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Supporting Information

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Ring-Contraction Strategy for the Practical, Scalable, Catalytic Asymmetric Synthesis of Versatile γ-Quaternary Acylcyclopentenes**

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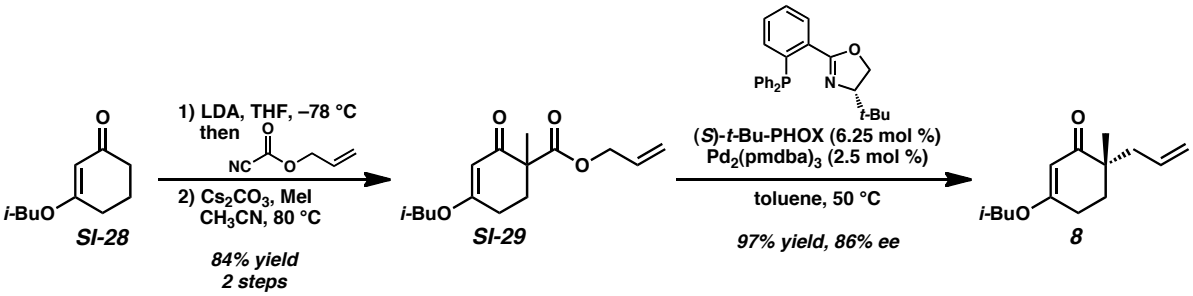
Materials and Methods. Unless otherwise stated, reactions were performed in flame-dried glassware under an argon or nitrogen atmosphere using dry, deoxygenated solvents. Reaction progress was monitored by thin-layer chromatography (TLC). THF was distilled over sodium/fluorenone or dried by passage through an activated alumina column under argon prior to use. *p*-Dioxane was distilled over sodium or dried by passage through an activated alumina column under argon prior to use. Methanol was distilled over $Mg(OMe)_2$ prior to use. Other solvents were dried by passage through an activated alumina column under argon. Diisopropylamine and triethylamine were distilled over CaH_2 prior to use. Iodomethane, iodoethane, acrylonitrile, and acrolein were distilled prior to use. Purified water was obtained using a Barnstead NANOpure Infinity UV/UF system. Brine solutions are saturated aqueous solutions of sodium chloride. $MePh_3PBr$ from Sigma-Aldrich was stored in a glove box prior to use. NaH (60% wt. dispersion in mineral oil) from Sigma-Aldrich was purified by trituration with hexanes under a N_2 atmosphere and removal of residual solvent under vacuum. $LiOCH_2CF_3$ was prepared according to the method of Shreeve.[1] Allyl cyanoformate was prepared according to the method of Mander or Rattigan.[2] Gramine methiodide was prepared according to the method of Armen.[3] The procedure of Maruyama and Naruta was used to prepare 1-chloro-2,4-pentadiene (92:8 *E*:*Z*).[4] Phosphinooxazoline (PHOX) ligands were prepared by methods described in our previous work.[5] Tris(4,4'-methoxydibenzylideneacetone)dipalladium(0) ($Pd_2(pmdba)_3$) was prepared according to the method of Ibers[6] or Fairlamb.[7] Herrmann's catalyst was prepared according to a literature procedure.[8] All other reagents were purchased from Sigma-Aldrich, Acros Organics, Strem, or Alfa Aesar and used as received unless otherwise stated. Reaction temperatures were controlled by an IKAmag temperature modulator. Microwave-assisted reactions were performed in a Biotage Initiator 2.5 microwave reactor. Glove box manipulations were performed under a N_2 atmospere. TLC was performed using E. Merck silica gel 60 F254 precoated glass plates (0.25 mm) and visualized by UV fluorescence quenching, *p*-anisaldehyde, or $KMnO_4$ staining. ICN silica gel (particle size 0.032–0.0653 mm) was used for flash column chromatography. Automated flash column chromatography was performed on a Teledyne Isco CombiFlash R_f system. ^{1}H NMR spectra were recorded on a Varian Mercury 300 MHz, a Varian 400 MR 400 MHz, or a Varian Inova 500 MHz spectrometer and are reported relative to residual $CHCl_3$ (δ 7.26 ppm). ^{13}C NMR spectra are recorded on a Varian Mercury 300 MHz, a Varian 400 MR 400 MHz, or a Varian Inova 500 MHz spectrometer (at 75 MHz, 100 MHz, and 125 MHz respectively) and are reported relative to $CDCl_3$ (δ 77.16 ppm). Data for ^{1}H NMR are reported as follows: chemical shift (δ ppm) (multiplicity, coupling constant (Hz), integration). Multiplicities are reported as follows: s = singlet, d = doublet, t = triplet, q = quartet, p = pentet, sept = septuplet, m = multiplet, br s = broad singlet, br d = broad doublet, app = apparent. Data for ^{13}C are reported in terms of chemical shifts (δ ppm). IR spectra were obtained using a Perkin Elmer Paragon 1000 or Perkin Elmer Spectrum BXII spectrometer using thin films deposited on NaCl plates and reported in frequency of absorption (cm^{-1}). Optical rotations were measured with a Jasco P-1010 or Jasco P-2000 polarimeter operating on the sodium D-line (589 nm) using a 100 mm path-length cell and are reported as: $[\alpha]_D^T$ (concentration in g/100 mL, solvent, ee). Melting points were measured using a Thomas-Hoover capillary melting point apparatus and the reported values are uncorrected. Analytical chiral HPLC was performed with an Agilent 1100 Series HPLC utilizing a Chiralcel AD or OD-H columns (4.6 mm x 25 cm) obtained from Daicel Chemical Industries Ltd. with visualization at 254 nm. Analytical chiral SFC was performed with a Mettler Toledo SFC supercritical CO_2 analytical chromatography system with a Chiralcel AD-H column (4.6 mm x 25 cm) with visualization at 254 nm/210 nm. Analytical chiral GC was performed with an Agilent 6850 GC utilizing a G-TA (30 m x 0.25 mm) column (1.0 mL/min carrier gas flow). High-resolution mass

spectra (HRMS) were obtained from the Caltech Mass Spectral Facility (EI+ or FAB+) or on a Agilent 6200 Series TOF with an Agilent G1978A Multimode source in electrospray ionization (ESI+), atmospheric pressure chemical ionization (APCI+), or mixed (MM: ESI-APCI+) ionization mode.

List of Abbreviations. The following abbreviations are used in experimental procedures:

CDI = 1,1'-carbonyldiimidazole
DDQ = 2,3-dichloro-5,6-dicyano-*p*-benzoquinone
DMA = *N*,*N*'-dimethylacetamide
DMAD = dimethyl acetylenedicarboxylate
DMAP = 4-(dimethylamino)pyridine
DMF = *N*,*N*'-dimethylformamide
HFIP = 1,1,1,3,3,3-hexafluoro-2-propanol
i-Bu = isobutyl
IPA = isopropanol
LDA = lithium diisopropylamide
$Pd_2(pmdba)_3$ = tris(4,4'-methoxydibenzylideneacetone)dipalladium(0)
PHOX = phosphinooxazoline
PPTS = pyridinium *p*-toluenesulfonate
TBAA = tetrabutylammonium acetate
TBAF = tetrabutylammonium fluoride
TBAI = tetrabutylammonium iodide
TBDPS = *tert*-butyldiphenylsilyl
TBDPSCl = *tert*-butyl(chloro)diphenylsilane
TBSOTf = *tert*-butyldimethylsilyl trifluoromethanesulfonate
TFE = 2,2,2-trifluoroethanol
TMS = trimethylsilyl
TMSCl = chlorotrimethylsilane
μwaves = microwave irradiation

Procedure for the Synthesis of Cyclohexenone 9

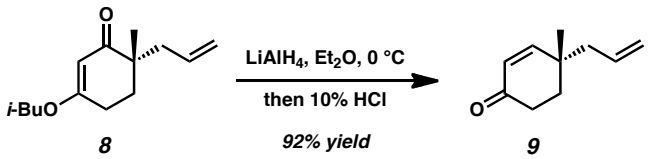


***β*-Ketoester SI-29.** To a solution of diisopropylamine (0.49 mL, 3.47 mmol, 1.17 equiv) in THF (10 mL) in a 50 mL round-bottom flask at 0 °C was added *n*-BuLi (1.70 mL, 3.40 mmol, 2.1 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the reaction was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **SI-28**[9] (0.50 g, 2.97 mmol, 1.00 equiv) in THF (5.0 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (0.37 mL, 3.40 mmol, 1.15 equiv) was added dropwise. The reaction was stirred at –78 °C for 2.5 h, quenched by addition of sat aqueous NH_4Cl and H_2O (5 mL each), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (25 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (2 x 25 mL) and the combined organic phases were dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford a pale red oil.

The crude oil was added to a 25 mL Schlenk flask and dissolved in CH_3CN (10 mL). MeI (0.56 mL, 8.90 mmol, 3.00 equiv) was added, followed by Cs_2CO_3 (1.26 g, 3.90 mmol, 1.30 equiv). The flask was sealed with a Teflon valve, immersed in an oil bath, and heated to 80 °C. After 14 h of vigorous stirring, the suspension was allowed to cool to ambient temperature, diluted with EtOAc (25 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 20 cm, 19:1→9:1→ 4:1, Hexanes:EtOAc) to afford *β*-ketoester **SI-29** (0.67 g, 2.52 mmol, 84% yield over 2 steps) as a pale yellow oil; R_f = 0.36 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.81 (dddd, *J* = 17.2, 10.7, 5.5, 5.5 Hz, 1H), 5.30 (s, 1H), 5.22 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.14 (app dq, *J* = 10.5, 1.3 Hz, 1H), 4.65–4.46 (m, 2H), 3.55 (d, *J* = 6.5 Hz, 2H), 2.60–2.23 (m, 3H), 1.97 (app sept, *J* = 6.6 Hz, 1H), 1.89–1.70 (m, 1H), 1.35 (s, 3H), 0.91 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 196.4, 176.7, 172.5, 131.9, 118.0, 101.7, 74.9, 65.5, 52.3, 31.7, 27.7, 26.3, 20.6, 19.0; IR (Neat Film NaCl) 2961, 2937, 2876, 1733, 1660, 1608, 1457, 1427, 1406, 1385, 1369, 1346, 1319, 1248, 1199, 1176, 1113, 1039, 991, 928, 837, 818, 772, 751 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{15}H_{22}O_4$ $[M]^{+\bullet}$: 266.1518; found 266.1510.

Vinylogous Ester 8. *β*-Ketoester **SI-29** (180 mg, 0.68 mmol, 1.00 equiv) in a 20 mL scintillation vial and a septum-fitted screw cap were evacuated/backfilled with N_2 (3 cycles, 5 min evacuation per cycle) in a glove box antechamber before being transferred into a glove box. A separate 20 mL scintillation vial in the glove box was loaded with (*S*)-*t*-Bu-PHOX (16.4 mg, 0.042 mmol, 6.25 mol %), $Pd_2(pmdba)_3$ (18.5 mg, 0.017 mmol, 2.5 mol %), and a magnetic stir bar. Toluene (4 mL) was added and the black suspension was stirred at 30 °C in a heating block for 30 min. *β*-Ketoester **SI-29** was dissolved in toluene (2.8 mL) and added to the orange catalyst solution, causing an immediate color change to olive green. The vial was capped with the septum-fitted screw cap and the edges were sealed with electrical tape. The vial was removed from the glove box, connected to a N_2-filled Schlenk manifold, and immersed in a 50 °C oil bath.

After 22 h, the reaction was an orange-brown solution. The mixture was concentrated under reduced pressure and purified by flash column chromatography (SiO_2, 2 x 25 cm, 20:1→10:1, Hexanes:EtOAc) to afford vinylogous ester **8** (146 mg, 0.66 mmol, 97% yield) as a clear, colorless oil; R_f = 0.57 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.81–5.63 (m, 1H), 5.22 (s, 1H), 5.08–4.98 (m, 2H), 3.56 (d, *J* = 6.5 Hz, 2H), 2.40 (app t, *J* = 6.4 Hz, 2H), 2.33 (dddd, *J* = 13.8, 7.6, 1.0, 1.0 Hz, 1H), 2.16 (dddd, *J* = 13.8, 7.6, 1.0, 1.0 Hz, 1H), 2.00 (app sept, *J* = 6.7 Hz, 1H), 1.90 (ddd, *J* = 13.4, 6.6, 6.6 Hz, 1H), 1.68 (ddd, *J* = 13.6, 6.2, 6.2 Hz, 1H), 1.06 (s, 3H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 203.5, 176.1, 134.4, 117.9, 101.4, 74.8, 43.3, 41.6, 31.9, 27.9, 26.0, 22.3, 19.2; IR (Neat Film NaCl) 3074, 2962, 2932, 2875, 1655, 1611, 1470, 1464, 1429, 1404, 1384, 1368, 1327, 1307, 1299, 1240, 1195, 1178, 1123, 1080, 1032, 996, 968, 951, 913, 862, 840, 806, 786, 736 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{14}H_{22}O_2$ $[M]^{+\bullet}$: 222.1620; found 222.1627; $[\alpha]_D^{25.0}$ –10.67 (*c* 0.98, $CHCl_3$, 86.3% ee); HPLC conditions: 5% IPA in Hexanes, OD-H column, t_R (min): major = 5.80, minor = 6.53.

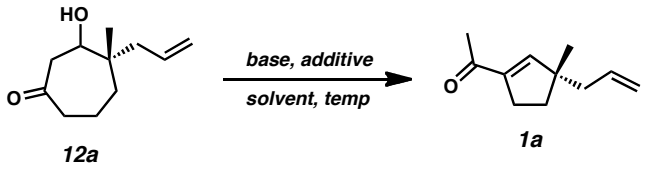


8 *9*

Cyclohexenone 9. A 50 mL round-bottom flask was charged with Et_2O (11.1 mL) and cooled to 0 °C. $LiAlH_4$ (13.6 mg, 0.36 mmol, 0.55 equiv) was added in one portion. After 10 min, a solution of vinylogous ester **8** (146 mg, 0.66 mmol, 1.00 equiv) in Et_2O (2.0 mL) was added dropwise using positive pressure cannulation. After 30 min of stirring at 0 °C, an additional portion of $LiAlH_4$ (2.5 mg, 0.066 mmol, 0.10 equiv) was added. After 60 min of stirring, the reaction was quenched by slow addition of aqueous HCl (1.0 mL, 10% w/w). The resulting biphasic system was allowed to warm to ambient temperature and stirred vigorously for 8.5 h. The phases were separated and the aqueous phase was extracted with Et_2O (3 x 15 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified using flash column chromatography (SiO_2, 2 x 25 cm, 10:1→4:1→1:1→1:2 Hexanes:Et_2O) to afford cyclohexenone **9** (90.5 mg, 0.60 mmol, 92% yield) as a yellow oil; R_f = 0.51 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.67 (d, *J* = 10.2 Hz, 1H), 5.88 (d, *J* = 10.2 Hz, 1H), 5.79 (dddd, *J* = 16.8, 10.3, 7.4, 7.4 Hz, 1H), 5.20–5.01 (m, 2H), 2.54–2.36 (m, 2H), 2.29–2.10 (m, 2H), 2.05–1.89 (m, 1H), 1.85–1.69 (m, 1H), 1.14 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 199.4, 158.4, 133.4, 127.6, 118.6, 45.2, 35.7, 34.1, 33.6, 24.7; IR (Neat Film NaCl) 3077, 3005, 2960, 2917, 2868, 2849, 1682, 1639, 1616, 1459, 1419, 1390, 1373, 1332, 1250, 1223, 1193, 1115, 996, 961, 918, 871, 803, 757 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{10}H_{14}O$ $[M]^{+\bullet}$: 150.1045; found 150.1056; $[\alpha]_D^{25.0}$ +26.72 (*c* 1.02, $CHCl_3$, 86.3% ee).

Ring Contraction Screening Protocol

Table SI-1. Ring Contraction Screen of β-Hydroxyketone 12a[a]

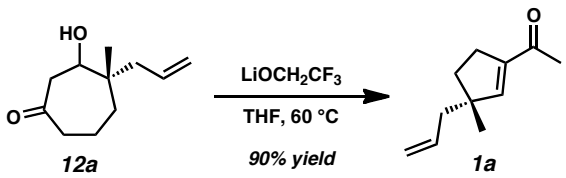


12a *1a*

Entry	Base	Additive	Solvent	T (°C)	time (h)	Yield (%)[b]
1	LiO*t*-Bu	—	*t*-BuOH	40	9	71
2	LiO*t*-Bu	—	THF	40	8	60
3	NaO*t*-Bu	—	THF	40	5	81
4	KO*t*-Bu	—	THF	40	5	85
5	NaOH	—	THF	60	4	89
6	KOH	—	THF	60	4	87
7	LiOH	—	THF	60	24	19[d]
8	LiOH	*t*-BuOH	THF	60	24	78
9	LiOH	HFIP[c]	THF	60	12.5	87
10	LiOH	TFE[c]	THF	60	12.5	96
11	$LiOCH_2CF_3$	—	THF	60	10	90[e]

[a] *Conditions*: β-hydroxyketone (1.0 equiv), additive (1.5 equiv), base (1.5 equiv) in solvent (0.1 M) at indicated temperature. [b] GC yield using an internal standard, unless otherwise stated. [c] HFIP = 1,1,1,3,3,3-hexafluoro-2-propanol; TFE = 2,2,2-trifluoroethanol. [d] Several reaction intermediates observed by TLC and GC analysis. [e] Isolated yield.

Ring Contraction Screen to Produce Acylcyclopentene 1a *(0.10 mmol scale, Table 1, entries 1–4 and Table SI-1, entries 1–10).* A benzene solution of β-hydroxyketone **12a** was transferred to a dry 1 dram vial and concentrated under reduced pressure to obtain a starting mass. To this vial was added a magnetic stir bar and 1,4-diisopropylbenzene (internal standard). The contents were solvated in either *t*-BuOH or THF (0.1 M). After complete solvation, an appropriate additive (*t*-BuOH, TFE, or HFIP; 1.50 equiv) was added, followed by base (1.50 equiv). The head space of the vial was purged with N_2, and the vial was capped with a teflon-lined hard cap and stirred the appropriate temperature (40 or 60 °C) in a heating block. Reaction progress was initially followed by TLC analysis and when necessary aliquots were removed and flushed through a small SiO_2 plug with EtOAc for GC analysis. GC conditions: 90 °C isothermal for 5 min, then ramp 10 °C/min to 250 °C, DB-WAX column, t_R (min): 1,4-diisopropylbenzene = 5.3, acylcyclopentene **1a** = 9.3, β-hydroxyketone **12a** = 17.1 and 17.2 (two diastereomers). (For characterization data, see p. 33).



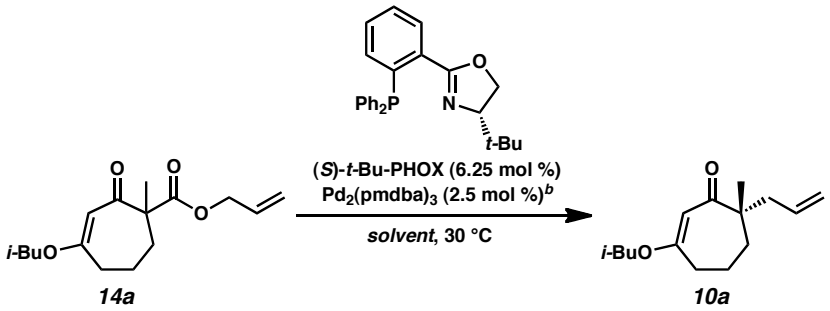
12a *1a*

Ring Contraction using $LiOCH_2CF_3$ *(Table SI-1, entry 11).* β-Hydroxyketone **12a** (30.0 mg, 0.16 mmol, 1.00 equiv) was measured into a 1 dram vial with magnetic stir bar with a septum-fitted screw cap. $LiOCH_2CF_3$[1] (26.0 mg, 0.25 mmol, 1.50 equiv) was measured into a separate 1

dram vial, capped with a septum, evacuated/backfilled with N_2 (3 cycles, 5 min evacuation per cycle), and dissolved in THF (0.5 mL). The solution was cannulated into the vial containing β-hydroxyketone along with additional THF rinses (2 x 0.5 mL). The yellow solution was stirred at 60 °C in a heating block. After 10 h, the reaction was cooled to ambient temperature. The tubid brown solution was diluted with Et_2O and stirred with Na_2SO_4 for 30 min. The reaction was filtered and concentrated in vacuo at 0 °C in an ice/water bath. The residue was purified by flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O) to afford acylcyclopentene **1a** (24.4 mg, 0.149 mmol, 90% yield) as a clear, colorless oil. (For characterization data, see p. 33).

Enantioselective Pd-Catalyzed Decarboxylative Alkylation Screening Protocol

Table SI-2. Solvent Screen for the Enantioselective Alkylation of 14a[a]

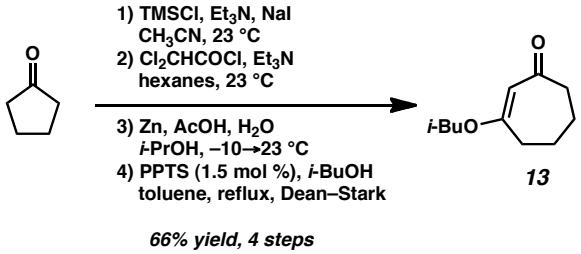


Entry	Solvent	Yield (%)[c]	ee (%)[d]
1	THF	94	84
2	TBME[e]	88	85
3	Et_2O	93	86
4	benzene	84	86
5	toluene	91	88

[a] *Conditions*: β-ketoester (1.0 equiv), $Pd_2(pmdba)_3$ (2.5 mol %), (*S*)-*t*-Bu-PHOX (6.25 mol %) in solvent (0.1 M) at 30 °C.
[b] pmdba = 4,4'-methoxydibenzylideneacetone. [c] Isolated yield.
[d] Determined by chiral HPLC. [e] TBME = *tert*-butyl methyl ether.

Enantioselective Allylation Screen to Produce Vinylogous Ester 10a *(0.20 mmol scale).* To a 25 mL flask was added $Pd_2(pmdba)_3$ (5.00 μmol, 2.5 mol %) and (*S*)-*t*-Bu-PHOX (12.5 μmol, 6.25 mol %). The flask was evacuated/backfilled with N_2 (3 cycles, 5 min evacuation per cycle). Solvent (most of total volume, 0.1 M final concentration) was added and the black suspension was stirred for 30 min at 30 °C using an oil bath. A solution of β-ketoester **14a** (0.20 mmol, 1.00 equiv) in solvent (remainder of total volume) was transferred to the catalyst solution using positive pressure cannulation. When judged complete by TLC analysis, the reaction was filtered through a small plug of SiO_2, eluted with Et_2O, and concentrated under reduced pressure. Purification by flash column chromatography (SiO_2, 1.5 x 15 cm, 9:1→6:1 Hexanes:EtOAc) or preparative TLC (SiO_2, 2:1 Hexanes:EtOAc) provided ketone **10a** for analysis. HPLC conditions: 1% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): major = 6.30, minor = 7.26. (For characterization data, see p. 22).

Procedures for the Synthesis of Parent Vinylogous Ester 13[10]



Vinylogous ester 13. NaI (157 g, 1.05 mol, 1.25 equiv) was placed in a 3 L 3-neck round-bottom flask, dried under high vacuum at 90 °C for 12 h, and allowed to cool to ambient temperature under N_2. CH_3CN (1.3 L) was added to dissolve the NaI. To the solution was added cyclopentanone (74.3 mL, 0.84 mol, 1.00 equiv), followed by Et_3N (146 mL, 1.05 mol, 1.25 equiv). The flask was fitted with an addition funnel, and the funnel was charged with TMSCl (122 mL, 0.96 mmol, 1.14 equiv), which was added dropwise over 30 min. The resulting suspension was stirred for an additional 1 h at ambient temperature. Pentane (1.0 L) was added, and the biphasic system was stirred vigorously for 10 min. The phases were separated and the CH_3CN layer was extracted with pentane (3 x 400 mL). The combined pentane phases were washed with H_2O (2 x 500 mL) and brine (500 mL), dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford the desired product (131 g, quantitative) as a colorless oil.

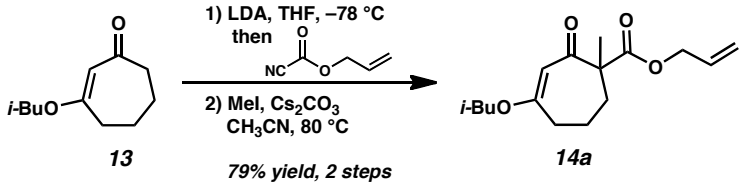
A portion of the above trimethylsilylether (89.7 g, 0.57 mol, 1.00 equiv) was placed in a 3 L 3-neck round-bottom flask fitted with a stopper, an addition funnel, and an overhead stirrer. Hexanes (900 mL) was added followed by Et_3N (111 mL, 0.80 mol, 1.39 equiv). Dichloroacetyl chloride (66.4 mL, 0.69 mol, 1.21 equiv) was dissolved in hexanes (400 mL) and added dropwise over 9.5 h. After 18 h of stirring at ambient temperature, the brown suspension was filtered, rinsing with EtOAc (3 x 500 mL). The clear brown solution was concentrated under reduced pressure and then filtered through a pad of Al_2O_3 (7 x 18 cm, neutral) using EtOAc as eluent. The solution was concentrated under reduced pressure to afford the desired product (125 g, 0.47 mol, 82% yield) as a brown oil that crystallized in the freezer (–20 °C).

A portion of the above dichlorocyclobutanone (53.4 g, 0.20 mol, 1.00 equiv) was placed in a 3 L 3-neck round-bottom flask fitted with a thermometer, an addition funnel, and an overhead stirrer. Isopropyl alcohol and purified water (170 mL each) were added and the suspension was cooled to –10 °C (internal temperature) using a MeOH/ice bath. Zn dust (58.8 g, 0.90 mol, 4.50 equiv) was added in four portions (5 min between each) and AcOH (63 mL, 1.10 mol, 5.50 equiv) dissolved in H_2O (130 mL) was added dropwise while keeping the internal temperature below 0 °C (usually added over 1.5 h). The reaction was stirred for an additional 30 min at –10 °C (internal temperature) before the cooling bath was removed and the reaction was allowed to warm to ambient temperature. After 8.5 h, the reaction was filtered, rinsing with isopropyl alcohol (100 mL). The mixture was cooled to 0 °C and neutralized by portionwise addition of K_2CO_3 (74.6 g, 0.54 mol, 5.50 equiv). The viscous suspension was filtered, rinsing with H_2O (100 mL) and EtOAc (300 mL). The biphasic system was concentrated under reduced pressure to ~200 mL and extracted with CH_2Cl_2. The combined organics were dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford the desired product (24.2 g, 0.19 mol, 96% yield) as a pale orange oil.

To a solution of 1,3-cycloheptanedione (35.8 g, 0.28 mol, 1.00 equiv) in toluene (280 mL) in a 1 L flask fitted with a reflux condenser and Dean–Stark trap was added isobutanol (208

mL, 2.27 mol, 8.11 equiv) and pyridinium *p*-toluenesulfonate (1.07 g, 4.26 mmol, 1.50 mol %). The solution was immersed in an oil bath at 130 °C and monitored by TLC. When the starting material was consumed (typically within 4–6 h), the reaction was allowed to cool to ambient temperature. The resulting dark orange solution was washed with sat aqueous $NaHCO_3$ (200 mL). The aqueous phase was extracted with EtOAc (3 x 150 mL) and the combined organics were washed with brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford a thick dark orange oil. The crude oil was flushed through a silica gel plug (SiO_2, 7 x 9 cm, 1:4→3:7→1:1 Et_2O-Hexanes) to afford vinylogous ester **13** (43.5 g, 0.24 mol, 84% yield, 66% yield over 4 steps) as a pale orange oil; R_f = 0.22 (2:1 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.37 (s, 1H), 3.49 (d, *J* = 6.6 Hz, 2H), 2.60–2.56 (m, 4H), 2.00 (sept, *J* = 6.6 Hz, 1H), 1.88–1.77 (m, 4H), 0.96 (d, *J* = 6.8 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 202.5, 176.6, 106.0, 75.0, 41.9, 33.1, 27.9, 23.7, 21.5, 19.3; IR (Neat Film NaCl) 2958, 2872, 1646, 1607, 1469, 1237, 1190, 1174 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{11}H_{18}O_2$ $[M]^{+\bullet}$: 182.1307; found 182.1310.

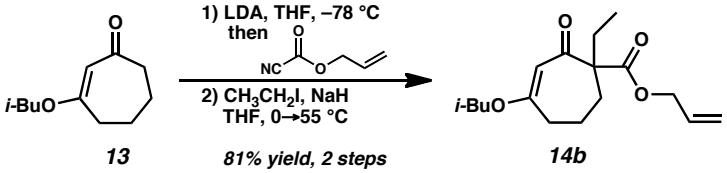
Procedures for the Preparation of β-Ketoesters 14



β-Ketoester 14a. To a solution of diisopropylamine (6.46 mL, 46.1 mmol, 1.20 equiv) in THF (180 mL) in a 500 mL round-bottom flask at 0 °C was added *n*-BuLi (17.2 mL, 44.2 mmol, 2.57 M in hexanes, 1.15 equiv) dropwise over 15 min using a syringe pump. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (7.01 g, 38.4 mmol, 1.00 equiv) in THF (20 mL) was added dropwise over 20 min using a syringe pump. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (4.60 mL, 42.2 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of sat aqueous NH_4Cl and H_2O (30 mL each), and allowed to warm to ambient temperature. The reaction was diluted with Et_2O (100 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (2 x 100 mL). The combined organic phases were dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford a pale orange oil.

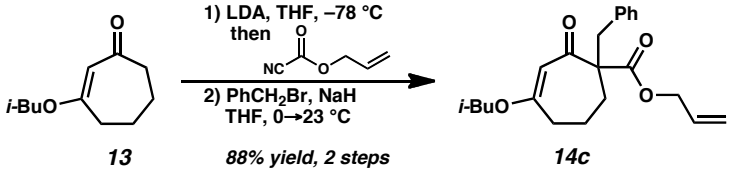
The crude oil was dissolved in CH_3CN (130 mL) in a 500 mL round-bottom flask and treated with MeI (7.2 mL, 115 mmol, 3.00 equiv) and Cs_2CO_3 (16.76 g, 49.9 mmol, 1.30 equiv). The flask was fitted with a condenser, immersed in an oil bath, and heated to 80 °C with vigorous stirring. After 12 h of stirring at 80 °C, the reaction was allowed to cool to ambient temperature, diluted with EtOAc (100 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford an orange oil. The crude product was purified by flash column chromatography (SiO_2, 5 x 15 cm, 19:1→9:1 Hexanes:EtOAc, dry-loaded using Celite) to afford β-ketoester **14a** (8.51 g, 30.4 mmol, 79% yield over 2 steps) as a pale yellow oil; R_f = 0.43 (4:1 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.86 (dddd, *J* = 17.1, 10.7, 5.6, 5.6 Hz, 1H), 5.39 (s, 1H), 5.29 (app dq, *J* = 17.1, 1.5 Hz, 1H), 5.20 (app dq, *J* = 10.5, 1.4 Hz, 1H), 4.62 (dddd, *J* = 13.3, 5.6, 1.2, 1.2 Hz, 1H), 4.56 (dddd, *J* = 13.4, 5.6, 1.2, 1.2 Hz, 1H), 3.54–3.42 (m, 2H),

2.59 (ddd, J = 17.8, 9.8, 3.9 Hz, 1H), 2.45–2.38 (m, 2H), 2.02–1.94 (m, 2H), 1.84–1.75 (m, 1H), 1.70 (ddd, J = 14.4, 7.3, 4.4 Hz, 1H), 1.43 (s, 3H), 0.94 (d, J = 6.6 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 199.1, 174.0, 173.5, 132.0, 118.4, 105.2, 74.8, 65.8, 59.1, 34.3, 33.9, 27.9, 24.2, 21.4, 19.3; IR (Neat Film NaCl) 2959, 2936, 2875, 1734, 1650, 1613, 1456, 1384, 1233, 1170, 1115, 994 cm^{-1}; HRMS (EI+) m/z calc'd for $C_{16}H_{24}O_4$ $[M]^{+\bullet}$: 280.1675; found 280.1686.



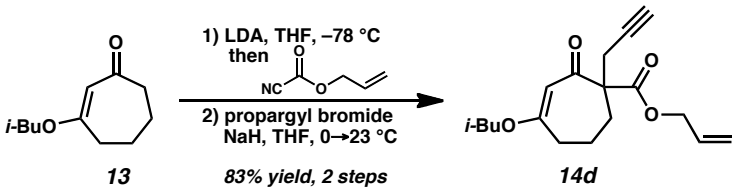
β-Ketoester 14b. To a solution of diisopropylamine (0.92 mL, 6.58 mmol, 1.20 equiv) in THF (27 mL) in a 100 mL round-bottom flask at 0 °C was added *n*-BuLi (2.56 mL, 6.30 mmol, 2.46 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (1.00 g, 5.48 mmol, 1.00 equiv) in THF (2 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (0.67 mL, 6.02 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (8 mL), and allowed to warm to ambient temperature. The reaction was diluted with Et_2O (25 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 25 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil.

The crude oil was dissolved in THF (8 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (158 mg, 6.58 mmol, 1.20 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. CH_3CH_2I (1.31 mL, 16.4 mmol, 3.00 equiv) was added dropwise. The reaction was allowed to warm to ambient temperature and stirred for 4.5 h. The mixture was heated to 45 °C and stirred for 1.5 h. Additional CH_3CH_2I (0.65 mL, 8.22 mmol, 1.50 equiv) was added dropwise and the mixture was stirred at 45 °C for 6 h. A third portion of CH_3CH_2I (0.33 mL, 4.11 mmol, 0.75 equiv) was added dropwise and the reaction was warmed to 55 °C and stirred for 1.5 h. The flask was cooled to ambient temperature and quenched by addition of 50% sat aqueous NH_4Cl (10 mL). The phases were separated and the aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 5 x 20 cm, 9:1→6:1→3:1→2:1 Hexanes:EtOAc) to afford β-ketoester **14b** (1.31 g, 4.44 mmol, 81% yield over 2 steps) as a yellow oil; R_f = 0.53 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.85 (dddd, J = 17.5, 10.2, 5.7, 5.7 Hz, 1H), 5.35 (s, 1H), 5.29 (app dq, J = 17.2, 1.5 Hz, 1H), 5.19 (app dq, J = 10.4, 1.3 Hz, 1H), 4.62 (dddd, J = 13.2, 5.7, 1.4, 1.4 Hz, 1H), 4.54 (dddd, J = 13.2, 5.7, 1.4, 1.4 Hz, 1H), 3.57–3.34 (m, 2H), 2.60 (dddd, J = 17.9, 9.9, 3.7, 1.2 Hz, 1H), 2.49–2.26 (m, 2H), 2.12–1.85 (m, 4H), 1.85–1.57 (m, 2H), 0.93 (d, J = 6.7 Hz, 6H), 0.84 (t, J = 7.5 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.7, 173.7, 173.2, 132.0, 118.5, 105.5, 74.7, 65.7, 63.1, 34.1, 31.0, 30.6, 27.9, 22.0, 19.3, 9.0; IR (Neat Film NaCl) 3085, 2960, 2937, 2876, 1731, 1663, 1613, 1471, 1461, 1453, 1424, 1383, 1369, 1328, 1304, 1278, 1229, 1199, 1170, 1121, 1006, 988, 931, 875, 858, 813 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{17}H_{27}O_4$ $[M+H]^+$: 295.1904; found 295.1918.



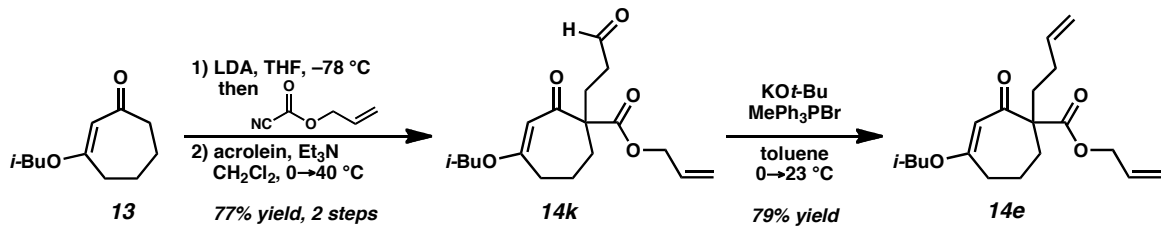
***β*-Ketoester 14c.** To a solution of diisopropylamine (0.92 mL, 6.58 mmol, 1.20 equiv) in THF (27 mL) in a 100 mL round-bottom flask at 0 °C was added *n*-BuLi (2.56 mL, 6.30 mmol, 2.46 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (1.00 g, 5.48 mmol, 1.00 equiv) in THF (2 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (0.67 mL, 6.02 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (8 mL), and allowed to warm to ambient temperature. The reaction was diluted with Et_2O (25 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 25 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil.

The crude oil was dissolved in THF (8 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (197 mg, 8.22 mmol, 1.50 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. Benzyl bromide (1.96 mL, 16.44 mmol, 3.00 equiv) was added dropwise. The reaction was allowed to warm to ambient temperature and stirred for 3 h. The reaction was quenched by addition of 50% sat aqueous NH_4Cl (10 mL). The phases were separated and the aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic phases were washed with brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 23 cm, Hexanes→10:1 Hexanes:EtOAc) to afford *β*-ketoester **14c** (1.72 g, 4.83 mmol, 88% yield over 2 steps) as a pale yellow oil; R_f = 0.26 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30–7.15 (m, 3H), 7.15–7.06 (m, 2H), 5.85 (dddd, *J* = 17.1, 10.4, 5.8, 5.8 Hz, 1H), 5.36 (s, 1H), 5.30 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.21 (app dq, *J* = 10.4, 1.3 Hz, 1H), 4.63 (dddd, *J* = 13.2, 5.7, 1.3, 1.3 Hz, 1H), 4.52 (dddd, *J* = 13.2, 5.8, 1.3, 1.3 Hz, 1H), 3.42 (d, *J* = 6.5 Hz, 2H), 3.30 (d, *J* = 13.5 Hz, 1H), 3.23 (d, *J* = 13.5 Hz, 1H), 2.54 (ddd, *J* = 12.1, 10.0, 3.5 Hz, 1H), 2.38–2.18 (m, 2H), 2.04–1.83 (m, 2H), 1.81–1.64 (m, 2H), 0.92 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.0, 174.0, 172.7, 137.0, 131.8, 130.7, 128.1, 126.8, 118.8, 105.7, 74.8, 66.0, 64.0, 43.1, 34.0, 31.3, 27.9, 22.0, 19.2; IR (Neat Film NaCl) 3085, 3062, 3029, 2959, 2934, 2873, 1736, 1732, 1661, 1652, 1611, 1495, 1471, 1454, 1423, 1383, 1368, 1270, 1235, 1173, 1088, 1007, 957, 992, 930, 862, 815, 741 cm^{-1}; HRMS (APCI+) *m/z* calc'd for $C_{22}H_{29}O_4$ $[M+H]^+$: 357.2060; found 357.2051.



β-Ketoester 14d. To a solution of diisopropylamine (0.92 mL, 6.58 mmol, 1.20 equiv) in THF (27 mL) in a 100 mL round-bottom flask at 0 °C was added *n*-BuLi (2.56 mL, 6.30 mmol, 2.46 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (1.00 g, 5.48 mmol, 1.00 equiv) in THF (2 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (0.67 mL, 6.02 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (8 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (25 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 25 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil.

The crude oil was dissolved in THF (8 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (197 mg, 8.22 mmol, 1.5 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. Propargyl bromide (1.22 mL, 10.96 mmol, 80% wt in toluene, 2.00 equiv) was added dropwise and the reaction was allowed to warm to ambient temperature and stirred for 5.5 h. The reaction was quenched by addition of 50% sat aqueous NH_4Cl (10 mL). The phases were separated and the aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 24 cm, Hexanes→20:1→15:1→10:1 Hexanes:EtOAc) to afford β-ketoester **14d** (1.38 g, 4.53 mmol, 83% yield over 2 steps) as a pale yellow oil; R_f = 0.55 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.85 (dddd, *J* = 17.2, 10.4, 5.7, 5.7 Hz, 1H), 5.38 (s, 1H), 5.29 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.19 (app dq, *J* = 10.4, 1.3 Hz, 1H), 4.63 (dddd, *J* = 13.2, 5.6, 1.4, 1.4 Hz, 1H), 4.56 (dddd, *J* = 13.2, 5.7, 1.4, 1.4 Hz, 1H), 3.56–3.38 (m, 2H), 2.79 (dd, *J* = 2.7, 0.6 Hz, 1H), 2.72–2.32 (m, 4H), 2.15–1.89 (m, 4H), 1.89–1.71 (m, 1H), 0.93 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 196.5, 174.8, 171.7, 131.7, 118.7, 105.0, 80.2, 74.9, 71.4, 66.1, 62.0, 34.3, 31.2, 27.9, 27.5, 21.7, 19.2; IR (Neat Film NaCl) 3289, 3085, 2959, 2933, 2874, 2120, 1740, 1735, 1654, 1649, 1470, 1452, 1424, 1402, 1384, 1369, 1309, 1291, 1272, 1232, 1187, 1173, 1133, 1085, 1066, 1007, 968, 930, 863, 820 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{18}H_{25}O_4$ $[M+H]^+$: 305.1753; found 305.1746.

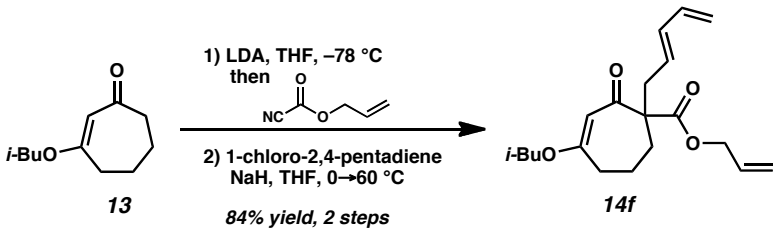


***β*-Ketoester 14k.** To a solution of diisopropylamine (1.49 mL, 10.63 mmol, 1.20 equiv) in THF (43 mL) in a 250 mL round-bottom flask at 0 °C was added *n*-BuLi (4.74 mL, 10.19 mmol, 2.51 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (1.61 g, 8.86 mmol, 1.00 equiv) in THF (3 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (1.06 mL, 9.74 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (12.9 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (50 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 25 g loading cartridge, 330 g column, hold 0% [3 min]→ramp to 20% [10 min]→hold 20% [10 min]→ramp to 50% [4 min]→hold 50% EtOAc in Hexanes [5 min]) to afford the intermediate *β*-ketoester (2.02 g, 7.58 mmol, 86% yield).

A portion of the intermediate *β*-ketoester (990 mg, 3.72 mmol, 1.00 equiv) was dissolved in CH_2Cl_2 (10 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and treated with Et_3N (0.518 mL, 3.72 mmol, 1.00 equiv). Acrolein (0.248 mL, 3.72 mmol, 1.00 equiv) was added dropwise and the reaction was allowed to warm to ambient temperature. After 51 h, the reaction was cooled to 0 °C and an additional portion of acrolein (0.125 mL, 1.86 mmol, 0.50 equiv) was added. After 100 h, the reaction was concentrated under reduced pressure, dissolved in Et_2O, and filtered through a cotton plug to remove salts. The filtrate was concentrated under reduced pressure and the crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 10:1→6:1→4:1 Hexanes:EtOAc) to afford *β*-ketoester **14k** (1.07 g, 3.34 mmol, 90% yield, 77% yield over 2 steps) as a clear oil; R_f = 0.23, broad (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.73 (t, *J* = 1.3 Hz, 1H), 5.86 (dddd, *J* = 17.1, 10.4, 5.8, 5.8 Hz, 1H), 5.36 (s, 1H), 5.30 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.22 (app dq, *J* = 10.4, 1.2 Hz, 1H), 4.63 (dddd, *J* = 13.1, 5.7, 1.3, 1.3 Hz, 1H), 4.55 (dddd, *J* = 13.2, 5.8, 1.3, 1.3 Hz, 1H), 3.55–3.40 (m, 2H), 2.66–2.29 (m, 5H), 2.29–2.08 (m, 2H), 2.08–1.89 (m, 2H), 1.89–1.59 (m, 2H), 0.94 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 201.6, 197.9, 173.9, 172.7, 131.7, 119.0, 105.3, 74.9, 66.0, 61.8, 39.7, 34.2, 32.1, 29.6, 27.9, 21.5, 19.2; IR (Neat Film NaCl) 3084, 2960, 2936, 2875, 2829, 2723, 1727, 1649, 1611, 1471, 1454, 1422, 1403, 1385, 1369, 1306, 1270, 1234, 1191, 1173, 1104, 1004, 990, 931, 877, 862, 822 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{18}H_{27}O_5$ $[M+H]^+$: 323.1858; found 323.1860.

***β*-Ketoester 14e.** $MePh_3PBr$ (1.33 g, 3.72 mmol, 1.26 equiv) was suspended in toluene (20 mL) in 100 mL round-bottom flask and cooled to 0 °C. KO*t*-Bu (0.348 g, 3.10 mmol, 1.05 equiv) was added in one portion and the bright yellow mixture was stirred at 0 °C for 30 min, warmed to ambient temperature, and stirred for an additional 2 h. The mixture was cooled to 0 °C and a solution of aldehyde **14k** (0.95 g, 2.94 mmol, 1.00 equiv) in toluene (2 mL) was added to the

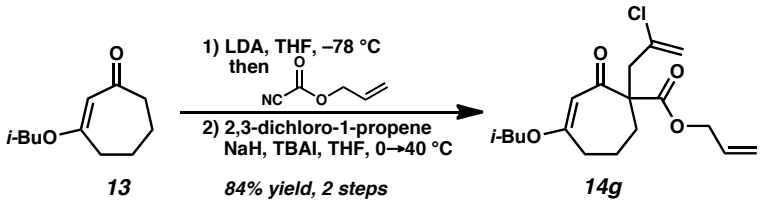
reaction using positive pressure cannulation. The mixture turned brown. The reaction was maintained at 0 °C for 1.5 h, warmed to ambient temperature, and stirred for 4 h. The reaction was quenched by addition of 50% sat aqueous NH_4Cl (4 mL). The phases were separated and the aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1 Hexanes:EtOAc) to afford *β*-ketoester **14e** (747 mg, 2.33 mmol, 79% yield) as a pale yellow oil; R_f = 0.66 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.85 (dddd, *J* = 17.2, 10.4, 5.7, 5.7 Hz, 1H), 5.84–5.69 (m, 1H), 5.35 (s, 1H), 5.29 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.20 (app dq, *J* = 10.4, 1.3 Hz, 1H), 5.08–4.96 (m, 1H), 4.96–4.87 (m, 1H), 4.62 (dddd, *J* = 13.1, 5.7, 1.4, 1.4 Hz, 1H), 4.54 (dddd, *J* = 13.1, 5.7, 1.4, 1.4 Hz, 1H), 3.53–3.38 (m, 2H), 2.59 (dddd, *J* = 17.9, 9.8, 3.7, 1.1 Hz, 1H), 2.51–2.29 (m, 2H), 2.09–1.87 (m, 6H), 1.87–1.66 (m, 2H), 0.94 (d, *J* = 6.7, 3H), 0.94 (d, *J* = 6.7, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.4, 173.7, 173.0, 138.2, 131.9, 118.6, 114.9, 105.4, 74.8, 65.8, 62.6, 36.8, 34.1, 31.5, 28.8, 27.9, 22.0, 19.3; IR (Neat Film NaCl) 3078, 2959, 2935, 2874, 1732, 1662, 1612, 1471, 1453, 1423, 1401, 1384, 1369, 1307, 1270, 1231, 1194, 1170, 1091, 993, 913, 874, 817, 766 cm^{-1}; HRMS (EI+) *m*/*z* calc'd for $C_{19}H_{28}O_4$ $[M]^{+\bullet}$: 320.1988; found 320.1977.



***β*-Ketoester 14f.** To a solution of diisopropylamine (0.406 mL, 2.90 mmol, 1.20 equiv) in THF (12 mL) in a 50 mL round-bottom flask at 0 °C was added *n*-BuLi (1.10 mL, 2.77 mmol, 2.51 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (0.44 g, 2.41 mmol, 1.00 equiv) in THF (2 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (0.288 mL, 2.65 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (4 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (15 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 15 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 5 g loading cartridge, 40 g column, hold 0% [1 min]→ramp to 20% [8 min]→hold 20% [5 min]→ramp to 50% [4 min]→50% EtOAc in Hexanes [6 min]) to afford the intermediate *β*-ketoester (590 mg, 2.21 mmol, 92% yield).

