O(2)-C(6)-C(7)-C(8)	52.0(3)
C(2)-C(6)-C(7)-C(8)	178.9(2)
O(3)-C(7)-C(8)-O(4)	-84.9(2)
C(6)-C(7)-C(8)-O(4)	153.74(19)

C(7)-C(8)-O(4)-C(9)	168.1(2)
C(8)-O(4)-C(9)-O(5)	-4.8(4)
C(8)-O(4)-C(9)-C(10)	173.7(2)
C(1)-C(2)-C(11)-C(12)	179.2(2)
C(3)-C(2)-C(11)-C(12)	57.3(3)
C(6)-C(2)-C(11)-C(12)	-63.6(3)
C(1)-C(2)-C(3)-C(4)	24.6(3)
C(6)-C(2)-C(3)-C(4)	-99.7(2)
C(11)-C(2)-C(3)-C(4)	140.5(2)
C(2)-C(3)-C(4)-C(5)	-56.6(3)
C(1)-N(1)-C(5)-C(4)	-23.0(3)
C(13)-N(1)-C(5)-C(4)	156.9(2)
C(3)-C(4)-C(5)-N(1)	55.1(3)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for compound **10** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(2)-H(2O)...O(1)	0.83(2)	1.88(2)	2.645(2)	152(3)
O(3)-H(3O)...O(2)#1	0.83(2)	1.91(2)	2.730(2)	169(3)
C(10)-H(10C)...O(5)#2	0.98	2.47	3.374(3)	153.9
C(4)-H(4A)...O(2)#1	0.99	2.57	3.530(3)	163.7
C(4)-H(4A)...O(3)	0.99	2.63	3.364(3)	131.0

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