A portion of the intermediate *β*-ketoester (250 mg, 0.94 mmol, 1.00 equiv) was dissolved in THF (5 mL) in a 50 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (33.8 mg, 6.58 mmol, 1.50 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. 1-chloro-2,4-pentadiene[4] (144 mg, 1.41 mmol, 1.50 equiv) was added dropwise and the reaction was allowed to warm to ambient temperature and then heated to 40 °C. After 10.5 h, an

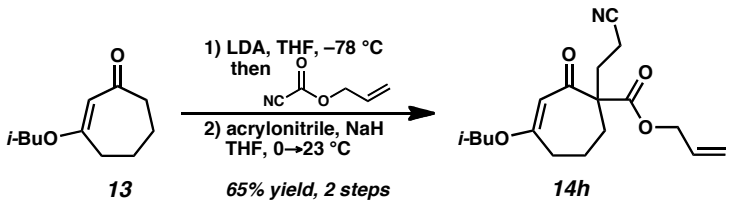
additional portion of 1-chloro-2,4-pentadiene (144 mg, 1.41 mmol, 1.50 equiv) was added and the reaction was heated at 50 °C for 11.5 h. The flask was cooled to ambient temperature and the reaction was quenched by addition of 50% sat aqueous NH_4Cl (2 mL). The phases were separated and the aqueous layer was extracted with Et_2O (3 x 10 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1→10:1 Hexanes:EtOAc) to afford *β*-ketoester **14f** (286 mg, 0.86 mmol, 91% yield, 84% yield over 2 steps) as a pale yellow oil; R_f = 0.59 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.25 (ddd, *J* = 16.7, 10.3, 10.3 Hz, 1H), 6.11–5.98 (m, 1H), 5.83 (dddd, *J* = 17.2, 10.4, 5.7, 5.7 Hz, 1H), 5.58 (ddd, *J* = 15.1, 7.7, 7.7 Hz, 1H), 5.36 (s, 1H), 5.27 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.18 (app dq, *J* = 10.4, 1.2 Hz, 1H), 5.08 (dd, *J* = 16.9, 1.6 Hz, 1H), 4.96 (dd, *J* = 16.9, 1.6 Hz, 1H), 4.60 (dddd, *J* = 13.2, 5.8, 1.4, 1.4 Hz, 1H), 4.52 (dddd, *J* = 13.2, 5.8, 1.4, 1.4 Hz, 1H), 3.57–3.35 (m, 2H), 2.65 (d, *J* = 7.7 Hz, 2H), 2.56 (ddd, *J* = 12.7, 6.8, 2.3 Hz, 1H), 2.48–2.19 (m, 2H), 2.10–1.85 (m, 2H), 1.85–1.63 (m, 2H), 0.92 (d, *J* = 6.7, 3H), 0.92 (d, *J* = 6.7, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 197.9, 174.0, 172.7, 136.9, 134.6, 131.9, 129.7, 118.6, 116.1, 105.4, 74.8, 65.9, 62.9, 41.0, 34.1, 31.4, 27.9, 21.8, 19.2; IR (Neat Film NaCl) 3085, 2959, 2933, 2874, 1733, 1650, 1612, 1471, 1453, 1434, 1402, 1384, 1369, 1307, 1272, 1234, 1194, 1171, 1093, 1006, 968, 955, 929, 900, 864, 822, 761 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_{20}H_{29}O_4$ $[M+H]^+$: 333.2066; found 333.2052.



***β*-Ketoester 14g.** To a solution of diisopropylamine (0.92 mL, 6.58 mmol, 1.20 equiv) in THF (27 mL) in a 100 mL round-bottom flask at 0 °C was added *n*-BuLi (2.56 mL, 6.30 mmol, 2.46 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (1.00 g, 5.48 mmol, 1.00 equiv) in THF (2 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (0.67 mL, 6.02 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (8 mL), and allowed to warm to ambient temperature. The reaction was diluted with Et_2O (25 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 25 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil.

The crude oil was dissolved in THF (8 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (197 mg, 8.22 mmol, 1.50 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. 2,3-dichloro-1-propene (1.00 mL, 10.96 mmol, 2.0 equiv) was added dropwise and the reaction was allowed to warm to ambient temperature. After 10 h, TBAI (202 mg, 0.548 mmol, 0.10 equiv) was added and the reaction was heated to 40 °C. After 41 h, the reaction was cooled to ambient temperature and quenched by addition of 50% sat aqueous NH_4Cl (10 mL). The phases were separated and the aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and

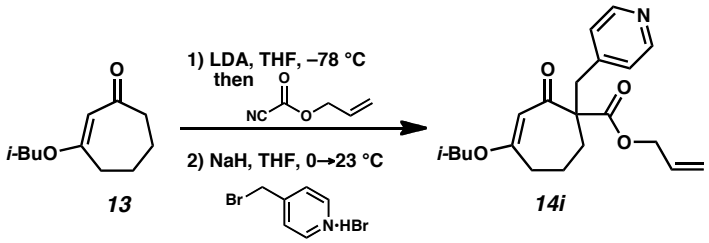
concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1 Hexanes:EtOAc) to afford *β*-ketoester **14g** (1.57 g, 4.61 mmol, 84% yield over 2 steps) as a yellow oil; R_f = 0.60 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.87 (dddd, *J* = 17.1, 10.4, 5.8, 5.8 Hz, 1H), 5.38–5.25 (m, 3H), 5.25–5.16 (m, 2H), 4.65 (dddd, *J* = 13.2, 5.8, 1.3, 1.3 Hz, 1H), 4.52 (dddd, *J* = 13.1, 5.8, 1.3, 1.3 Hz, 1H), 3.45 (ddd, *J* = 21.1, 9.3, 6.5 Hz, 2H), 3.04 (s, 2H), 2.71 (dddd, *J* = 18.2, 10.2, 3.0, 1.3 Hz, 1H), 2.62–2.47 (m, 1H), 2.39 (ddd, *J* = 17.2, 6.9, 2.6 Hz, 1H), 2.10–1.90 (m, 2H), 1.89–1.65 (m, 2H), 0.94 (d, *J* = 6.7 Hz, 3H), 0.94 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 196.6, 174.8, 172.1, 138.1, 131.7, 118.8, 117.1, 104.9, 74.8, 66.2, 62.2, 46.1, 33.9, 30.7, 27.8, 22.6, 19.2; IR (Neat Film NaCl) 3085, 2960, 2935, 2875, 1737, 1662, 1610, 1471, 1452, 1427, 1384, 1369, 1298, 1272, 1229, 1198, 1171, 1153, 1079, 1008, 967, 930, 890, 862, 813 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{18}H_{25}O_4$ [M–Cl]$^+$: 305.1753; found 305.1742.



***β*-Ketoester 14h.** To a solution of diisopropylamine (1.53 mL, 10.93 mmol, 1.20 equiv) in THF (45 mL) in a 250 mL round-bottom flask at 0 °C was added *n*-BuLi (4.17 mL, 10.47 mmol, 2.51 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (1.66 g, 9.11 mmol, 1.00 equiv) in THF (2 mL) was added dropwise over 10 min. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (1.09 mL, 10.0 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (13.5 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (50 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 25 g loading cartridge, 80 g column, multi-step gradient, hold 0% [2 min]→ramp to 20% [4 min]→hold 20% [15 min]→ramp to 50% [7 min]→hold 50% EtOAc in Hexanes [5 min]) to afford the intermediate *β*-ketoester (2.08 g, 7.80 mmol, 86% yield).

One third of the intermediate *β*-ketoester (694 mg, 2.60 mmol, 1.00 equiv) was dissolved in THF (5 mL) in a 50 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (15.6 mg, 0.65 mmol, 0.25 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. Acrylonitrile (0.256 mL, 3.90 mmol, 1.50 equiv) was added dropwise and the reaction was allowed to warm to ambient temperature. After 40 h, the reaction was diluted with Et_2O (30 mL) and washed with H_2O (5 mL) and brine (5 mL). The aqueous layer was extracted with Et_2O (3 x 20 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 10:1→6:1→4:1 Hexanes:EtOAc) to afford *β*-ketoester **14h** (620 mg, 1.94 mmol, 75% yield, 65% yield over 2 steps) as a clear, colorless oil; R_f = 0.29 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.87 (dddd, *J* = 16.2, 10.4, 5.8, 5.8 Hz, 1H),

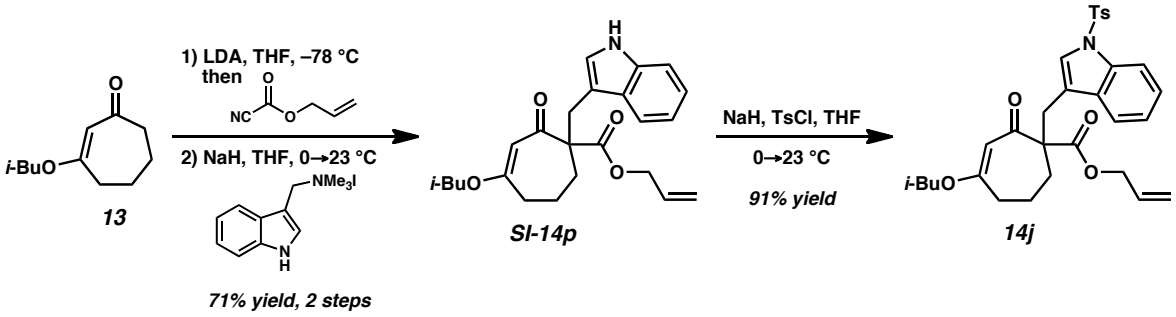
5.38 (s, 1H), 5.32 (app dq, J = 17.2, 1.4 Hz, 1H), 5.25 (app dq, J = 10.4, 1.1 Hz, 1H), 4.67 (dddd, J = 13.0, 5.8, 1.2, 1.2 Hz, 1H), 4.58 (dddd, J = 13.1, 5.9, 1.2, 1.2 Hz, 1H), 3.57–3.39 (m, 2H), 2.58 (ddd, J = 13.1, 9.6, 3.9 Hz, 1H), 2.51–2.32 (m, 4H), 2.32–2.11 (m, 2H), 2.11–1.90 (m, 2H), 1.90–1.64 (m, 2H), 0.95 (d, J = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 196.9, 174.4, 172.0, 131.4, 119.7, 119.3, 105.1, 75.0, 66.3, 61.5, 34.1, 33.1, 32.0, 27.9, 21.4, 19.2, 13.3; IR (Neat Film NaCl) 3081, 2959, 2936, 2875, 2247, 1733, 1648, 1609, 1471, 1454, 1423, 1403, 1385, 1369, 1297, 1269, 1235, 1192, 1173, 1096, 996, 932, 874, 824, 764 cm^{-1}; HRMS (EI+) m/z calc'd for $C_{18}H_{25}O_4N$ $[M]^{+\bullet}$: 319.1784; found 319.1777.



***β*-Ketoester 14i.** To a solution of diisopropylamine (3.54 mL, 25.27 mmol, 1.20 equiv) in THF (108 mL) in a 250 mL round-bottom flask at 0 °C was added *n*-BuLi (10.26 mL, 24.22 mmol, 2.36 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (3.84 g, 21.06 mmol, 1.00 equiv) in THF (10 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (2.52 mL, 9.74 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (30.7 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (100 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 32 g loading cartridge, 330 g column, multi-step gradient, hold 0% [2 min]→ramp to 20% [10 min]→hold 20% [6 min]→ramp to 50% [3 min]→hold 50% EtOAc in Hexanes [11 min]) to afford the intermediate *β*-ketoester (4.66 g, 17.50 mmol, 83% yield) as a pale orange oil.

A portion of the intermediate *β*-ketoester (1.00 g, 3.75 mmol, 1.00 equiv) was dissolved in THF (25 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (90 mg, 3.75 mmol, 1.00 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. Additional NaH (202 mg, 8.43 mmol, 2.25 equiv) was added, giving a thick yellow suspension. After 5 min, 4-(bromomethyl)pyridine hydrogen bromide (996 mg, 3.94 mmol, 1.05 equiv) was added portionwise and the reaction was allowed to warm to ambient temperature. After 14 h, the reaction was quenched by addition of 50% sat aqueous NH_4Cl (16 mL) to give a brown biphasic mixture. The phases were separated and the aqueous layer was extracted with Et_2O (3 x 25 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 1:1→1:4 Hexanes:EtOAc→EtOAc) to afford *β*-ketoester **14i** (1.16 g, 3.23 mmol, 86% yield, 71% yield over 2 steps) as a yellow oil; R_f = 0.28, broad (1:2 Hexanes:EtOAc); ^{1}H NMR (300

MHz, $CDCl_3$) δ 8.44 (dd, *J* = 4.4, 1.6 Hz, 2H), 7.06 (dd, *J* = 4.4, 1.6 Hz, 2H), 5.82 (dddd, *J* = 17.1, 10.4, 5.8, 5.8 Hz, 1H), 5.37 (s, 1H), 5.28 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.21 (app dq, *J* = 10.4, 1.2 Hz, 1H), 4.61 (dddd, *J* = 13.1, 5.9, 1.3, 1.3 Hz, 1H), 4.50 (dddd, *J* = 13.1, 5.9, 1.3, 1.3 Hz, 1H), 3.42 (d, *J* = 6.5 Hz, 2H), 3.27 (d, *J* = 13.3 Hz, 1H), 3.18 (d, *J* = 13.3 Hz, 1H), 2.54 (ddd, *J* = 17.2, 9.3, 3.0 Hz, 1H), 2.38–2.21 (m, 2H), 2.03–1.86 (m, 2H), 1.83–1.59 (m, 2H), 0.91 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 197.0, 174.3, 172.3, 149.6, 146.1, 131.4, 126.0, 119.2, 105.6, 74.9, 66.1, 63.5, 42.4, 33.9, 31.5, 27.8, 21.8, 19.2; IR (Neat Film NaCl) 3072, 3026, 2959, 2935, 2874, 1733, 1660, 1608, 1557, 1496, 1470, 1452, 1415, 1384, 1369, 1293, 1272, 1232, 1201, 1172, 1095, 1074, 1005, 994, 956, 935, 862, 823, 773 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{21}H_{27}O_4N$ $[M]^{+\bullet}$: 357.1940; found 357.1945.

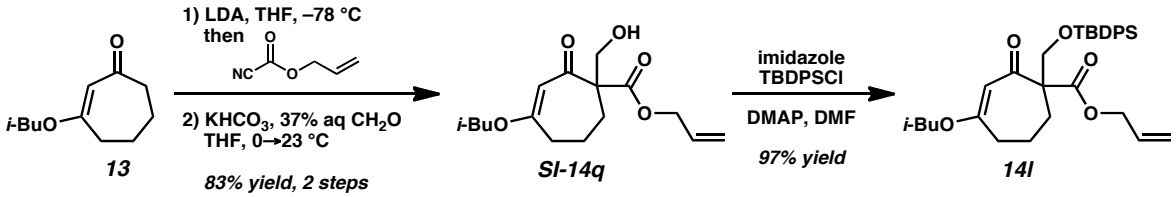


Indolyl β-Ketoester SI-14p. To a solution of diisopropylamine (3.54 mL, 25.27 mmol, 1.20 equiv) in THF (108 mL) in a 250 mL round-bottom flask at 0 °C was added *n*-BuLi (10.26 mL, 24.22 mmol, 2.36 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (3.84 g, 21.06 mmol, 1.00 equiv) in THF (10 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (2.52 mL, 9.74 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (30.7 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (100 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 32 g loading cartridge, 330 g column, multi-step gradient, hold 0% [2 min]→ramp to 20% [10 min]→hold 20% [6 min]→ramp to 50% [3 min]→hold 50% EtOAc in Hexanes [11 min]) to afford the intermediate β-ketoester (4.66 g, 17.50 mmol, 83% yield) as a pale orange oil.

A portion of the intermediate β-ketoester (0.85 g, 3.19 mmol, 1.00 equiv) was dissolved in THF (32 mL) in a 100 mL round-bottom flask, cooled to 0 °C, and stirred vigorously as hexane-washed NaH (84 mg, 3.51 mmol, 1.10 equiv) was added in one portion. Evolution of gas was observed and the reaction was stirred at 0 °C for 30 min to give a yellow-orange solution. Gramine methiodide[3] (1.06 g, 3.35 mmol, 1.05 equiv) was added portionwise to give a suspension. After 11.5 h, the reaction was a brown-orange solution. Additional gramine methiodide (212 mg, 0.67 mmol, 0.31 equiv) was added. After 30 min, the reaction was quenched by addition of 50% sat aqueous NH_4Cl (4.3 mL) to give a brown biphasic mixture. Volatiles were removed under reduced pressure. The residue was extracted with EtOAc (3 x 40 mL), dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was

dissolved in a minimal amount of 1:1 Hexanes:EtOAc and filtered through a silica gel pad (1.5 x 10 cm, 1:1 Hexanes:EtOAc). The filtrate was concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 5 x 20 cm, 6:1→ 4:1→2:1 Hexanes:EtOAc) to afford β-ketoester **SI-14p** (1.09 g, 2.75 mmol, 86% yield, 71% yield over 2 steps) as an orange-brown semi-solid; R_f = 0.21 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.67–7.54 (m, 1H), 7.38–7.29 (m, 1H), 7.21–7.04 (m, 2H), 7.00 (d, *J* = 2.4 Hz, 1H), 5.84 (dddd, *J* = 17.2, 10.4, 5.7, 5.7 Hz, 1H), 5.37 (s, 1H), 5.29 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.20 (app dq, *J* = 10.4, 1.3 Hz, 1H), 4.60 (dddd, *J* = 13.2, 5.6, 1.4, 1.4 Hz, 1H), 4.50 (dddd, *J* = 13.2, 5.8, 1.4, 1.4 Hz, 1H), 3.52 (dd, *J* = 14.3, 0.5 Hz, 1H), 3.47–3.31 (m, 3H), 2.63–2.34 (m, 2H), 2.28 (ddd, *J* = 17.8, 7.7, 4.0 Hz, 1H), 2.02–1.63 (m, 4H), 0.90 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.8, 173.7, 173.2, 135.8, 131.9, 128.8, 124.3, 121.8, 119.5, 119.2, 118.6, 111.1, 111.0, 106.0, 74.7, 65.9, 64.3, 34.0, 32.8, 31.6, 27.8, 21.7, 19.2; IR (Neat Film NaCl) 3785, 3584, 3392, 3079, 3057, 2958, 2930, 2874, 1729, 1641, 1607, 1457, 1457, 1433, 1423, 1384, 1368, 1341, 1233, 1191, 1174, 1127, 1085, 1010, 932, 879, 863, 822, 742 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{24}H_{29}O_4N$ $[M]^{+\bullet}$: 395.2097; found 395.2097.

Tosylindolyl β-Ketoester 14j. To a solution of indole **SI-14p** (250 mg, 0.63 mmol, 1.00 equiv) in THF (9 mL) in a 100 mL round-bottom flask was added TsCl (241 mg, 1.26 mmol, 2.00 equiv). The mixture was cooled to 0 °C and stirred vigorously as hexane-washed NaH (61 mg, 2.53 mmol, 4.00 equiv) was added in one portion. The reaction was maintained at 0 °C for 5 min before warming to ambient temperature. After 24 h, the white suspension was cooled to 0 °C and additional TsCl (241 mg, 1.26 mmol, 2.00 equiv) was added, followed by hexane-washed NaH (121 mg, 5.06 mmol, 8.00 equiv) in one portion. The reaction was allowed to warm to ambient temperature. After 46 h, the reaction was quenched by addition of 50% sat aqueous NH_4Cl (3 mL). The phases were separated and the aqueous phase was extracted with Et_2O (3 x 15 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 10:1→6:1→4:1 Hexanes:EtOAc) to afford β-ketoester **14j** (317 mg, 5.76 mmol, 91% yield) as a yellow foam; R_f = 0.40 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.97–7.89 (m, 1H), 7.75–7.66 (m, 2H), 7.53–7.44 (m, 1H), 7.35 (s, 1H), 7.31–7.13 (m, 4H), 5.77 (dddd, *J* = 17.1, 10.4, 5.8 Hz, 1H), 5.39 (s, 1H), 5.25 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.18 (app dq, *J* = 10.4, 1.2 Hz, 1H), 4.52 (dddd, *J* = 13.1, 5.7, 1.3, 1.3 Hz, 1H), 4.42 (dddd, *J* = 13.2, 5.9, 1.3, 1.3 Hz, 1H), 3.48–3.32 (m, 3H), 3.26 (d, *J* = 14.4 Hz, 1H), 2.52 (ddd, *J* = 17.7, 9.2, 3.3 Hz, 1H), 2.41–2.19 (m, 5H), 2.02–1.82 (m, 2H), 1.78–1.58 (m, 2H), 0.92 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 197.8, 174.0, 172.8, 144.8, 135.4, 134.9, 132.1, 131.6, 129.9, 127.0, 125.8, 124.6, 123.2, 119.9, 118.9, 118.0, 113.7, 105.9, 74.8, 66.1, 63.6, 34.1, 32.2, 31.7, 27.9, 21.7, 21.6, 19.2; IR (Neat Film NaCl) 3854, 3401, 2959, 2931, 2874, 1731, 1657, 1650, 1609, 1448, 1368, 1279, 1233, 1188, 1173, 1121, 1098, 1087, 1019, 1007, 992, 976, 938, 864, 813, 748 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{31}H_{36}O_6N$ $[M+H]^+$: 550.2263; found 550.2250.



Hydroxy β-Ketoester SI-14q. To a solution of diisopropylamine (1.84 mL, 13.15 mmol, 1.20 equiv) in THF (54 mL) in a 250 mL round-bottom flask at 0 °C was added *n*-BuLi (5.12 mL, 12.60 mmol, 2.51 M in hexanes, 1.15 equiv) dropwise over 10 min. After 15 min of stirring at 0 °C, the mixture was cooled to –78 °C using an acetone/CO_2(s) bath. A solution of vinylogous ester **13** (2.00 g, 10.96 mmol, 1.00 equiv) in THF (4 mL) was added dropwise using positive pressure cannulation. After an additional 1 h of stirring at –78 °C, allyl cyanoformate (1.34 mL, 12.06 mmol, 1.10 equiv) was added dropwise over 10 min. The mixture was stirred at –78 °C for 2.5 h, quenched by addition of 50% sat aqueous NH_4Cl (16 mL), and then allowed to warm to ambient temperature. The reaction was diluted with Et_2O (200 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford a pale orange oil (2.92 g).

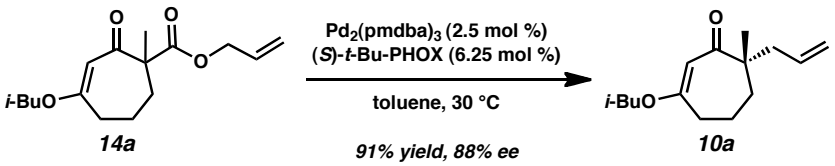
Half of the crude oil (1.46 g) was dissolved in THF (10 mL) in a 50 mL round-bottom flask and cooled to 0 °C. $KHCO_3$ (1.65 g, 16.44 mmol, 3.00 equiv) and 37% wt. aqueous formaldehyde (2.81 mL, 37.73 mmol, 6.9 equiv) were added. The reaction was allowed to warm to ambient temperature. After 11 h, the reaction was diluted with H_2O and CH_2Cl_2 (25 mL each). The phases were separated and the aqueous layer was extracted with CH_2Cl_2 (4 x 12 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 3 x 25 cm, 4:1→2:1→1:1 Hexanes:EtOAc) to afford β-ketoester **SI-14q** (1.35 g, 4.55 mmol, 83% yield over 2 steps) as a pale yellow oil; R_f = 0.21 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.89 (dddd, *J* = 17.2, 10.4, 5.7, 5.7 Hz, 1H), 5.43 (s, 1H), 5.32 (app dq, *J* = 17.2, 1.5 Hz, 1H), 5.23 (app dq, *J* = 10.4, 1.3 Hz, 1H), 4.76–4.54 (m, 2H), 3.93–3.72 (m, 2H), 3.51 (d, *J* = 6.5 Hz, 2H), 3.59–3.45 (m, 1H) 2.68–2.50 (m, 1H), 2.50–2.35 (m, 1H), 2.31–2.12 (m 1H), 2.10–1.91 (m, 2H), 1.91–1.71 (m, 2H), 0.96 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 200.2, 175.1, 171.9, 131.6, 118.9, 105.6, 75.1, 68.7, 66.1, 63.6, 33.7, 28.6, 27.9, 20.9, 19.2; IR (Neat Film NaCl) 3448, 3083, 2959, 2937, 2875, 1733, 1646, 1608, 1471, 1457, 1420, 1404, 1385, 1369, 1298, 1235, 1195, 1171, 1099, 1044, 998, 928, 869, 825 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{16}H_{25}O_5$ $[M+H]^+$: 297.1702; found 297.1715.

Siloxy β-Ketoester 14l. Alcohol **SI-14q** (895 mg, 3.02 mmol, 1.00 equiv), DMAP (553 mg, 4.53 mmol, 1.50 equiv), and imidazole (308 mg, 4.53 mmol, 1.50 equiv) were dissolved in DMF (11 mL) in a 20 mL scintillation vial with magnetic stir bar and septum fitted screw cap. TBDPSCl (0.942 mL, 3.62 mmol, 1.20 equiv) was added dropwise. The stirred mixture turned into a turbid white suspension within 5 min. After 54 h, the reaction was poured into H_2O (35 mL) and 2:1 CH_2Cl_2/Hexanes (75 mL). The phases were separated and the aqueous layer was further extracted with 2:1 CH_2Cl_2/Hexanes (4 x 35 mL). The combined organics were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, 5 x 25 cm, 40:1→20:1 Hexanes:EtOAc) to afford siloxy β-ketoester **14l** (1.567 g, 2.93 mmol, 97% yield) as a clear, colorless oil; R_f = 0.58 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.70–7.61 (m, 4H), 7.47–7.32 (m, 6H), 5.86

(dddd, J = 17.1, 10.5, 5.7, 5.7 Hz, 1H), 5.39 (s, 1H), 5.29 (app dq, J = 17.2, 1.5 Hz, 1H), 5.19 (app dq, J = 10.4, 1.2 Hz, 1H), 4.65 (dddd, J = 13.2, 5.7, 1.3, 1.3 Hz, 1H), 4.52 (dddd, J = 13.3, 5.7, 1.3, 1.3 Hz, 1H), 4.15 (d, J = 9.6 Hz, 1H), 4.05 (d, J = 9.6 Hz, 1H), 3.47 (d, J = 6.5 Hz, 2H), 2.80–2.51 (m, 2H), 2.43 (ddd, J = 11.0, 7.4, 2.9 Hz, 1H), 2.17–1.89 (m, 3H), 1.89–1.68 (m, 1H), 1.04 (s, 9H), 0.95 (d, J = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 197.5, 174.8, 171.6, 135.8, 135.7, 133.3, 133.2, 131.89, 129.8, 129.7, 127.8, 127.7, 118.5, 105.8, 74.8, 69.0, 65.9, 65.1, 34.5, 30.0, 27.8, 26.8, 21.9, 19.4, 19.2; IR (Neat Film NaCl) 3460, 3071, 3049, 2958, 2931, 2890, 2857, 1738, 1650, 1609, 1472, 1429, 1384, 1362, 1299, 1236, 1200, 1173, 1113, 1007, 998, 936, 864, 822, 740 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_{32}H_{43}O_5Si$ $[M+H]^+$: 535.2880; found 535.2880.

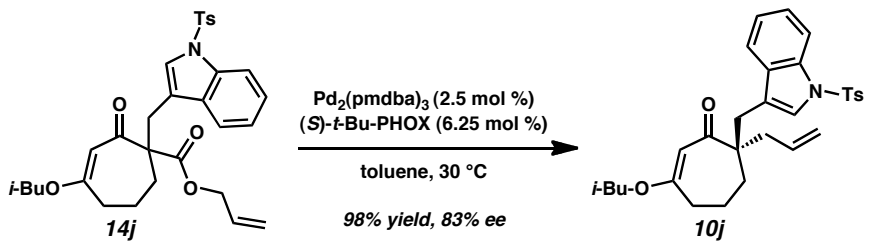
Procedures for Synthesis of Enantioenriched Vinylogous Esters 10 using Enantioselective Decarboxylative Alkylation Reactions

General Method SI-A: Schlenk Manifold Method



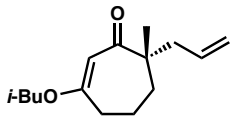
Vinylogous Ester 10a. $Pd_2(pmdba)_3$ (5.0 mg, 4.5 μmol, 2.5 mol %) and (*S*)-*t*-Bu-PHOX (4.4 mg, 11 μmol, 6.25 mol %) were placed in a 1 dram vial. The flask was evacuated/backfilled with N_2 (3 cycles, 10 min evacuation per cycle). Toluene (1.3 mL, sparged with N_2 for 1 h immediately before use) was added and the black suspension was immersed in an oil bath preheated to 30 °C. After 30 min of stirring, β-ketoester **14a** (50.7 mg, 0.181 mmol, 1.00 equiv) was added as a solution in toluene (0.5 mL, sparged with N_2 immediately before use) using positive pressure cannulation. The dark orange catalyst solution turned olive green immediately upon addition of β-ketoester **14a**. The reaction was stirred at 30 °C for 21 h, allowed to cool to ambient temperature, filtered through a silica gel plug (2 x 2 cm, Et_2O), and concentrated under reduced pressure. The crude oil was purified by preparative TLC (SiO_2, 4:1 Hexanes:EtOAc) to afford vinylogous ester **10a** (38.8 mg, 0.164 mmol, 91% yield, 88% ee) as a pale yellow oil. (For characterization data, see p. 22).

General Method SI-B: Glove Box Method



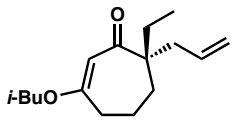
Vinylogous Ester 10j. A 20 mL scintillation vial was loaded with β-ketoester **14j** (447 mg, 0.81 mmol, 1.00 equiv). A separate 20 mL scintillation vial was loaded with $Pd_2(pmdba)_3$ (19.7 mg,

0.051 mmol, 6.25 mol %), (*S*)-*t*-Bu-PHOX (22.3 mg, 0.020 mmol, 2.5 mol %), and magnetic stir bar. The two vials and a teflon-lined hard cap were evacuated/backfilled with N_2 in a glove box antechamber (3 cycles, 5 min evacuation per cycle) before being transferred into the glove box. Toluene (5 mL) was added to the vial containing $Pd_2(pmdba)_3$ and (*S*)-*t*-BuPHOX. The vial was capped and heated to 30 °C for 30 min. During this time, the mixture developed a dark orange color. β-Ketoester **14j** was dissolved in toluene (3 mL) and added to the catalyst solution dropwise, causing the solution to turn olive green. The solution was stirred at 30 °C in a heating block. The capped vial was removed from the glove box after 29 h of stirring. The crude product was concentrated under reduced pressure and purified by flash column chromatography (SiO_2, 5 x 25 cm, 15:1→10:1→8:1→6:1 Hexanes:EtOAc) to afford vinylogous ester **10j** (403 mg, 0.796 mmol, 98% yield, 82.9% ee) as a thick, white semi-solid. (For characterization data, see p. 26).



10a

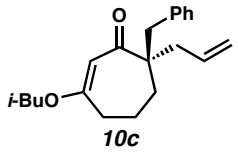
Vinylogous Ester 10a ***(Table 2, entry 1).*** Prepared using General Method SI-A. 38.8 mg, 0.164 mmol, 91% yield. Preparative TLC (SiO_2, 4:1 Hexanes:EtOAc); R_f = 0.31 (3:1 Hexanes:Et_2O); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.72 (dddd, *J* = 16.6, 10.5, 7.3, 7.3 Hz, 1H), 5.31 (s, 1H), 5.05–5.00 (m, 2H), 3.50 (dd, *J* = 9.3, 6.6 Hz, 1H), 3.47 (dd, *J* = 9.3, 6.6 Hz, 1H), 2.53–2.42 (m, 2H), 2.38 (dd, *J* = 13.7, 7.1 Hz, 1H), 2.20 (dd, *J* = 13.7, 7.8 Hz, 1H), 1.98 (app sept, *J* = 6.6 Hz, 1H), 1.86–1.70 (m, 3H), 1.62–1.56 (m, 1H), 1.14 (s, 3H), 0.95 (d, *J* = 6.6 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.7, 171.3, 134.6, 117.9, 105.0, 74.5, 51.5, 45.4, 36.1, 35.2, 28.0, 25.2, 19.9, 19.3, 19.3; IR (Neat Film NaCl) 2960, 2933, 2873, 1614, 1470, 1387, 1192, 1171, 998, 912 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{15}H_{24}O_2$ $[M]^{+\bullet}$: 236.1776; found 236.1767; $[\alpha]_D^{25.6}$ –69.04 (*c* 1.08, $CHCl_3$, 88.0% ee); HPLC conditions: 1% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): major = 6.30, minor = 7.26.



10b

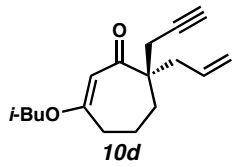
Vinylogous Ester 10b ***(Table 2, entry 2).*** Prepared using General Method SI-A. 226.3 mg, 0.90 mmol, 89% yield. Flash column chromatography (SiO_2, 3 x 24 cm, 20:1→15:1→10:1 Hexanes:EtOAc); R_f = 0.43 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.82–5.62 (m, 1H), 5.29 (s, 1H), 5.06–4.98 (m, 2H), 3.48 (dd, *J* = 11.1, 6.6 Hz, 1H), 3.45 (dd, *J* = 11.2, 6.6 Hz, 1H), 2.49–2.42 (m, 2H), 2.40 (dddd, *J* = 13.8, 7.1, 1.2 Hz, 1H), 2.23 (dddd, *J* = 13.8, 7.7, 1.1, 1.1 Hz, 1H), 1.97 (app sept, *J* = 6.7 Hz, 1H), 1.84–1.44 (m, 6H), 0.98–0.91 (d, *J* = 6.7 Hz, 6H), 0.79 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 206.2, 171.0, 135.1, 117.6, 105.5, 74.4, 54.8, 41.9, 36.1, 32.3, 31.3, 28.0, 20.0, 19.3, 8.6; IR (Neat Film NaCl) 3073, 2960, 2933, 2876, 1617, 1613, 1459, 1400, 1387, 1369, 1314, 1220, 1190, 1173, 996, 969, 954, 912, 883, 873, 856, 782 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{16}H_{26}O_2$ $[M]^{+\bullet}$: 250.1933; found 250.1909;

$[\alpha]_D^{25.0}$ +25.83 (*c* 1.04, $CHCl_3$, 91.6% ee); HPLC conditions: 0.25% IPA in Hexanes, 1.0 mL/min, AD column, t_R (min): minor = 16.23, major = 18.08.



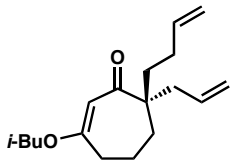
10c

Vinylogous Ester 10c ***(Table 2, entry 3).*** Prepared using General Method SI-A. 172.5 mg, 0.552 mmol, 98% yield. Flash column chromatography (SiO_2, 3 x 24 cm, 20:1→15:1→10:1 Hexanes:EtOAc); R_f = 0.50 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.28–7.14 (m, 3H), 7.14–7.08 (m, 2H), 5.85–5.68 (m, 1H), 5.31 (s, 1H), 5.10–4.99 (m, 2H), 3.44 (dd, *J* = 14.7, 6.6 Hz, 1H), 3.41 (dd, *J* = 14.7, 6.6 Hz, 1H), 3.14 (d, *J* = 13.3 Hz, 1H), 2.71 (d, *J* = 13.3 Hz, 1H), 2.51 (dddd, *J* = 13.7, 6.8, 1.2, 1.2 Hz, 1H), 2.45–2.32 (m, 2H), 2.16 (dddd, *J* = 13.7, 7.9, 1.1, 1.1 Hz, 1H), 1.93 (app sept, *J* = 6.7 Hz, 1H), 1.83–1.56 (m, 4H), 0.92 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 205.5, 171.4, 138.3, 134.5, 130.8, 128.0, 126.3, 118.2, 106.3, 74.5, 56.2, 44.1, 43.9, 36.3, 31.3, 27.9, 19.5, 19.3; IR (Neat Film NaCl) 3072, 3061, 3027, 3002, 2957, 2931, 2871, 1610, 1495, 1471, 1454, 1422, 1403, 1387, 1368, 1318, 1280, 1217, 1189, 1173, 1081, 1031, 1007, 969, 957, 913, 875, 856, 831, 760, 746, 733 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{21}H_{28}O_2$ $[M]^{+\bullet}$: 312.2089; found 312.2083; $[\alpha]_D^{25.0}$ +2.91 (*c* 0.98, $CHCl_3$, 86.3% ee); HPLC conditions: 0.5% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): minor = 13.96, major = 15.70.



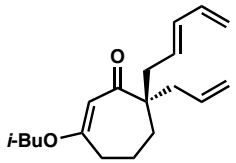
10d

Vinylogous Ester 10d ***(Table 2, entry 4).*** Prepared using General Method SI-A. 224.7 mg, 0.86 mmol, 88% yield. Flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1 Hexanes:EtOAc); R_f = 0.44 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.74–5.59 (m, 1H), 5.32 (s, 1H), 5.12–5.02 (m, 2H), 3.50 (dd, *J* = 14.9, 6.5 Hz, 1H), 3.47 (dd, *J* = 14.7, 6.6 Hz, 1H), 2.53–2.48 (m, 4H), 2.46 (dddd, *J* = 13.7, 7.3, 1.2, 1.2 Hz, 1H), 2.35 (dddd, *J* = 13.7, 7.6, 1.1, 1.1 Hz, 1H), 2.09–1.67 (m, 5H), 1.57 (s, 1H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 204.0, 171.7, 133.7, 118.5, 105.0, 81.7, 74.6, 70.8, 54.2, 42.9, 36.1, 32.5, 28.0, 27.1, 20.0, 19.3; IR (Neat Film NaCl) 3301, 3075, 2957, 2930, 2873, 2116, 1612, 1471, 1457, 1435, 1423, 1402, 1387, 1368, 1320, 1221, 1191, 1175, 995, 969, 916, 874, 845 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{17}H_{24}O_2$ $[M]^{+\bullet}$: 260.1776; found 260.1737; $[\alpha]_D^{25.0}$ –26.51 (*c* 1.03, $CHCl_3$, 88.5% ee); HPLC conditions: 0.5% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): major = 12.35, minor = 13.43.



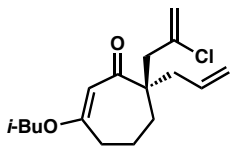
10e

Vinylogous Ester 10e ***(Table 2, entry 5).*** Prepared using General Method SI-B. 287.5 mg, 1.04 mmol, 95% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 20:1 Hexanes:EtOAc); R_f = 0.44 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.84–5.64 (m, 2H), 5.30 (s, 1H), 5.09–4.87 (m, 4H), 3.49 (dd, *J* = 11.2, 6.6 Hz, 1H), 3.46 (dd, *J* = 11.1, 6.6 Hz, 1H), 2.54–2.37 (m, 3H), 2.27 (dddd, *J* = 13.8, 7.7, 1.2, 1.2 Hz, 1H), 2.07–1.89 (m, 3H), 1.86–1.45 (m, 6H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 205.8, 171.1, 138.9, 134.8, 117.9, 114.5, 105.5, 74.8, 54.4, 42.3, 38.0, 36.1, 32.7, 28.6, 28.0, 19.9, 19.3; IR (Neat Film NaCl) 3076, 2958, 2932, 2874, 1639, 1614, 1471, 1455, 1434, 1424, 1402, 1387, 1368, 1317, 1280, 1216, 1190, 1174, 1086, 996, 969, 955, 910, 878, 853, 829, 771 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{18}H_{28}O_2$ $[M]^{+\bullet}$: 276.2089; found 276.2060; $[\alpha]_D^{25.0}$ +15.28 (*c* 0.97, $CHCl_3$, 86.9% ee); HPLC conditions: 0.8% IPA in Hexanes, 2.0 mL/min, AD column, t_R (min): major = 5.03, minor = 6.06.



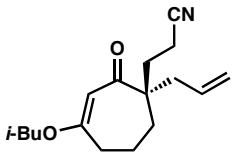
10f

Vinylogous Ester 10f ***(Table 2, entry 6).*** Prepared using General Method SI-A. 232.9 mg, 0.81 mmol, 90% yield. Flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1 Hexanes:EtOAc); R_f = 0.45 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.30 (dt, *J* = 16.9, 10.3 Hz, 1H), 6.04 (dd, *J* = 15.1, 10.4 Hz, 1H), 5.82–5.53 (m, 2H), 5.31 (s, 1H), 5.15–4.92 (m, 4H), 3.48 (d, *J* = 6.5 Hz, 2H), 2.55–2.36 (m, 4H), 2.30–2.16 (m, 2H), 1.98 (app sept, *J* = 6.7 Hz, 1H), 1.84–1.67 (m, 4H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 205.3, 171.4, 137.2, 134.5, 134.1, 130.8, 118.0, 115.5, 105.5, 74.5, 55.1, 43.1, 41.6, 36.1, 32.5, 28.0, 19.9, 19.3; IR (Neat Film NaCl) 3075, 3036, 3007, 2958, 2931, 2873, 1726, 1635, 1611, 1471, 1456, 1436, 1402, 1387, 1368, 1312, 1277, 1219, 1190, 1173, 1085, 1005, 954, 911, 874, 831 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{19}H_{29}O_2$ $[M+H]^+$: 289.2168; found 289.2172; $[\alpha]_D^{25.0}$ –20.62 (*c* 1.05, $CHCl_3$, 89.6% ee); SFC conditions: 5.0% IPA in Hexanes, 2.5 mL/min, AD-H column, t_R (min): minor = 6.31, major = 6.99.



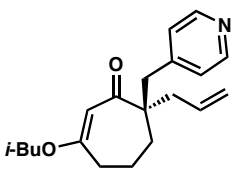
10g

Vinylogous Ester 10g ***(Table 2, entry 7).*** Prepared using General Method SI-A. 259.5 mg, 0.87 mmol, 99% yield. Flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1 Hexanes:EtOAc); R_f = 0.36 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.78–5.62 (m, 1H), 5.36 (s, 1H), 5.25 (s, 1H), 5.14 (s, 1H), 5.11–5.01 (m, 2H), 3.54–3.43 (m, 2H), 2.95 (dd, *J* = 14.4, 0.7 Hz, 1H), 2.54–2.41 (m, 4H), 2.25 (dddd, *J* = 13.9, 7.9, 1.1, 1.1 Hz, 1H), 2.07–1.89 (m, 2H), 1.88–1.70 (m, 3H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 204.3, 171.6, 139.4, 133.9, 118.7, 116.6, 105.9, 74.6, 54.7, 46.7, 43.7, 36.3, 31.5, 28.0, 19.6, 19.3; IR (Neat Film NaCl) 3075, 2958, 2934, 2874, 1612, 1471, 1458, 1424, 1403, 1388, 1368, 1339, 1321, 1297, 1222, 1192, 1175, 1082, 1010, 995, 968, 956, 916, 875, 847, 746 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{17}H_{26}O_2Cl$ $[M+H]^+$: 297.1621; found 297.1623; $[\alpha]_D^{25.0}$ +4.20 (*c* 1.02, $CHCl_3$, 85.7% ee); HPLC conditions: 0.1% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): minor = 24.19, major = 27.22.



10h

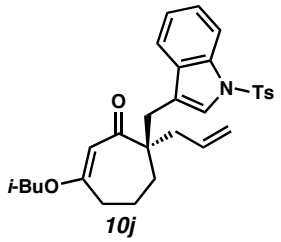
Vinylogous Ester 10h ***(Table 2, entry 8).*** Prepared using General Method SI-A. 292.8 mg, 1.06 mmol, 96% yield. (SiO_2, 3 x 25 cm, 20:1→10:1→8:1→6:1 Hexanes:EtOAc); R_f = 0.39 broad (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.75–5.58 (m, 1H), 5.31 (s, 1H), 5.15–5.04 (m, 2H), 3.48 (d, *J* = 6.5 Hz, 2H), 2.51 (t, *J* = 6.1 Hz, 2H), 2.40 (dddd, *J* = 14.0, 7.0, 1.2, 1.2 Hz, 1H), 2.35–2.22 (m, 3H), 2.11–1.93 (m, 2H), 1.93–1.62 (m, 5H), 0.96 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 203.9, 172.1, 133.1, 120.3, 119.2, 104.9, 74.7, 53.6, 41.8, 36.1, 33.9, 32.8, 28.0, 19.8, 19.3, 12.8; IR (Neat Film NaCl) 3076, 2958, 2933, 2874, 2246, 1635, 1609, 1472, 1458, 1420, 1404, 1388, 1368, 1319, 1281, 1214, 1192, 1175, 1084, 1003, 917, 880, 854, 827, 766 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{17}H_{25}O_2N$ $[M]^{+\bullet}$: 275.1885; found 275.1893; $[\alpha]_D^{25.0}$ –20.97 (*c* 1.06, $CHCl_3$, 87.4% ee); HPLC conditions: 5.0% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): major = 10.67, minor = 14.66.



10i

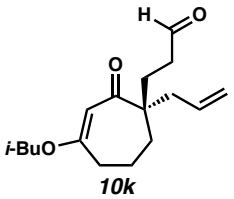
Vinylogous Ester 10i ***(Table 2, entry 9).*** Prepared using General Method SI-B. 339.6 mg, 1.08 mmol, 97% yield. Flash column chromatography (SiO_2, 3 x 20 cm, 1:1→ 1 : 4

Hexanes:EtOAc→EtOAc); R_f = 0.28, broad (1:2 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.45 (dd, *J* = 4.5, 1.5 Hz, 2H), 7.05 (dd, *J* = 4.5, 1.6 Hz, 2H), 5.84–5.66 (m, 1H), 5.31 (s, 1H), 5.15–5.02 (m, 2H), 3.44 (dd, *J* = 15.1, 6.3 Hz, 1H), 3.41 (dd, *J* = 15.0, 6.3 Hz, 1H), 3.20 (d, *J* = 12.9 Hz, 1H), 2.60 (d, *J* = 12.9 Hz, 1H), 2.48 (dddd, *J* = 13.8, 6.9, 1.2, 1.2 Hz, 1H), 2.43–2.29 (m, 2H), 2.23 (dddd, *J* = 13.8, 7.8, 1.1, 1.1 Hz, 1H), 1.94 (app sept, *J* = 6.7 Hz, 1H), 1.84–1.67 (m, 2H), 1.67–1.51 (m, 2H), 0.92 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 204.4, 171.8, 149.5, 147.6, 133.7, 126.2, 118.9, 106.0, 74.6, 55.8, 43.8, 43.5, 36.2, 31.5, 27.9, 19.4, 19.3; IR (Neat Film NaCl) 3072, 3024, 2957, 2931, 2873, 1608, 1558, 1496, 1471, 1458, 1438, 1415, 1388, 1368, 1320, 1220, 1190, 1173, 1072, 994, 957, 916, 876, 844, 796 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{20}H_{27}O_2N$ $[M]^{+\bullet}$: 313.2042; found 313.2045; $[\alpha]_D^{25.0}$ +22.44 (*c* 1.16, $CHCl_3$, 84.6% ee); HPLC conditions: 5.0% EtOH in Hexanes, 1.0 mL/min, AD column, t_R (min): major = 13.22, minor = 15.13.



10j

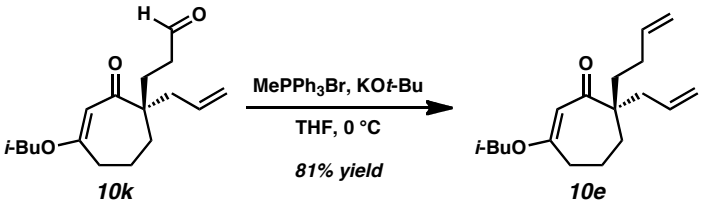
Vinylogous Ester 10j ***(Table 2, entry 10).*** Prepared using General Method SI-B. 403 mg, 0.796 mmol, 98% yield. Flash column chromatography (SiO_2, 5 x 25 cm, 15:1→10:1→8:1→6:1 Hexanes:EtOAc); R_f = 0.49 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.96 (dm, *J* = 8.4 Hz, 1H), 7.70 (dm, *J* = 8.4 Hz, 2H), 7.48 (dm, *J* = 7.9 Hz, 1H), 7.31–7.13 (m, 5H), 5.86–5.68 (m, 1H), 5.32 (s, 1H), 5.13–5.00 (m, 2H), 3.42 (dd, *J* = 17.0, 7.7 Hz, 1H), 3.38 (dd, *J* = 17.0, 7.6 Hz, 1H), 3.20 (dd, *J* = 14.2, 0.7 Hz, 1H), 2.73 (d, *J* = 14.1 Hz, 1H), 2.51 (dddd, *J* = 13.7, 6.9, 1.3, 1.3 Hz, 1H), 2.44–2.15 (m, 6H), 1.92 (app sept, *J* = 6.7 Hz, 1H), 1.76–1.46 (m, 4H), 0.92 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 205.2, 171.7, 144.8, 135.4, 135.0, 134.1, 132.4, 129.8, 126.9, 125.4, 124.5, 123.2, 120.1, 119.6, 118.6, 113.8, 106.4, 74.6, 55.9, 44.1, 36.3, 33.0, 31.9, 27.9, 21.7, 19.5, 19.3; IR (Neat Film NaCl) 3584, 3401, 2068, 2958, 2930, 2873, 1609, 1494, 1470, 1448, 1422, 1402, 1368, 1306, 1279, 1215, 1188, 1174, 1120, 1097, 1020, 975, 916, 876, 813, 782, 747 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{30}H_{36}O_4NS$ $[M+H]^+$: 506.2365; found 506.2358; $[\alpha]_D^{25.0}$ +9.10 (*c* 1.00, $CHCl_3$, 82.9% ee); HPLC conditions: 5.0% EtOH in Hexanes, 1.0 mL/min, AD column, t_R (min): major = 11.11, minor = 16.64.



10k

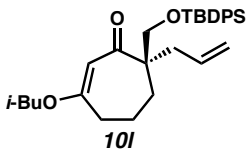
Vinylogous Ester 10k ***(Table 2, entry 11).*** Prepared using General Method SI-B. 77.3 mg, 0.278 mmol, 90% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 6:1→4:1 Hexanes:EtOAc); R_f = 0.35, broad (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.73

(t, J = 1.5 Hz, 1H), 5.78–5.61 (m, 1H), 5.29 (s, 1H), 5.11–5.02 (m, 2H), 3.47 (m, 2H), 2.54–2.33 (m, 5H), 2.28 (dddd, J = 14.0, 7.6, 1.2, 1.2 Hz, 1H), 2.07–1.73 (m, 5H), 1.73–1.56 (m, 2H), 0.95 (d, J = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 205.0, 202.3, 171.7, 134.0, 118.5, 105.2, 74.6, 53.6, 42.1, 39.4, 36.1, 33.1, 30.3, 28.0, 19.9, 19.3; IR (Neat Film NaCl) 3075, 2958, 2931, 2719, 1724, 1611, 1471, 1458, 1421, 1403, 1388, 1368, 1213, 1191, 1175, 998, 915, 878 cm^{-1}; HRMS (FAB+) m/z calc'd for $C_{17}H_{27}O_3$ $[M+H]^+$: 279.1960; found 279.1969; $[\alpha]_D^{25.0}$ +15.37 (c 1.03, $CHCl_3$, 79.5% ee); Compound **10k** was derivatized using procedure below to determine ee using the corresponding chiral HPLC assay for vinylogous ester **10e**.



10k *10e*

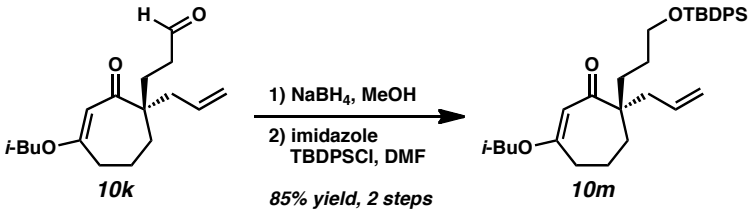
Vinylogous Ester 10e. To a solution of $MePh_3PBr$ (323.2 mg, 0.905 mmol, 0.84 equiv) in THF (14.0 mL) in a 50 mL round-bottom flask at 0 °C was added KO*t*-Bu (84.6 mg, 0.754 mmol, 0.699 equiv) to give a bright yellow suspension. Aldehyde **10k** (299.9 mg, 1.078 mmol, 1.00 equiv) in THF (2 mL) was added to the suspension using positive pressure cannulation and maintained at 0 °C. The reaction faded to an off-white suspension. After 1.5 h of stirring, an additional portion of Wittig reagent was prepared in a 20 mL scintillation vial. $MePPh_3Br$ (323.2 mg, 0.905 mmol, 0.84 equiv) was added to the vial. The vial was sealed with a septum, evacuated/backfilled with N_2 (3 cycles, 5 min evacuation per cycle). Anhydrous THF (3 mL) was added and the vial was cooled to 0 °C. KO*t*-Bu (84.6 mg, 0.754 mmol, 0.699 equiv) was added in one portion, giving a bright yellow suspension which was added to the reaction flask using positive pressure cannulation. The tan suspension was stirred at 0 °C for 1 h. An additional portion of Wittig reagent using $MePPh_3Br$ (323.2 mg, 0.905 mmol, 0.84 equiv), KO*t*-Bu (84.6 mg, 0.754 mmol, 0.699 equiv) and THF (3 mL) was prepared at 0 °C and added using positive pressure cannulation as previously described. The reaction showed a persistent yellow color. After 30 min of stirring at 0 °C, the reaction was quenched by addition of sat aqueous NH_4Cl (5 mL) and stirred for 30 min while the mixture was allowed to warm to ambient temperature. The mixture was extracted with Et_2O (3 x 20 mL), dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography (SiO_2, 3 x 25 cm, 1%→2%→3%→5% EtOAc in Hexanes) to afford vinylogous ester **10e** (243.7 mg, 0.882 mmol, 81% yield) as a yellow liquid; HPLC conditions: 0.8% IPA in Hexanes, 2.0 mL/min, AD column, t_R (min): major = 4.39, minor = 3.17. (For characterization data, see p. 24).



10l

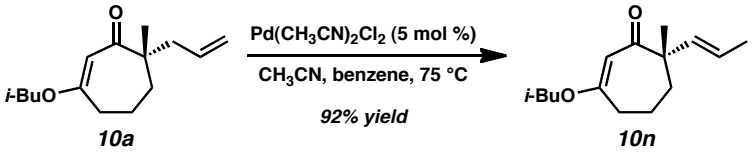
Vinylogous Ester 10l. Prepared using General Method SI-B. 242.0 mg, 0.493 mmol, 66% yield. Flash column chromatography (SiO_2, 3 x 25 cm, 2%→5%→10% EtOAc in Hexanes); R_f = 0.44 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.67–7.61 (m, 4H), 7.46–7.33 (m,

6H), 5.78–5.60 (m, 1H), 5.32 (s, 1H), 5.08–4.96 (m, 2H), 3.78 (d, *J* = 9.7 Hz, 1H), 3.67 (d, *J* = 9.7 Hz, 1H), 3.46 (dd, *J* = 14.7, 6.5 Hz, 1H), 3.43 (dd, *J* = 14.6, 6.5 Hz, 1H), 2.49 (dddd, *J* = 13.7, 6.6, 1.3, 1.3 Hz, 1H), 2.48–2.41 (m, 2H), 2.33 (dddd, *J* = 13.8, 7.8, 1.2, 1.2 Hz, 1H), 2.09–1.88 (m, 2H), 1.82–1.65 (m, 3H), 1.04 (s, 9H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 204.5, 171.5, 135.9, 135.8, 134.7, 133.7, 133.5, 129.7, 127.8, 127.7, 117.8, 106.1, 74.5, 69.0, 57.4, 41.0, 36.3, 30.3, 28.0, 27.0, 20.0, 19.5, 19.3; IR (Neat Film NaCl) 3071, 3050, 2957, 2930, 2857, 1731, 1614, 1472, 1428, 1402, 1388, 1368, 1315, 1261, 1222, 1190, 1174, 1112, 1007, 998, 969, 955, 938, 914, 880, 824, 810, 740 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{31}H_{43}O_3Si$ [M+H]$^+$: 491.2982; found 491.2993; $[\alpha]_D^{25.0}$ –6.72 (*c* 1.09, $CHCl_3$, 57.8% ee); HPLC conditions: 0.2% IPA in Hexanes, 1.0 mL/min, OD-H column, t_R (min): major = 21.74, minor = 25.53.

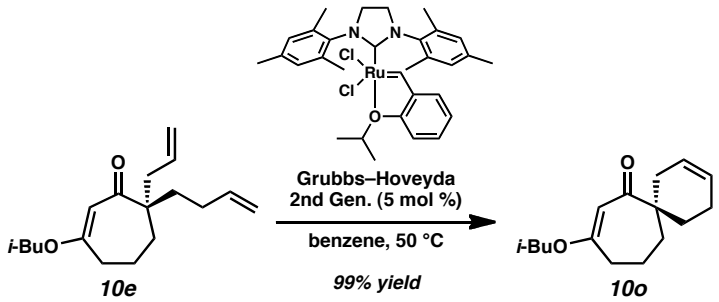


Vinylogous Ester 10m. A round-bottom flask with magnetic stir bar was charged with aldehyde **10k** (40.2 mg, 0.14 mmol, 1.00 equiv) and MeOH (3.0 mL). The flask was cooled to 0 °C and $NaBH_4$ (5.5 mg, 0.14 mmol, 1.00 equiv) was added slowly portionwise. The mixture was stirred for 1 h at 0 °C. Sat aqueous $NaHCO_3$ (3 mL) was added, followed by CH_2Cl_2 (10 mL). The mixture was stirred vigorously for 5 min. The phases were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). Combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude alcohol was used directly in the next step without further purification. R_f = 0.29 (2:1 Hexanes:EtOAc).

To a 2 dram vial with a solution of crude alcohol and imidazole (11.8 mg, 0.17 mmol, 1.20 equiv) in DMF (0.7 mL) at 0 °C was added TBDPSCl (39.6 μL, 0.14 mmol, 1.00 equiv) dropwise. After 2 h of stirring, the reaction was quenched by addition of H_2O (0.3 mL) and extracted with Et_2O (5 x 5 mL). The combined organics were dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 12 g loading cartridge, 80 g column, multi-step gradient, hold 2% [2 min]→ramp to 5% [10 min]→hold 5% [10 min]→ramp to 10% [32 min]→hold 10% Et_2O in Hexanes [5 min]) to afford vinylogous ester **10m** (63.3 mg, 0.12 mmol, 85% yield over 2 steps) as a pale, white oil; R_f = 0.42 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.69–7.62 (m, 4H), 7.46–7.33 (m, 6H), 5.82–5.62 (m, 1H), 5.29 (s, 1H), 5.08–4.96 (m, 2H), 3.61 (t, *J* = 6.1 Hz, 2H), 3.48 (dd, *J* = 13.7, 6.6 Hz, 1H), 3.45 (dd, *J* = 13.7, 6.6 Hz, 1H), 2.50–2.43 (m, 2H), 2.40 (dddd, *J* = 13.8, 7.0, 1.2 Hz, 1H), 2.25 (dddd, *J* = 13.9, 7.8, 1.1 Hz, 1H), 1.98 (app sept, *J* = 6.7 Hz, 1H), 1.86–1.38 (m, 8H), 1.04 (s, 9H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 206.0, 171.0, 135.7, 134.9, 134.1, 129.6, 127.7, 117.7, 105.2, 74.4, 64.4, 54.2, 42.1, 36.1, 34.8, 32.8, 28.0, 27.3, 27.0, 20.0, 19.3; IR (Neat Film NaCl) 3071, 3051, 3013, 2998, 2956, 2930, 2858, 1614, 1471, 1428, 1401, 1387, 1368, 1311, 1214, 1188, 1174, 1111, 1028, 1007, 998, 966, 913, 872, 823, 780, 740, 725 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{33}H_{47}O_3Si$ [M+H]$^+$: 519.3295; found 519.3275; $[\alpha]_D^{25.0}$ +9.06 (*c* 0.95, $CHCl_3$, 78.4% ee).



Vinylogous Ester 10n. $Pd(CH_3CN)_2Cl_2$ (49.1 mg, 0.189 mmol, 5 mol %) was placed in a 50 mL round-bottom Schlenk flask and evacuated/backfilled with N_2 (3 cycles, 5 min per cycle). Benzene (10 mL) was added, followed by acetonitrile (90 μL). A solution of vinylogous ester **10a** (895 mg, 3.79 mmol, 1.00 equiv) in benzene (5.0 mL) was added using positive pressure cannulation. The resulting orange solution was heated to 75 °C in an oil bath. After 11 h of stirring, the reaction was cooled to ambient temperature, filtered through a Celite plug (eluted with Et_2O), and concentrated carefully under reduced pressure, allowing for a film of ice to form on the outside of the flask, to afford a pale yellow oil. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 25 g loading cartridge, 80 g column, linear gradient, 0→10% EtOAc in Hexanes [33 min]) to afford vinylogous ester **10n** (823.6 mg, 3.48 mmol, 92% yield) in a 20:1 ratio to isomeric starting material **10a**. Analytically pure samples could be obtained using the above column conditions; R_f = 0.56 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.56 (dq, *J* = 15.7, 1.4 Hz, 1H), 5.41 (dq, *J* = 15.7, 6.2, Hz, 1H), 5.34 (s, 1H), 3.48 (d, *J* = 6.5 Hz, 2H), 2.63–2.33 (m, 2H), 2.04–1.91 (m, 1H), 1.90–1.70 (m, 4H), 1.67 (dd, *J* = 6.2, 1.4 Hz, 3H), 1.22 (s, 3H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 205.3, 171.6, 136.5, 123.9, 105.2, 74.5, 53.9, 36.2, 33.3, 28.0, 27.2, 20.2, 19.3, 18.4; IR (Neat Film NaCl) 3022, 2960, 2873, 1614, 1471, 1455, 1423, 1402, 1387, 1370, 1212, 1192, 1173, 1120, 967, 883, 858, 827 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{15}H_{25}O_2$ $[M+H]^+$: 237.1849; found 237.1848; $[\alpha]_D^{25.0}$ +4.05 (*c* 1.39, $CHCl_3$, 88.0 % ee).



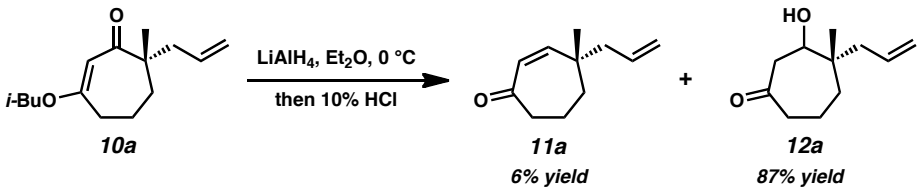
Vinylogous Ester 10o. Vinylogous ester **10e** (100 mg, 0.362 mmol, 1.00 equiv) was added to a 50 mL 2-neck flask fitted with a rubber septum and oven-dried reflux condenser. The flask was evacuated/backfilled with Ar (3 cycles, 5 min evacuation per cycle). Dry degassed benzene (36.2 mL, sparged with N_2 for 1 h immediately before use) was added. Grubbs–Hoveyda 2nd Generation catalyst (11.3 mg, 18.1 μmol, 5 mol %) was added to the reaction, giving the solution an olive green color. The mixture was kept under Ar, stirred until homogeneous, and heated to 50 °C using an oil bath. After 30 min of stirring, the reaction was cooled to ambient temperature and several drops of ethyl vinyl ether were added. After 30 min, the reaction developed a deep brown color. The mixture was concentrated under reduced pressure and filtered through a silica

gel plug (3 x 5 cm, 1:1 Hexanes:Et_2O). The solvents were removed under reduced pressure and the residue was purified by flash column chromatography (SiO_2, 3 x 25 cm, 20:1→15:1→10:1 Hexanes:EtOAc) to afford vinylogous ester **10o** (89.2 mg, 0.359 mmol, 99% yield) as a white solid. R_f = 0.39 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.69–5.58 (m, 2H), 5.30 (s, 1H), 3.49 (dd, *J* = 14.4, 6.5 Hz, 1H), 3.46 (dd, *J* = 14.3, 6.5 Hz, 1H), 2.70–2.57 (m, 1H), 2.54–2.44 (m, 2H), 2.08–1.91 (m, 3H), 1.91–1.57 (m, 7H), 0.95 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 207.2, 171.3, 125.6, 125.4, 104.0, 74.4, 50.5, 35.9, 33.9, 32.3, 32.2, 28.0, 22.4, 20.6, 19.3; IR (Neat Film NaCl) 3050, 3023, 2981, 2958, 2928, 2890, 2874, 2837, 1726, 1633, 1610, 1470, 1457, 1435, 1416, 1406, 1392, 1364, 1327, 1295, 1270, 1218, 1178, 1189, 1117, 1096, 1045, 1028, 1003, 953, 935, 917, 888, 850, 837, 807, 758, 731 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{16}H_{24}O_2$ $[M]^{+\bullet}$: 248.1776; found 248.1774; $[\alpha]_D^{25.0}$ –32.18 (*c* 0.97, $CHCl_3$, 78.4% ee).

Procedures for the Synthesis of Acylcyclopentenes 1 by Ring Contraction

Full characterization data is reported for acylcyclopentenes **1**, cycloheptenone **11a**, and *β*-hydroxyketone intermediate **12a** (mixture of diastereomers). For all other *β*-hydroxyketone intermediates (**12b–j, l–o,** mixtures of diastereomers), R_f, IR, and HRMS data are reported and ^{1}H NMR and IR spectra are provided for reference in **Figures SI-35–SI-48**. For acylcyclopentenes **1a**, the ee value was unchanged from corresponding vinylogous ester **10a**. For all other acylcyclopentenes **1b–j, l–o**, ee values are assumed to be unchanged from the corresponding vinylogous esters **10b–j, l–o**.

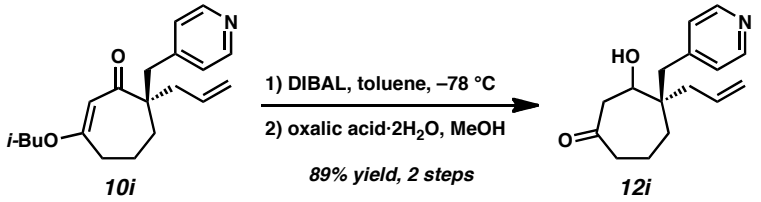
General Method A: Lithium Aluminum Hydride Reduction / 10% Aq HCl Hydrolysis



10a *11a* 6% yield *12a* 87% yield

Cycloheptenone 11a and ***β*-Hydroxyketone 12a.** A 500 mL round-bottom flask with magnetic stir bar was charged with Et_2O (150 mL) and cooled to 0 °C. $LiAlH_4$ (806 mg, 21.2 mmol) was added in one portion. After 10 min, a solution of vinylogous ester **10a** (9.13 g, 38.6 mmol) in Et_2O (43 mL) was added dropwise using positive pressure cannulation. The grey suspension was stirred for 40 min and additional $LiAlH_4$ (148 mg, 3.9 mmol) was added in one portion. After an additional 30 min of stirring at 0 °C, the reaction was quenched by slow addition of aqueous HCl (110 mL, 10% w/w). The resulting biphasic system was allowed to warm to ambient temperature and stirred vigorously for 8.5 h. The phases were separated and the aqueous phase was extracted with Et_2O (3 x 100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was azeotroped with toluene (3 x 20 mL) and purified using flash column chromatography (SiO_2, 5 x 15 cm, 9:1→ 3:1 Hexanes:EtOAc, dry-loaded using Celite) to afford *β*-hydroxyketone **12a** (6.09 g, 87% yield, 1.3:1 dr) as a colorless semi-solid and cycloheptenone **11a** (387 mg, 6% yield) as a colorless oil. (For characterization data, see p. 32–33).

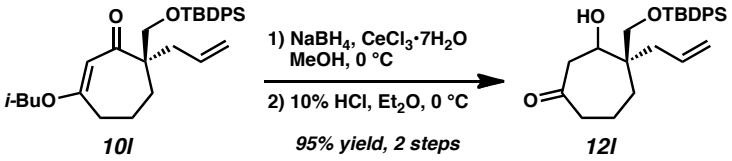
General Method B: DIBAL Reduction / Oxalic Acid Hydrolysis



***β*-Hydroxyketone 12i.** A 25 mL pear shaped flask was charged with vinylogous ester **10i** (29.4 mg, 0.094 mmol, 1.00 equiv) and toluene (3.0 mL). The solution was cooled to –78 °C using an acetone/CO_2(s) bath. A 1.0 M solution of DIBAL in toluene (112.6 μL, 0.113 mmol, 1.00 equiv) was added dropwise and the solution was stirred for 10 min. MeOH (180 μL), $Na_2SO_4 \cdot 10H_2O$ (1.08 g), and Celite (360 mg) were added. The reaction was stirred vigorously and allowed to warm slowly to ambient temperature. The mixture was filtered through a Celite plug (3 x 3 cm, EtOAc), and concentrated in vacuo. $R_f = 0.28$, broad (1:2 Hexanes:EtOAc).

The crude hydroxy isobutyl enol ether was added to a 25 mL round-bottom flask and dissolved in MeOH (4.0 mL). Oxalic acid dihydrate (354.9 mg, 2.82 mmol, 30.0 equiv) was added in one portion. After 1 h of stirring, the reaction was neutralized to pH 7 with 1 M aqueous pH 7 NaH_2PO_4/Na_2HPO_4 buffer (6 mL). The biphasic mixture was stirred vigorously for 10 min and the phases were separated. The aqueous layer was extracted with Et_2O (4 x 15 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified using flash column chromatography (SiO_2, 1.5 x 25 cm, 4:1→2:1→1:2 Hexanes-Acetone) to afford *β*-hydroxyketone **12i** as a mixture of diastereomers (21.6 mg, 0.083 mmol, 89% yield over 2 steps, 2.8:1 dr) as a clear, colorless residue which solidified upon standing. $R_f = 0.10$ (4:1 Hexanes-Acetone). (For characterization data, see p. 38).

General Method C: Luche Reduction / 10% Aq HCl Hydrolysis

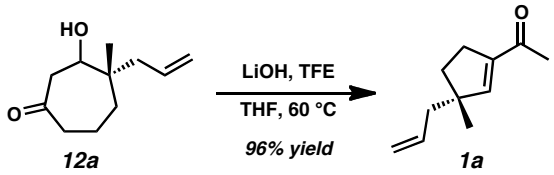


***β*-Hydroxyketone 12l.** A 100 mL round-bottom flask with magnetic stir bar was charged with vinylogous ester **10l** (65.6 mg, 0.134 mmol, 1.00 equiv) and anhydrous MeOH (8.3 mL). The solution was cooled to 0 °C. $CeCl_3 \cdot 7H_2O$ (78.2 mg, 0.21 mmol, 1.56 equiv) was added in one portion and the mixture was stirred for 5 min. Addition of $NaBH_4$ (23.8 mg, 0.63 mmol, 4.70 equiv) led to the evolution of gas and a turbid solution that became clear after several minutes. The reaction was stirred at 0 °C. After 15 min, the reaction was diluted with CH_2Cl_2 (20 mL) until turbid, filtered through a Celite plug (3 x 3 cm, CH_2Cl_2), and concentrated in vacuo. The residue was taken up in CH_2Cl_2, filtered through a Celite plug (3 x 5 cm, CH_2Cl_2), and concentrated in vacuo a second time. $R_f = 0.33$ (10:1 Hexanes:EtOAc).

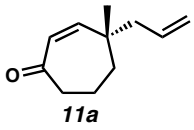
The crude hydroxy isobutyl enol ether was added to a 25 mL round-bottom flask with amagnetic stir bar and dissolved in Et_2O (3.8 mL). The vigorously stirred solution was cooled to

0 °C and aqueous HCl (384 μL, 10% w/w) was added dropwise via syringe. After 30 min, the reaction was allowed to warm to ambient temperature and extracted with Et_2O (3 x 5 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified using flash column chromatography (SiO_2, 1.5 x 25 cm, 6:1→4:1 Hexanes:EtOAc) to afford β-hydroxyketone **12l** as a mixture of diastereomers (55.6 mg, 0.13 mmol, 95% yield over 2 steps, 3.5:1 dr) as a colorless oil; R_f = 0.22, 0.28 (two diastereomers) (4:1 Hexanes:EtOAc); (For characterization data, see p. 40).

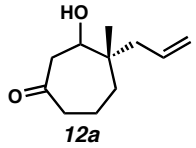
General Method D: β-Hydroxyketone Ring Contraction



Acylcyclopentene 1a. Alcohol **12a** (6.09 g, 33.4 mmol, 1.00 equiv) was dissolved in THF (334 mL) in a 500 mL round-bottom flask. The solution was treated with 2,2,2-trifluoroethanol (3.67 mL, 50.1 mmol, 1.50 equiv) and anhydrous LiOH (1.20 g, 50.1 mmol, 1.50 equiv). The flask was fitted with a condenser, purged with N_2, and heated to 60 °C using an oil bath. After 18 h of stirring, the suspension was allowed to cool to ambient temperature, diluted with Et_2O (150 mL), dried over Na_2SO_4 (30 min of stirring), filtered, and concentrated carefully under reduced pressure, allowing for a film of ice to form on the outside of the flask. The crude product was purified using flash column chromatography (SiO_2, 5 x 15 cm, 15:1 Hexanes:Et_2O) to afford acylcyclopentene **1a** (5.29 g, 32.2 mmol, 96% yield) as a colorless fragrant oil. (For characterization data, see p. 33).

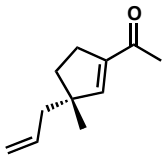


Cycloheptenone 11a. Prepared using General Method A. 387 mg, 2.36 mmol, 6.1% yield. R_f = 0.54 (7:3 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.04 (dd, J = 12.9, 0.7 Hz, 1H), 5.82 (d, J = 12.9 Hz, 1H), 5.75 (dddd, J = 17.1, 10.3, 7.8, 7.1 Hz, 1H), 5.10 (dddd, J = 10.3, 1.2, 1.2, 1.2 Hz, 1H), 5.08–5.03 (m, 1H), 2.65–2.52 (m, 2H), 2.19 (app dd, J = 13.7, 6.8 Hz, 1H), 2.11 (app dd, J = 13.7, 8.1 Hz, 1H), 1.84–1.76 (m, 3H), 1.68–1.63 (m, 1H), 1.10 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 204.7, 152.5, 133.8, 128.6. 118.6, 47.2, 45.1, 42.7, 38.2, 27.1, 18.4; IR (Neat Film NaCl) 3076, 3011, 2962, 2934, 2870, 1659, 1454, 1402, 1373, 1349, 1335, 1278, 1208, 1172, 997, 916, 874, 822, 772 cm^{-1}; HRMS (EI+) m/z calc'd for $C_{11}H_{16}O$ $[M]^{+\bullet}$: 164.1201; found 164.1209; $[\alpha]_D^{21.0}$ –9.55 (c 1.07, $CHCl_3$, 88.0% ee).



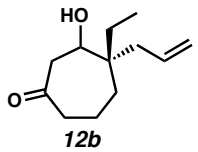
12a

β*-Hydroxyketone 12a *(Table 3, entry 1). Prepared using General Method A. 6.09 g, 33.41 mmol, 87% yield. R_f = 0.23 (7:3 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ **major epimer**; 5.88 (dddd, *J* = 15.1, 9.0, 7.6, 7.6 Hz, 1H), 5.12–5.08 (m, 2H), 3.70 (dd, *J* = 4.9, 3.9 Hz, 1H), 2.86 (dd, *J* = 15.6, 1.7 Hz, 1H), 2.65 (dd, *J* = 15.6, 7.3 Hz, 1H), 2.54–2.43 (m, 2H), 2.24 (dd, *J* = 13.7, 7.8 Hz, 1H), 2.07 (dd, *J* = 13.4, 7.3 Hz, 1H), 1.99 (dd, *J* = 15.9, 4.4 Hz, 1H), 1.82–1.69 (m, 2H), 1.45–1.41 (m, 1H), 0.96 (s, 3H); **minor epimer** 5.83 (dddd, *J* = 14.9, 10.3, 7.6, 7.6 Hz, 1H), 5.12–5.06 (m, 2H), 3.68 (dd, *J* = 4.1, 2.4 Hz, 1H) 2.80 (dd, *J* = 15.4, 2.4 Hz, 1H), 2.74 (dd, *J* = 15.4, 8.1 Hz 1H), 2.46–2.38 (m, 2H), 2.18 (dd, *J* = 13.9, 7.3 Hz, 1H), 2.09 (dd, *J* = 12.9, 7.8 Hz, 1H), 1.82–1.65 (m, 3H) 1.50–1.47 (m, 1H), 1.02 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ **major epimer**; 213.2, 135.0, 118.1, 72.9, 46.7, 44.9, 44.2, 41.0, 36.3, 21.9, 18.9; **minor epimer**; 212.6, 134.2, 118.3, 73.3, 47.2, 42.8, 41.0, 35.9, 22.6, 18.7; IR (Neat Film NaCl) 3436, 3074, 2932, 1692, 1638, 1443, 1403, 1380, 1352, 1318, 1246, 1168, 1106, 1069, 999, 913, 840 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{11}H_{18}O_2$ $[M]^{+\bullet}$: 182.1313; found 182.1307; $[\alpha]_D^{22.8}$ –57.10 (*c* 2.56, $CHCl_3$, 88.0% ee).



1a

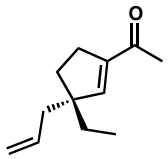
Acylcyclopentene 1a *(Table 3, entry 1).* Prepared using General Method D. 5.29 g, 32.2 mmol, 96% yield. R_f = 0.67 (8:2 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.45 (app t, *J* = 1.7 Hz, 1H), 5.76 (dddd, *J* = 16.4, 10.7, 7.3, 7.3 Hz, 1H), 5.07–5.03 (m, 2H), 2.59–2.48 (m, 2H), 2.30 (s, 3H), 2.21–2.14 (m, 2H), 1.85 (ddd, *J* = 12.9, 8.3, 6.3 Hz, 1H), 1.64 (ddd, *J* = 12.9, 8.5, 6.1 Hz, 1H), 1.11 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.5, 151.9, 143.8, 134.9, 117.8, 50.0, 45.3, 36.0, 29.7, 26.8, 25.6; IR (Neat Film NaCl) 3077, 2956, 2863, 1668, 1635, 1616, 1454, 1435, 1372, 1366, 1309, 1265, 1213, 1177, 993, 914, 862 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{11}H_{17}O$ $[M+H]^{+\bullet}$: 165.1279; found 165.1281; $[\alpha]_D^{21.4}$ +17.30 (*c* 0.955, $CHCl_3$, 88.0% ee); GC conditions: 80 °C isothermal, GTA column, t_R (min): major = 54.7, minor = 60.2.



12b

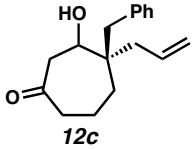
β*-Hydroxyketone 12b *(Table 3, entry 2). Prepared using General Method A. 111.5 mg, 0.57 mmol, 95% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→3:1 Hexanes:EtOAc); R_f = 0.36 (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see

Figure SI-36; IR (Neat Film NaCl) 3448, 3073, 2965, 2933, 1832, 1696, 1691, 1673, 1459, 1413, 1381, 1352, 1334, 1323, 1306, 1269, 1252, 1269, 1252, 1172, 1138, 1111, 1084, 1071, 1050, 997, 955, 930, 912, 876, 825, 777, 737 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{12}H_{20}O_2$ $[M]^{+\bullet}$: 196.1463; found 196.1480.



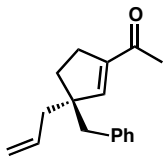
1b

Acylcyclopentene 1b ***(Table 3, entry 2).*** Prepared using General Method D. 21.8 mg, 0.12 mmol, 95% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.73 (2:1 Hexanes:EtOAc); ^1H NMR (300 MHz, $CDCl_3$) δ 6.44 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.80–5.64 (m, 1H), 5.08–5.04 (m, 1H), 5.03–5.00 (m, 1H), 2.55–2.46 (m, 2H), 2.30 (s, 3H), 2.19–2.16 (m, 2H), 1.81–1.68 (m, 2H), 1.52–1.41 (m, 2H), 0.85 (dd, *J* = 7.5, 7.5 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.4, 150.7, 144.6, 134.8, 117.7, 54.0, 43.1, 32.9, 31.3, 30.1, 26.9, 9.1; IR (Neat Film NaCl) 3075, 2962, 2922, 2878, 2855, 1669, 1639, 1617, 1459, 1437, 1372, 1319, 1266, 1207, 1052, 995, 913, 868, 784 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{12}H_{19}O$ $[M+H]^+$: 179.1436; found 179.1401; $[\alpha]_D^{25.0}$ +7.06 (*c* 0.98, $CHCl_3$, 91.6% ee).



12c

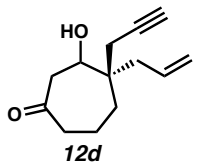
β*-Hydroxyketone 12c** ***(Table 3, entry 3). Prepared using General Method A. 109.9 mg, 0.43 mmol, 89% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→3:1 Hexanes:EtOAc); R_f = 0.11 (4:1 Hexanes:EtOAc); ^1H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-37**; IR (Neat Film NaCl) 3443, 3072, 3028, 3003, 2930, 2865, 1696, 1692, 1685, 1636, 1601, 1582, 1495, 1453, 1413, 1400, 1352, 1340, 1255, 1182, 1163, 1118, 1058, 1031, 995, 970, 916, 885, 848, 809, 754 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{17}H_{22}O_2$ $[M]^{+\bullet}$: 258.1620; found 258.1642.



1c

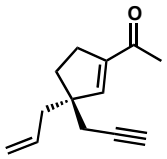
Acylcyclopentene 1c ***(Table 3, entry 3).*** Prepared using General Method D. 22.7 mg, 0.094 mmol, 97% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.54 (4:1 Hexanes:EtOAc); ^1H NMR (300 MHz, $CDCl_3$) δ 7.30–7.18 (m, 3H), 7.14–7.08 (m,

2H), 6.45 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.78 (dddd, *J* = 16.3, 10.8, 7.7, 7.0 Hz, 1H), 5.13–5.10 (m, 1H), 5.07 (dddd, *J* = 9.1, 2.2, 1.2, 1.2 Hz, 1H), 2.79 (d, *J* = 13.3 Hz, 1H), 2.73 (d, *J* = 13.3 Hz, 1H), 2.43 (dddd, *J* = 16.5, 8.6, 5.7, 1.7 Hz, 1H), 2.27–2.17 (m, 3H), 2.21 (s, 3H), 1.91–1.75 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.1, 150.1, 144.9, 138.2, 134.7, 130.4, 128.1, 126.4, 118.3, 54.6, 45.2, 43.3, 33.3, 30.0, 26.9; IR (Neat Film NaCl) 3061 3027, 3002, 2920, 2853, 1668, 1638. 1617, 1495, 1453, 1442, 1371, 1314, 1264, 1197, 1089, 1030, 995, 914, 861, 734 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{17}H_{20}O$ $[M]^{+\bullet}$: 240.1514; found 240.1530; $[\alpha]_D^{25.0}$ –20.63 (*c* 0.83, $CHCl_3$, 86.3% ee).



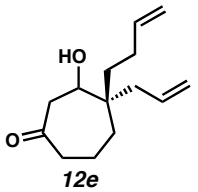
12d

β*-Hydroxyketone 12d *(Table 3, entry 4). Prepared using General Method A. 117 mg, 0.56 mmol, 98% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→3:1 Hexanes:EtOAc); R_f = 0.35 (10:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-38**; IR (Neat Film NaCl) 3434, 3295, 3074, 3002, 2932, 2114, 1690, 1684, 1637, 1447, 1354, 1252, 1166, 1124, 1064, 977, 917, 886, 838 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{13}H_{18}O_2$ $[M]^{+\bullet}$: 206.1307; found 206.1311.



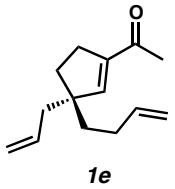
1d

Acylcyclopentene 1d *(Table 3, entry 4).* Prepared using General Method D. 22.5 mg, 0.12 mmol, 97% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.74 (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.51 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.73 (dddd, *J* = 16.9, 10.2, 7.4, 7.4 Hz, 1H), 5.13 (dm, *J* = 10.2 Hz, 1H), 5.10–5.07 (m, 1H), 2.66–2.46 (m, 2H), 2.34–2.33 (m, 1H), 2.33–2.32 (m, 1H), 2.32 (s, 3H), 2.32–2.30 (m, 2H), 1.99 (dd, *J* = 2.7, 2.7 Hz, 1H), 1.93–1.75 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.3, 148.6, 145.2, 133.9, 118.6, 81.4, 70.3, 53.2, 42.4, 33.4, 30.0, 28.5, 26.9; IR (Neat Film NaCl) 3298, 3075, 3001, 2924, 2857, 2116, 1669, 1639, 1617, 1457, 1437, 1372, 1318, 1265, 1222, 1204, 996, 919, 867 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{13}H_{16}O$ $[M]^{+\bullet}$: 188.1201; found 188.1211; $[\alpha]_D^{25.0}$ –58.65 (*c* 0.71, $CHCl_3$, 88.5% ee).



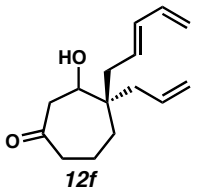
12e

β-Hydroxyketone 12e ***(Table 3, entry 5).*** Prepared using General Method A. 116.7 mg, 0.52 mmol, 97% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→3:1 Hexanes:EtOAc); R_f = 0.15 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-39**; IR (Neat Film NaCl) 3447, 3075, 3001, 2975, 2931, 2866, 1827, 1693, 1639, 1456, 1415, 1352, 1336, 1250, 1169, 1116, 1073, 995, 910, 855, 763, 714 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{18}H_{28}O_2$ $[M]^{+\bullet}$: 276.2089; found 276.2060.



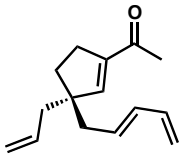
1e

Acylcyclopentene 1e ***(Table 3, entry 5).*** Prepared using General Method D. 19.1 mg, 0.093 mmol, 90% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.62 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.45 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.79 (dddd, *J* = 16.8, 10.2, 6.5, 6.5 Hz, 1H), 5.72 (dddd, *J* = 16.8, 9.5, 7.3, 7.3 Hz, 1H), 5.09–5.07 (m, 1H), 5.05–4.97 (m, 2H), 4.94 (dm, *J* = 10.2 Hz, 1H), 2.56–2.49 (m, 2H), 2.30 (s, 3H), 2.23–2.17 (m, 2H), 2.15–1.91 (m, 2H), 1.85–1.70 (m, 2H), 1.58–1.50 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.3, 150.4, 144.6, 138.8, 134.6, 117.9, 114.6, 53.5, 43.6, 38.1, 33.3, 30.1, 29.2, 26.9; IR (Neat Film NaCl) 3076, 3001, 2976, 2919, 2854, 1670, 1640, 1618, 1437, 1372, 1314, 1265, 1204, 995, 911, 865 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{14}H_{21}O$ $[M+H]^+$: 205.1592; found 205.1588; $[\alpha]_D^{25.0}$ –30.08 (*c* 0.92, $CHCl_3$, 86.9% ee).



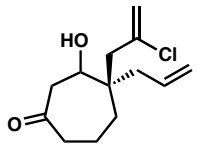
12f

β-Hydroxyketone 12f ***(Table 3, entry 6).*** Prepared using General Method A. 117.5 mg, 0.50 mmol, 96% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→3:1 Hexanes:EtOAc); R_f = 0.19 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-40**; IR (Neat Film NaCl) 3448, 3075, 3035, 3007, 2972, 2929, 2865, 1700, 1696, 1691, 1685, 1648, 1637, 1600, 1449, 1415, 1352, 1333, 1245, 1171, 1120, 1068, 1052, 1005, 969, 954, 912, 855, 838, 817, 720 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{15}H_{23}O_2$ $[M+H]^+$: 235.1698; found 235.1697.



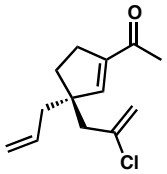
1f

Acylcyclopentene 1f ***(Table 3, entry 6).*** Prepared using General Method D. 25.2 mg, 0.12 mmol, 95% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.65 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.45 (dd, *J* = 1.8, 1.8 Hz, 1H), 6.30 (ddd, *J* = 16.9, 10.2, 10.2 Hz, 1H), 6.08 (dd, *J* = 15.0, 10.4 Hz, 1H), 5.73 (dddd, *J* = 16.4, 11.6, 8.9, 7.5 Hz, 1H), 5.63 (ddd, *J* = 15.0, 7.6, 7.6 Hz, 1H), 5.14–5.09 (m, 2H), 5.06–5.02 (m, 1H), 5.00 (dm, *J* = 10.1 Hz, 1H), 2.54–2.46 (m, 2H), 2.30 (s, 3H), 2.25–2.17 (m, 4H), 1.80–1.74 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.3, 150.0, 144.8, 137.0, 134.5, 134.3, 130.4, 118.1, 115.9, 54.0, 43.3, 42.0, 33.2, 30.0, 26.9; IR (Neat Film NaCl) 3079, 3006, 2929, 2857, 1735, 1670, 1640, 1617, 1439, 1371, 1318, 1267, 1201, 1175, 1084, 1004, 952, 912 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{15}H_{21}O$ $[M+H]^+$: 217.1592; found 217.1568; $[\alpha]_D^{25.0}$ –32.14 (*c* 1.26, $CHCl_3$, 89.6% ee).



12g

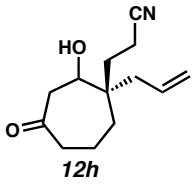
β*-Hydroxyketone 12g** ***(Table 3, entry 7). Prepared using General Method A. 114.9 mg, 0.47 mmol, 93% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→3:1 Hexanes:EtOAc); R_f = 0.15 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-41**; IR (Neat Film NaCl) 3436, 3075, 2931, 2869, 1695, 1627, 1452, 1414, 1352, 1297, 1251, 1222, 1151, 1064, 1021, 997, 974, 915, 887, 839 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{13}H_{19}O_2Cl$ $[M]^{+\bullet}$: 242.1074; found 242.1063.



1g

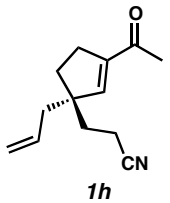
Acylcyclopentene 1g ***(Table 3, entry 7).*** Prepared using General Method D. 23.8 mg, 0.11 mmol, 99% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.55 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.61 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.73 (dddd, *J* = 15.9, 11.1, 7.9, 7.3 Hz, 1H), 5.29 (d, *J* = 1.2 Hz, 1H), 5.15–5.14 (m, 1H), 5.11–5.10 (m, 1H), 5.08–5.04 (m, 1H), 2.56–2.48 (m, 4H), 2.31 (s, 3H), 2.28–2.25 (m, 2H), 1.93 (ddd, *J* = 13.3, 8.4, 6.6 Hz, 1H), 1.84 (ddd, *J* = 13.3, 8.1, 6.4 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.3,

149.6, 144.4, 139.4, 134.0, 118.7, 116.4, 53.4, 48.0, 43.4, 33.3, 29.8, 26.9; IR (Neat Film NaCl) 3076, 2946, 2857, 1669, 1629, 1434, 1372, 1320, 1266, 1230, 1206, 1167, 996, 917, 886 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{13}H_{18}OCl$ $[M+H]^+$: 225.1046; found 225.1053; $[\alpha]_D^{25.0}$ +46.29 (*c* 1.06, $CHCl_3$, 85.7% ee).



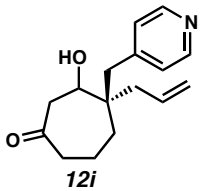
12h

β-Hydroxyketone 12h *(Table 3, entry 8).* Prepared using General Method A. 72.4 mg, 0.33 mmol, 90% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 4:1→2:1→1:1 Hexanes:EtOAc); R_f = 0.40, broad (1:1 Hexanes:EtOAc); ^1H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-42**; IR (Neat Film NaCl) 3468, 3075, 2932, 2871, 2247, 1696, 1458, 1437, 1420, 1352, 1319, 1252, 1169, 1122, 1070, 999, 921, 853, 754 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{13}H_{19}O_2N$ $[M]^{+\bullet}$: 221.1416; found 221.1411.



1h

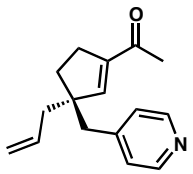
Acylcyclopentene 1h *(Table 3, entry 8).* Prepared using General Method D. 19.4 mg, 0.095 mmol, 94% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 2:1→3:2→1:1 Hexanes:Et_2O); R_f = 0.84, broad (1:1 Hexanes:EtOAc); ^1H NMR (300 MHz, $CDCl_3$) δ 6.42 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.70 (dddd, *J* = 16.4, 10.6, 7.4, 7.4 Hz, 1H), 5.15–5.12 (m, 1H), 5.15–5.06 (m, 1H), 2.60–2.52 (m, 2H), 2.37–2.22 (m, 2H), 2.32 (s, 3H), 2.23–2.20 (m, 2H), 1.93–1.82 (m, 3H), 1.73 (ddd, *J* = 13.6, 8.2, 7.0 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) 196.8, 147.2, 146.0, 133.3, 120.0, 119.0, 53.2, 43.5, 34.2, 32.7, 30.2, 27.0, 13.1; IR (Neat Film NaCl) 3074, 2923, 2857, 2245, 1667, 1640, 1618, 1423, 1373, 1308, 1264, 1202, 1090, 996, 918, 867 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{13}H_{18}NO$ $[M+H]^+$: 204.1388; found 204.1385; $[\alpha]_D^{25.0}$ –31.11 (*c* 0.90, $CHCl_3$, 87.4% ee).



12i

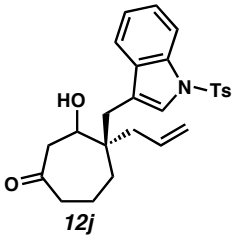
β-Hydroxyketone 12i *(Table 3, entry 9).* Prepared using General Method B. 21.6 mg, 0.083 mmol, 89% yield over 2 steps. Flash column chromatography (SiO_2, 1.5 x 25 cm, 4:1→2:1→1:2

Hexanes-Acetone); R_f = 0.10 (2:1 Hexanes-Acetone); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-43**; IR (Neat Film NaCl) 3391, 3201, 3073, 2929, 2865, 1699, 1636, 1603, 1557, 1497, 1456, 1418, 1352, 1332, 1297, 1258, 1222, 1187, 1161, 1113, 1069, 1005, 995, 972, 915, 886, 851, 802, 735 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{16}H_{22}O_2N$ $[M+H]^+$: 260.1650; found 260.1649.



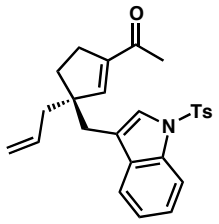
1i

Acylcyclopentene 1i ***(Table 3, entry 9).*** Prepared using General Method D. 15.7 mg, 0.065 mmol, 90% yield. Flash column chromatography (SiO_2, 1.5 x 16 cm, 2:1→1:1 Hexanes-Acetone); R_f = 0.47 (2:1 Hexanes-Acetone); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.49 (br d, *J* = 3.8 Hz, 2H), 7.04 (d, *J* = 5.7 Hz, 2H), 6.40 (dd, *J* = 1.7, 1.7 Hz, 1H), 5.75 (dddd, *J* = 17.3, 10.3, 7.3, 7.3 Hz, 1H), 5.16–5.04 (m, 2H), 2.77 (d, *J* = 13.0 Hz, 1H), 2.71 (d, *J* = 13.0 Hz, 1H), 2.52–2.39 (m, 1H), 2.33–2.35 (m, 1H), 2.28 (s, 3H), 2.24–2.20 (m, 2H), 1.85–1.80 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) 196.8, 149.6, 148.6, 147.3, 145.4, 134.0, 125.7, 118.8, 54.2, 44.4, 43.3, 33.3, 30.0, 27.0; IR (Neat Film NaCl) 3401, 3071, 3025, 2922, 2856, 1668, 1640, 1618, 1600, 1557, 1495, 1441, 1415, 1373, 1318, 1277, 1265, 1220, 1194, 1071, 994, 917, 874, 844, 810, 763 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{16}H_{19}ON$ $[M]^{+\bullet}$: 176.1467; found 176.1458; $[\alpha]_D^{25.0}$ –8.58 (*c* 0.77, $CHCl_3$, 84.6% ee).



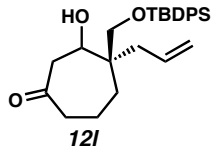
12j

β*-Hydroxyketone 12j** ***(Table 3, entry 10). Prepared using General Method A. 300.1 mg, 0.67 mmol, 94% yield. Flash column chromatography (SiO_2, 3 x 25 cm, 4:1→3:1→2:1→1:1 Hexanes:EtOAc); R_f = 0.20, 0.26 (two diastereomers) (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-44**; IR (Neat Film NaCl) 3436, 3068, 2930, 2873, 1693, 1639, 1597, 1494, 1447, 1365, 1402, 1365, 1279, 1211, 1188, 1172, 1133, 1121, 1095, 1063, 1020, 995, 975, 913, 813, 778, 747 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{26}H_{30}O_4NS$ $[M+H]^+$: 452.1896; found 452.1896.



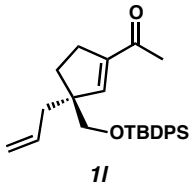
1j

Acylcyclopentene 1j ***(Table 3, entry 10).*** Prepared using General Method D. 55.7 mg, 0.10 mmol, 93% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 10:1→8:1→6:1→4:1 Hexanes:EtOAc); R_f = 0.67 (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.98 (br d, *J* = 8.2 Hz, 1H), 7.63 (dm, *J* = 8.4 Hz, 2H), 7.40 (dd, *J* = 7.3, 0.8 Hz, 1H), 7.33 (br s, 1H), 7.30 (ddd, *J* = 8.2, 8.2, 1.3 Hz, 1H), 7.21 (ddd, *J* = 7.5, 7.5, 1.1 Hz, 1H), 7.17 (dm, *J* = 8.2 Hz, 2H), 6.35 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.75 (dddd, *J* = 16.9, 10.3, 7.7, 6.9 Hz, 1H), 5.13–5.10 (m, 1H), 5.10–5.04 (m, 1H), 2.82 (s, 3H), 2.44 (dddd, *J* = 14.7, 8.8, 5.9, 1.7 Hz, 1H), 2.33 (br s, 2H), 2.31–2.18 (m, 3H), 2.16 (s, 3H), 1.86 (ddd, *J* = 14.6, 8.6, 6.1 Hz, 1H), 1.79 (ddd, *J* = 14.8, 7.6, 5.8 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) 196.9, 149.9, 145.1, 144.9, 135.2, 135.1, 134.3, 131.9, 130.0, 126.7, 124.8, 124.7, 123.2, 119.9, 119.4, 118.5, 113.9, 54.5, 43.5, 33.8, 33.4, 30.0, 26.8, 21.7; IR (Neat Film NaCl) 3316, 3129, 3101, 3068, 3001, 2974, 2922, 2855, 1667, 1639, 1618, 1597, 1562, 1493, 1448, 1400, 1372, 1307, 1293, 1277, 1211, 1188, 1174, 1121, 1094, 1020, 978, 916, 853, 813, 747 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{26}H_{27}O_3NS$ $[M]^{+\bullet}$: 433.1712; found 433.1694; $[\alpha]_D^{25.0}$ +0.35 (*c* 1.09, $CHCl_3$, 82.9% ee).



12l

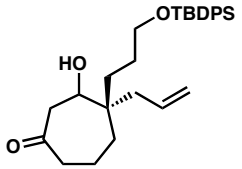
β*-Hydroxyketone 12l** ***(Table 3, entry 11). Prepared using General Method C. 55.6 mg, 0.13 mmol, 95% yield over 2 steps. Flash column chromatography (SiO_2, 1.5 x 25 cm, 6:1→4:1 Hexanes:EtOAc); R_f = 0.22, 0.28 (two diastereomers) (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-45**; IR (Neat Film NaCl) 3468, 3072, 3050, 2999, 3013, 2931, 2895, 2858, 2248, 1960, 1891, 1823, 1772, 1698, 1638, 1590, 1472, 1462, 1446, 1428, 1391, 1361, 1337, 1260, 1222, 1186, 1172, 1158, 1113, 1088, 1030, 1006, 999, 976, 914, 841, 823, 810, 740 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{27}H_{37}O_3Si$ $[M+H]^+$: 437.2512; found 437.2517.



1l

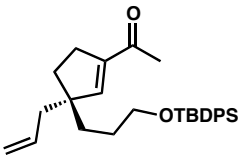
Acylcyclopentene 1l ***(Table 3, entry 11).*** Prepared using General Method D. 32.6 mg, 0.078 mmol, 96% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f =

0.60 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.67–7.60 (m, 4H), 7.47–7.34 (m, 6H), 6.50 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.71 (dddd, *J* = 17.0, 10.1, 7.8, 6.9 Hz, 1H), 5.12–5.08 (m, 1H), 5.06–5.02 (m, 1H), 3.57 (d, *J* = 9.8 Hz, 1H), 3.53 (d, *J* = 9.8 Hz, 1H), 2.54–2.48 (m, 2H), 2.38 (ddd, *J* = 13.8, 6.9, 1.1 Hz, 1H), 2.31–2.25 (m, 1H), 2.29 (s, 3H), 1.81–1.72 (m, 2H), 1.07 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.2, 148.5, 145.7, 135.8, 135.7, 134.5, 133.6, 133.6, 129.9, 129.9, 127.8, 118.0, 69.1, 56.5, 40.4, 30.7, 30.0, 27.0, 26.8, 19.5; IR (Neat Film NaCl) 3072, 3050, 2999, 2956, 2931, 2896, 2857, 1671, 1639, 1618, 1472, 1463, 1427m 1367, 1320, 1266, 1232, 1188, 1112, 998, 936, 915, 864, 824, 740 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{27}H_{34}O_2Si$ $[M]^{+\bullet}$: 433.1712; found 433.1694; $[\alpha]_D^{25.0}$ –17.58 (*c* 0.94, $CHCl_3$, 51.4% ee).



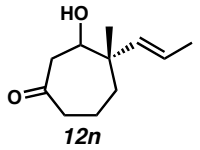
12m

β-Hydroxyketone 12m ***(Table 3, entry 12).*** Prepared using General Method C. 110.6 mg, 0.24 mmol, 92% yield over 2 steps. Flash column chromatography (SiO_2, 2 x 25 cm, 6:1→4:1 Hexanes:EtOAc); R_f = 0.15 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-46**; IR (Neat Film NaCl) 3436, 3071, 3050, 3013, 2999, 2931, 2896, 2859, 1960, 1891, 1826, 1694, 1638, 1589, 1472, 1461, 1428, 1390, 1360, 1325, 1307, 1251, 1218, 1188, 1168, 1111, 1092, 1007, 998, 973, 934, 914, 823, 798, 740 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{29}H_{41}O_3Si$ $[M+H]^+$: 465.2825; found 465.2810.



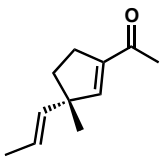
1m

Acylcyclopentene 1m ***(Table 3, entry 12).*** Prepared using General Method D. 92.2 mg, 0.21 mmol, 92% yield. Flash column chromatography (SiO_2, 2 x 25 cm, 15:1 Hexanes:Et_2O); R_f = 0.64 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.71–7.64 (m, 4H), 7.48–7.35 (m, 6H), 6.44 (dd, *J* = 1.7, 1.7 Hz, 1H), 5.81–5.65 (m, 1H), 5.10–5.07 (m, 1H), 5.05–5.02 (m, 1H), 3.69–3.64 (m, 2H), 2.55–2.49 (m, 2H), 2.31 (s, 3H), 2.20–2.18 (m, 2H), 1.84–1.67 (m, 2H), 1.53–1.48 (m, 4H), 1.07 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.3, 150.7, 144.4, 135.7, 134.7, 134.0, 129.7, 127.7, 117.8, 64.3, 53.3, 43.5, 34.8, 33.3, 30.0, 28.0, 27.0, 26.8, 19.3; IR (Neat Film NaCl) 3071, 3050, 3013, 2999, 2931, 2897, 2857, 1670, 638, 1618, 1589, 1472, 1461, 1448, 1428, 1388, 1372, 1316, 1263, 1201, 1157, 1111, 1093, 1030, 1008, 998, 937, 915, 865, 823, 803, 741, 726 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{25}H_{29}O_2Si$ $[M–C_4H_9]^+$: 389.1968; found 389.1958; $[\alpha]_D^{25.0}$ –14.19 (*c* 0.92, $CHCl_3$, 78.4% ee).



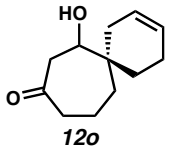
12n

β*-Hydroxyketone 12n *(Table 3, entry 13). Prepared using General Method A. 429.5 mg, 2.36 mmol, 87% yield. Flash column chromatography (SiO_2, 3 x 20 cm, 9:1→3:1 Hexanes:EtOAc); R_f = 0.14 (4:1 Hexanes:EtOAc); ^{1}H NMR (400 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-47**; IR (Neat Film NaCl) 3449, 3027, 2963, 2928, 2873, 1694, 1454, 1404, 1350, 1320, 1251, 1170, 1066, 969 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{11}H_{19}O_2$ $[M+H]^+$: 165.1274; found 165.1278.



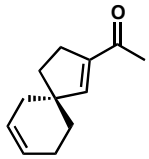
1n

Acylcyclopentene 1n *(Table 3, entry 13).* Prepared using General Method D. Due to the volatility of acylcyclopentene **1n**, the work-up solvent (Et_2O) was removed using ambient pressure distillation (50→80 °C). 323.8 mg, 1.97 mmol, 93% yield. The crude oil was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 32 g loading cartridge, 80 g column, linear gradient, 0→30% Et_2O in Pentane [33 min]) and solvent was removed using ambient pressure distillation (60 °C); R_f = 0.55 (4:1 Hexanes:EtOAc); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.41 (dd, *J* = 1.7, 1.7 Hz, 1H), 5.50 (dq, *J* = 15.5, 1.3 Hz, 1H), 5.39 (dq, *J* = 15.6, 6.2 Hz, 1H), 2.58–2.52 (m, 2H), 2.31–2.28 (m, 1H), 2.30 (s, 3H), 1.91 (ddd, *J* = 12.8, 7.4, 7.4 Hz, 1H), 1.74 (ddd, *J* = 12.8, 7.2, 7.2 Hz, 1H), 1.68–1.64 (m, 2H), 1.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.5, 151.4, 143.8, 137.5, 122.3, 51.5, 38.1, 29.6, 26.8, 25.4, 18.2; IR (Neat Film NaCl) 3022, 2958, 2859, 1674, 1617, 1451, 1377, 1365, 1310, 1271, 1229, 1165, 967 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{11}H_{17}O$ $[M+H]^+$: 165.1279; found 165.1278; $[\alpha]_D^{25.0}$ +89.82 (*c* 1.04, $CHCl_3$, 88.0 % ee).



12o

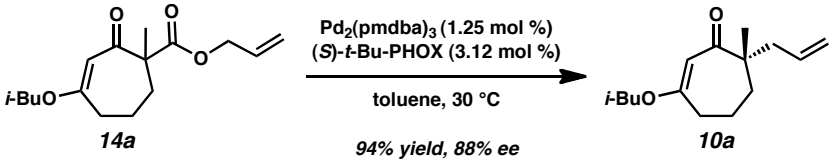
β*-Hydroxyketone 12o *(Table 3, entry 14). Prepared using General Method A. 29.1 mg, 0.150 mmol, 96% yield. Flash column chromatography (SiO_2, 2 x 20 cm, 9:1→3:1 Hexanes:EtOAc); R_f = 0.09 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-48**; IR (Neat Film NaCl) 3436, 3021, 2922, 2873, 2842, 2697, 1692, 1656, 1436, 1402, 1353, 1318, 1256, 1202, 1184, 1172, 1152, 1093, 1071, 1050, 1000, 981, 970, 949, 932, 876, 850, 834, 798, 750 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{12}H_{18}O_2$ $[M]^{+\bullet}$: 194.1307; found 194.1315.



1o

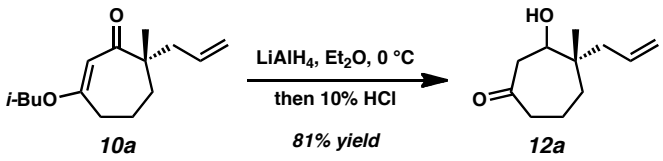
Acylcyclopentene 1o ***(Table 3, entry 14).*** Prepared using General Method D. 21.7 mg, 0.123 mmol, 91% yield. Flash column chromatography (SiO_2, 1 x 20 cm, 15:1 Hexanes:Et_2O); R_f = 0.65 (4:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.58 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.72 (dm, *J* = 10.0 Hz, 1H), 5.65 (dm, *J* = 10.0 Hz, 1H), 2.59–2.52 (m, 2H), 2.30 (s, 3H), 2.13–2.04 (m, 2H), 2.02–1.98 (m, 2H), 1.77–1.70 (m, 2H), 1.69 (ddd, *J* = 12.8, 6.3, 6.3 Hz, 1H), 1.56 (ddd, *J* = 12.8, 6.5, 6.5 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) 197.8, 151.4, 143.9, 127.0, 125.5, 48.7, 35.8, 35.8, 32.5, 28.9, 26.8, 23.1; IR (Neat Film NaCl) 3320, 3023, 2918, 2856, 1704, 1669, 1616, 1436, 1371, 1436, 1371, 1316, 1269, 1231, 11945, 1116, 1086, 1045, 1020, 980, 962, 935, 864, 763 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{12}H_{16}O$ $[M]^{+\bullet}$: 176.1201; found 176.1234; $[\alpha]_D^{25.0}$ –10.42 (*c* 1.08, $CHCl_3$, 78.4% ee).

Procedure for the Large Scale Synthesis of Acylcyclopentene 1a

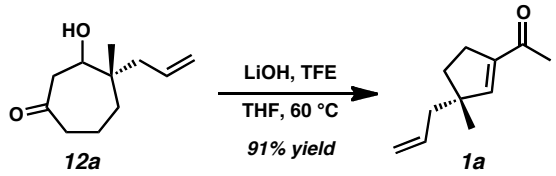


14a *10a*

Vinylogous Ester 10a. $Pd_2(pmdba)_3$ (733.1 mg, 0.67 mmol, 0.0125) and (*S*)-*t*-BuPHOX (647.0 mg, 1.67 mmol, 0.0312 equiv) were placed in a 500 mL round-bottom flask. The flask was evacuated/backfilled with N_2 (3 cycles, 10 min evacuation per cycle). Toluene (222 mL, sparged with N_2 for 1 h immediately before use) was added and the black suspension was immersed in an oil bath preheated to 30 °C. After 30 min of stirring, the vinylogous ester **14a** (15.0 g, 53.5 mmol, 1.0 equiv) in toluene (46 mL, sparged with N_2 immediately before use) was added using positive pressure cannulation. The dark orange catalyst solution turned olive green immediately after the addition of *β*-ketoester **14a**. The solution was stirred at 30 °C for 32 h, allowed to cool to ambient temperature, filtered through a silica gel plug (2 x 5.5 cm SiO_2, Et_2O), and concentrated under reduced pressure. The crude oil was purified by flash column chromatography (SiO_2, 8 x 12 cm, 19:1 Hexanes:EtOAc, dry-loaded using SiO_2) to afford vinylogous ester **10a** (11.83 g, 50.1 mmol, 94% yield, 88% ee) as a pale yellow oil. (For characterization data, see p. 22).

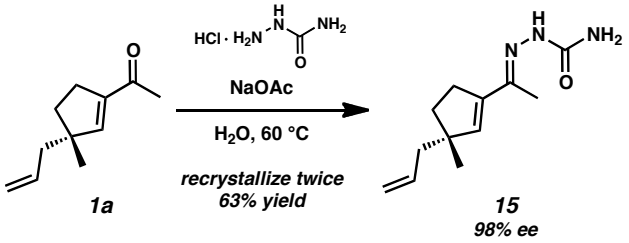


β-Hydroxyketone 12a. A 500 mL round-bottom flask with magnetic stir bar was charged with Et_2O (150 mL) and cooled to 0 °C. $LiAlH_4$ (1.04 g, 0.0275 mol, 0.55 equiv) was added in one portion. After 10 min, a solution of vinylogous ester **10a** (11.83 g, 50 mmol, 1.0 equiv) in Et_2O (50 and 25 mL for quantitative transfer) was added dropwise using positive pressure cannulation. The grey suspension was stirred for 60 min after which $LiAlH_4$ (190 mg, 5.0 mmol, 0.1 equiv) was added in one portion. After an additional 10 min of stirring at 0 °C, the reaction was quenched by slow addition of aqueous HCl (143 mL, 10% w/w). The resulting biphasic system was allowed to warm to ambient temperature and stirred vigorously for 10 h. The reaction was diluted with Et_2O, the phases were separated and the aqueous phase was extracted with Et_2O (3 x 150 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was azeotroped with toluene (50 mL) and purified using flash column chromatography (SiO_2, 8 x 13 cm, 9:1→3:1 Hexanes:EtOAc, dry-loaded using Celite) to afford β-hydroxyketone **12a** (7.25 g, 39.8 mmol, 81% yield) as a colorless semi-solid. (For characterization data, see p. 33).



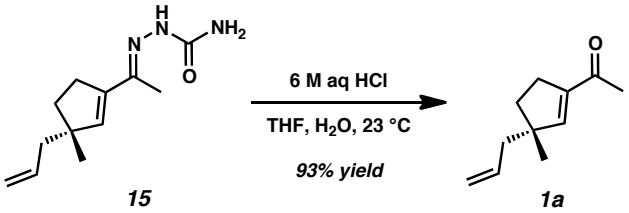
Acylcyclopentene 1a. Alcohol **12a** (7.25 g, 39.8 mmol, 1.0 equiv) was dissolved in THF (400 mL) in a 1 L round-bottom flask. The solution was treated with 2,2,2-trifluoroethanol (5.99 g, 4.36 mL, 59.7 mmol, 1.5 equiv) and LiOH (1.43 g, 59.7 mmol, 1.5 equiv). The flask was fitted with a reflux condenser, purged with N_2, and heated to 60 °C using an oil bath. After 18 h of stirring, the suspension was allowed to cool to ambient temperature, diluted with Et_2O (200 mL), stirred with Na_2SO_4 for 30 min, filtered, and concentrated carefully under reduced pressure, allowing for a film of ice to form on the outside of the flask. The crude product was purified using flash column chromatography (SiO_2, 8 x 12 cm, 15:1→9:1 Pentane:Et_2O) to afford acylcyclopentene **1a** (5.93 g, 36.1 mmol, 91% yield) as a colorless fragrant oil. (For characterization data, see p. 33).

Procedures for the Synthesis of Acylcyclopentene Derivatives



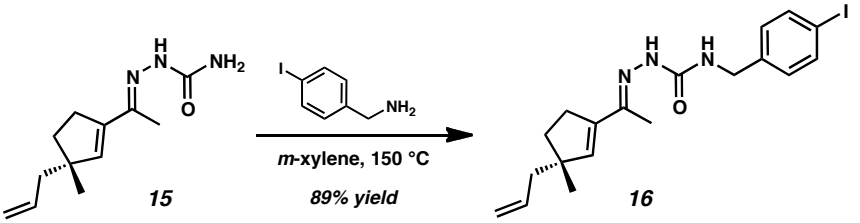
Semicarbazone 1a. A 15 mL round-bottom flask was charged with sodium acetate (150 mg, 1.83 mmol, 1.20 equiv), semicarbazide hydrochloride (204 mg, 1.83 mmol, 1.20 equiv), and a magnetic stir bar. Purified water (1.7 mL) was added and the mixture was stirred until all the solids had dissolved. Acylcyclopentene **1a** (250 mg, 1.52 mmol, 1.00 equiv) was added neat and the mixture was heated to 60 °C for 4 h. The slurry was allowed to cool to ambient temperature while stirring and vacuum filtered (water aspirator). The white solid was dried under reduced pressure to afford semicarbazone **15** (311 mg, 1.40 mmol, 92% yield). The ee of the semicarbazone at this point was found to be 91% (measured by hydrolysis to ketone **1a,** GC conditions: 80 °C isothermal for 90 min, G-TA column, t_R (min): acylcyclopentene **1a** = 54.98).

The semicarbazone **15** (300 mg, 1.36 mmol) was transferred to a round-bottom flask, the solids were suspended in toluene-hexanes (50:50), and the mixture was heated to 90 °C while stirring. After a few min of stirring, the solids had dissolved completely to afford a clear, colorless solution. Heating was discontinued and the stirring mixture was allowed to cool to ambient temperature while still immersed in the oil bath. After 10 h had elapsed, the slurry was vacuum filtered to afford **15** (246 mg, 1.11 mmol, 82% yield, 63% overall yield after recrystallizing twice). The ee at this point was found to be 94.5% (measured by hydrolysis to ketone **1a**). A second recrystallization following the above procedure employing **15** (241 mg, 1.09 mmol) afforded **15** (201 mg, 0.91 mmol, 83% yield). The ee at this point was found to be 97.9% (measured by hydrolysis to ketone **1a**); R_f = 0.30 (9:1 $CHCl_3$-MeOH); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 (br s, 1H), 6.06 (br s, 1H), 5.85 (app t, *J* = 1.6 Hz, 1H), 5.76 (dddd, *J* = 16.7, 9.3, 7.4, 7.4 Hz, 1H), 5.47 (br s, 1H), 5.06–4.98 (m, 2H), 2.67–2.49 (m, 2H), 2.15–2.12 (m, 2H), 1.98 (s, 3H), 1.82 (ddd, *J* = 12.8, 8.2, 6.9 Hz, 1H), 1.62 (ddd, *J* = 12.8, 8.5, 6.4 Hz, 1H), 1.07 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.1, 145.0, 141.7, 141.2, 135.6, 117.2, 49.2, 45.9, 36.2, 30.8, 26.3, 12.8; IR (Neat Film NaCl) 3473, 3266, 3189, 2946, 2858, 1698, 1579, 1478, 1437, 1377, 1349, 1321, 1130, 1109, 993, 910, 845, 768 cm^{-1}; HRMS (ESI+) *m*/*z* calc'd for $C_{12}H_{20}N_3O$ $[M+H]^+$: 222.1606; found 222.1610; $[\alpha]_D^{22.6}$ +39.80 (*c* 0.84, $CHCl_3$, 97.9% ee); mp = 145–146 °C (1:1 toluene-hexanes).

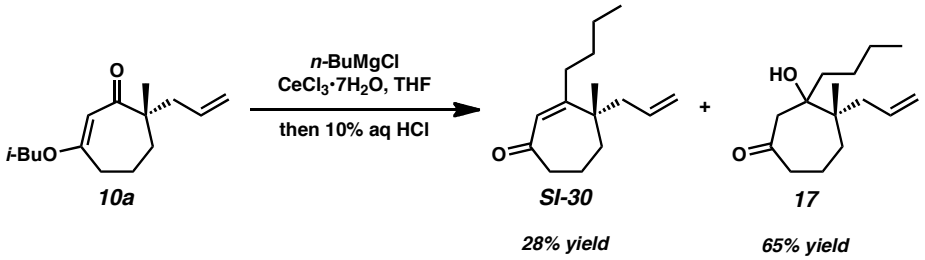


Acylcyclopentene 1a. A solution of semicarbazone **15** (191.8 mg, 0.867 mmol, 1.00 equiv) in THF (1.92 mL) was treated with aqueous HCl (3.84 mL, 6.0 M, in H_2O) was added. The

resulting biphasic mixture was stirred vigorously at ambient temperature for 30 h. The reaction was diluted with Et_2O (10 mL), the phases were separated, and the aqueous phase was extracted with Et_2O (2 x 10 mL). The combined organics were dried over $MgSO_4$, filtered, and concentrated carefully under reduced pressure, allowing for a film of ice to form on the outside of the flask. The residue was filtered through a short silica gel plug (1 x 10 cm SiO_2, 4:1 Hexanes:Et_2O) to afford acylcyclopentene **1a** (132.6 mg, 0.81 mmol, 93% yield); $[\alpha]_D^{22.6}$ +39.80 (*c* 0.84, $CHCl_3$, 97.9% ee). (For characterization data, see p. 33).



Iodoarene 16. To a solution of semicarbazone **15** (50 mg, 0.23 mmol, 1.00 equiv) in *m*-xylene (2.2 mL) was added 4-iodo-benzylamine (63 mg, 0.27 mmol, 1.17 equiv). The resulting pale yellow solution was immersed in an oil bath and heated to 150 °C. After 9 h of stirring at 150 °C, the reaction was allowed to cool to ambient temperature and concentrated under reduced pressure to afford a pale yellow solid. The crude solid was purified by flash column chromatography (1.0 x 15 cm SiO_2, 9:1→7:3 Hexanes:EtOAc) to afford iodoarene **16** (88 mg, 0.20 mmol, 89% yield) as a white solid. X-ray quality crystals were obtained by slow vapor diffusion of pentane into a chloroform solution of **16**; R_f = 0.52 (9:1 $CHCl_3$-MeOH); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (s, 1H), 7.66–7.64 (m, 2H), 7.08 (d, *J* = 8.5 Hz, 2H), 6.50 (t, *J* = 6.1 Hz, 1H), 5.86 (app t, *J* = 1.5 Hz, 1H), 5.76 (dddd, *J* = 16.9, 9.0, 7.6, 7.6 Hz, 1H), 5.04–5.01 (m, 2H), 4.46 (d, *J* = 6.3 Hz, 2H), 2.60–2.49 (m, 2H), 2.18–2.10 (m, 2H); 1.95 (s, 3H), 1.82 (ddd, *J* = 12.9, 8.5, 6.3 Hz, 1H), 1.62 (ddd, *J* = 12.9, 8.5, 6.1 Hz, 1H), 1.07 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 156.3, 144.5, 141.5, 141.4, 139.2, 137.8, 135.6, 129.4, 117.2, 92.6, 49.3, 45.9, 43.2, 36.2, 30.9, 26.3, 12.5; IR (Neat Film NaCl) 3411, 3194, 3075, 2946, 2920, 2863, 1677, 1528, 1486, 1401, 1323, 1259, 1142, 1114, 1057, 1000, 913, 845 cm^{-1}; HRMS (FAB+) *m/z* calc'd for $C_{19}H_{25}N_3OI$ $[M+H]^+$: 438.1043; found 438.1036; $[\alpha]_D^{22.2}$ +31.43 (*c* 0.36, $CHCl_3$, 91.0% ee); mp = 123–124 °C ($CHCl_3$-*n*-pentane).

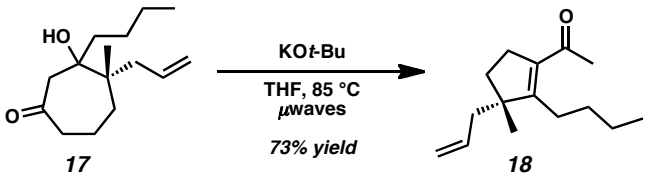


Acylcyclopentene SI-30 and **β-Hydroxyketone 17.** $CeCl_3 \cdot 7H_2O$ (419 mg, 1.13 mmol, 2.55 equiv) in a 100 mL round-bottom flask was immersed in a preheated oil bath at 150 °C and placed under vacuum for 4 h while stirring. The flask was cooled to ambient temperature, backfilled with N_2, and charged with THF (4 mL). After 15 h of stirring, additional THF (4 mL)

and *n*-butylmagnesium chloride solution (1.2 mL, 1.86 M in THF, 2.23 mmol, 5.02 equiv) were added to the flask. The resulting slurry was stirred for 4.25 h before vinylogous ester **10a** (105 mg, 0.444 mmol, 1.00 equiv) dissolved in THF (1 mL) was added using positive pressure cannulation followed by two THF rinses (2 x 0.5 mL). After 45 min of stirring, the reaction was quenched by addition of 10% w/w HCl (10 mL). The phases were separated and the aqueous layer was extracted with ethyl acetate (3 x 15 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography using a Teledyne Isco CombiFlash R_f system (SiO_2, 25 g loading cartridge, 12 g column, multi-step gradient, hold 0% [1 min]→ramp to 10% [5 min]→hold 10% [31 min]→100% EtOAc in Hexanes [10 min]) to afford acylcyclopentene **30** (28 mg, 0.13 mmol, 28% yield) and β-hydroxyketone **17** (69 mg, 0.29 mmol, 65% yield) as pale yellow oils.

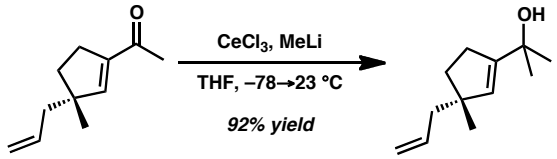
Acylcyclopentene SI-30. R_f = 0.68 (30% EtOAc in Hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.89 (s, 1H), 5.63 (dddd, *J* = 16.9, 10.3, 7.9, 6.7 Hz, 1H), 5.10–4.98 (m, 2H), 2.61–2.54 (m, 2H), 2.37 (dddd, *J* = 14.1, 6.7, 1.3, 1.3 Hz, 1H), 2.18–2.03 (m, 3H), 1.85–1.72 (m, 3H), 1.66–1.56 (m, 1H), 1.53–1.43 (m, 2H), 1.37 (app. septuplet, *J* = 7.3 Hz, 2H), 1.15 (s, 3H), 0.92 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 205.4, 163.0, 134.2, 128.7, 118.1, 45.7, 45.3, 44.4, 38.8, 34.0, 32.4, 25.7, 23.0, 17.6, 14.1; IR (Neat Film NaCl) 3076, 2957, 2933, 2872, 1652, 1611, 1467, 1414, 1379, 1342, 1263, 1218, 1178, 1109, 1072, 996, 962, 914, 841, 780, 713 cm^{-1}; HRMS (MM: ESI–APCI+) calc'd for $C_{15}H_{25}O$ $[M+H]^+$: 221.1900; found 221.1905; $[\alpha]_D^{25.0}$ –33.17 (*c* 1.17, $CHCl_3$, 88.0% ee).

β-Hydroxyketone 17. R_f = 0.48 (30% EtOAc in Hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-66**; IR (Neat Film NaCl) 3502, 3073, 2956, 2871, 1695, 1638, 1468, 1404, 1380, 1341, 1286, 1181, 1125, 1052, 1028, 998, 913, 868, 796, 732 cm^{-1}; HRMS (MM: ESI–APCI+) calc'd for $C_{15}H_{27}O_2$ $[M+H]^+$: 239.2006; found 239.2013.

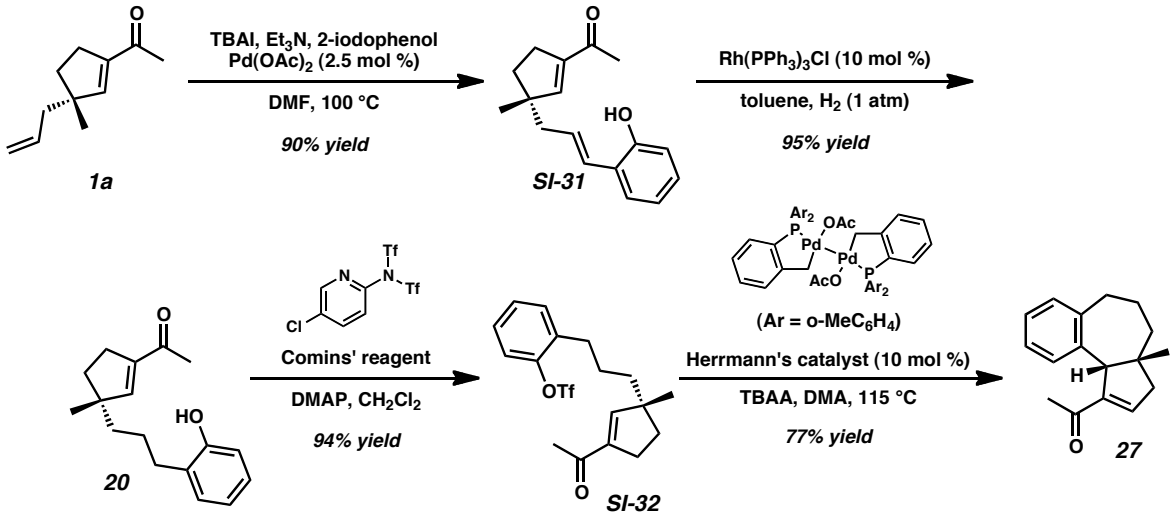


Acylcyclopentene 18. KO*t*-Bu (32 mg, 0.283 mmol, 1.62 equiv), THF (1.75 mL), and β-hydroxyketone **17** (175 μL, 1.0 M in benzene, 0.175 mmol, 1.00 equiv) were added to a 0.5–2.0 mL microwave vial with a magnetic spin vane. The pale yellow solution was subjected to microwave irradiation in a Biotage Initiator microwave reactor (temperature: 85 °C, sensitivity: normal). After 5 min of irradiation, the crimp cap was removed and Na_2SO_4 was added to the vial. The contents were filtered through a silica gel plug with Et_2O, concentrated under reduced pressure, and purified by flash column chromatography (5% Et_2O in Pentane) to yield acylcyclopentene **18** (31 mg, 0.14 mmol, 73% yield) as a pale yellow oil; R_f = 0.81 (30% EtOAc in Hexanes); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.77–5.65 (m, 1H), 5.08–5.00 (m, 2H), 2.60–2.49 (m, 2H), 2.45–2.37 (m, 1H), 2.24–2.17 (m, 4H), 2.15–2.10 (m, 2H), 1.85 (ddd, *J* = 12.8, 7.7, 6.2 Hz, 1H), 1.60–1.51 (m, 1H), 1.47–1.34 (m, 4H), 1.06 (s, 3H), 0.93 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR

(125 MHz, $CDCl_3$) δ 198.8, 164.2, 135.0, 134.7, 117.6, 52.6, 43.8, 35.0, 32.1, 31.5, 30.4, 27.6, 24.7, 23.8, 14.0; IR (Neat film NaCl) 3075, 3002, 2957, 2930, 2870, 2859, 1677, 1653, 1639, 1602, 1456, 1432, 1373, 1355, 1311, 1275, 1258, 1188, 1141, 1089, 995, 959, 913, 848, 801, 726 cm^{-1}; HRMS (MM: ESI–APCI+) calc'd for $C_{15}H_{25}O$ $[M+H]^+$: 221.1900; found 221.1900; $[\alpha]_D^{25.0}$ –1.44 (*c* 1.35, $CHCl_3$, 88.0% ee).



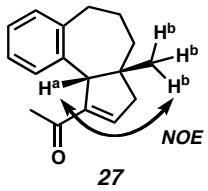
Alcohol 19. $CeCl_3$ (187 mg, 0.759 mmol, 2.50 equiv) was weighed out in a glovebox and placed in a 25 mL round-bottom flask. The flask was sealed with a septum and removed from the glovebox. THF (3 mL) was added to the flask, the suspension was cooled to –78 °C using an acetone/CO_2 (s) bath, and MeLi (326 μL, 0.912 mmol, 2.80 M in DME, 3.00 equiv) was added in a dropwise manner. The resulting pale brown suspension was stirred at –78 °C for 30 min. Acylcyclopentene **1a** (50.0 mg, 0.304 mmol, 1.00 equiv) was added neat to the reaction in a dropwise manner. After 30 min of stirring at –78 °C, the reaction was quenched by dropwise addition of sat aqueous NH_4Cl (1.0 mL), the cooling bath was removed, and the reaction was allowed to warm to ambient temperature. The reaction was diluted with Et_2O (10 mL) and H_2O (10 mL) and the phases were separated. The aqueous phase was extracted with Et_2O (3 x 15 mL) and the combined organic phases were washed with brine (10 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 5 g loading cartridge, 12 g column, multi-step gradient, 5% [5 min]→10% Et_2O in Pentane) to afford alcohol **19** (50.4 mg, 0.280 mmol, 92% yield) as a pale yellow oil; R_f = 0.31 (4:1 Hexanes:EtOAc); ^1H NMR (400 MHz, $CDCl_3$) δ 5.78 (dddd, *J* = 14.7, 11.8, 9.3, 7.4 Hz, 1H), 5.34 (dd, *J* = 1.8, 1.8 Hz, 1H), 5.04–5.00 (m, 1H), 5.00–4.97 (m, 1H), 2.45–2.29 (m, 2H), 2.18–2.00 (m, 2H), 1.81 (ddd, *J* = 12.7, 8.3, 6.0 Hz, 1H), 1.60 (ddd, *J* = 12.7, 8.5, 6.1 Hz, 1H), 1.44 (br s, 1H), 1.34 (s, 6H), 1.02 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.7, 136.21, 131.6, 116.7, 70.9, 48.2, 46.2, 36.9, 30.9, 29.3, 29.3, 26.5; IR (Neat Film NaCl) 3370, 3077, 2973, 2943, 2859, 1637, 1454, 1412, 1367, 1328, 1254, 1212, 1162, 1137, 997, 960, 940, 910, 853, 806 cm^{-1}; HRMS (MM: ESI-APCI+) *m/z* calc'd for $C_{12}H_{19}$ $[M-OH]^+$: 163.1481; found 163.1482; $[\alpha]_D^{25.0}$ +5.34 (*c* 1.16, $CHCl_3$, 88.0 % ee).



Phenol 20. DMF (1.52 mL) was sparged with N_2 in a 25 mL Schlenk flask for 1 h. Et_3N (0.849 mL, 6.09 mmol, 5.0 equiv), TBAI (450 mg, 1.22 mmol, 1.0 equiv) and 2-iodophenol (282.2 mg, 1.28 mmol, 1.05 equiv) were added, followed by $Pd(OAc)_2$ (6.84 mg, 0.030 mmol, 2.5 mol %). The flask was carefully evacuated/backfilled with N_2 (3 cycles, 1 min evacuation per cycle) followed by addition of acylcyclopentene **1a** (200 mg, 1.22 mmol, 1.0 equiv). The suspension was immersed in an oil bath at 100 °C. The reaction turned orange within 15 min of stirring. After 5 h of stirring, the reaction was allowed to cool to ambient temperature, diluted with EtOAc (10 mL), and poured into aqueous HCl (10 mL, 1.0 M). The phases were separated and the aqueous phase was extracted with EtOAc (2 x 10 mL). The combined organic phases were washed with brine (10 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude oil was purified by flash column chromatography using a Teledyne Isco CombiFlash R_f system (SiO_2, 12 g loading cartridge, 40 g column, linear gradient, 5%→30% EtOAc in Hexanes [25 min]) to afford styrenyl phenol **SI-31** (283.0 mg, 1.10 mmol, 90% yield) as a colorless oil. $R_f = 0.17$ (4:1 Hexanes:EtOAc).

$Rh(PPh_3)_3Cl$ (22.2 mg, 0.024 mmol, 0.10 equiv) was weighed out in a glove box and added to a long reaction tube with magnetic stir bar. Styrenyl phenol **SI-31** (61.5 mg, 0.240 mmol, 1.0 equiv) was dissolved in toluene (4.8 mL) and added to the reaction tube using positive pressure cannulation. H_2 was bubbled through the suspension for 5 min and the reaction tube was fitted with a balloon containing H_2 (1 atm). The reaction was stirred for an additional 6 h at which point TLC analysis indicated complete conversion of the starting material. The resulting clear orange reaction mixture was adsorbed onto a 12 g Isco loading cartridge and purified by flash column chromatography using a Teledyne Isco CombiFlash R_f system (SiO_2, 12 g loading cartridge, 24 g column, linear gradient, 5%→50% Et_2O in Hexanes [40 min]) to afford phenol **20** (58.9 mg, 0.228 mmol, 95% yield) as a pale yellow oil; $R_f = 0.18$ (4:1 Hexanes:EtOAc); ^1H NMR (300 MHz, $CDCl_3$) δ 7.13–7.04 (m, 2H), 6.87 (t, J = 7.4 Hz, 1H), 6.75 (d, J = 7.9 Hz, 1H), 6.46 (app t, J = 1.7 Hz, 1H), 4.82 (bs, 1H), 2.60 (t, J = 7.3 Hz, 2H), 2.56–2.50 (m, 2H), 2.29 (s, 3H), 1.87–1.75 (m, 1H), 1.71–1.42 (m, 5H), 1.09 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.9, 153.6, 152.8, 143.4, 130.4, 128.4, 127.3, 120.9, 115.3, 50.1, 40.8, 36.2, 30.8, 29.7, 26.8, 25.8, 25.5; IR (Neat Film NaCl) 3344, 3054, 3039, 2951, 2863, 1651, 1610, 1592, 1507, 1455, 1377, 1365, 1313, 1272, 1238, 1179, 1155, 1127, 1106, 1042, 907, 853, 752 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{17}H_{23}O_2$ $[M+H]^+$: 259.1693; found 259.1691; $[\alpha]_D^{25.0}$ +28.73 (c 0.74, $CHCl_3$, 88.0% ee).

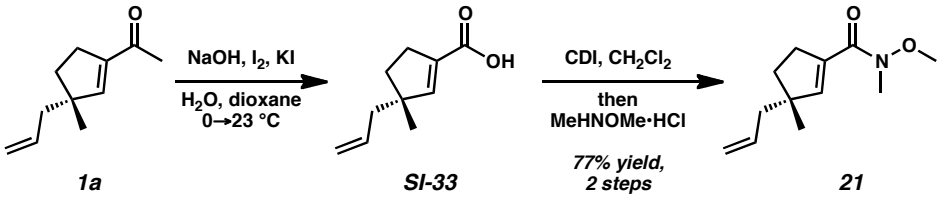
Triflate SI-32. To a solution of phenol **20** (104.2 mg, 0.40 mmol, 1.00 equiv) in CH_2Cl_2 (8.0 mL) in a 20 mL vial was added DMAP (97.8 mg, 0.80 mmol, 2.0 equiv) in one portion, followed by *N*,*N*-Bis(trifluoromethylsulfonyl)-5-chloro-2-pyridylamine (172.8 mg, 0.44 mmol, 1.1 equiv). After 15 min of stirring at ambient temperature, TLC revealed full conversion of phenol **20**. The reaction mixture was adsorbed onto a 12 g Isco loading cartridge and purified by flash column chromatography using a Teledyne Isco CombiFlash R_f system (SiO_2, 12 g loading cartridge, 40 g column, linear gradient, 5→20% EtOAc in Hexanes [25 min]) to afford triflate **SI-32** (146.2 mg, 0.374 mmol, 94% yield) as a clear, colorless oil; R_f = 0.44. (4:1 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32–7.30 (m, 2H), 7.28 (dd, *J* = 8.5, 4.0 Hz, 1H), 7.24 (dm, *J* = 7.8 Hz, 1H), 6.44 (app t, *J* = 1.8 Hz, 1H), 2.69 (t, *J* = 7.7 Hz, 2H), 2.61–2.46 (m, 2H), 2.29 (s, 3H), 1.80 (ddd, *J* = 13.0, 8.7, 6.5 Hz, 1H), 1.66 (ddd, *J* = 11.8, 8.0, 5.2 Hz, 1H), 1.64–1.45 (m, 3H), 1.50 (ddd, *J* = 11.4, 7.5, 5.1 Hz, 1H), 1.10 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.6, 152.0, 148.1, 143.7, 135.1, 131.3, 128.5, 128.0, 121.5, 118.7 (q, *J* = 320 Hz, 1C), 50.0, 40.7, 36.1, 30.8, 29.8, 26.8, 25.8, 25.7; IR (Neat Film NaCl) 3032, 2958, 2868, 1671, 1617, 1486, 1454, 1420, 1365, 1303, 1251, 1217, 1140, 1100, 1073, 893, 814, 767 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{18}H_{22}F_3O_4S$ $[M+H]^+$: 391.1188; found 391.1193; $[\alpha]_D^{25.0}$ +22.00 (c 1.31, $CHCl_3$, 88.0% ee).



27

Acylcyclopentene 27. To a solution of triflate **SI-32** (30.0 mg, 0.077 mmol, 1.0 equiv) in dry DMA (1.54 mL) in a 4 dram vial was added TBAA (57.9 mg, 0.19 mmol, 2.5 equiv, stored and weighed out in a glovebox). The resulting clear, colorless solution was degassed by bubbling Ar though the solution for 1 h. Herrmann's catalyst[8] (7.2 mg, 7.7 μmol, 0.10 equiv) was placed in a reaction tube which was subsequently evacuated/backfilled with Ar (3 cycles, 1 min evacuation per cycle). The solution containing triflate **SI-32** was added to the catalyst using positive pressure cannulation. The resulting pale green-yellow solution was immersed in an oil bath at ambient temperature and heated to 115 °C. After 2 h of stirring, the reaction was allowed to cool to ambient temperature, diluted with EtOAc (10 mL), and poured into aqueous HCl (1.0 M, 5.0 mL). The phases were separated and the aqueous phase was extracted with EtOAc (10 mL). The combined organics were washed with brine (5.0 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography using a Teledyne Isco CombiFlash R_f system (SiO_2, 2.5 g loading cartridge, 4 g column, multi-step gradient, hold 5% [10 min]→hold 10% [4 min]→hold 20% [3 min]→hold 60% EtOAc in Hexanes [3 min]) to afford acylcyclopentene **27** (14.3 mg, 0.0595 mmol, 77% yield, 62% yield over 4 steps) as a pale yellow solid. The relative stereochemistry was assigned based on strong NOE interaction between H^a and H^b; R_f = 0.46 (4:1 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.17–7.06 (m, 3H), 6.95 (app t, *J* = 2.4 Hz, 1H), 6.63 (bd, *J* = 6.2 Hz, 1H), 3.86 (s, 1H), 2.92–2.84 (m, 1H), 2.66 (app dd, *J* = 13.5, 7.9 Hz, 1H), 2.41 (s, 3H), 2.32–2.18 (m, 2H) 1.84 (app ddt, *J* = 13.5, 7.7, 5.6 Hz, 1H), 1.58–1.43 (m, 1H), 1.30 (ddd, *J* = 14.0, 5.1, 2.3 Hz, 1H), 1.18 (s, 3H), 0.85 (app dt, *J* = 13.5, 5.6 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.7, 146.2, 144.6, 139.6, 139.2, 128.5, 126.7, 126.2, 125.0, 55.5, 48.4, 43.9, 34.1, 30.6, 26.9, 25.9,

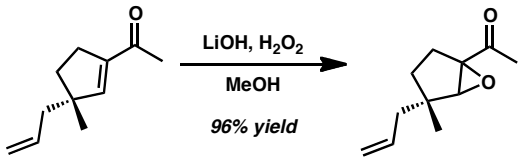
21.4; IR (Neat Film NaCl) 3062, 3012, 2933, 2893, 2859, 1659, 1617, 1476, 1456, 1446, 1370, 1278, 1266, 1244, 1199, 1123, 997, 935, 794, 757, 752, 730 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{17}H_{21}O$ $[M+H]^+$: 241.1587; found 241.1591; $[\alpha]_D^{25.0}$ +3.88 (*c* 1.43, $CHCl_3$, 88.0% ee).



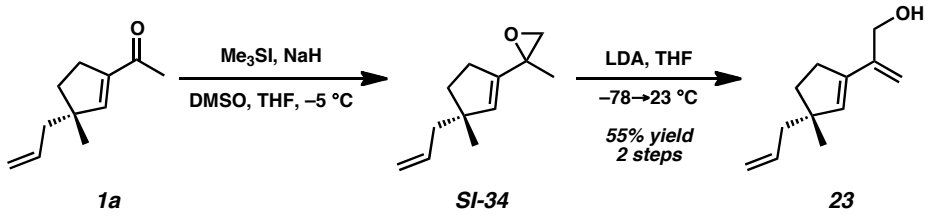
Carboxylic acid SI-33. A 50 mL round-bottom flask with magnetic stir bar was charged with acylcyclopentene **1a** (200 mg, 1.22 mmol, 1.00 equiv) and dioxane (10 mL). The solution was cooled to 0 °C and 5 M aqueous NaOH (10 mL) was added dropwise. The white suspension was stirred for 5 min at 0 °C. A dark brown solution of I_2 (1.37 g, 5.40 mmol, 4.40 equiv) and KI (2.09 g, 12.59 mmol, 10.50 equiv) in purified H_2O (10 mL) was added to the reaction dropwise, causing the reaction to become a yellow suspension. After 6.5 h of stirring at 0 °C, an additional portion of I_2 (343 mg, 1.35 mmol, 1.11 equiv) in dioxane (2 mL) was added to the reaction. After 30 min of stirring at 0 °C, the reaction was acidified to pH 2 using 2 M aqueous HCl. The reaction was extracted with Et_2O (3 x 30 mL) until the organic layer was clear. The combined organic phases were washed with sat aqueous $K_2S_2O_3$ (2 x 10 mL), H_2O (2 x 10 mL), and brine (2 x 10 mL). The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure to give a yellow semi-solid. The residue was taken up in EtOAc, filtered through a silica gel plug (3 x 3 cm, EtOAc), and concentrated to give carboxylic acid **SI-33** as a pale yellow oil which was used directly in the next step; R_f = 0.35, broad (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.69 (app t, *J* = 1.9 Hz, 1H), 5.89–5.62 (m, 1H), 5.11–4.99 (m, 2H), 2.68–2.47 (m, 2H), 2.26–2.09 (m, 2H), 1.91 (ddd, *J* = 13.0, 8.2, 7.0 Hz, 1H), 1.69 (ddd, *J* = 13.0, 8.2, 6.2 Hz, 1H), 1.10 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.7, 154.3, 134.8, 133.9, 117.8, 49.8, 45.2, 36.3, 30.3, 25.5; IR (Neat Film NaCl) 3076, 3004, 2956, 2926, 2865, 2610, 1687, 1634, 1454, 1424, 1374, 1348, 1306, 1280, 1216, 1180, 1083, 995, 915, 745, 720 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_7H_9O_2$ $[M–C_3H_5]^+$: 125.0603; found 125.0629; $[\alpha]_D^{25.0}$ +1.43 (*c* 0.80, $CHCl_3$, 88.0% ee).

Amide 21. A 50 mL flask with magnetic stir bar was charged with carboxylic acid **SI-33** (202.7 mg, 1.22 mmol, 1.00 equiv) and anhydrous CH_2Cl_2 (4.0 mL). To the vigorously stirred reaction was added 1,1'-carbonyldiimidazole (217 mg, 1.34 mmol, 1.10 equiv) in a portionwise manner. After 15 min, anhydrous *N*,*O*-dimethylhydroxylamine hydrochloride (143 mg, 1.46 mmol, 1.20 equiv) was added portionwise. The reaction became turbid after several min. After 21 h, an additional portion of *N*,*O*-dimethylhydroxylamine hydrochloride (14.3 mg, 0.146 mmol, 0.12 equiv) was added. At 23.5 h, the reaction was transferred to a separatory funnel, washed with 0.25 M HCl (2 x 2 mL), sat aqueous $NaHCO_3$, and brine. The combined organic phases were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography (SiO_2, 3 x 25 cm, 4:1→3:1 Hexanes:EtOAc) to afford amide **21** as a clear oil (196.7 mg, 0.94 mmol, 77% yield over 2 steps); R_f = 0.41 (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.26 (app t, *J* = 1.9 Hz, 1H), 5.87–5.68 (m, 1H), 5.09–4.97 (m, 2H), 3.63 (s, 3H), 3.23 (s, 3H), 2.77–2.55 (m, 2H), 2.21–2.11 (m, 2H), 1.83 (ddd, *J* = 12.8, 8.3,

6.4 Hz, 1H), 1.62 (ddd, J = 12.7, 8.4, 6.0 Hz, 1H), 1.08 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 167.5, 147.0, 135.4, 135.3, 117.4, 61.2, 49.4, 45.4, 35.9, 33.3, 32.9, 25.6; IR (Neat Film NaCl) 3584, 3401, 3078, 2954, 2930, 2864, 1641, 1609, 1454, 1441, 1414, 1378, 1329, 1198, 1177, 1152, 1105, 1043, 997, 969, 914, 812, 723 cm^{-1}; HRMS (EI+) m/z calc'd for $C_{12}H_{20}NO_2$ $[M+H]^+$: 210.1494; found 210.1498; $[\alpha]_D^{25.0}$ +1.41 (*c* 0.98, $CHCl_3$, 88.0% ee).



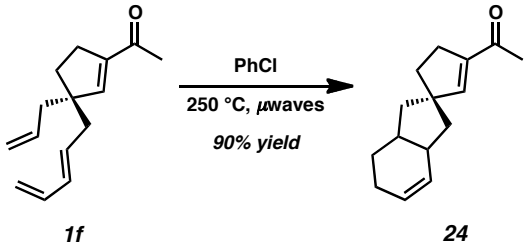
Epoxide 22. A solution of acylcyclopentene **1a** (100 mg, 0.609 mmol, 1.00 equiv) in MeOH (6.1 mL) in a 25 mL round-bottom flask was treated with LiOH (7.3 mg, 0.30 mmol, 0.50 equiv) in one portion. Aqueous H_2O_2 (75.0 μL, 83.3 mg, 2.00 equiv, 50% in H_2O) was added dropwise. After 12 h of stirring at ambient temperature additional aqueous H_2O_2 (75.0 μL, 83.3 mg, 2.00 equiv, 50% in H_2O) was added. The reaction was stirred for an additional 8 h, diluted with CH_2Cl_2 (10 mL), sat aqueous $NaHCO_3$ (1.0 mL), and water (1.0 mL). The phases were separated and the aqueous phase was extracted with CH_2Cl_2. The combined organic phases were dried over Mg_2SO_4, filtered, and concentrated carefully under reduced pressure. The crude product was purified by automated flash column chromatography using a Teledyne Isco CombiFlash R_f (SiO_2, 12 g loading cartridge, 25 g column, linear gradient, 5%→30% Et_2O in Pentane [15 min]) to afford epoxide **22** (106 mg, 0.588 mmol, 96% yield) as a colorless fragrant oil and as a 1:1.1 mixture of diastereomers; R_f = 0.54 (4:1 Hexanes:EtOAc); ^{1}H NMR (400 MHz, $CDCl_3$) 5.90–5.68 (m, 2H), 5.14–5.01 (m, 4H), 3.32 (s, 1H), 3.30 (s, 1H), 2.35–2.21 (m, 4H), 2.07 (s, 3H), 2.07 (s, 3H), 2.05–1.99 (m, 2H), 1.96–1.85 (m, 2H), 1.54–1.49 (m, 1H), 1.33–1.29 (m, 2H), 1.20–1.16 (m, 1H), 1.13 (s, 3H), 0.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) 205.8, 205.6, 134.7, 133.6, 118.4, 117.8, 70.3, 70.2, 69.4, 69.3, 42.7, 42.7, 42.4, 42.3, 41.3, 31.9, 31.4, 25.0, 24.8, 24.1, 21.7, 20.5; IR (Neat Film NaCl) 3072, 3002, 2958, 2878, 1706, 1642, 1459, 1444, 1419, 1397, 1360, 1325, 1286, 1261, 1115, 922, 856, 831 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{11}H_{17}$ $[M+H]^+$: 181.1223; found 181.1226; $[\alpha]_D^{25.0}$ –6.94 (*c* 1.40, $CHCl_3$, 88.0 % ee).



Allylic alcohol 23. NaH (36.5 mg, 0.91 mmol, 3.0 equiv, 60% w/w in mineral oil) was suspended in DMSO (1.2 mL) in a 25 mL round-bottom flask. After 20 min of stirring at ambient temperature, THF (3.7 mL) was added and the resulting mixture was cooled to –5 °C using a water/NaCl/ice bath. Me_3SI (192.3 mg, 0.95 mmol, 3.1 equiv) was dissolved in DMSO (1.2 mL) and added dropwise to the stirred reaction. After an additional 5 min of stirring, acylcyclopentene **1a** (50 mg, 0.30 mmol, 1.0 equiv) was added neat dropwise. After 1.5 h of

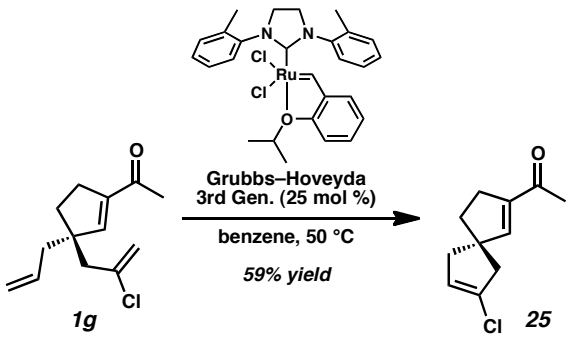
stirring at –5 °C, the reaction was diluted with Et_2O (15 mL) and quenched by pouring the reaction over 10 g of ice. The phases were separated and the aqueous layer was extracted with Et_2O (2 x 10 mL). The combined organic phases were washed with brine (10 mL), dried over $MgSO_4$, filtered, and concentrated carefully under reduced pressure, allowing for a film of ice to form on the outside of the flask, to give the volatile crude epoxide **SI-34** as a colorless oil; R_f = 0.60 (4:1 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-75**; ^{13}C NMR (100 MHz, $CDCl_3$) mixture of two diastereomers, see **Figure SI-75**; IR (Neat Film NaCl) 3072, 3037, 2953, 2923, 2864, 1637, 1451, 1437, 1385, 1370, 1338, 1259, 1140, 1105, 1066, 994, 910, 856, 846, 806, 730 cm^{-1}; HRMS (APCI+) calc'd for $C_{12}H_{19}O$ $[M+H]^+$: 179.1435; found 179.1430.

To a solution of diisopropylamine (0.11 mL, 0.76 mmol, 2.5 equiv) in THF (2.0 mL) in a 10 mL round-bottom flask at 0 °C was added *n*-BuLi (370 μL, 0.76 mmol, 2.05 M in cyclohexane, 2.5 equiv) dropwise over 10 min. After 15 min of stirring, the reaction was cooled to –78 °C using an acetone/CO_2(s) bath and crude epoxide **SI-34** in THF (1.0 mL) was added dropwise using positive pressure cannulation. The cooling bath was allowed to warm to ambient temperature and the reaction was stirred for 18 h. The reaction was diluted with Et_2O (10 mL) and quenched by addition of a 50:50 (v/v) mixture of sat aqueous NH_4Cl and water (2.0 mL each). The phases were separated and the aqueous phase was extracted with Et_2O (2 x 10 mL). The combined organic phases were washed with brine (10 mL), dried over $MgSO_4$, filtered, and concentrated carefully under reduced pressure, allowing for a film of ice to form on the outside of the flask, to afford a pale yellow oil. The residue was purified by flash column chromatography (SiO_2, 1 x 22 cm, 20% Et_2O in Pentane) to afford allylic alcohol **23** (29.9 mg, 0.17 mmol, 55% yield over 2 steps) as a colorless oil; R_f = 0.25 (4:1 Hexanes:EtOAc); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.82–5.72 (m, 1H), 5.60 (dd, *J* = 1.7, 1.7 Hz, 1H), 5.22 (app q, *J* = 1.4 Hz, 1H), 5.05–5.04 (m, 1H), 5.04–5.01 (m, 1H), 5.01–4.99 (m, 1H), 4.33 (br s, 2H), 2.58–2.45 (m, 2H), 2.17–2.08 (m, 2H), 1.82 (ddd, *J* = 12.7, 8.8, 5.9 Hz, 1H), 1.62 (ddd, *J* = 12.7, 8.8, 5.8 Hz, 1H), 1.51 (br s, 1H), 1.06 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 143.6, 139.1, 136.0, 135.9, 116.9, 111.9, 64.3, 49.3, 46.2, 35.9, 32.0, 26.4; IR (Neat Film NaCl) 3325, 3071, 3032, 2948, 2859, 1639, 1600, 1451, 1437, 1414, 1370, 1320, 1226, 1194, 1078, 1029, 994, 910, 848 cm^{-1}; HRMS (MM: ESI-APCI+) m/z calc'd for $C_{12}H_{17}$ $[M–OH]^+$: 161.1325; found 161.1324; $[\alpha]_D^{25.0}$ +17.59 (c 1.38, $CHCl_3$, 88.0% ee).

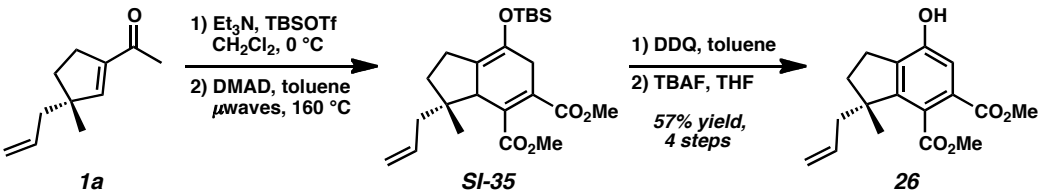


Cyclohexene 24. Acylcyclopentene **1f** (25.2 mg, 0.12 mmol, 1.00 equiv) was added to a 2.0–5.0 mL microwave vial with magnetic stir bar and sealed with a septum-fitted crimp cap. Chlorobenzene (5 mL) was added via syringe. The clear, colorless solution was subjected to microwave irradiation in a Biotage Initiator microwave reactor (temperature: 250 °C, sensitivity: low). After 2 h of irradiation, the vial was uncapped and the solvent was removed under reduced pressure. The yellow residue was purified by flash column chromatography (SiO_2, 1.5 x 15 cm,

15:1 Hexanes:Et_2O) to afford cyclohexene **24** as a yellow oil (22.5 mg, 0.104 mmol, 90% yield); R_f = 0.65 (4:1 Hexanes:EtOAc); ^1H NMR (500 MHz, $CDCl_3$) mixture of four diastereomers (2:2:1:1), see **Figure SI-77**; ^{13}C NMR (125 MHz, $CDCl_3$) mixture of four diastereomers, see **Figure SI-77**; IR (Neat Film NaCl) 3014, 2921, 2855, 1666, 1611, 1448, 1437, 1369, 1339, 1303, 1268, 1190, 1093, 1075, 1051, 1037, 1024, 935, 868, 798, 733, 703 cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{15}H_{20}O$ $[M]^{+\bullet}$: 216.1514; found 216.1518; $[\alpha]_D^{25.0}$ –15.57 (*c* 1.01, $CHCl_3$, 88.0% ee).



Spirocycle 25. A 2-neck flask fitted with rubber septum and reflux condenser under N_2 was charged with Grubbs–Hoveyda 3rd Generation catalyst (2.2 mg, 0.035 mmol, 6.1 mol %). Dry degassed benzene (4 mL, sparged with N_2 for 1 h immediately before use) was added to give a pale green solution. The flask was evacuated/backfilled with N_2 (3 cycles, 5 min evacuation per cycle). Acylcyclopentene **1g** (14.2 mg, 0.063 mmol, 1.0 equiv) in dry, degassed benzene (4 mL) under N_2 was added to the catalyst solution using positive pressure cannulation. The flask was rinsed with benzene (2 mL) and washes were added into the catalyst solution. The reaction was immersed in a preheated 50 °C oil bath and stirred for 44 h. An additional portion of Grubbs–Hoveyda 3rd Generation catalyst (4.4 mg, 0.070 mmol, 12.2 mol %) in degassed benzene (2 mL) was added into the reaction using positive pressure cannulation. After stirring for an additional 15 h, a third portion of Grubbs–Hoveyda 3rd Generation catalyst (2.2 mg, 0.035 mmol, 6.1 mol %) in degassed benzene (2 mL) was added into the reaction using positive pressure cannulation. After 31 h, the reaction was treated with several drops of ethyl vinyl ether and allowed to cool to ambient temperature. The solution was diluted with Et_2O (15 mL) and filtered through a short silica gel plug (2 x 10 cm, Et_2O). The orange filtrate was purified by flash column chromatography (SiO_2, 2 x 25 cm, 1%→3%→5%→6.5% Et_2O in Hexanes) to give volatile spirocycle **25** (7.3 mg, 0.0376 mmol, 59% yield); R_f = 0.49 (4:1 Hexanes:EtOAc); ^1H NMR (500 MHz, $CDCl_3$) δ 6.61 (app t, *J* = 1.7 Hz, 1H), 5.64 (app p, *J* = 2.2 Hz, 1H), 2.66 (ddd, *J* = 16.2, 4.5, 2.1 Hz, 1H), 2.62–2.53 (m, 3H), 2.51 (ddd, *J* = 16.2, 4.6, 2.4 Hz, 1H), 2.43 (ddd, *J* = 16.3, 4.6, 2.4 Hz, 1H), 2.31 (s, 3H), 2.09–1.95 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.3, 150.2, 144.2, 130.7, 125.2, 56.2, 49.7, 44.3, 39.4, 29.6, 26.8; IR (Neat Film NaCl) 2929, 2845, 1726, 1668, 1616, 1436, 1370, 1340, 1314, 1276, 1193, 1079, 1052, 990, 966, 936, 905, 866, 822, 804 cm^{-1}; HRMS (EI+) m/z calc'd for $C_{11}H_{13}OCl$ $[M]^{+\bullet}$: 196.0655; found 196.0655; $[\alpha]_D^{25.0}$ –19.80 (c 0.53, $CHCl_3$, 88.0% ee).



Phenol 26. A 15 mL flask with magnetic stir bar was charged with acylcyclopentene **1a** (50 mg, 0.274 mmol, 1.00 equiv) and anhydrous CH_2Cl_2 (3.0 mL). The flask was cooled to 0 °C and Et_3N (152.8 μL, 1.096 mmol, 4.00 equiv) was added, followed by dropwise addition of TBSOTf (125.8 μL, 0.548 mmol, 2.00 equiv). The reaction became a pale yellow solution. After 1 h of stirring at 0 °C, the reaction was quenched by the addition of sat aqueous $NaHCO_3$ and slowly allowed to warm to ambient temperature. The mixture was extracted with CH_2Cl_2 (3 x 10 mL) and the combined organics were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was filtered through a silica gel plug (2 x 3 cm, 5:1 H:Et_2O) and concentrated under reduced pressure to give crude silyl enol ether as a pale yellow oil. R_f = 0.79 (10:1 Hexanes:EtOAc).

The silyl enol ether was added to a 2.0–5.0 mL microwave vial with magnetic stir bar and sealed with a septum-fitted crimp cap. Toluene (5 mL) was added, followed by dimethyl acetylenedicarboxylate (101 μL, 0.822 mmol, 3.00 equiv). The clear, colorless solution was subjected to microwave irradiation in a Biotage Initiator microwave reactor (temperature: 160 °C, sensitivity: low). After 2.5 h of irradiation, the vial was uncapped and solvent was removed under reduced pressure. The yellow residue was purified by flash column chromatography (SiO_2, 3 x 25 cm, 15:1→10:1→4:1→2:1 Hexanes:EtOAc) to afford siloxydiene **SI-35**. R_f = 0.31 (10:1 Hexanes:EtOAc).

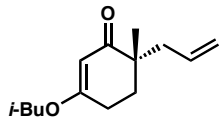
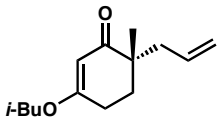
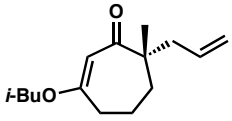
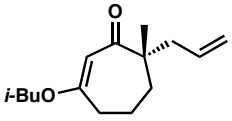
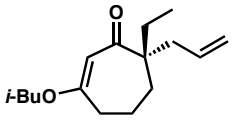
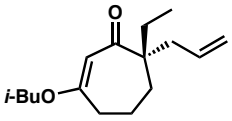
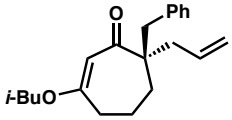
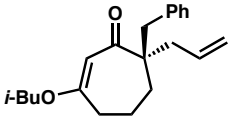
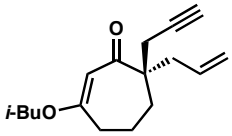
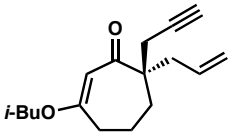
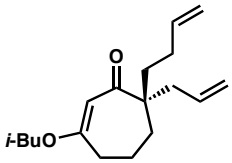
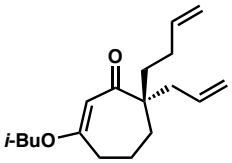
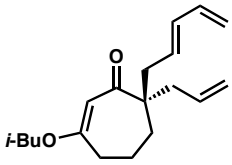
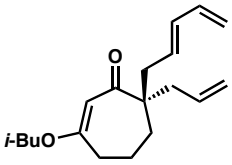
A 20 mL scintillation vial with magnetic stir bar was charged with siloxydiene **SI-35** and toluene (3.0 mL). DDQ (63.5 mg, 0.280 mmol, 1.02 equiv) was added portionwise. Upon complete addition, the solution became a turbid red suspension. After 2 h, the reaction was diluted with CH_2Cl_2 and filtered through a Celite plug (2 x 3 cm, CH_2Cl_2). The clear yellow solution was concentrated under reduced pressure. The residue was purified by flash column chromatography (SiO_2, 2 x 25 cm, 20:1→15:1→10:1→4:1→2:1 Hexanes:EtOAc) to afford the intermediate silyl aryl ether. R_f = 0.31 (10:1 Hexanes:EtOAc).

A 20 mL scintillation vial with magnetic stir bar was charged with silyl aryl ether. The vial was evacuated, and backfilled with N_2. Anhydrous THF (3 mL) was added and a TBAF solution (300 μL, 1.0 M in THF) was added dropwise, giving a bright red solution. After 10 min, the reaction was quenched by the addition of sat aqueous NH_4Cl (600 μL) and H_2O (600 μL). The mixture was stirred vigorously for 20 min and extracted with Et_2O (3 x 5 mL). The combined organics were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography (SiO_2, 2 x 25 cm, 5:1→ 4:1 Hexanes:EtOAc) to afford phenol **26** as a pale yellow oil (52.6 mg, 0.173 mmol, 57% yield over 4 steps); R_f = 0.11 (2:1 Hexanes:EtOAc); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30 (s, 1H), 5.89 (br s, *J* = 1.9 Hz, 1H), 5.66 (dddd, *J* = 17.3, 10.2, 7.9, 7.9 Hz, 1H), 5.09–4.91 (m, 2H), 3.88 (s, 3H), 3.83 (s, 3H), 2.76 (t, *J* = 7.3 Hz, 2H), 2.47–2.26 (m, 2H), 2.24–2.08 (ddd, *J* = 12.0, 7.0, 7.0 Hz, 1H), 1.85–1.70 (ddd, *J* = 12.7, 7.6, 7.6 Hz, 1H), 1.26 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.4, 166.7, 152.5, 150.0, 135.8, 135.3, 128.3, 124.0, 117.7, 115.4, 52.7, 52.5, 49.4, 44.1, 38.3, 26.1, 25.6; IR (Neat Film NaCl) 3401, 3075, 2953, 2871, 1723, 1639, 1588, 1435, 1418, 1376, 1330, 1311, 1258, 1192, 1175, 1142, 1047, 995, 964, 916, 884, 857, 794, 769, 738, 719

cm^{-1}; HRMS (EI+) *m/z* calc'd for $C_{17}H_{20}O_5$ $[M]^{+\bullet}$: 304.1311; found 304.1317; $[\alpha]_D^{25.0}$ –45.63 (*c* 0.91, $CHCl_3$, 88.0% ee).

Methods for Determination of Enantiomeric Excess

Table SI-3A. Methods for the Determination of Enantiomeric Excess (Chiral HPLC and SFC).

entry	product	compound assayed	assay conditions	retention time of major isomer (min)	retention time of minor isomer (min)	% ee
1	 ***8***	 ***8***	HPLC Chiralcel OD-H 5% IPA in hexane isocratic, 1.0 mL/min	5.80	6.53	86
2	 ***10a***	 ***10a***	HPLC Chiralcel OD-H 1% IPA in hexane isocratic, 1.0 mL/min	6.30	7.26	88
3	 ***10b***	 ***10b***	HPLC Chiralcel AD 0.25% IPA in hexane isocratic, 1.0 mL/min	18.08	16.23	92
4	 ***10c***	 ***10c***	HPLC Chiralcel OD-H 0.5% IPA in hexane isocratic, 1.0 mL/min	15.70	13.96	86
5	 ***10d***	 ***10d***	HPLC Chiralcel OD-H 0.5% IPA in hexane isocratic, 1.0 mL/min	12.35	13.43	89
6	 ***10e***	 ***10e***	HPLC Chiralcel AD 0.8% IPA in hexane isocratic, 2.0 mL/min	5.03	6.06	87
7	 ***10f***	 ***10f***	SFC Chiralcel AD-H 5% IPA in hexane isocratic, 2.5 mL/min	6.99	6.31	90

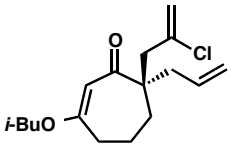
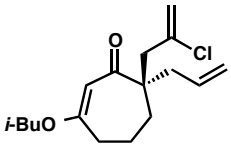
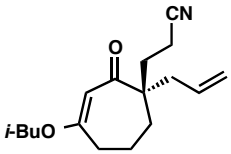
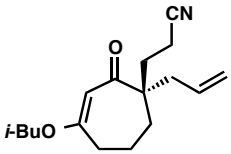
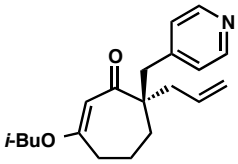
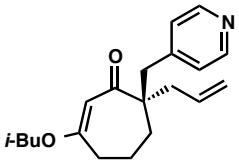
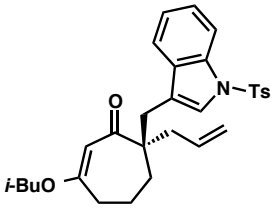
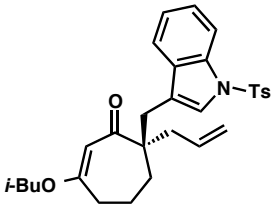
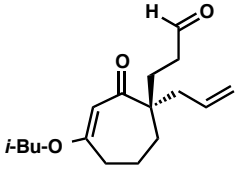
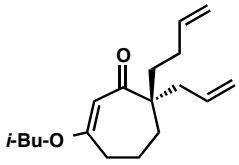
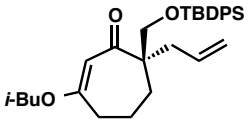
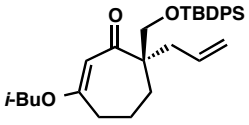
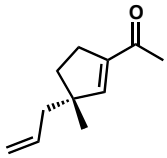
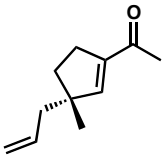
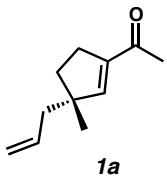
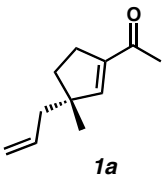
entry	product	compound assayed	assay conditions	retention time of major isomer (min)	retention time of minor isomer (min)	% ee
8	 ***10g***	 ***10g***	HPLC Chiralcel OD-H 0.1% IPA in hexane isocratic, 1.0 mL/min	27.22	24.19	86
9	 ***10h***	 ***10h***	HPLC Chiralcel OD-H 5% IPA in hexane isocratic, 1.0 mL/min	10.67	14.66	87
10	 ***10i***	 ***10i***	HPLC Chiralcel AD 5% EtOH in hexane isocratic, 1.0 mL/min	13.22	15.13	85
11	 ***10j***	 ***10j***	HPLC Chiralcel AD 5% EtOH in hexane isocratic, 1.0 mL/min	11.11	16.64	83
12	 ***10k***	 ***10e***	HPLC Chiralcel AD 0.8% IPA in hexane isocratic, 2.0 mL/min	4.39	5.17	80
13	 ***10l***	 ***10l***	HPLC Chiralcel OD-H 0.2% IPA in hexane isocratic, 1.0 mL/min	21.74	25.53	58

Table SI-3B. Methods for the Determination of Enantiomeric Excess (Chiral GC).

14	 ***1a***	 ***1a***	**GC G-TA 80 °C isotherm**	**54.98**	**61.35**	**88**
15	 ***1a***	 ***1a***	**GC G-TA 80 °C isotherm**	**54.74**	**60.24**	**98**

References:

[1] Mahmood, T.; Shreeve, J. M. *Inorg. Chem.* **1986**, *25*, 3830–3837.
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[10] (a) Ragan, J. A.; Makowski, T. W.; am Ende, D. J.; Clifford, P. J.; Young, G. R.; Conrad, A. K.; Eisenbeis, S. A. *Org. Process Res. Dev.* **1998**, *2*, 379–381; (b) Do, N., McDermott, R. E.; Ragan, J. A. *Org. Synth.* **2008**, *85*, 138–146.

Ring Contraction Strategy for the Practical, Scalable, Catalytic Asymmetric Synthesis of Versatile γ-Quaternary Acylcyclopentenes

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Andrew M. Harned, Brian M. Stoltz*

Supporting Information (X-ray, ^{1}H NMR, ^{13}C NMR, IR, HPLC, SFC, and GC)

Warren and Katharine Schlinger Laboratory for Chemistry and Chemical Engineering, Division of Chemistry and Chemical Engineering, California Institute of Technology, Pasadena, California 91125, USA

Table of Contents:

CALIFORNIA INSTITUTE OF TECHNOLOGY

BECKMAN INSTITUTE

X-RAY CRYSTALLOGRAPHY LABORATORY

Crystal Structure Analysis of 16

THJ03

(686849)

Contents:

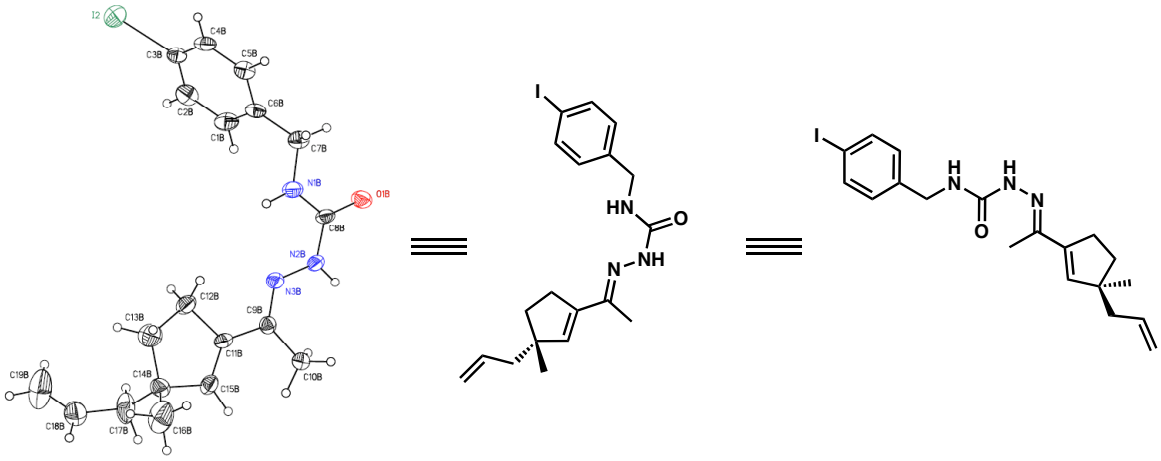


Table 1. Crystal data and structure refinement for THJ03 (CCDC 686849).

Empirical formula	$C_{19}H_{24}N_3OI$
Formula weight	437.31
Crystallization Solvent	Dichloromethane/pentane
Crystal Habit	Needle
Crystal size	0.28 x 0.11 x 0.07 mm^3
Crystal color	Colorless

Data Collection

Type of diffractometer	Bruker KAPPA APEX II
Wavelength	0.71073 Å MoKα
Data Collection Temperature	100(2) K
θ range for 9911 reflections used in lattice determination	2.57 to 28.78°
Unit cell dimensions	a = 17.160(4) Å b = 5.5921(14) Å β= 90.689(6)° c = 19.984(5) Å
Volume	1917.6(8) $Å^3$
Z	4
Crystal system	Monoclinic
Space group	$P2_1$
Density (calculated)	1.515 Mg/m^3
F(000)	880
Data collection program	Bruker APEX2 v2.1-0
θ range for data collection	1.55 to 29.84°
Completeness to θ = 29.84°	88.9 %
Index ranges	$-23 \le h \le 23$, $-7 \le k \le 7$, $-26 \le l \le 25$
Data collection scan type	ω scans; 16 settings
Data reduction program	Bruker SAINT-Plus v7.34A
Reflections collected	8962
Independent reflections	8962 [R_{int}= 0.0000]
Absorption coefficient	1.680 mm^{-1}
Absorption correction	Semi-empirical from equivalents (TWNABS)
Max. and min. transmission	0.7460 and 0.5010

Table 1 (cont.)

Structure solution and Refinement

Structure solution program	SHELXS-97 (Sheldrick, 2008)
Primary solution method	Direct methods
Secondary solution method	Difference Fourier map
Hydrogen placement	Geometric positions
Structure refinement program	SHELXL-97 (Sheldrick, 2008)
Refinement method	Full matrix least-squares on F^2
Data / restraints / parameters	8962 / 1 / 437
Treatment of hydrogen atoms	Riding
Goodness-of-fit on F^2	1.609
Final R indices [I>2σ(I), 7203 reflections]	R1 = 0.0409, *w*R2 = 0.0481
R indices (all data)	R1 = 0.0619, *w*R2 = 0.0493
Type of weighting scheme used	Sigma
Weighting scheme used	$w=1/\sigma^2(Fo^2)$
Max shift/error	0.002
Average shift/error	0.000
Absolute structure determination	Anomalous differences
Absolute structure parameter	0.003(11)
Largest diff. peak and hole	0.807 and -0.967 e.$Å^{-3}$

Special Refinement Details

The structure was refined as a single component, although the crystals were twins, using an HKLF4 format reflection file prepared with TWINABS (see below). The two orientations were separated using CELL_NOW as follows.

Rotated from first domain by 178.9 degrees about reciprocal axis -0.032 1.000 0.104 and real axis -0.001 1.000 0.007. Twin law to convert hkl from first to this domain (SHELXL TWIN matrix):

```
-1.000  -0.065   0.016
-0.003   0.998   0.014
-0.022   0.207  -0.999
```

From Saint integration; Twin Law, Sample 1 of 1 transforms h1.1(1)->h1.2(2)

```
-0.99897 -0.07583  0.01646
-0.00750  0.99693  0.01538
-0.02464  0.19596 -0.99910
```

Twinabs;

```
PART 1 - Refinement of parameters to model systematic errors

18757 data (   4443 unique ) involve domain  1 only,  mean I/sigma  13.7
18551 data (   4364 unique ) involve domain  2 only,  mean I/sigma   7.1
10342 data (   4106 unique ) involve   2 domains,  mean I/sigma  19.2

HKLF 4 dataset constructed from all observations involving domains 1..2
   8970 Corrected reflections written to file twin4.hkl
 Reflections merged according to point-group 2
 Minimum and maximum apparent transmission:  0.501007  0.745969
 Additional spherical absorption correction applied with mu*r =  0.2000
```

Crystals were mounted on a glass fiber using Paratone oil then placed on the diffractometer under a nitrogen stream at 100K.

Refinement of F^2 against ALL reflections. The weighted R-factor (*w*R) and goodness of fit (S) are based on F^2, conventional R-factors (R) are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > 2\sigma(F^2)$ is used only for calculating R-factors(gt) etc. and is not relevant to the choice of reflections for refinement. R-factors based on F^2 are statistically about twice as large as those based on F, and R-factors based on ALL data will be even larger.

All esds (except the esd in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell esds are taken into account individually in the estimation of esds in distances, angles and torsion angles; correlations between esds in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell esds is used for estimating esds involving l.s. planes.

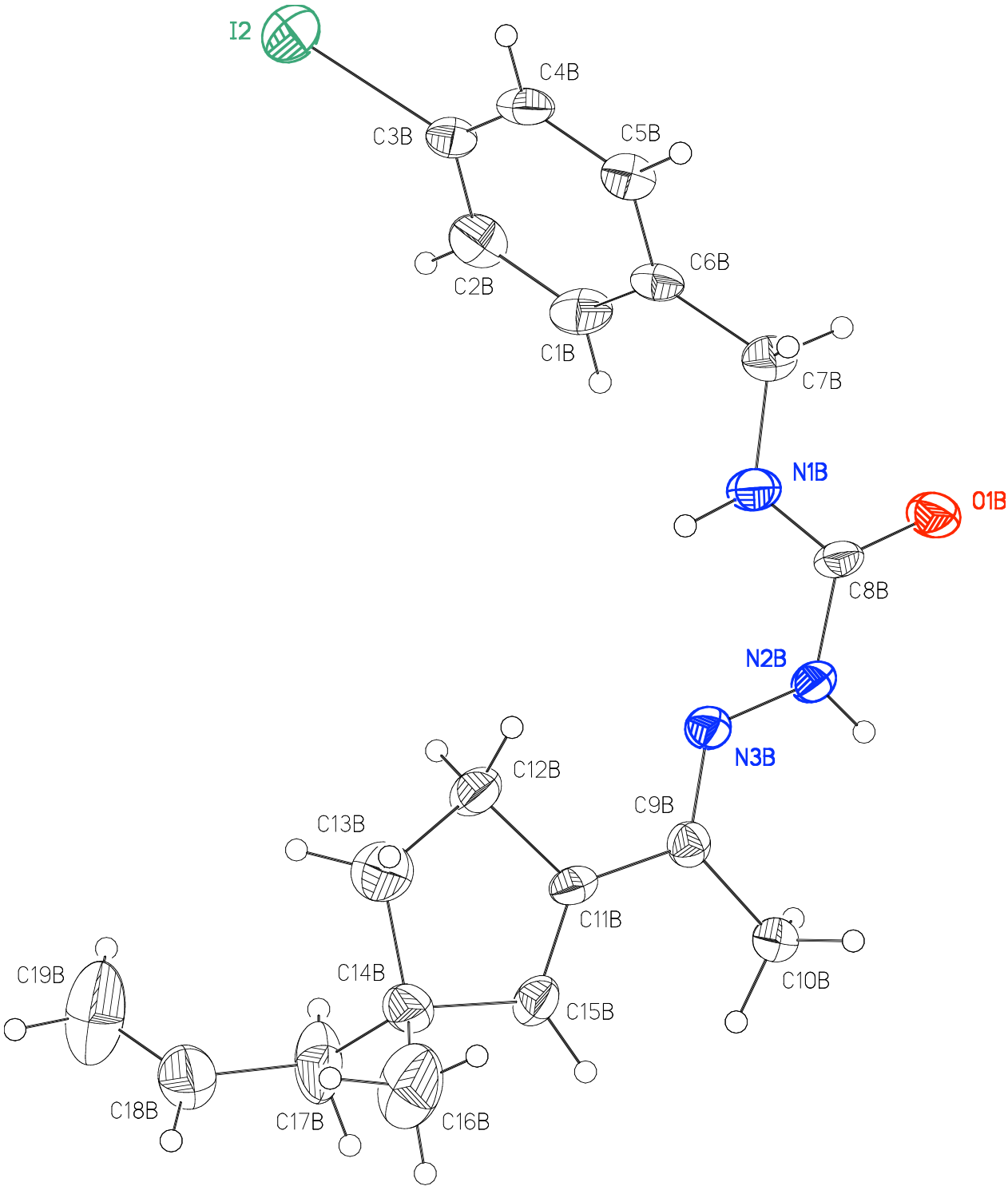

I2
C4B
C3B
C5B
C6B
C2B
C1B
C7B
N1B
O1B
C8B
N2B
N3B
C12B
C9B
C13B
C11B
C19B
C14B
C15B
C10B
C18B
C17B
C16B

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for THJ03 (CCDC 686849). U(eq) is defined as the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U_{eq}
I(1)	9525(1)	8297(1)	6590(1)	36(1)
O(1A)	7955(1)	941(3)	3051(1)	30(1)
N(1A)	7500(2)	3872(4)	3727(1)	30(1)
N(2A)	6670(2)	1070(4)	3270(1)	28(1)
N(3A)	6059(2)	2296(4)	3562(1)	28(1)
C(1A)	8489(2)	4383(5)	4938(2)	26(1)
C(2A)	8786(2)	5006(6)	5555(2)	27(1)
C(3A)	9158(2)	7186(5)	5637(2)	24(1)
C(4A)	9240(2)	8700(6)	5094(2)	23(1)
C(5A)	8934(2)	8049(6)	4481(2)	24(1)
C(6A)	8541(2)	5886(5)	4389(2)	21(1)
C(7A)	8214(2)	5251(6)	3716(2)	29(1)
C(8A)	7411(2)	1915(5)	3335(2)	24(1)
C(9A)	5356(2)	1676(5)	3411(2)	25(1)
C(10A)	5153(2)	-221(5)	2912(2)	34(1)
C(11A)	4738(2)	3016(6)	3736(2)	25(1)
C(12A)	4902(2)	5012(5)	4229(2)	30(1)
C(13A)	4096(2)	6199(5)	4302(2)	34(1)
C(14A)	3501(2)	4222(5)	4130(2)	33(1)
C(15A)	3985(2)	2625(5)	3693(2)	32(1)
C(16A)	3271(2)	2838(6)	4771(2)	47(1)
C(17A)	2751(2)	5160(6)	3793(2)	36(1)
C(18A)	2864(2)	6198(6)	3116(2)	39(1)
C(19A)	2612(2)	8233(8)	2900(2)	51(1)
I(2)	5760(1)	351(1)	-1541(1)	52(1)
O(1B)	6661(1)	7118(3)	2275(1)	34(1)
N(1B)	7173(2)	4167(4)	1625(1)	34(1)
N(2B)	7955(2)	7040(4)	2098(1)	27(1)
N(3B)	8578(2)	5882(4)	1807(1)	26(1)
C(1B)	6496(2)	3858(5)	289(2)	33(1)
C(2B)	6341(2)	3322(8)	-374(2)	35(1)
C(3B)	5958(2)	1240(6)	-534(2)	29(1)
C(4B)	5742(2)	-303(6)	-40(2)	31(1)
C(5B)	5895(2)	235(6)	618(2)	28(1)
C(6B)	6287(2)	2329(5)	795(2)	26(1)
C(7B)	6454(2)	2863(6)	1519(2)	32(1)
C(8B)	7233(2)	6143(5)	2016(2)	25(1)
C(9B)	9266(2)	6619(5)	1925(2)	24(1)
C(10B)	9471(2)	8670(6)	2382(2)	33(1)
C(11B)	9892(2)	5325(6)	1586(2)	25(1)
C(12B)	9704(2)	3469(7)	1051(2)	34(1)
C(13B)	10499(2)	2401(6)	903(2)	54(1)
C(14B)	11131(2)	4019(5)	1204(2)	33(1)
C(15B)	10659(2)	5558(6)	1666(2)	30(1)
C(16B)	11736(3)	2543(7)	1600(2)	67(2)
C(17B)	11522(2)	5571(7)	690(2)	58(1)
C(18B)	12017(3)	4302(6)	194(2)	52(1)
C(19B)	11859(3)	3982(7)	-416(2)	77(2)

Table 3. Bond lengths [Å] and angles [°] for THJ03 (CCDC 686849).

I(1)-C(3A)	2.092(3)	C(9A)-N(3A)-N(2A)	118.6(3)
O(1A)-C(8A)	1.226(4)	C(2A)-C(1A)-C(6A)	122.1(3)
N(1A)-C(8A)	1.354(4)	C(1A)-C(2A)-C(3A)	119.6(3)
N(1A)-C(7A)	1.449(4)	C(2A)-C(3A)-C(4A)	119.8(3)
N(2A)-C(8A)	1.361(4)	C(2A)-C(3A)-I(1)	120.1(2)
N(2A)-N(3A)	1.388(3)	C(4A)-C(3A)-I(1)	119.9(2)
N(3A)-C(9A)	1.289(4)	C(5A)-C(4A)-C(3A)	119.7(3)
C(1A)-C(2A)	1.375(5)	C(4A)-C(5A)-C(6A)	121.7(3)
C(1A)-C(6A)	1.386(4)	C(1A)-C(6A)-C(5A)	117.2(3)
C(2A)-C(3A)	1.385(4)	C(1A)-C(6A)-C(7A)	122.8(3)
C(3A)-C(4A)	1.384(4)	C(5A)-C(6A)-C(7A)	120.1(3)
C(4A)-C(5A)	1.376(4)	N(1A)-C(7A)-C(6A)	115.0(3)
C(5A)-C(6A)	1.397(5)	O(1A)-C(8A)-N(1A)	123.1(3)
C(6A)-C(7A)	1.494(4)	O(1A)-C(8A)-N(2A)	121.2(3)
C(9A)-C(11A)	1.457(4)	N(1A)-C(8A)-N(2A)	115.8(3)
C(9A)-C(10A)	1.494(4)	N(3A)-C(9A)-C(11A)	116.2(3)
C(11A)-C(15A)	1.312(4)	N(3A)-C(9A)-C(10A)	123.9(3)
C(11A)-C(12A)	1.514(5)	C(11A)-C(9A)-C(10A)	119.8(3)
C(12A)-C(13A)	1.542(4)	C(15A)-C(11A)-C(9A)	127.4(3)
C(13A)-C(14A)	1.542(5)	C(15A)-C(11A)-C(12A)	109.9(3)
C(14A)-C(15A)	1.505(4)	C(9A)-C(11A)-C(12A)	122.6(3)
C(14A)-C(17A)	1.538(5)	C(11A)-C(12A)-C(13A)	102.6(3)
C(14A)-C(16A)	1.552(5)	C(12A)-C(13A)-C(14A)	105.2(2)
C(17A)-C(18A)	1.487(5)	C(15A)-C(14A)-C(17A)	114.4(3)
C(18A)-C(19A)	1.290(5)	C(15A)-C(14A)-C(13A)	100.7(3)
I(2)-C(3B)	2.096(3)	C(17A)-C(14A)-C(13A)	113.7(3)
O(1B)-C(8B)	1.242(4)	C(15A)-C(14A)-C(16A)	109.3(3)
N(1B)-C(8B)	1.356(4)	C(17A)-C(14A)-C(16A)	108.2(3)
N(1B)-C(7B)	1.447(4)	C(13A)-C(14A)-C(16A)	110.3(3)
N(2B)-C(8B)	1.346(4)	C(11A)-C(15A)-C(14A)	114.4(3)
N(2B)-N(3B)	1.383(3)	C(18A)-C(17A)-C(14A)	114.4(3)
N(3B)-C(9B)	1.270(4)	C(19A)-C(18A)-C(17A)	127.0(3)
C(1B)-C(6B)	1.376(4)	C(8B)-N(1B)-C(7B)	123.6(3)
C(1B)-C(2B)	1.380(5)	C(8B)-N(2B)-N(3B)	119.3(3)
C(2B)-C(3B)	1.373(5)	C(9B)-N(3B)-N(2B)	119.4(3)
C(3B)-C(4B)	1.366(4)	C(6B)-C(1B)-C(2B)	121.4(3)
C(4B)-C(5B)	1.372(4)	C(3B)-C(2B)-C(1B)	119.6(3)
C(5B)-C(6B)	1.394(5)	C(4B)-C(3B)-C(2B)	120.0(3)
C(6B)-C(7B)	1.501(5)	C(4B)-C(3B)-I(2)	120.1(3)
C(9B)-C(11B)	1.467(4)	C(2B)-C(3B)-I(2)	119.8(2)
C(9B)-C(10B)	1.504(4)	C(3B)-C(4B)-C(5B)	120.3(3)
C(11B)-C(15B)	1.330(4)	C(4B)-C(5B)-C(6B)	120.9(3)
C(11B)-C(12B)	1.522(4)	C(1B)-C(6B)-C(5B)	117.7(3)
C(12B)-C(13B)	1.521(5)	C(1B)-C(6B)-C(7B)	122.4(3)
C(13B)-C(14B)	1.530(5)	C(5B)-C(6B)-C(7B)	119.8(3)
C(14B)-C(15B)	1.505(4)	N(1B)-C(7B)-C(6B)	113.3(3)
C(14B)-C(17B)	1.509(5)	O(1B)-C(8B)-N(2B)	121.1(3)
C(14B)-C(16B)	1.537(6)	O(1B)-C(8B)-N(1B)	123.0(3)
C(17B)-C(18B)	1.493(5)	N(2B)-C(8B)-N(1B)	115.9(3)
C(18B)-C(19B)	1.260(5)	N(3B)-C(9B)-C(11B)	116.0(3)
		N(3B)-C(9B)-C(10B)	124.7(3)
C(8A)-N(1A)-C(7A)	120.7(3)	C(11B)-C(9B)-C(10B)	119.3(3)
C(8A)-N(2A)-N(3A)	119.8(3)	C(15B)-C(11B)-C(9B)	128.7(3)

C(15B)-C(11B)-C(12B)	110.6(3)	C(15B)-C(14B)-C(16B)	110.9(3)
C(9B)-C(11B)-C(12B)	120.7(3)	C(17B)-C(14B)-C(16B)	110.8(3)
C(13B)-C(12B)-C(11B)	102.9(3)	C(13B)-C(14B)-C(16B)	110.9(3)
C(12B)-C(13B)-C(14B)	108.9(3)	C(11B)-C(15B)-C(14B)	114.2(3)
C(15B)-C(14B)-C(17B)	109.6(3)	C(18B)-C(17B)-C(14B)	116.1(3)
C(15B)-C(14B)-C(13B)	101.3(3)	C(19B)-C(18B)-C(17B)	126.3(5)
C(17B)-C(14B)-C(13B)	112.9(3)		

Table 4. Anisotropic displacement parameters ($Å^2 x\ 10^4$) for THJ03 (CCDC 686849). The anisotropic displacement factor exponent takes the form: $-2\pi^2[\ h^2 a^{*2} U^{11} + ... + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
I(1)	340(2)	433(1)	310(1)	1(1)	-116(1)	-2(1)
O(1A)	177(14)	294(13)	431(15)	-131(10)	-15(11)	35(10)
N(1A)	166(17)	377(19)	352(17)	-168(12)	3(13)	-6(12)
N(2A)	150(17)	315(15)	378(18)	-133(12)	-22(13)	22(12)
N(3A)	186(19)	310(15)	328(18)	-35(12)	-35(15)	38(13)
C(1A)	190(20)	176(16)	420(20)	13(15)	-22(18)	9(13)
C(2A)	250(20)	237(18)	320(20)	88(15)	-7(16)	-4(16)
C(3A)	170(20)	261(17)	270(20)	-18(14)	-7(16)	69(14)
C(4A)	180(20)	200(20)	310(20)	-23(14)	-29(15)	-13(14)
C(5A)	240(20)	201(19)	275(19)	26(16)	5(15)	34(16)
C(6A)	171(19)	195(18)	269(19)	-26(14)	-8(15)	64(14)
C(7A)	260(20)	280(18)	330(20)	-40(17)	-16(16)	-38(18)
C(8A)	200(20)	257(18)	260(20)	-33(14)	-61(17)	19(16)
C(9A)	200(20)	231(17)	330(20)	-9(14)	-9(18)	-26(15)
C(10A)	200(20)	410(20)	430(20)	-69(17)	3(18)	-44(17)
C(11A)	190(20)	240(20)	330(20)	21(16)	-31(15)	-26(17)
C(12A)	250(20)	283(18)	360(20)	-23(16)	-60(16)	-30(16)
C(13A)	260(20)	305(19)	440(20)	-99(15)	-50(18)	42(16)
C(14A)	190(20)	305(19)	490(30)	-7(15)	9(19)	19(15)
C(15A)	260(20)	240(20)	460(20)	-48(14)	-26(19)	-18(15)
C(16A)	360(30)	500(30)	540(30)	114(18)	30(20)	88(19)
C(17A)	250(20)	390(20)	450(20)	-34(18)	9(18)	40(20)
C(18A)	270(20)	480(20)	420(30)	-75(18)	-70(20)	77(18)
C(19A)	410(30)	600(20)	510(20)	40(20)	-88(19)	120(30)
I(2)	431(2)	791(2)	333(2)	-69(1)	-57(1)	-30(2)
O(1B)	227(16)	346(12)	447(16)	-105(10)	2(13)	9(11)
N(1B)	220(19)	350(17)	440(20)	-151(12)	-38(16)	9(12)
N(2B)	230(20)	301(15)	272(17)	-106(12)	-29(14)	3(13)
N(3B)	208(18)	309(16)	277(16)	-57(12)	-23(14)	26(14)
C(1B)	340(30)	190(20)	470(30)	-9(15)	-50(20)	-62(15)
C(2B)	310(20)	404(19)	350(20)	130(20)	-22(16)	20(20)
C(3B)	190(20)	370(20)	310(20)	-17(16)	-51(17)	17(16)
C(4B)	200(20)	270(20)	450(30)	-58(16)	-50(18)	-39(15)
C(5B)	270(20)	236(18)	340(20)	71(16)	-20(16)	-10(17)
C(6B)	170(20)	246(18)	350(20)	8(15)	-46(17)	-2(14)
C(7B)	300(20)	310(20)	360(20)	-12(15)	-23(17)	-59(16)
C(8B)	200(20)	282(19)	270(20)	-34(14)	-76(16)	-6(16)
C(9B)	250(20)	257(18)	220(20)	11(14)	2(17)	11(16)
C(10B)	260(20)	400(20)	330(20)	-104(16)	37(16)	-60(18)
C(11B)	250(20)	241(17)	253(19)	-25(16)	-45(15)	-52(18)
C(12B)	340(20)	341(18)	330(20)	-105(19)	-60(16)	10(20)
C(13B)	450(30)	450(20)	730(30)	-310(20)	70(30)	-4(19)
C(14B)	250(20)	350(20)	390(20)	-54(15)	20(19)	25(15)
C(15B)	340(20)	290(18)	266(19)	-75(16)	-25(16)	33(18)
C(16B)	720(40)	680(30)	610(30)	-170(20)	-50(30)	380(30)
C(17B)	840(30)	400(20)	510(30)	-150(20)	330(20)	-90(20)
C(18B)	500(30)	540(30)	520(30)	-104(19)	110(30)	-49(19)
C(19B)	1060(50)	830(40)	420(30)	40(20)	60(30)	500(30)

Table 5. Hydrogen bonds for THJ03 (CCDC 686849) [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(2A)-H(2A)...O(1B)#1	0.88	2.13	2.972(3)	159.7
N(2B)-H(2B)...O(1A)#2	0.88	2.04	2.895(3)	163.1

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

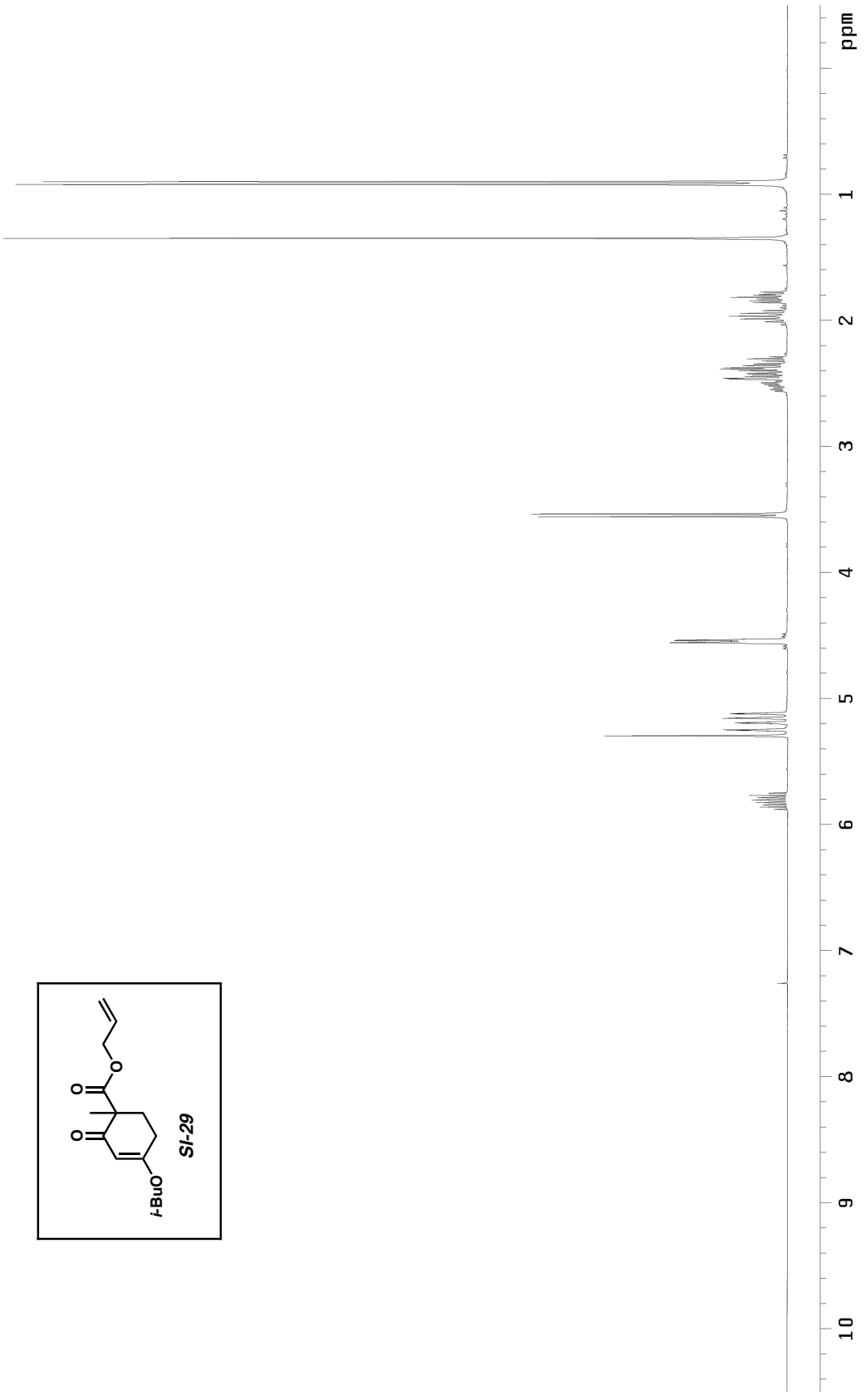


Figure SI-1A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **SI-29**.

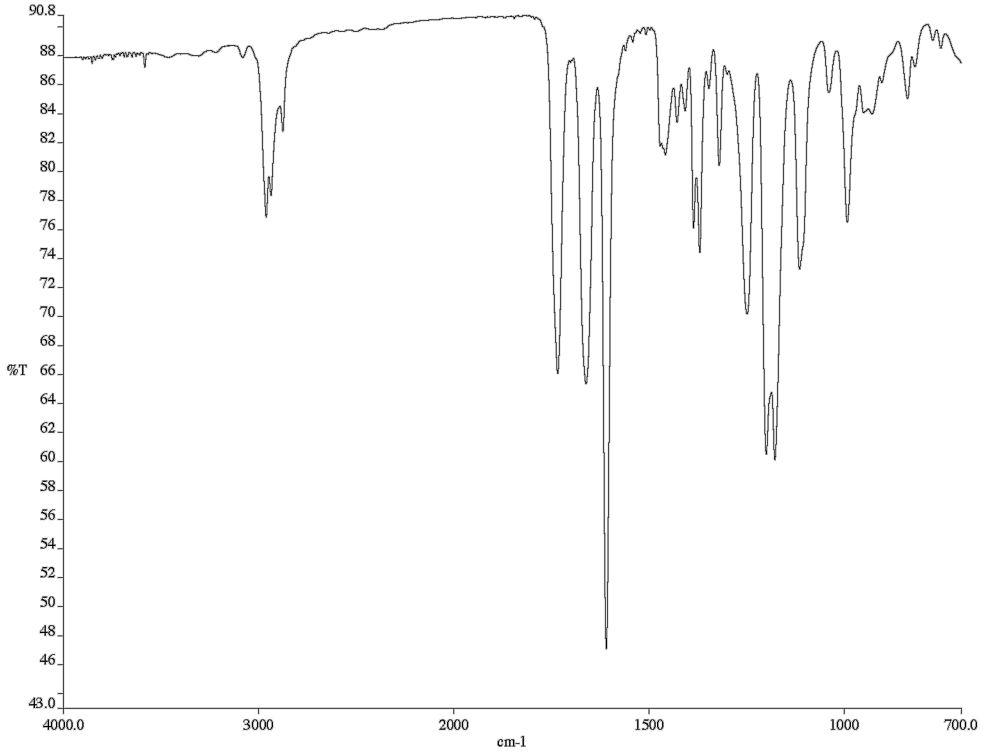


Figure SI-1B. Infrared spectrum (thin film/NaCl) of compound **SI-29**.

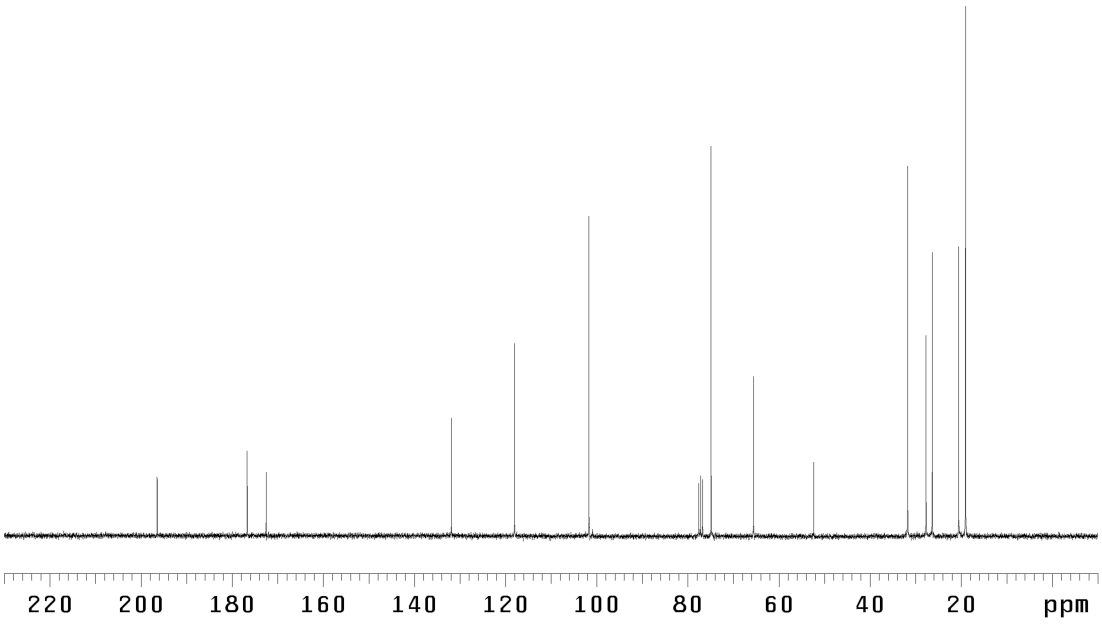


Figure SI-1C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **SI-29**.

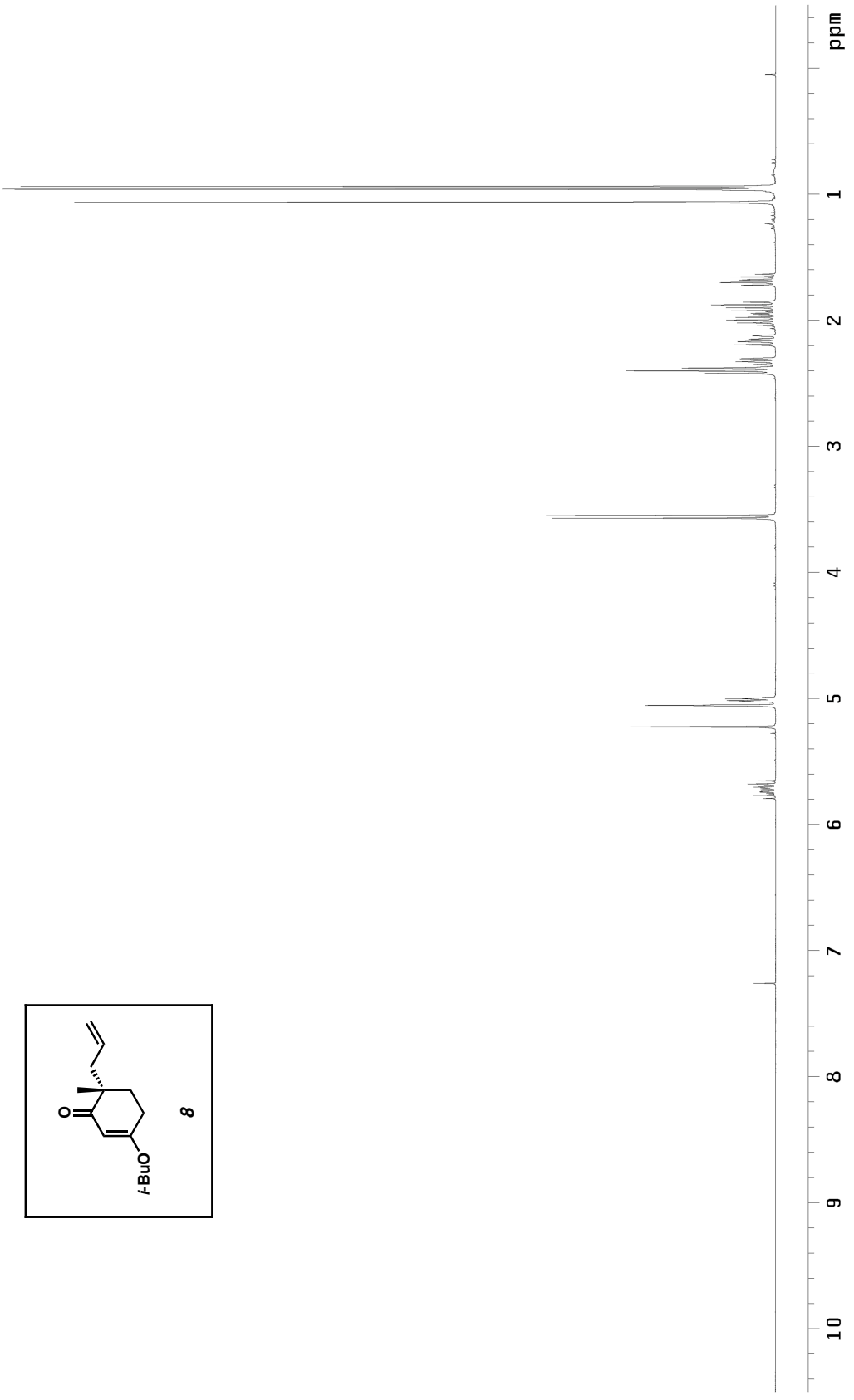


Figure SI-2A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **8**.

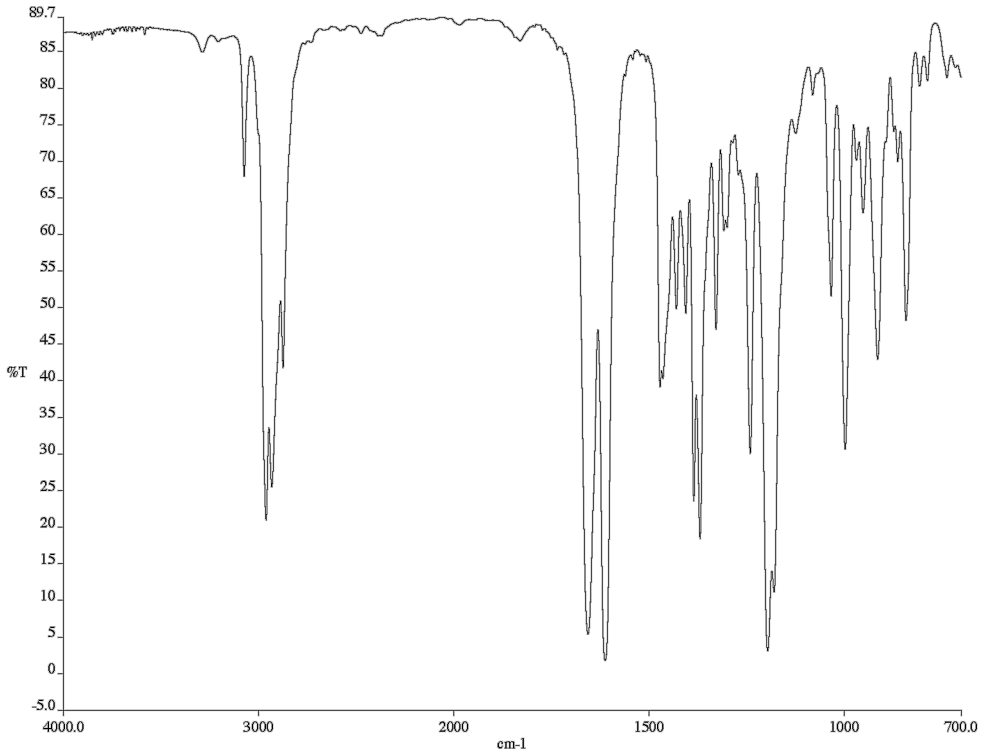


Figure SI-2B. Infrared spectrum (thin film/NaCl) of compound **8**.

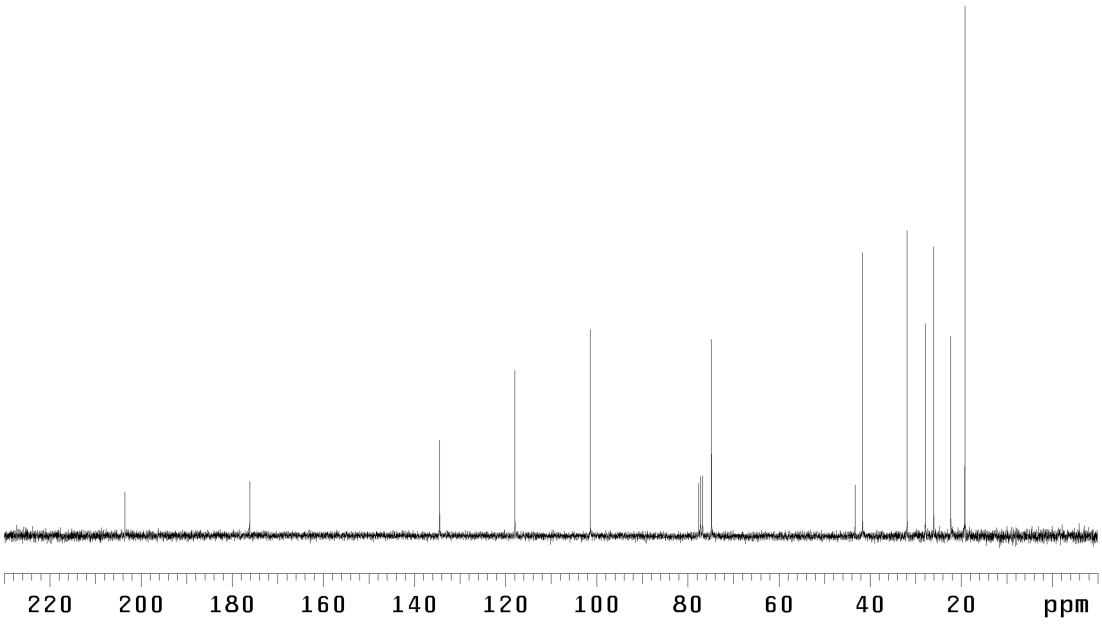


Figure SI-2C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **8**.

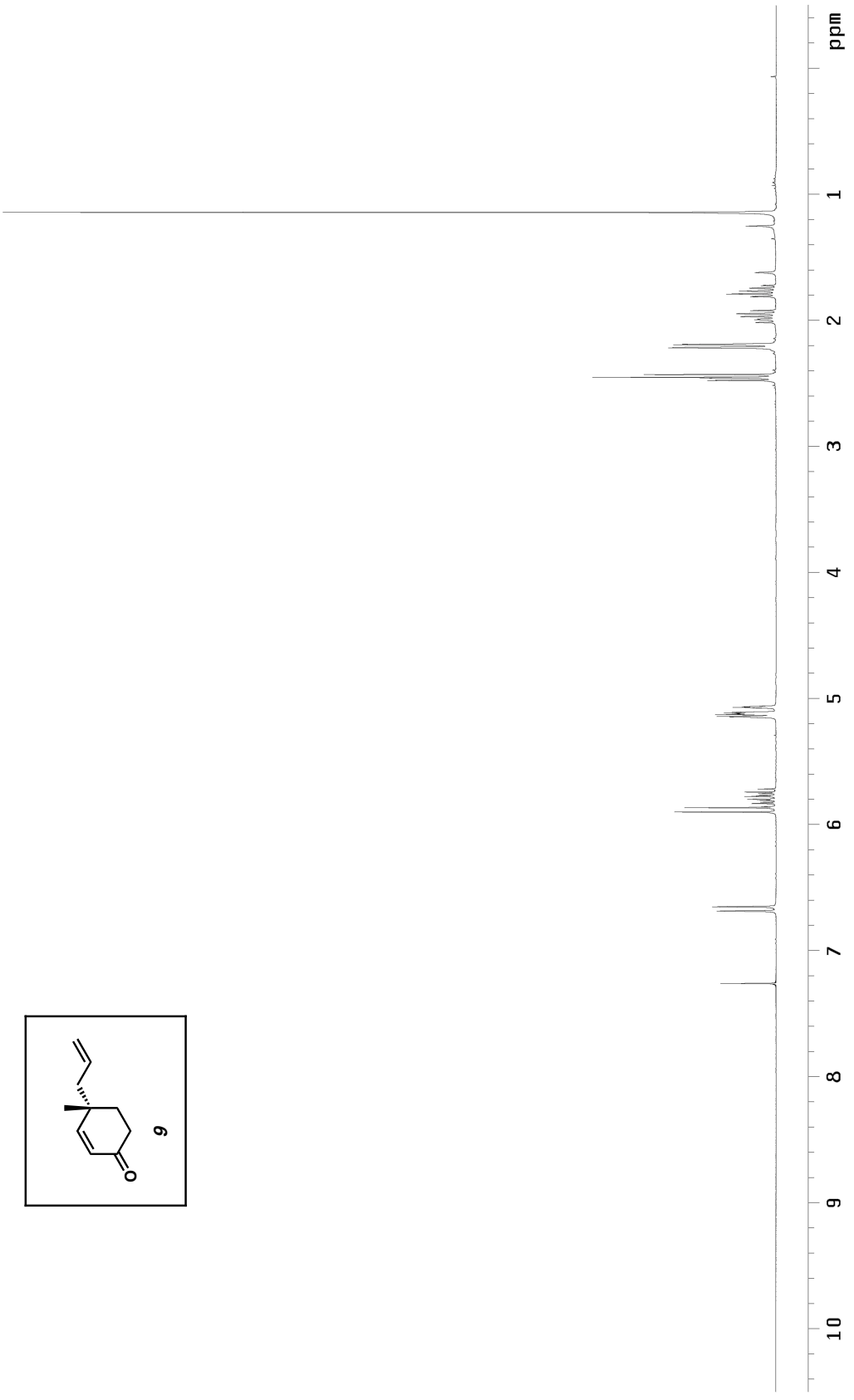


Figure SI-3A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **9**.

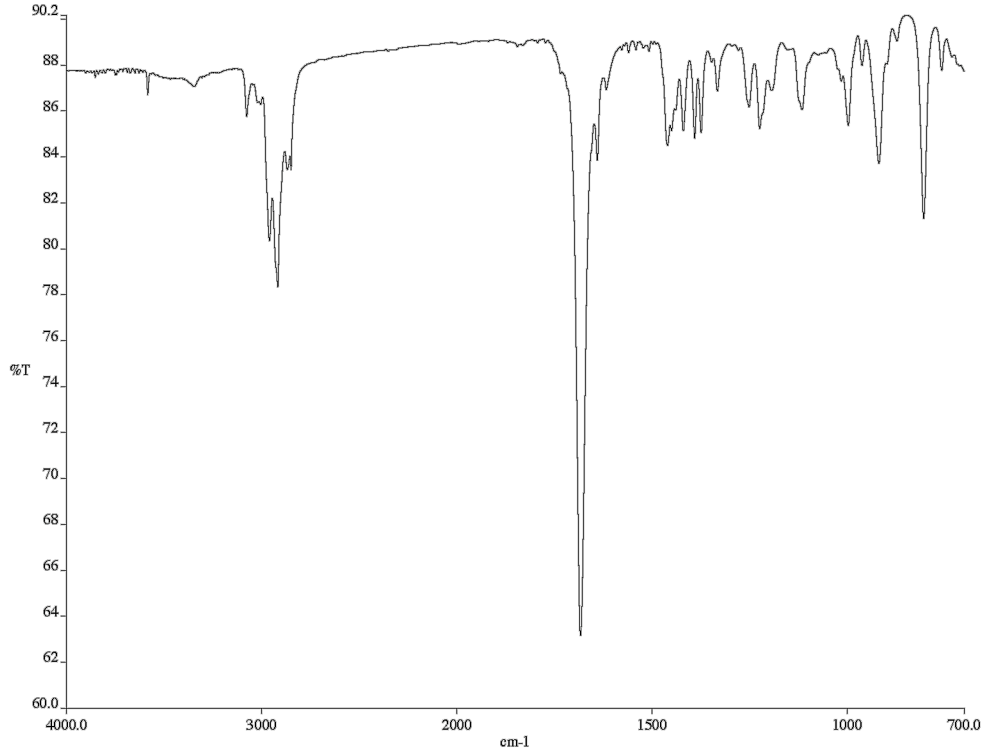


Figure SI-3B. Infrared spectrum (thin film/NaCl) of compound **9**.

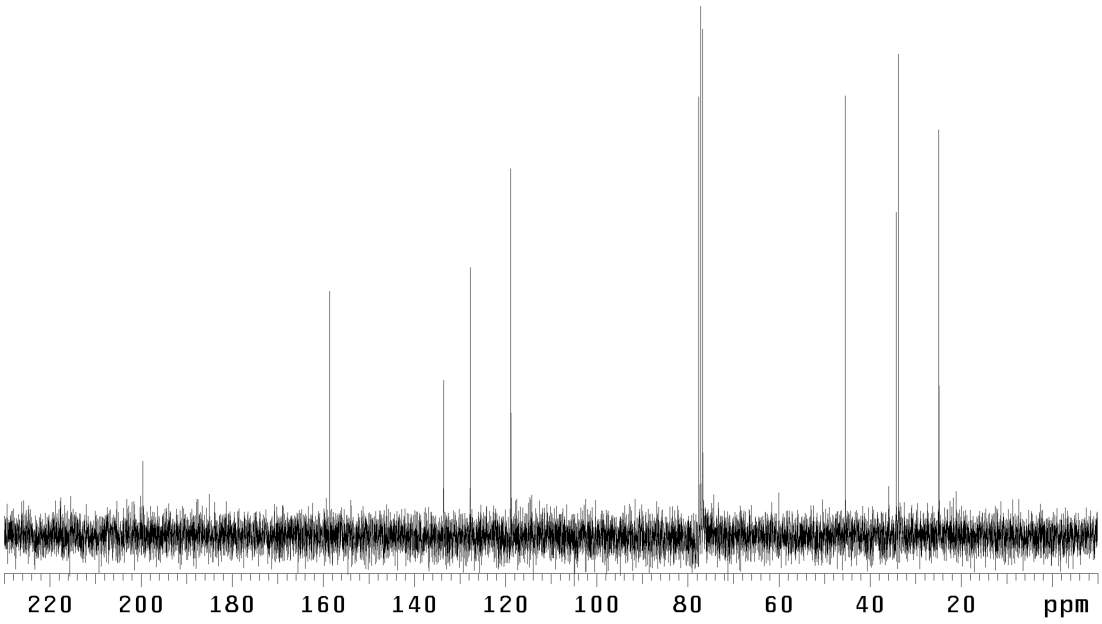


Figure SI-3C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **9**.

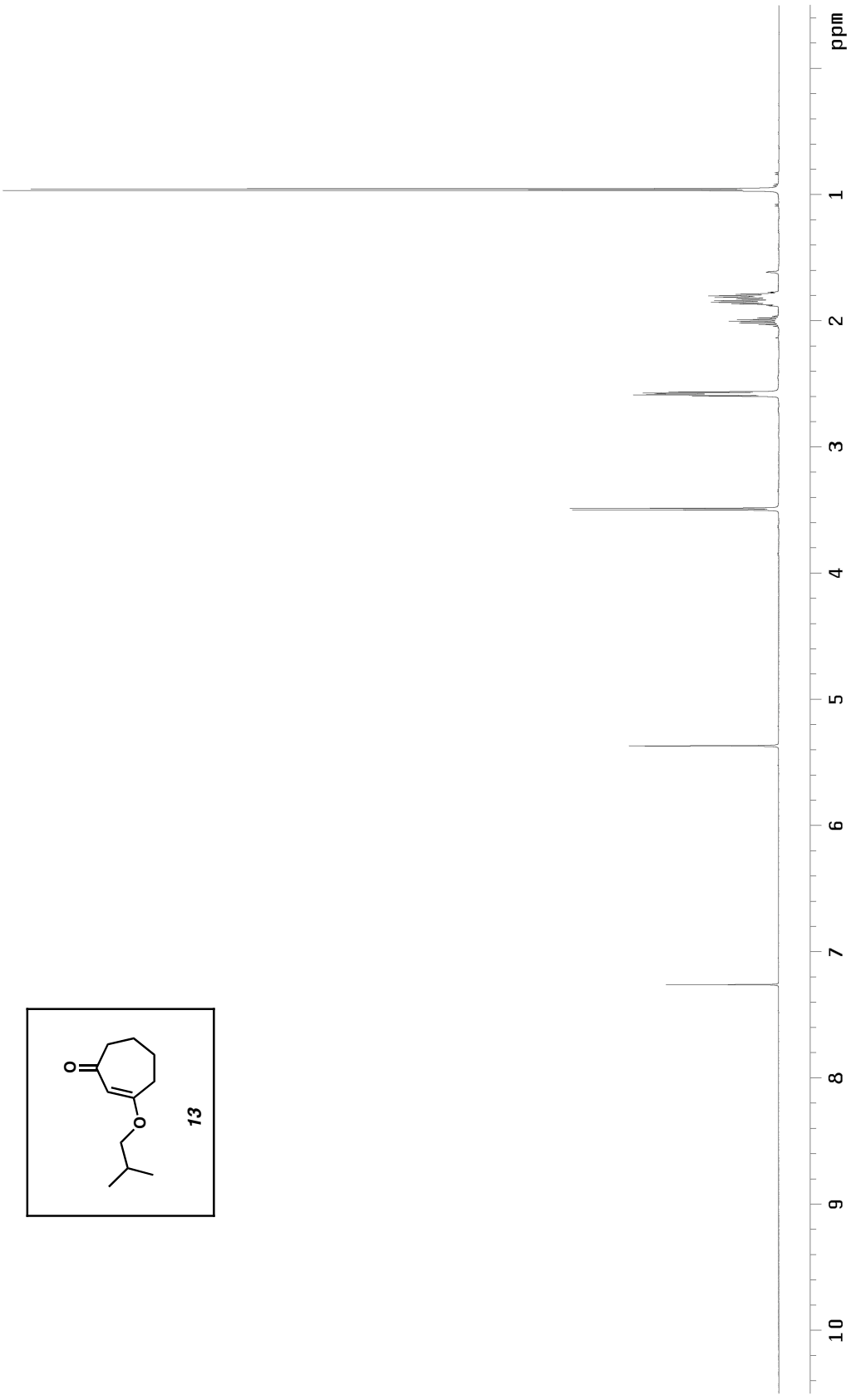


Figure SI-4A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **13**.

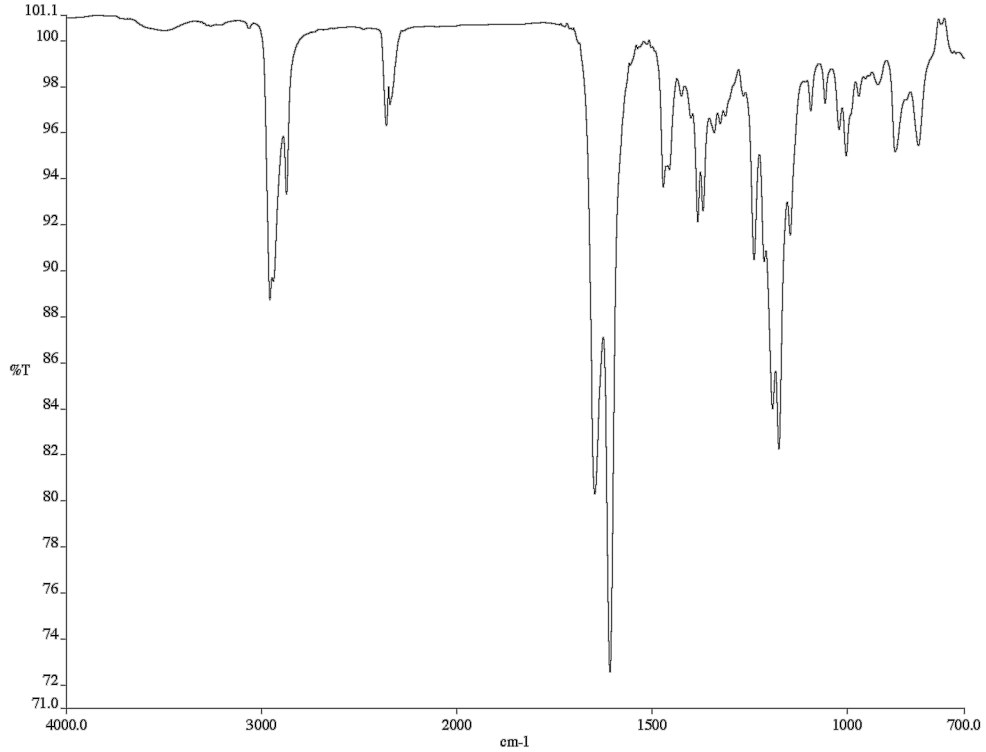


Figure SI-4B. Infrared spectrum (thin film/NaCl) of compound **13**.

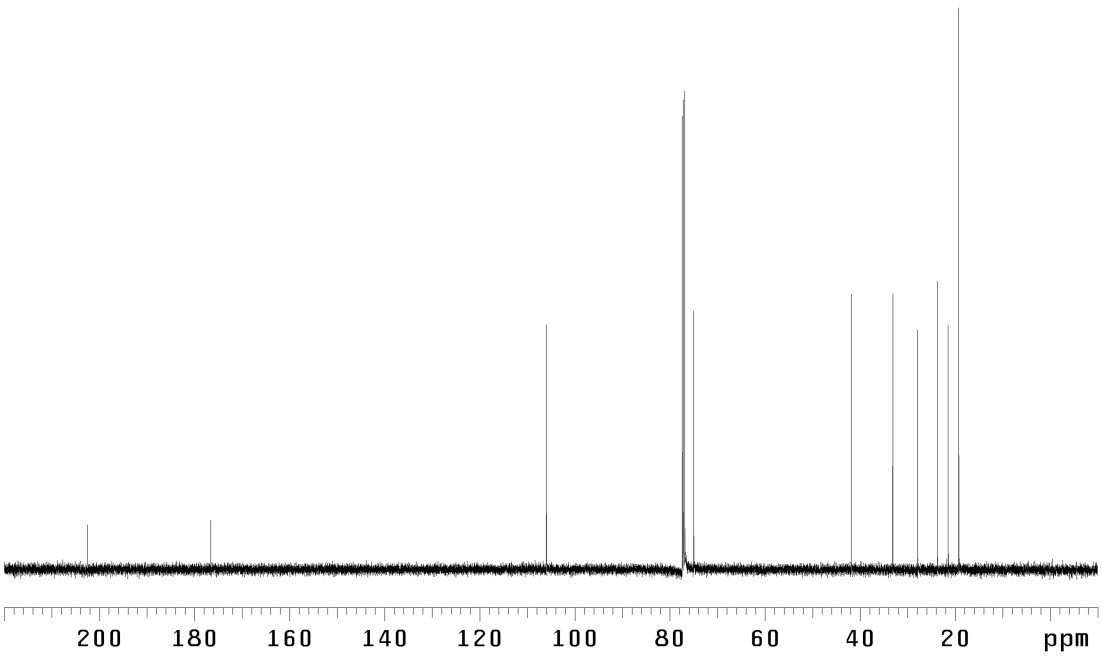


Figure SI-4C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **13**.

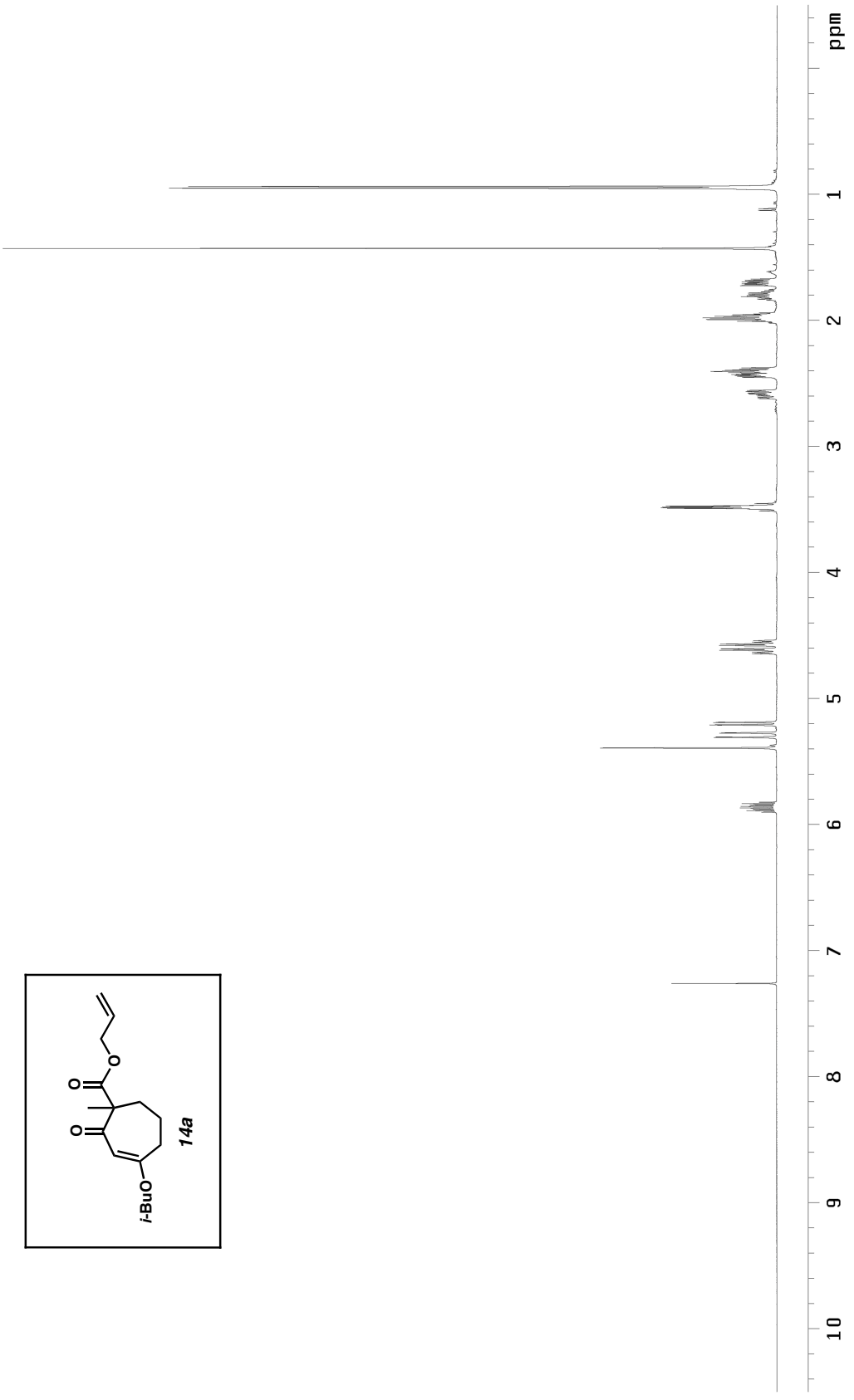


Figure SI-5A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **14a**.

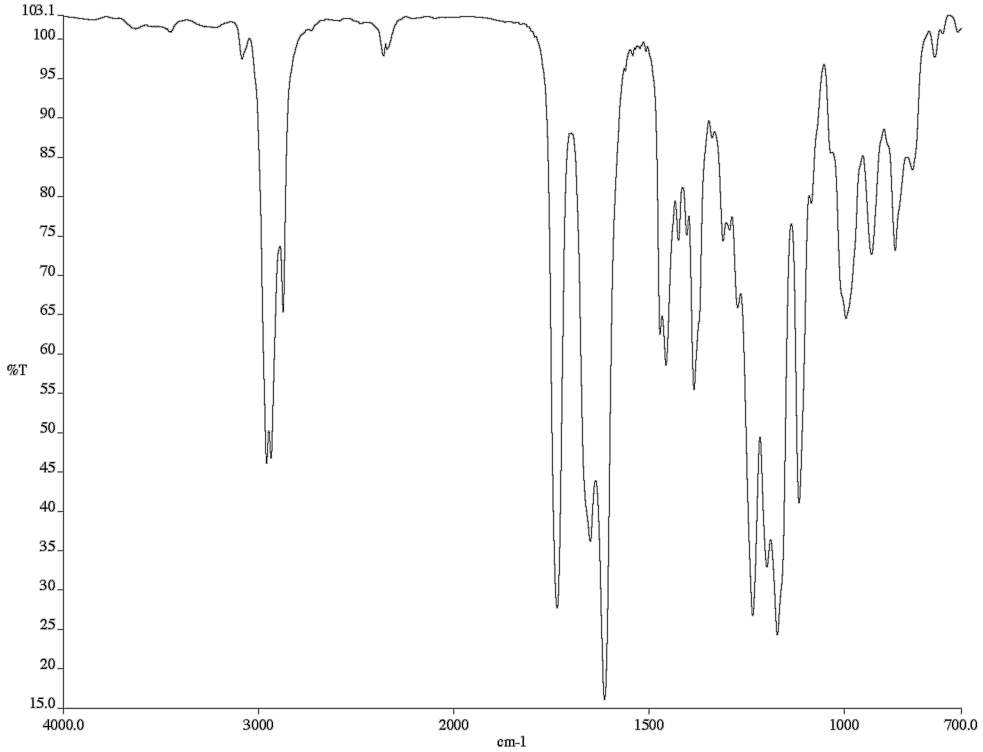


Figure SI-5B. Infrared spectrum (thin film/NaCl) of compound **14a**.

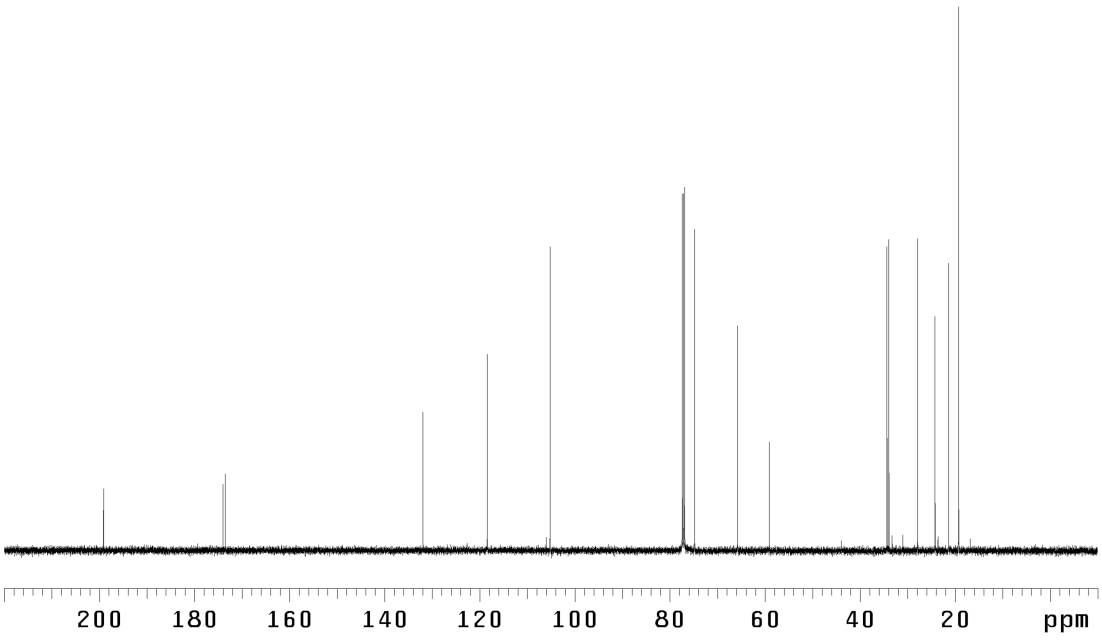


Figure SI-5C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **14a**.

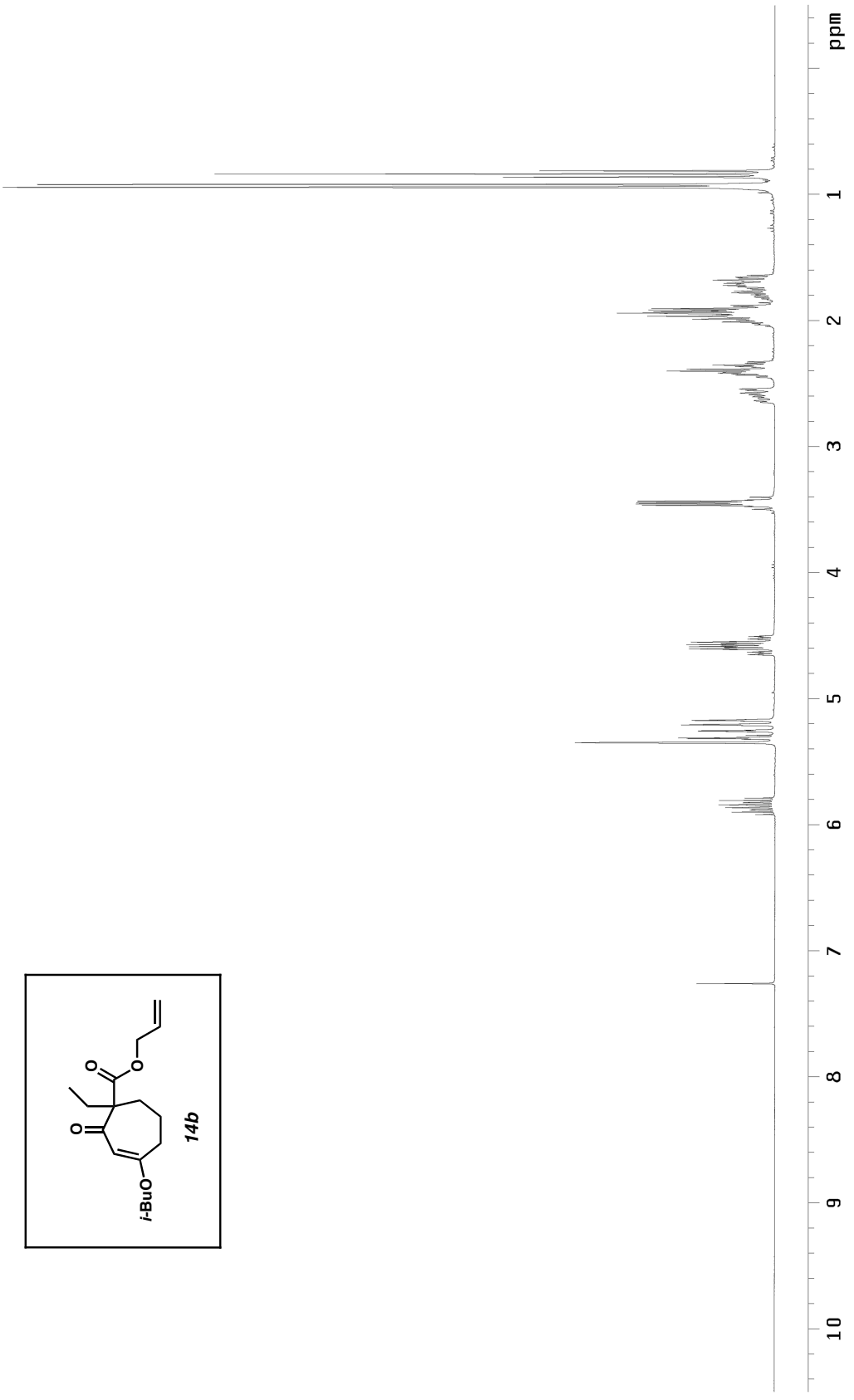


Figure SI-6A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14b**.

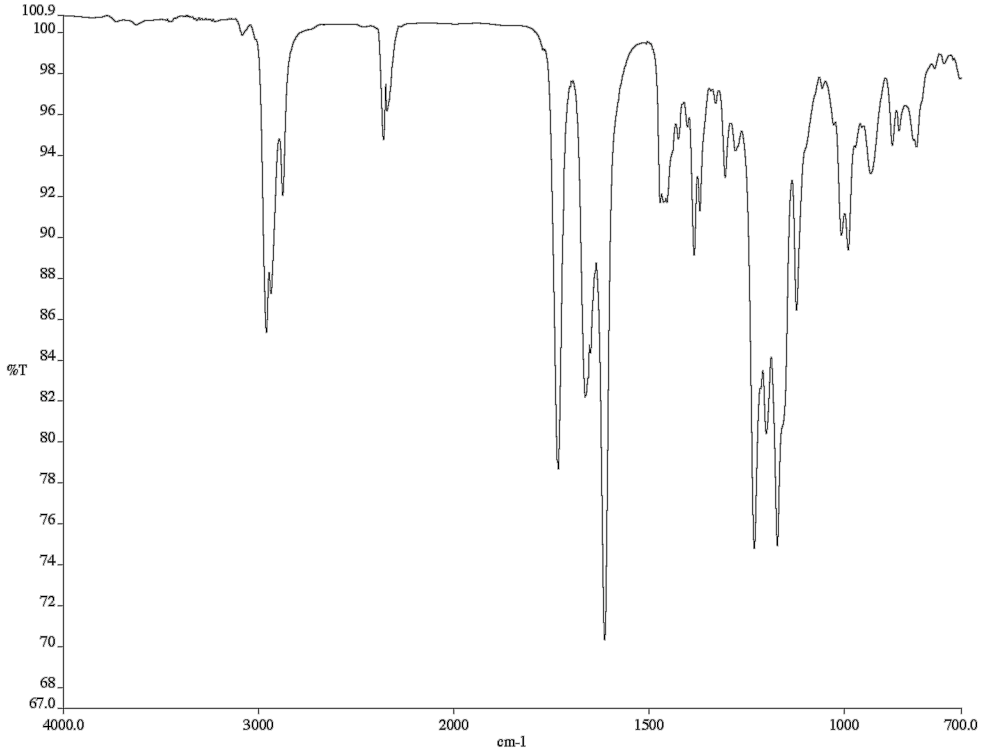


Figure SI-6B. Infrared spectrum (thin film/NaCl) of compound **14b**.

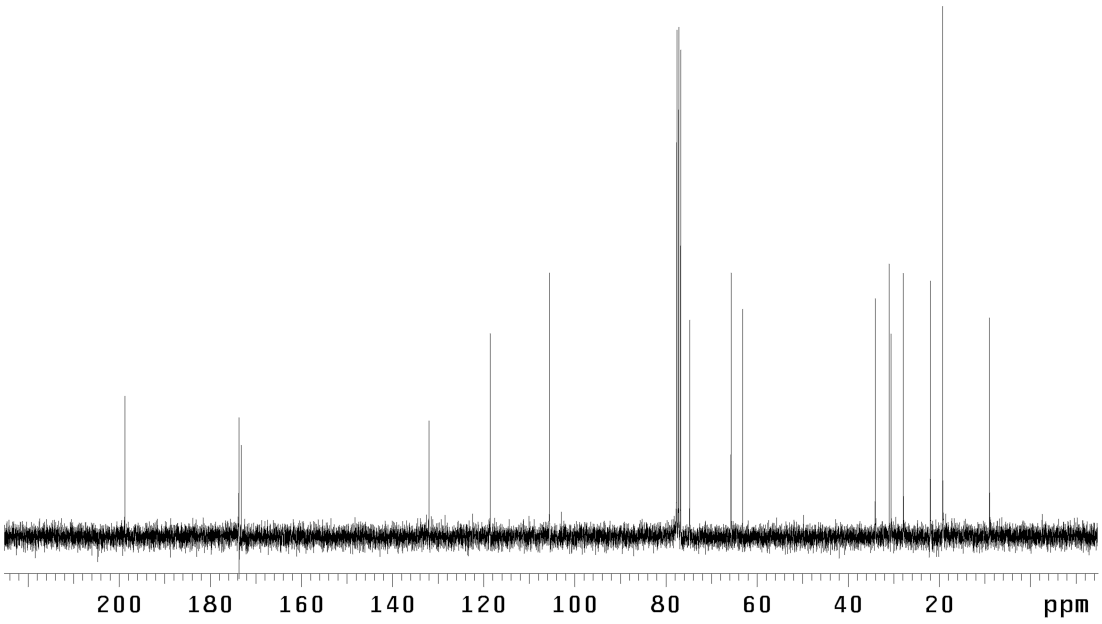


Figure SI-6C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14b**.

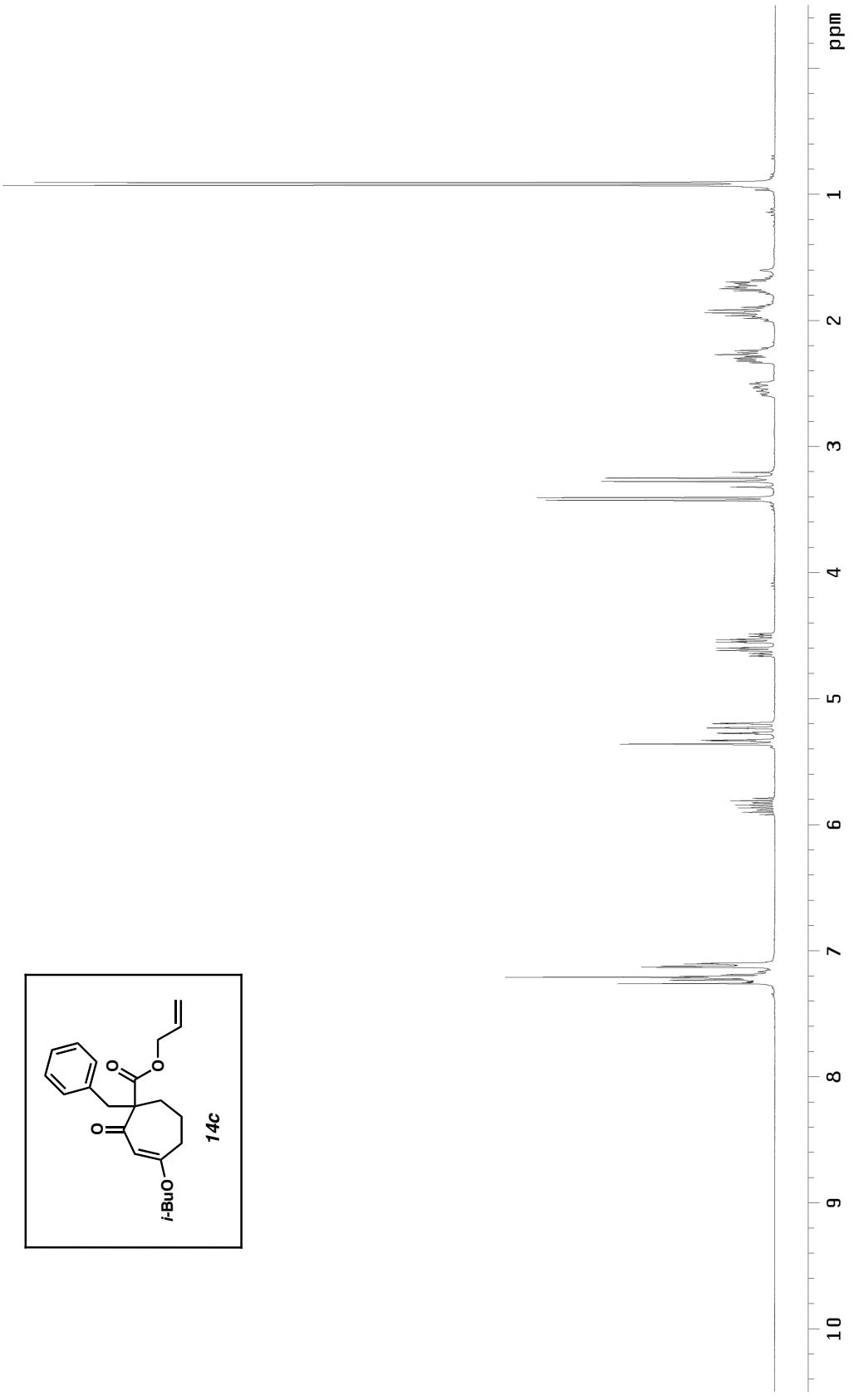


Figure SI-7A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14c**.

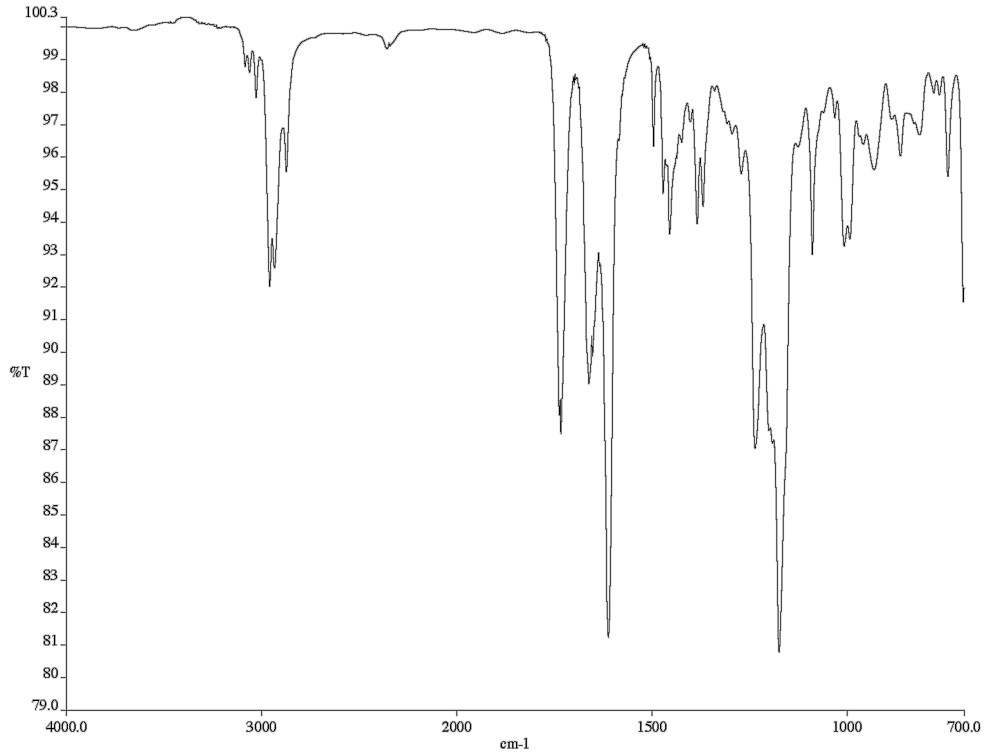


Figure SI-7B. Infrared spectrum (thin film/NaCl) of compound **14c**.

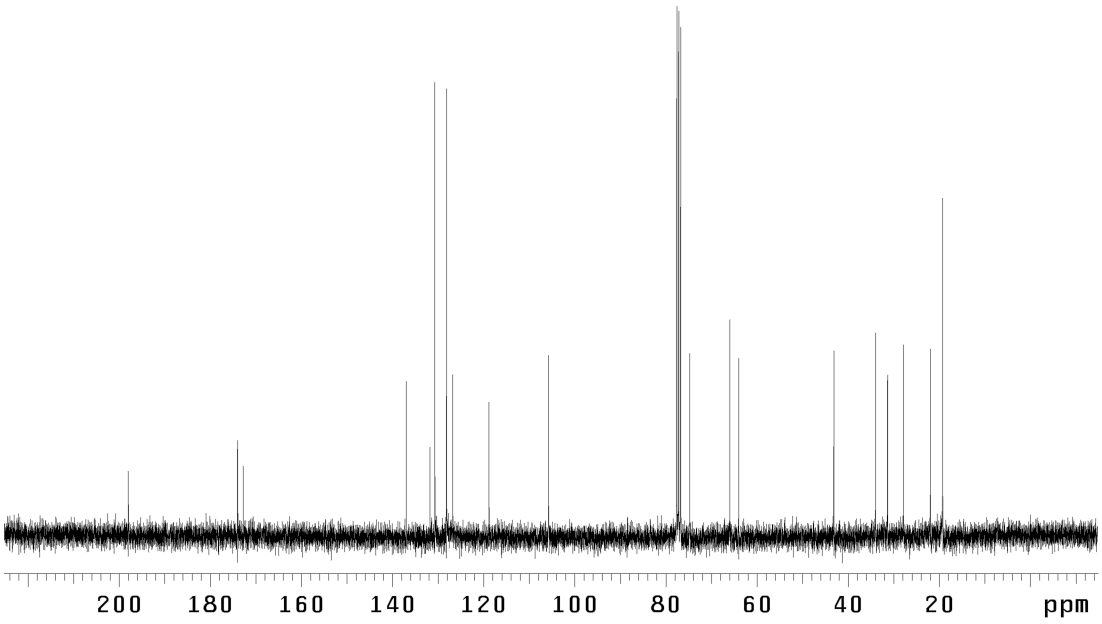


Figure SI-7C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14c**.

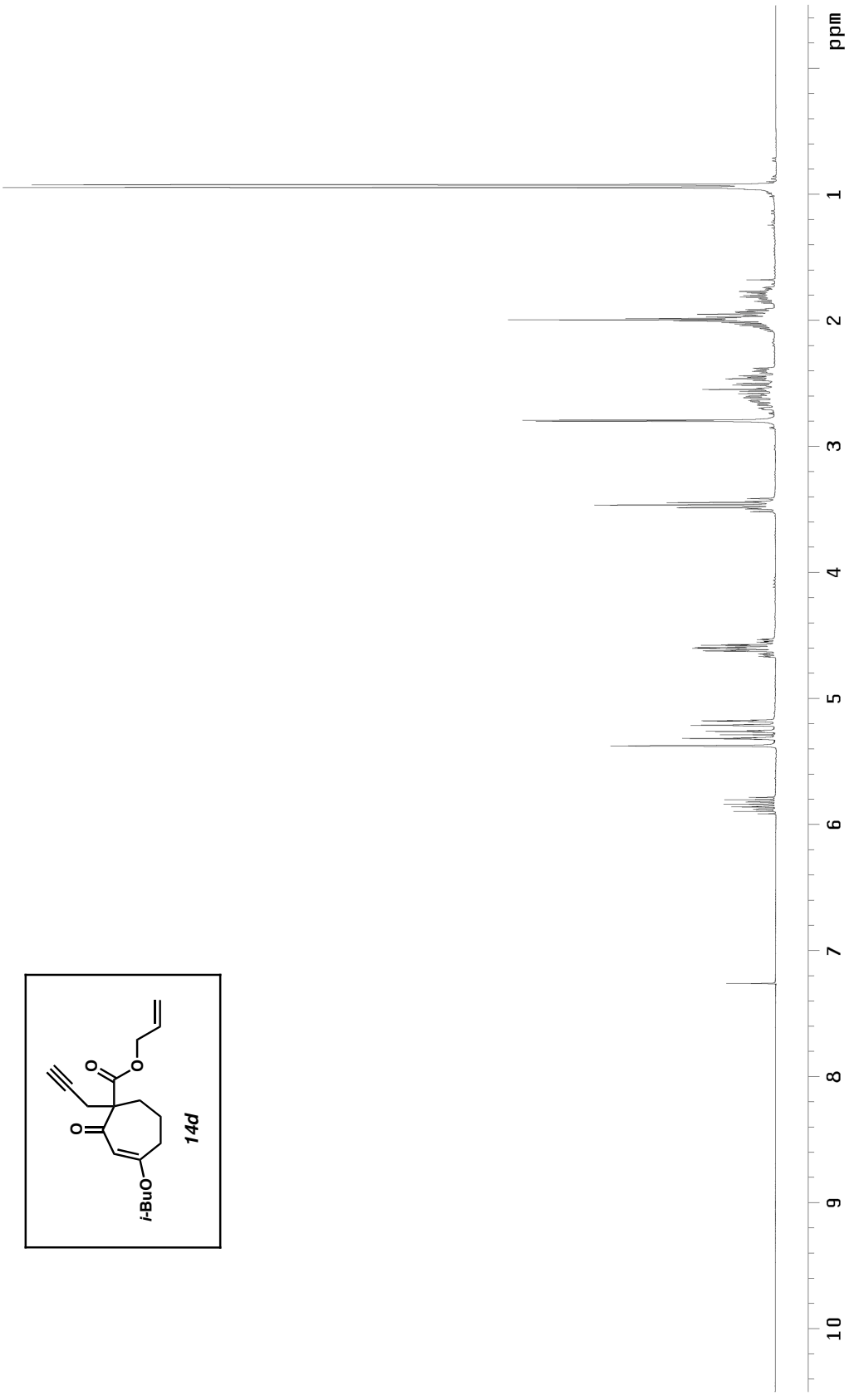


Figure SI-8A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14d**.

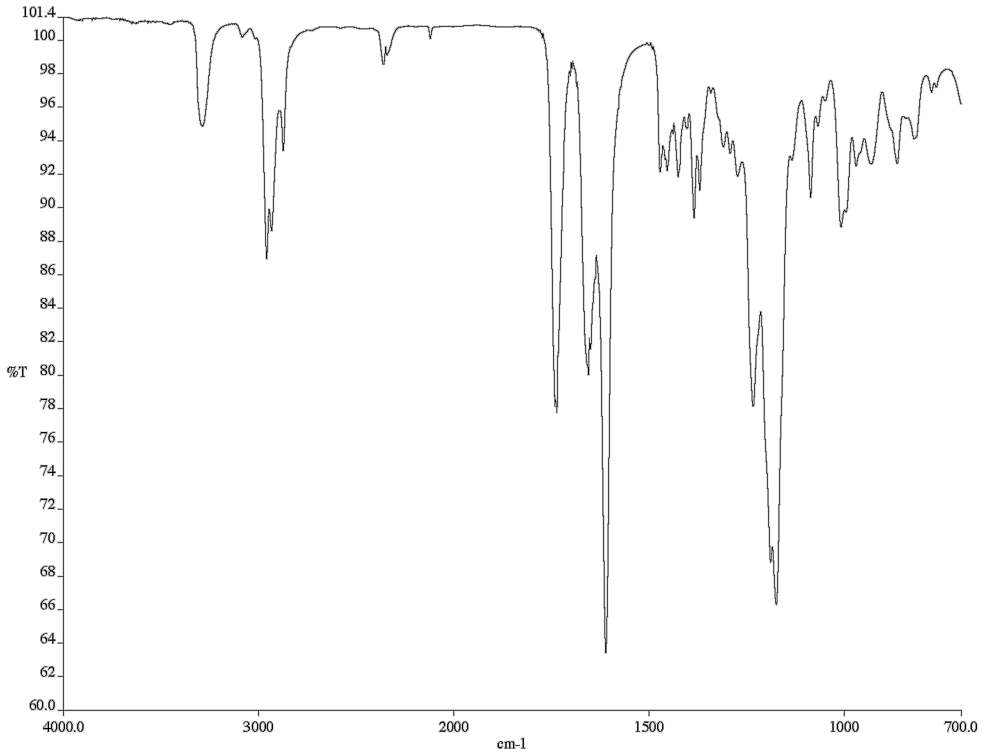


Figure SI-8B. Infrared spectrum (thin film/NaCl) of compound **14d**.

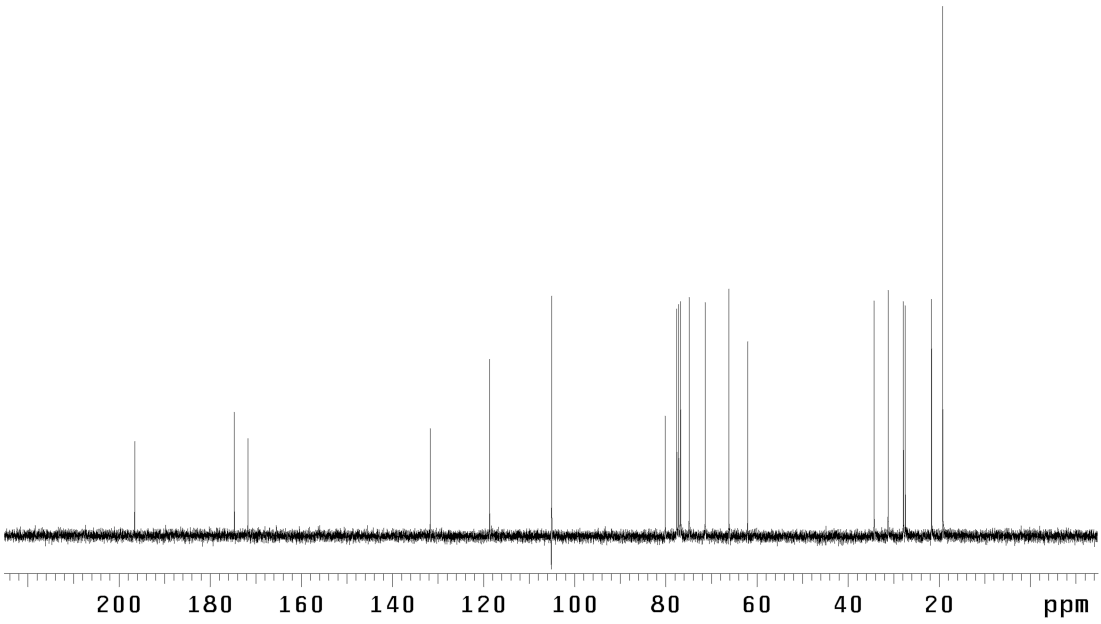


Figure SI-8C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14d**.

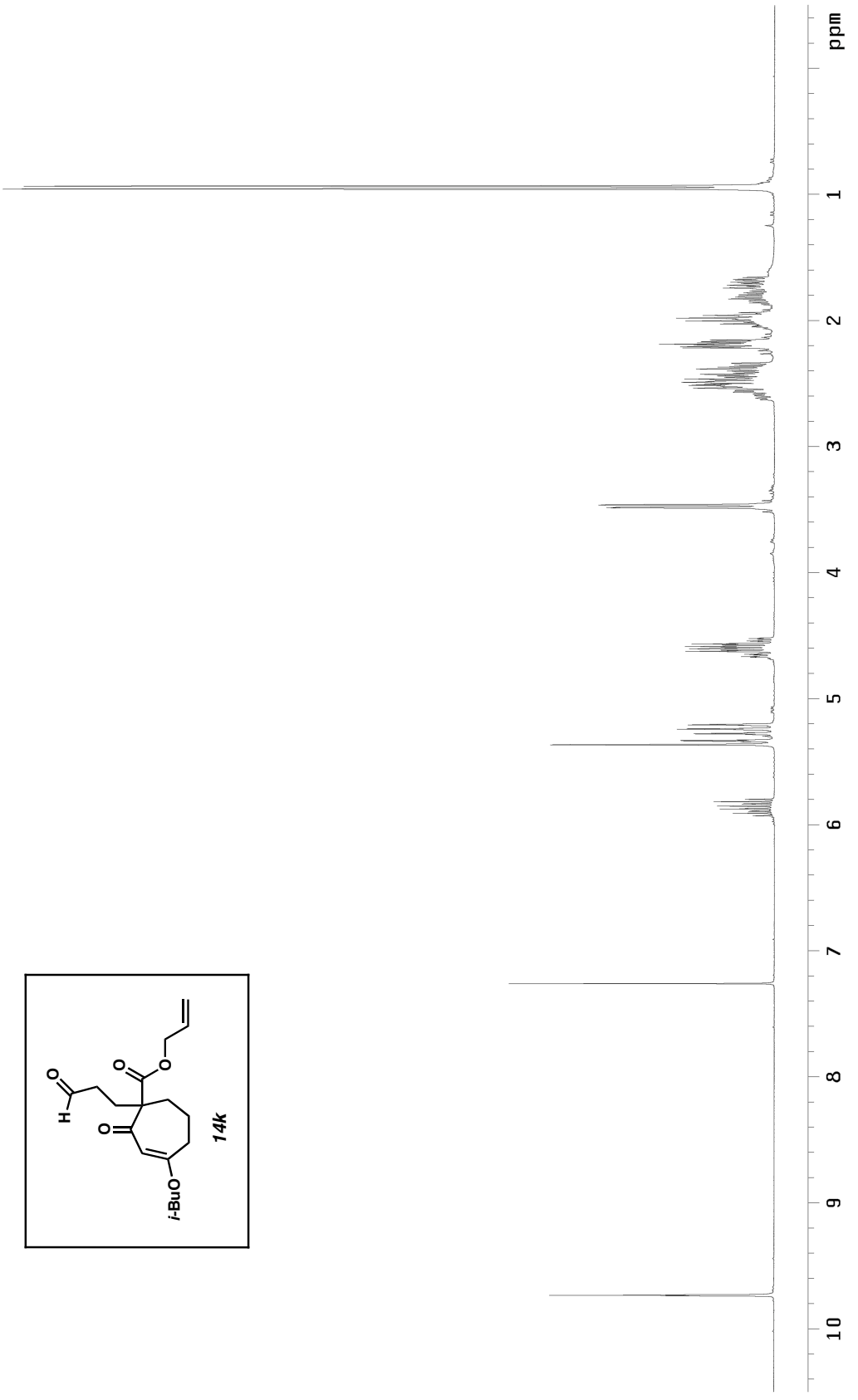


Figure SI-9A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14k**.

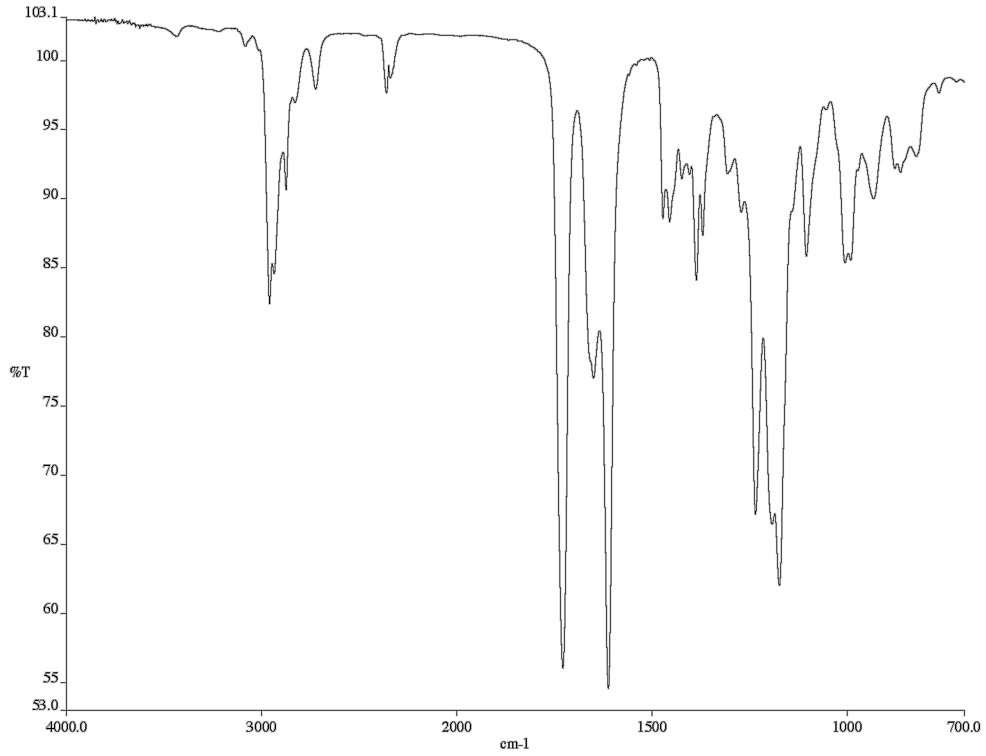


Figure SI-9B. Infrared spectrum (thin film/NaCl) of compound **14k**.

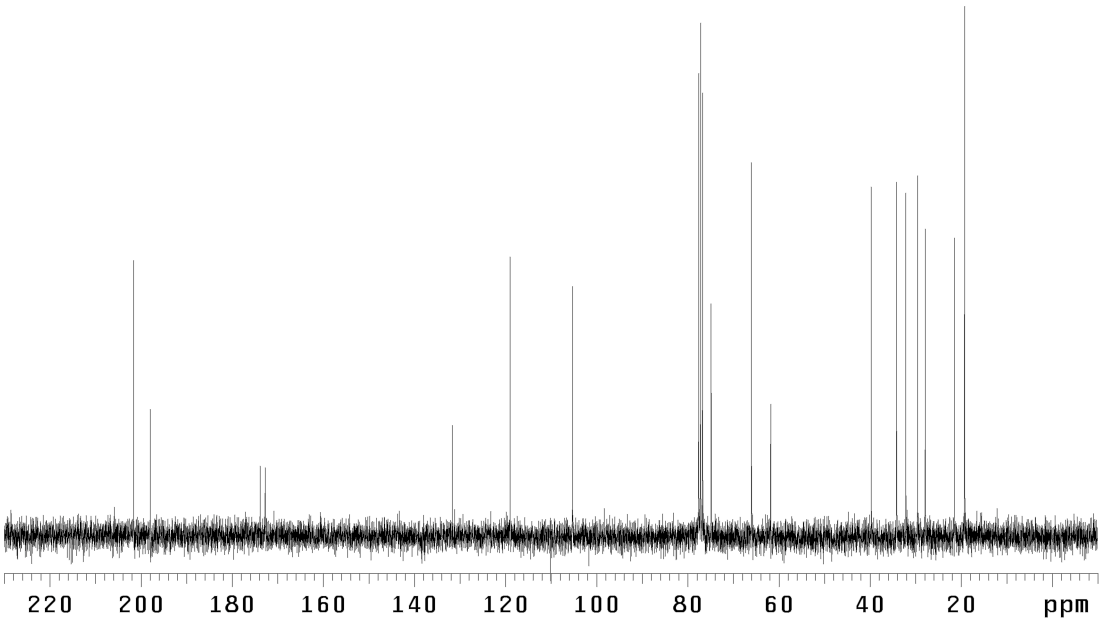


Figure SI-9C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14k**.

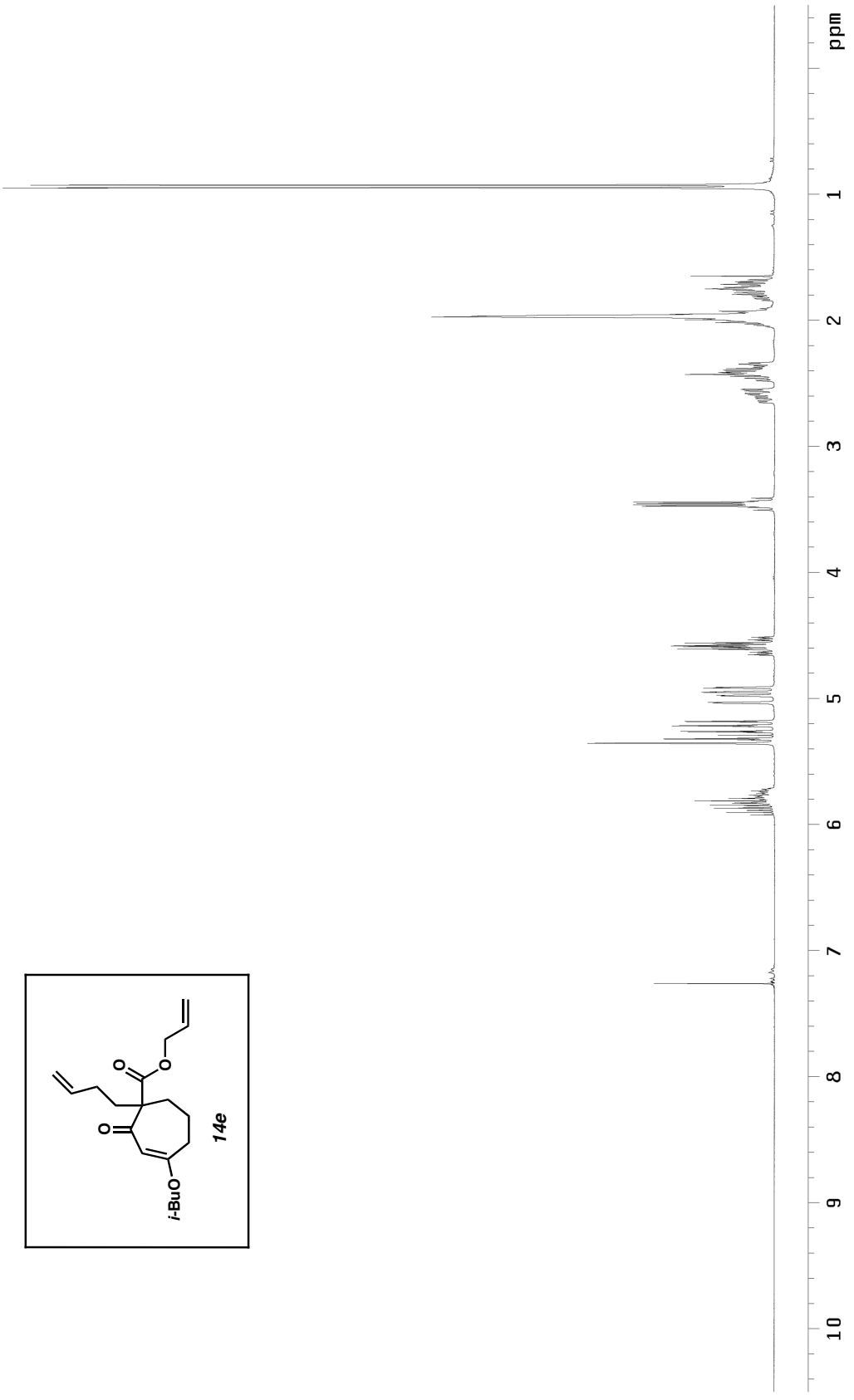


Figure SI-10A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14e**.

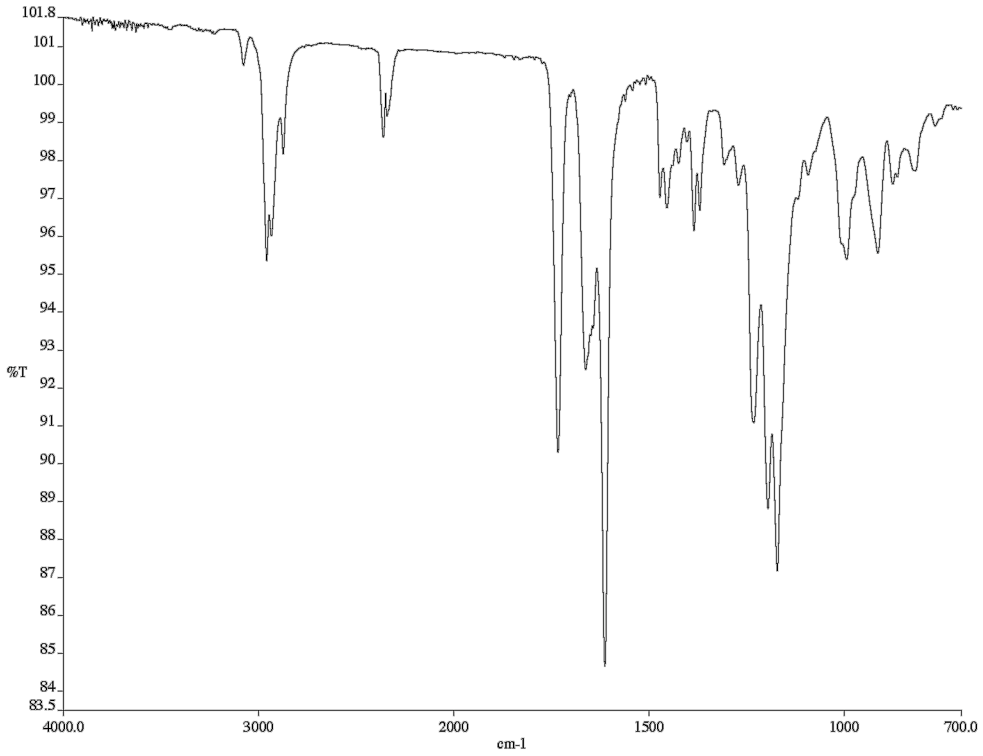


Figure SI-10B. Infrared spectrum (thin film/NaCl) of compound **14e**.

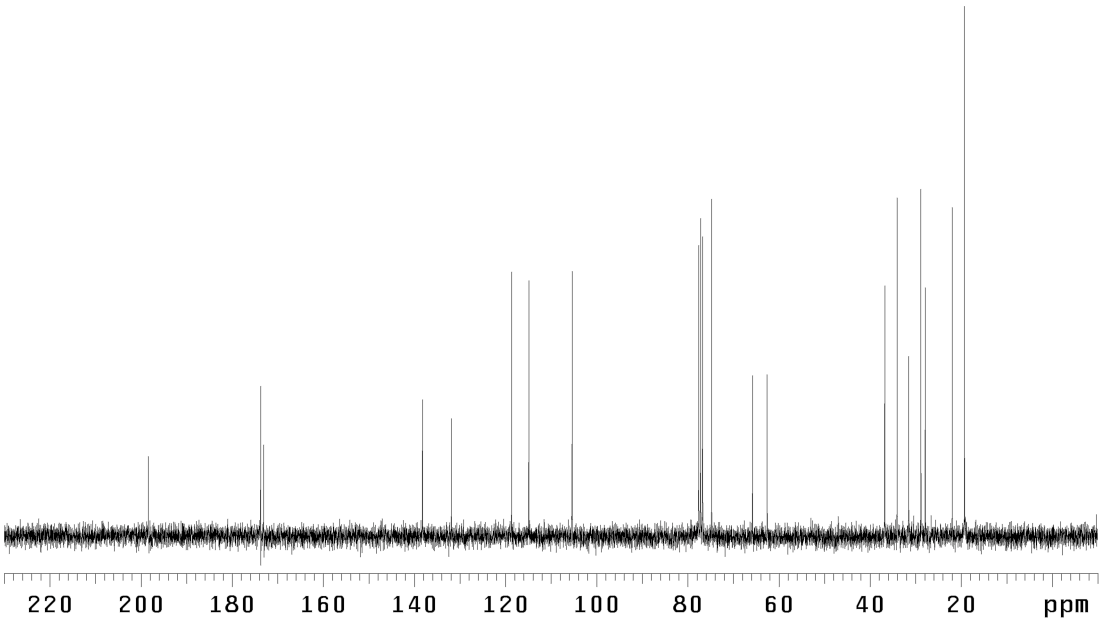


Figure SI-10C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14e**.

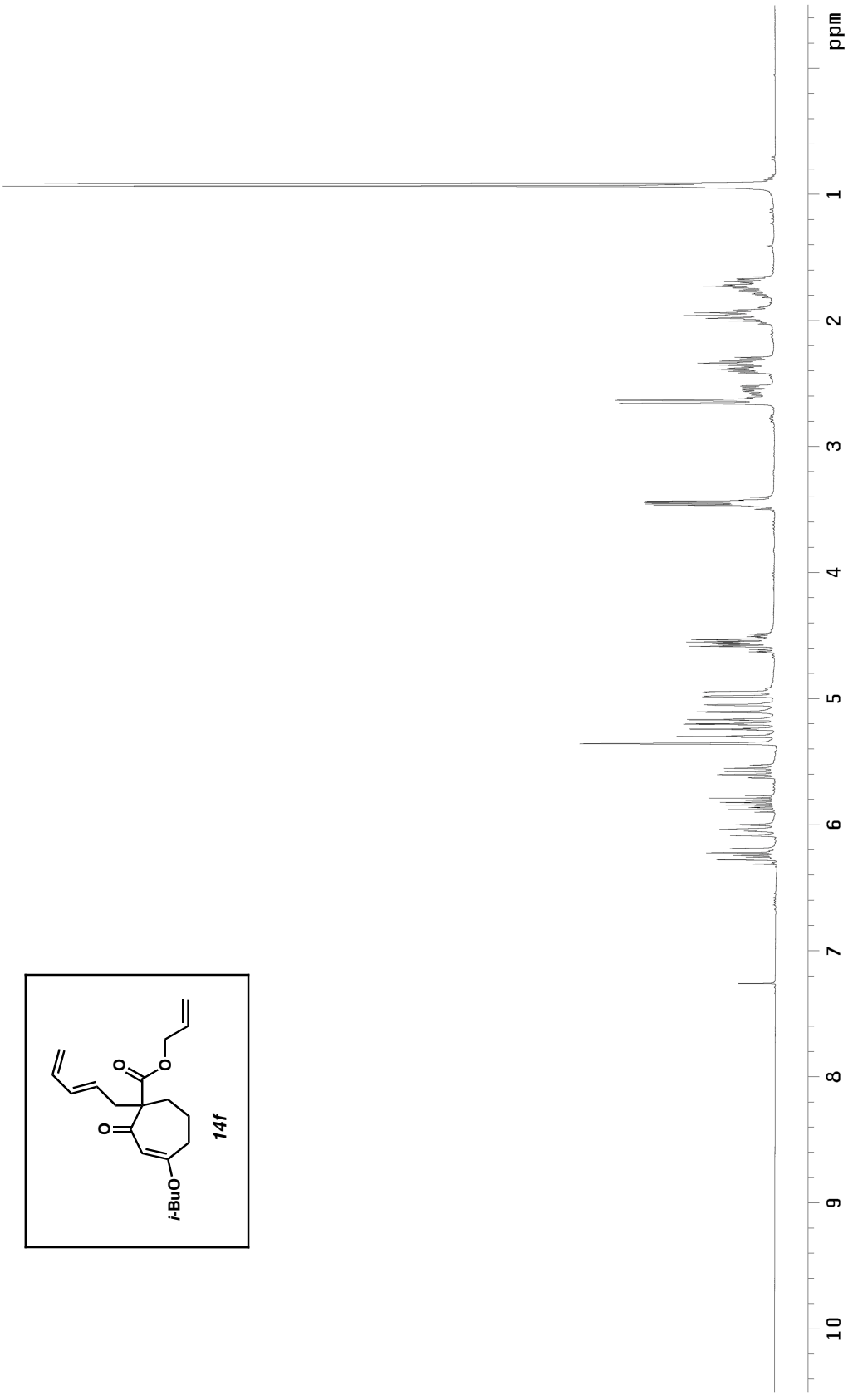


Figure SI-11A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14f**.

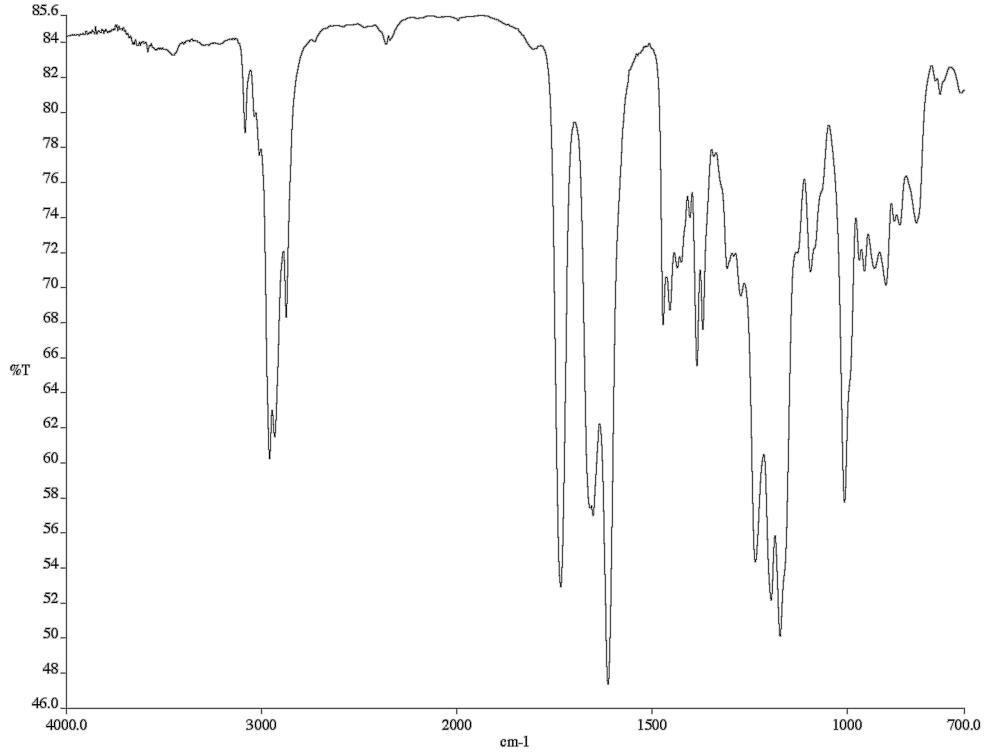


Figure SI-11B. Infrared spectrum (thin film/NaCl) of compound **14f**.

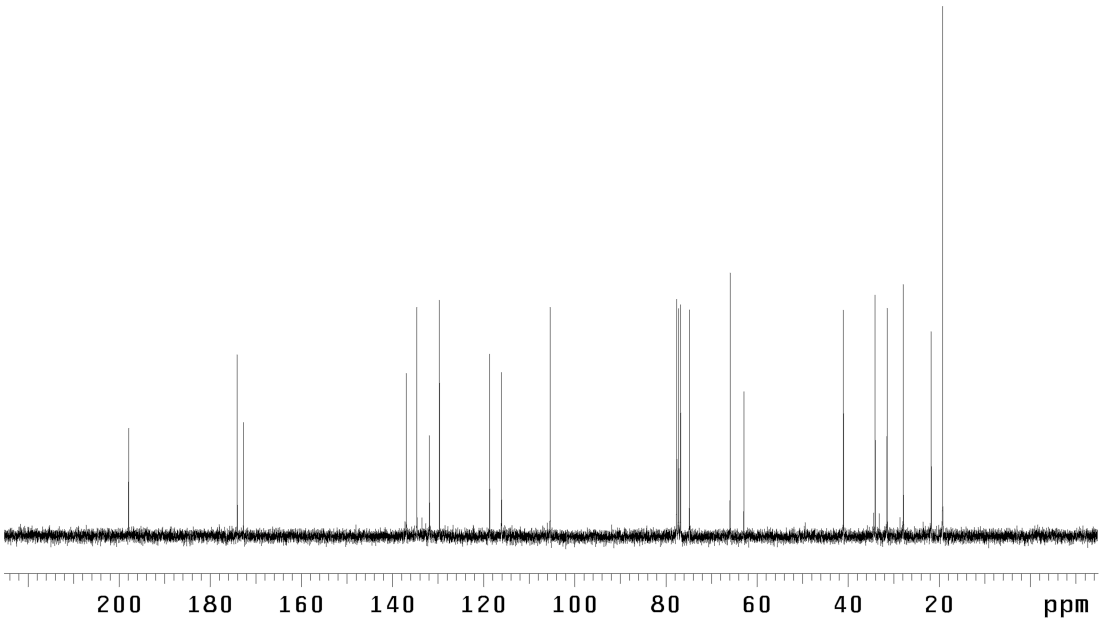


Figure SI-11C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14f**.

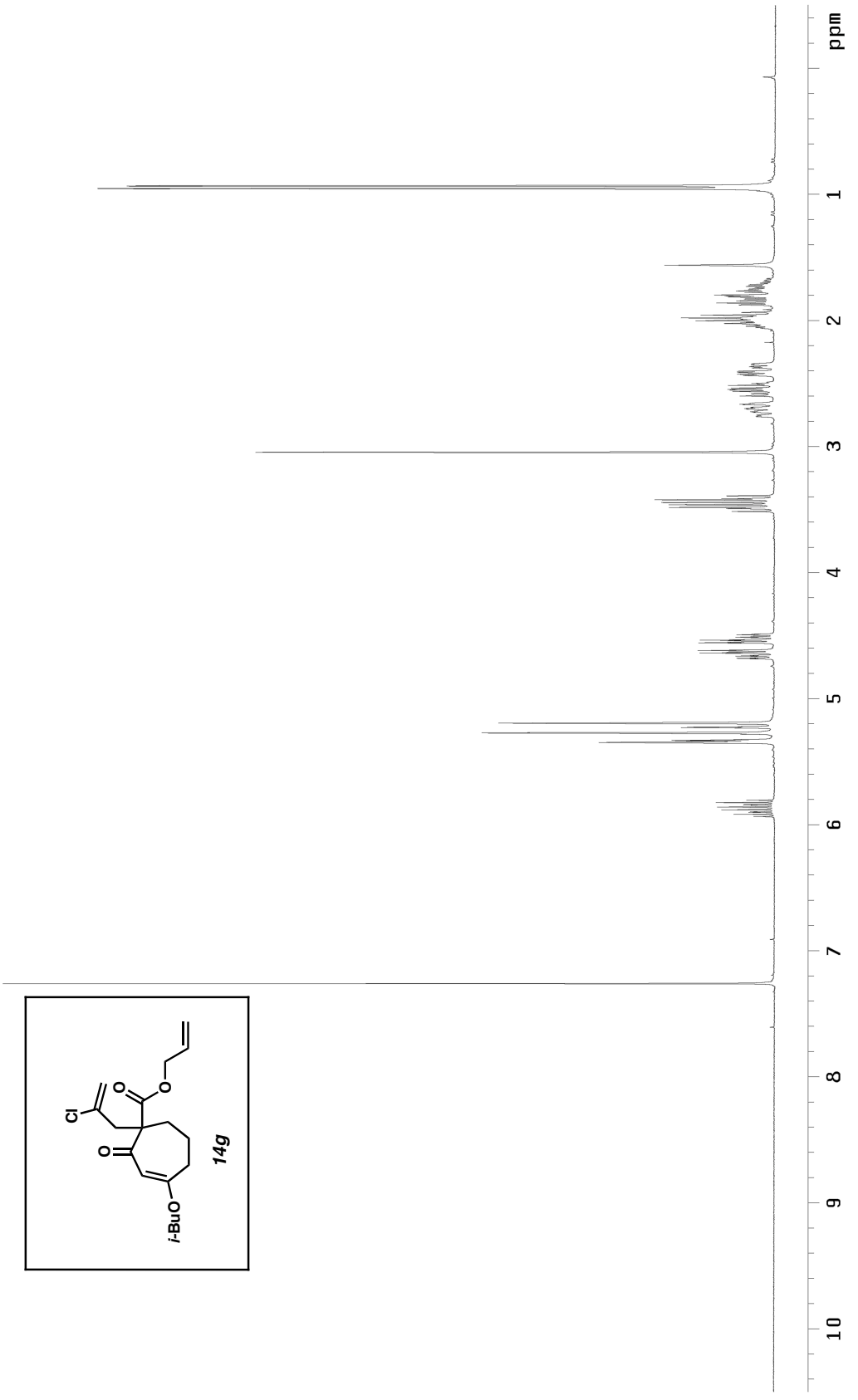


Figure SI-12A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14g**.

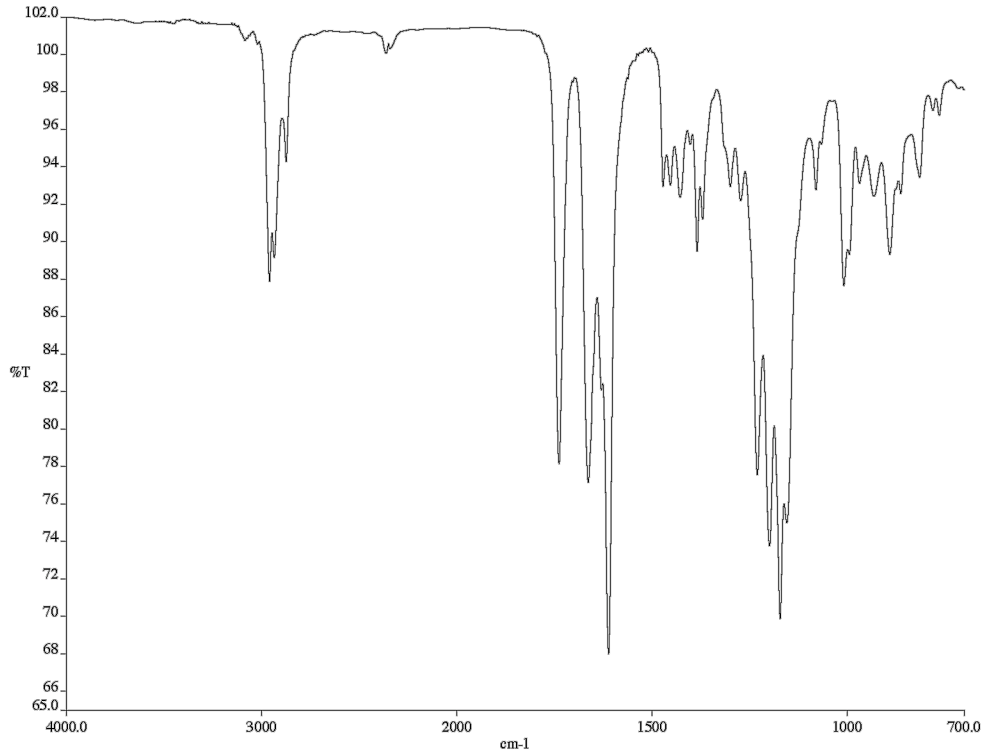


Figure SI-12B. Infrared spectrum (thin film/NaCl) of compound **14g**.

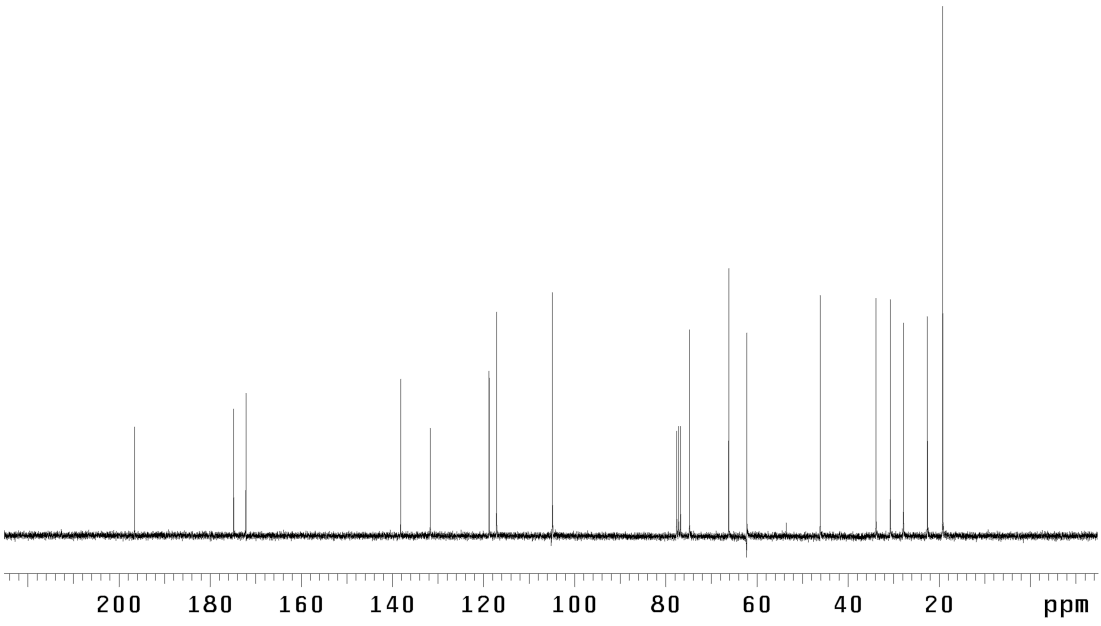


Figure SI-12C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14g**.

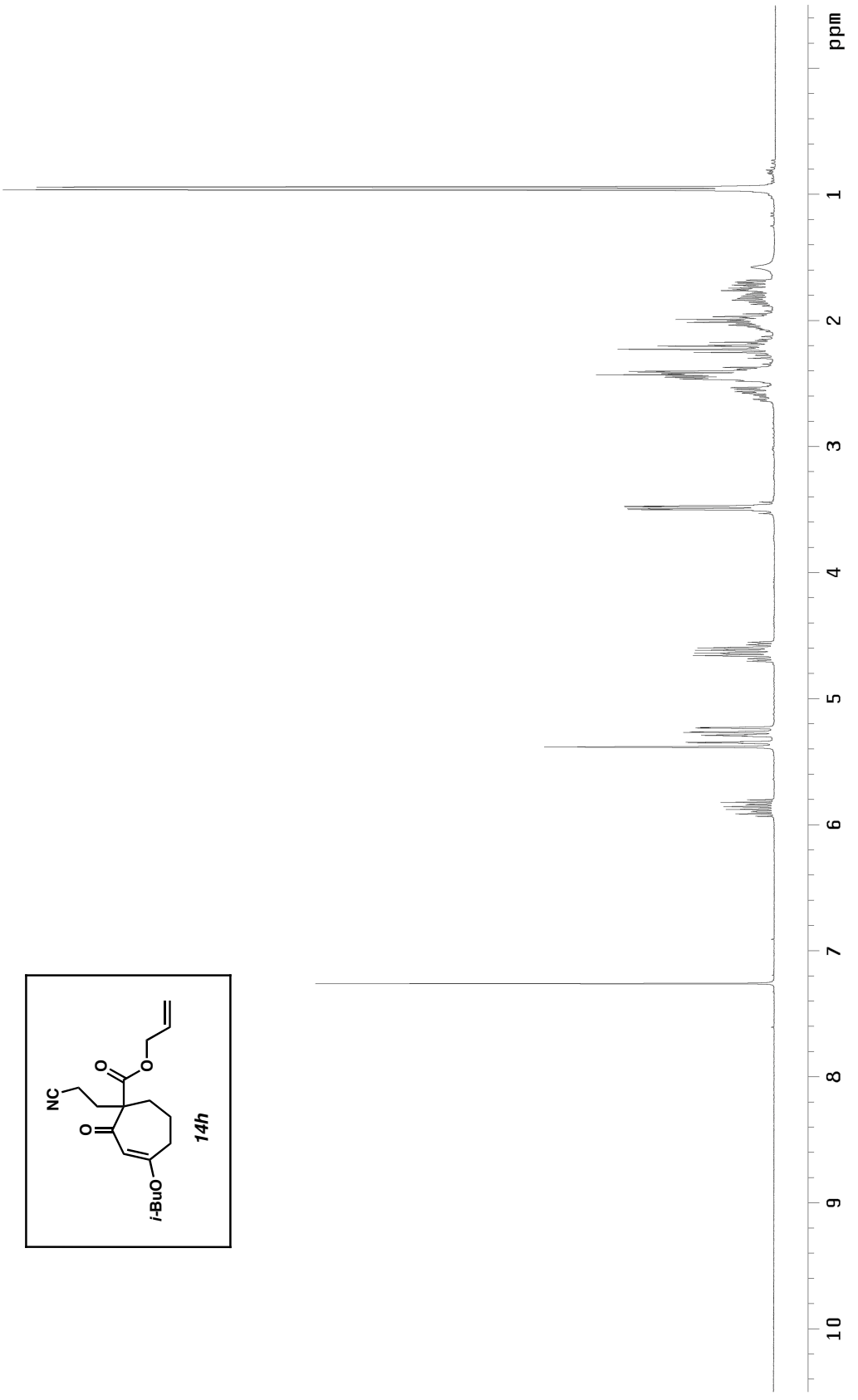


Figure SI-13A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14h**.

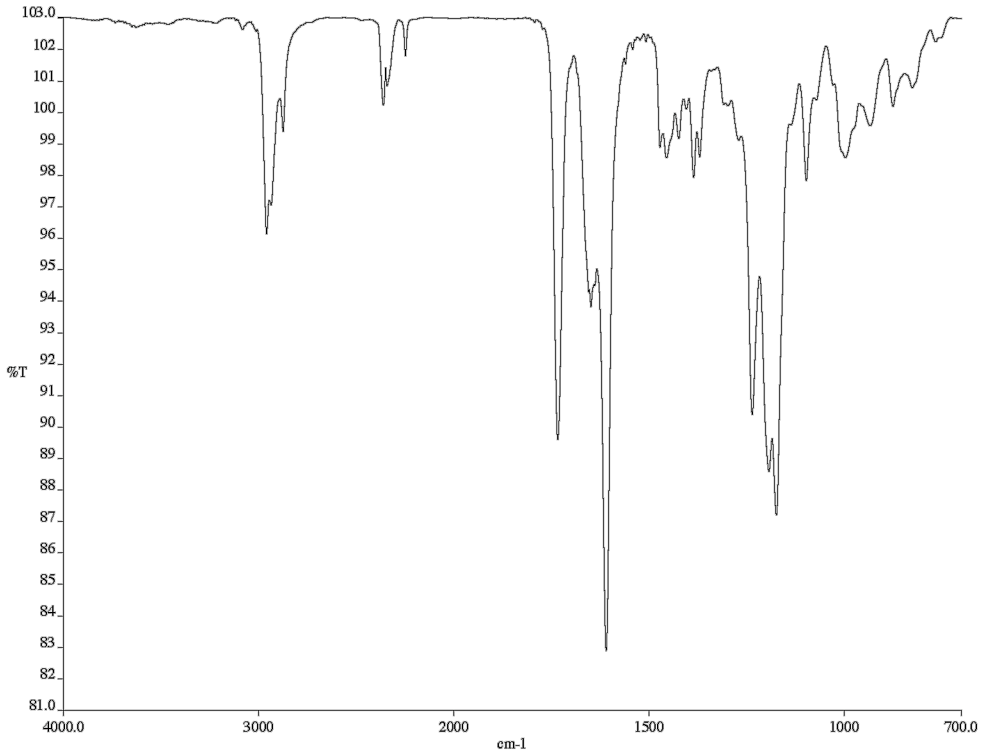


Figure SI-13B. Infrared spectrum (thin film/NaCl) of compound **14h**.

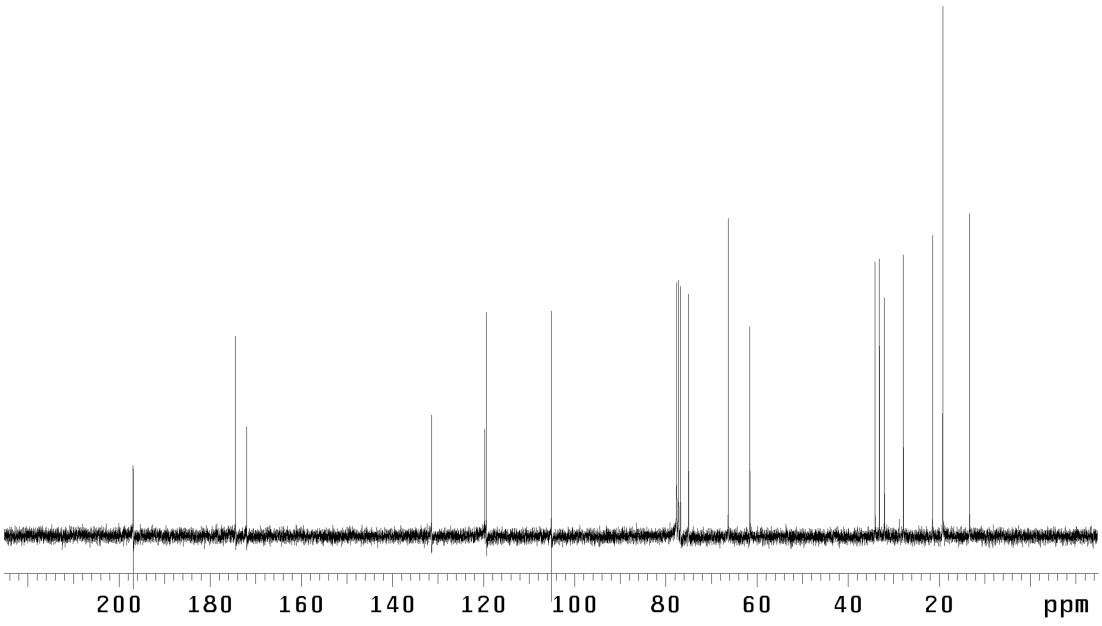


Figure SI-13C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14h**.

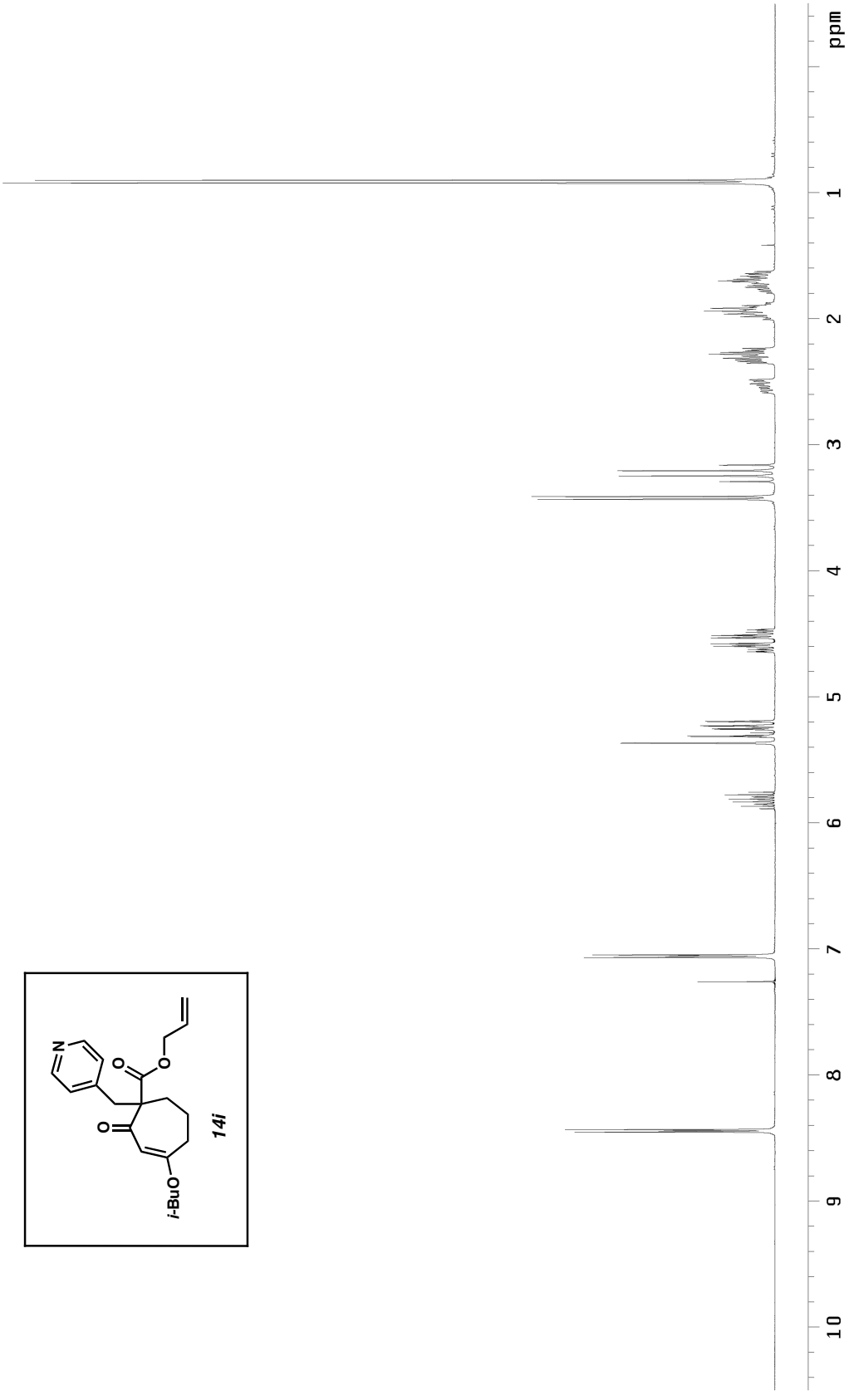


Figure SI-14A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14i**.

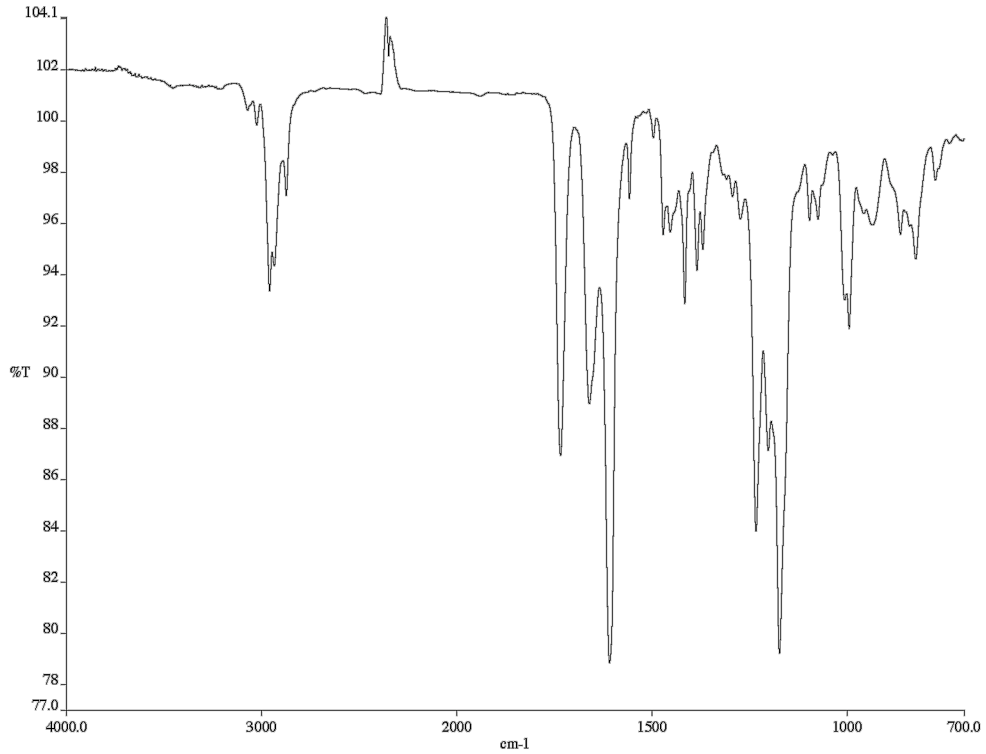


Figure SI-14B. Infrared spectrum (thin film/NaCl) of compound **14i**.

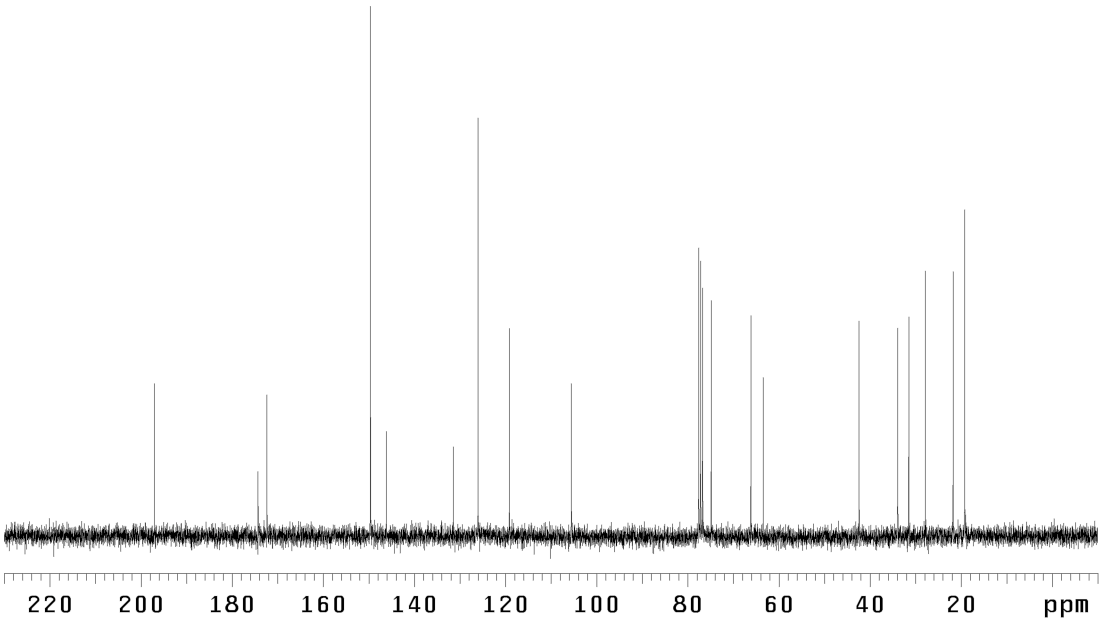


Figure SI-14C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14i**.

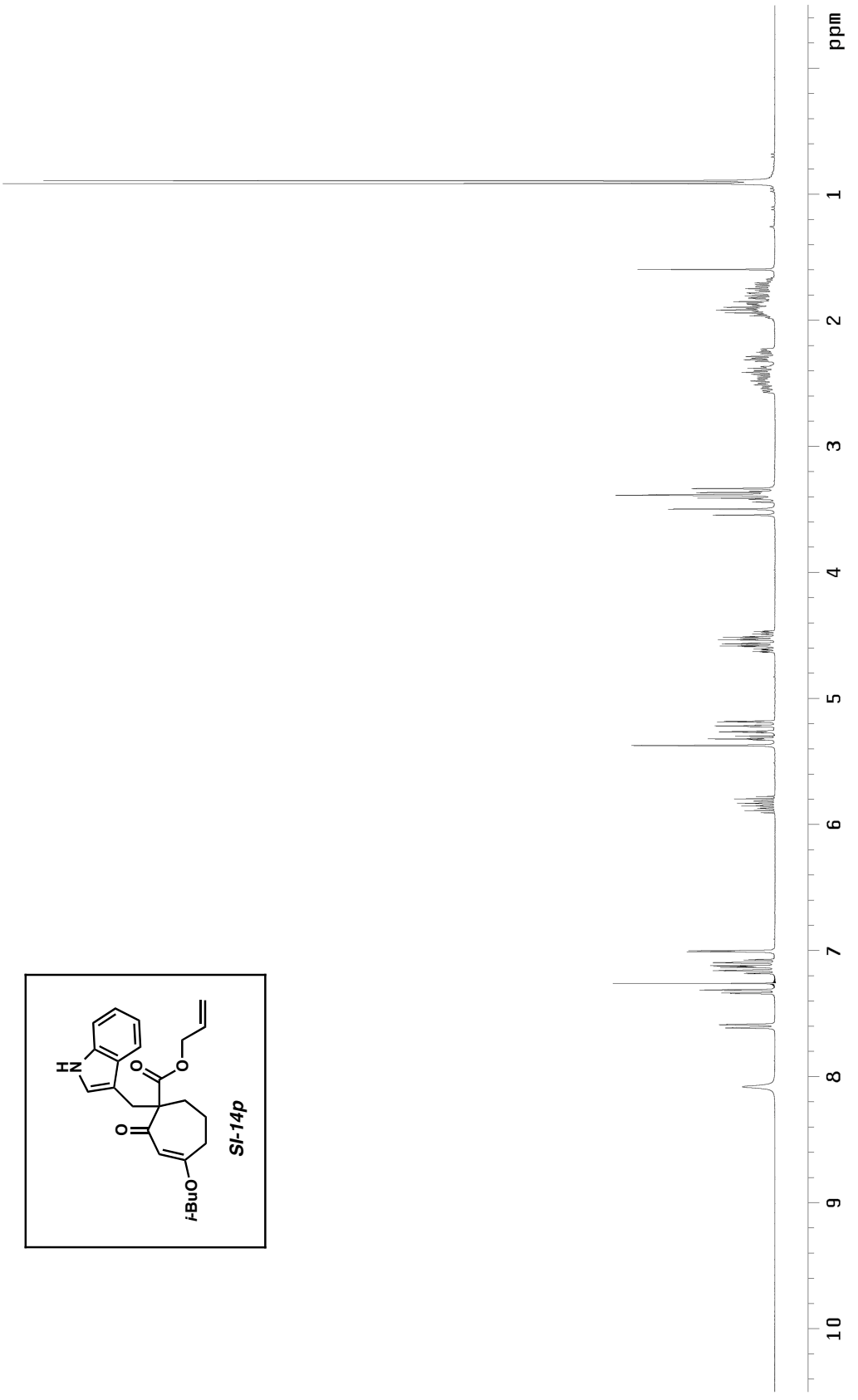


Figure SI-15A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **SI-14p**.

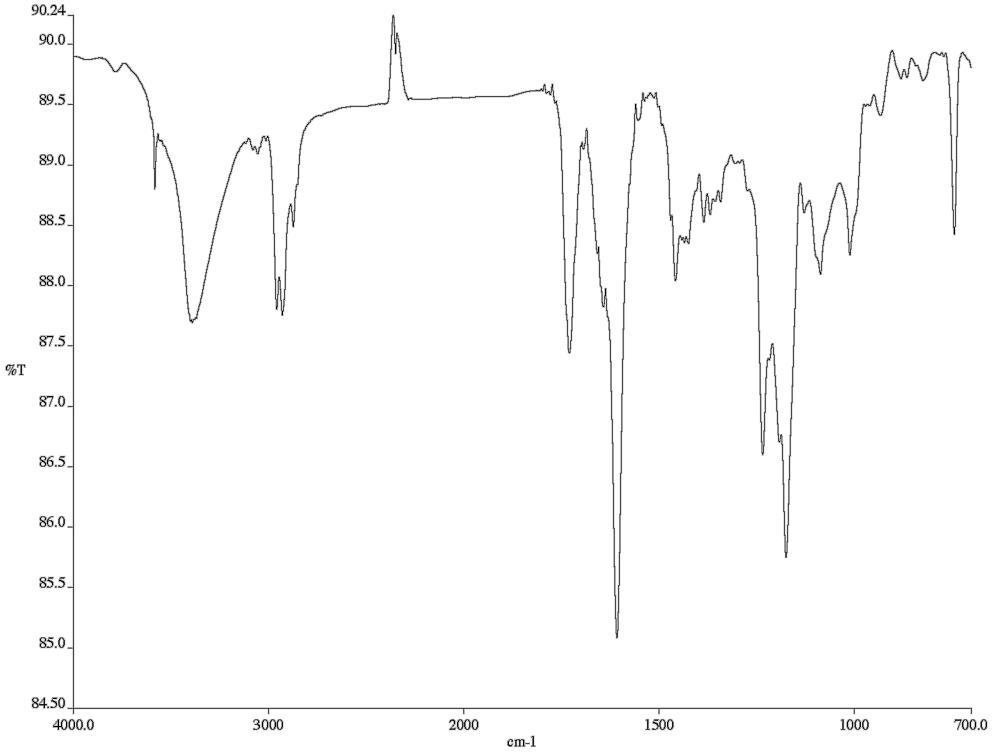


Figure SI-15B. Infrared spectrum (thin film/NaCl) of compound **SI-14p**.

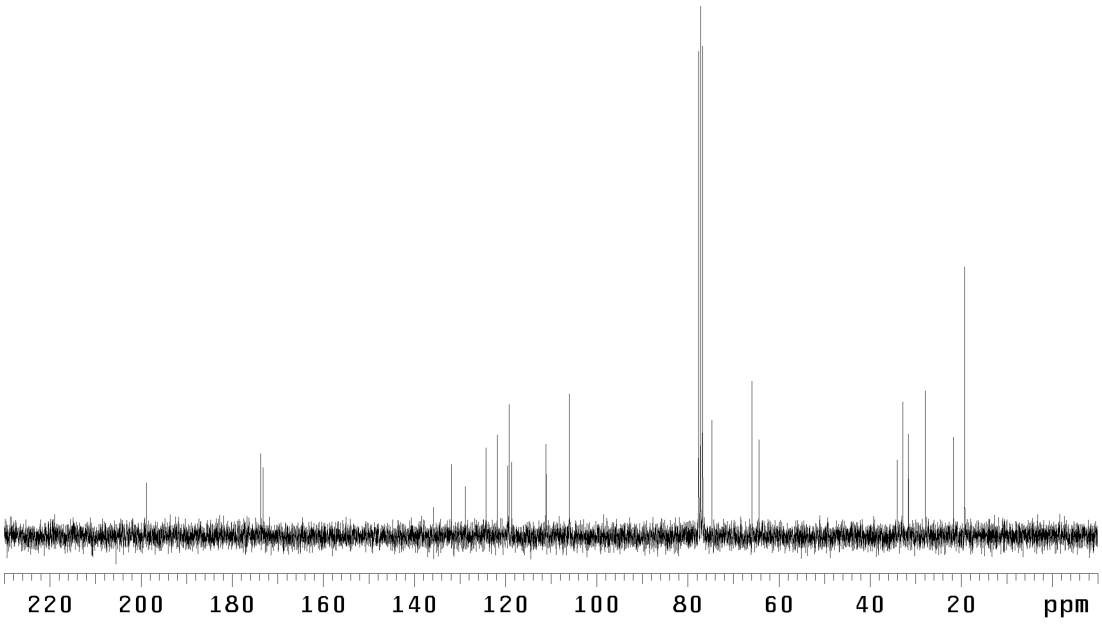


Figure SI-15C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **SI-14p**.

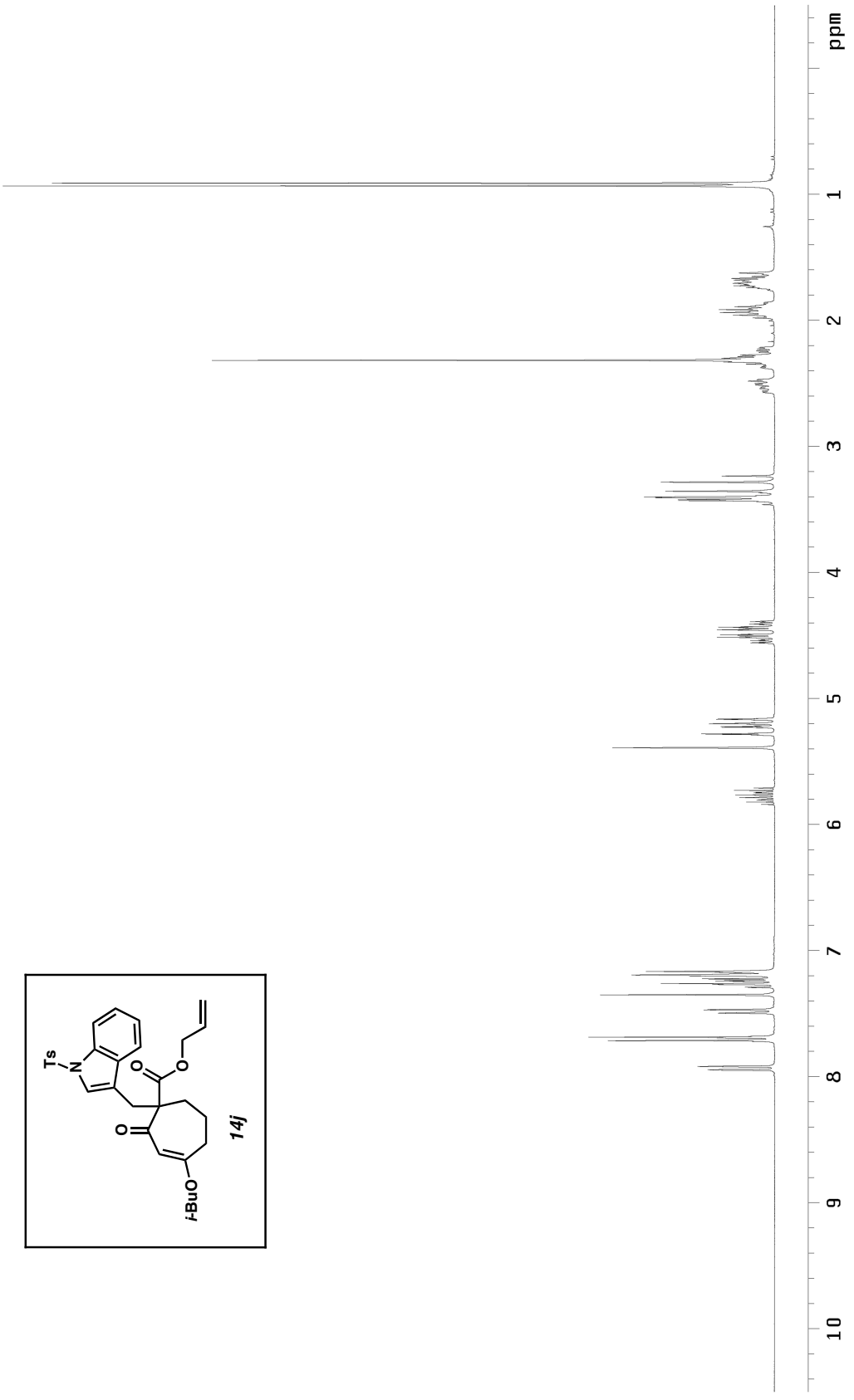


Figure SI-16A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14j**.

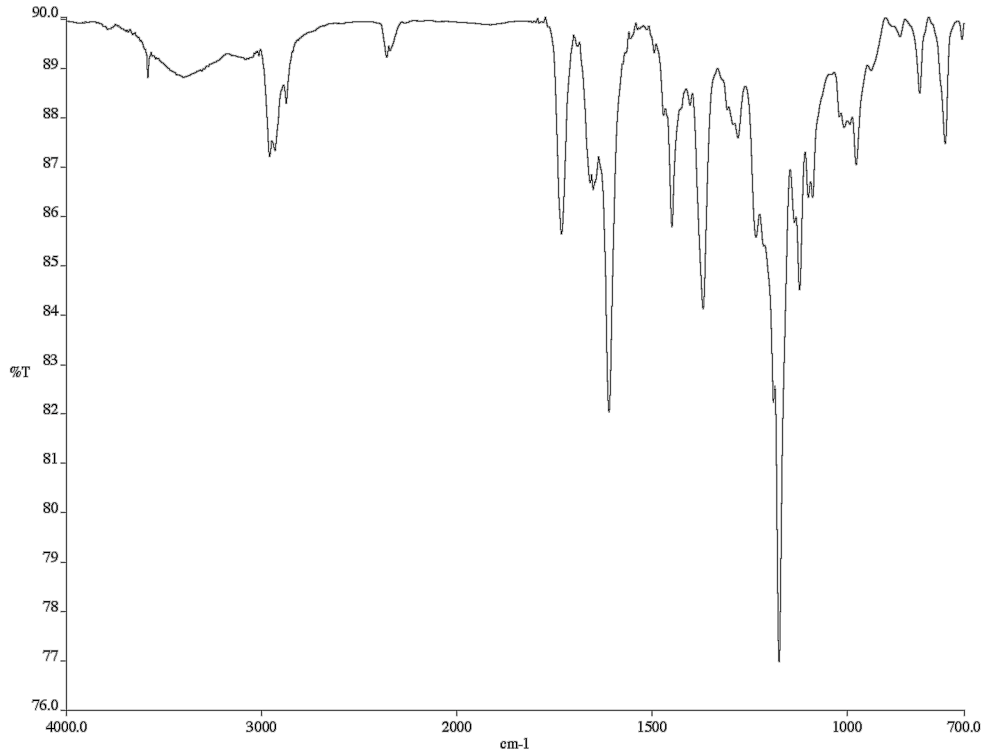


Figure SI-16B. Infrared spectrum (thin film/NaCl) of compound **14j**.

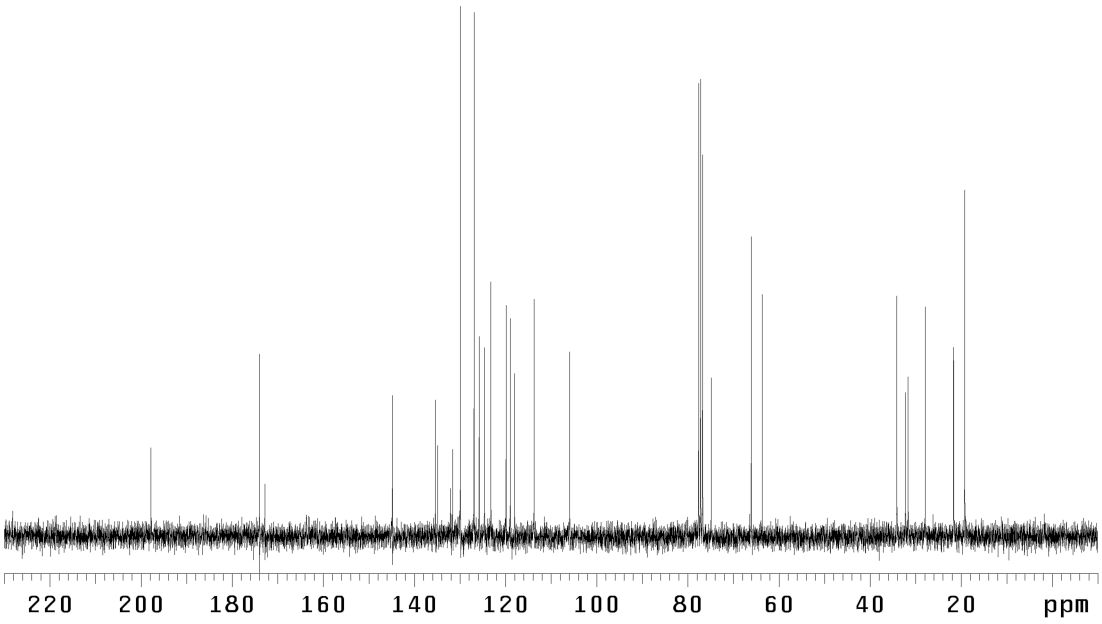


Figure SI-16C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14j**.

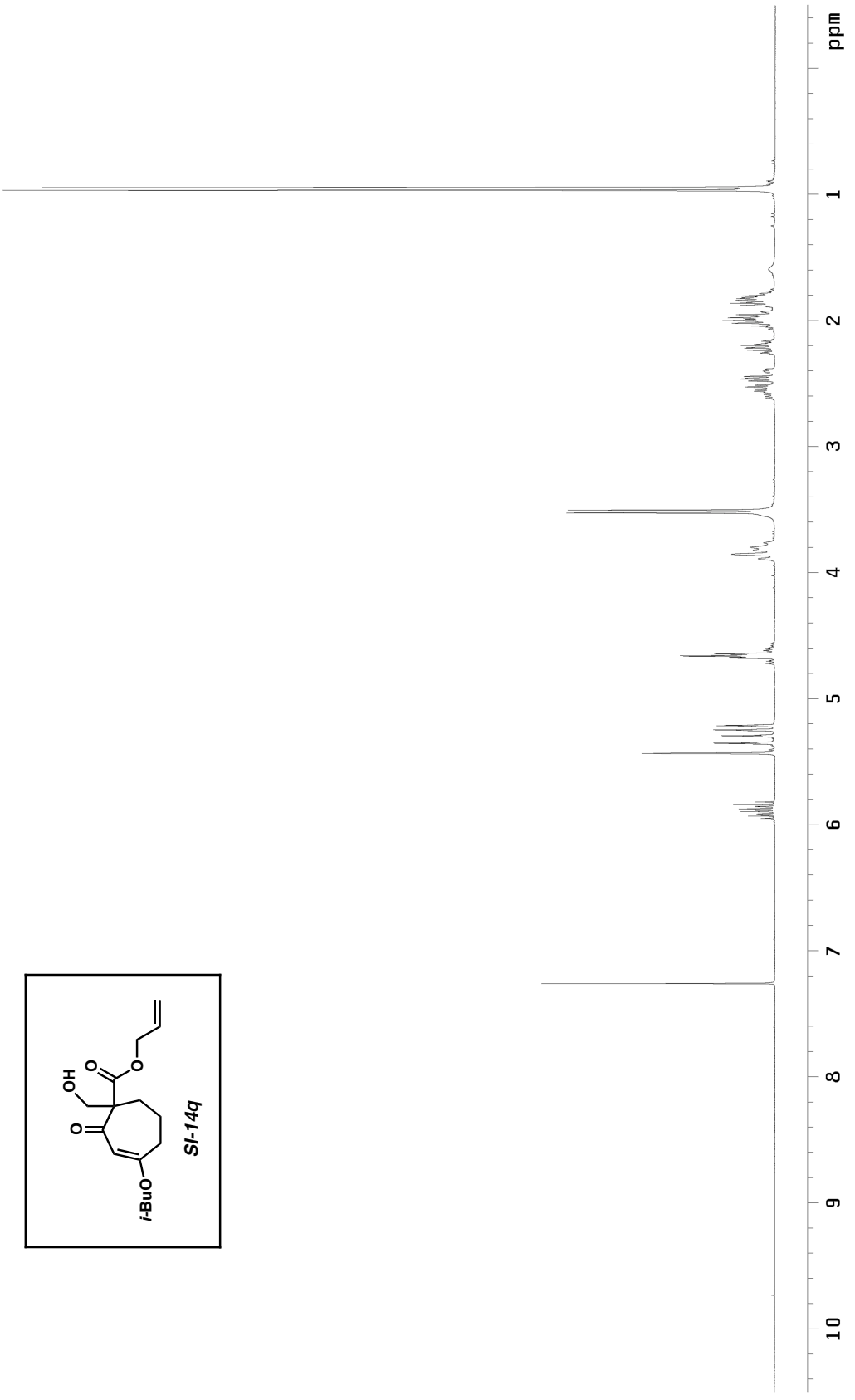


Figure SI-17A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **SI-14q**.

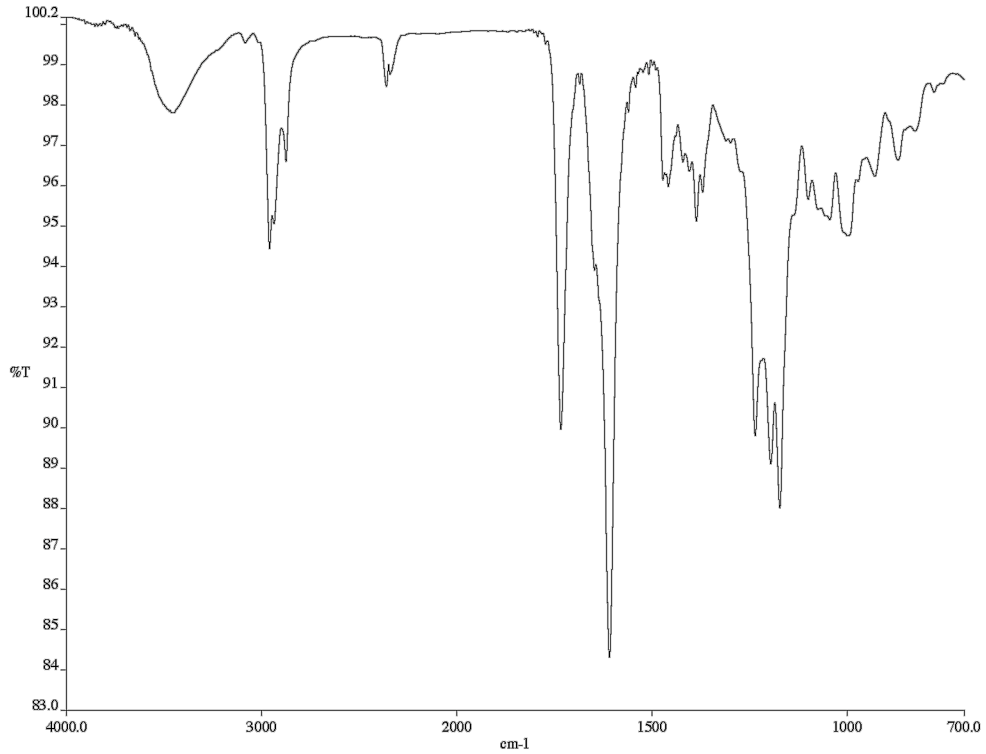


Figure SI-17B. Infrared spectrum (thin film/NaCl) of compound **SI-14q**.

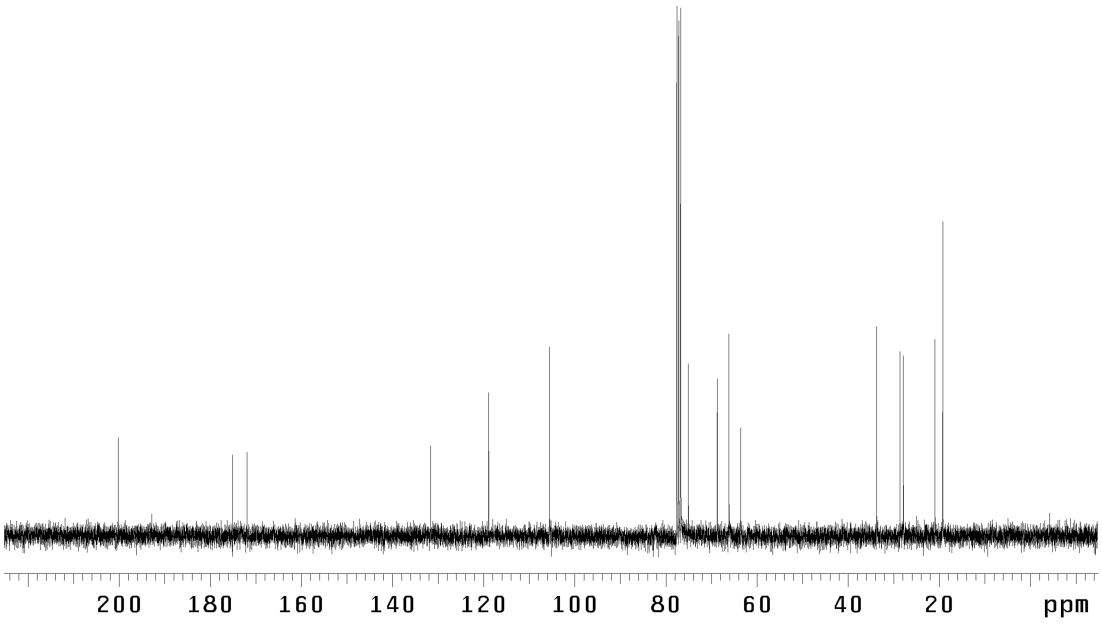


Figure SI-17C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **SI-14q**.

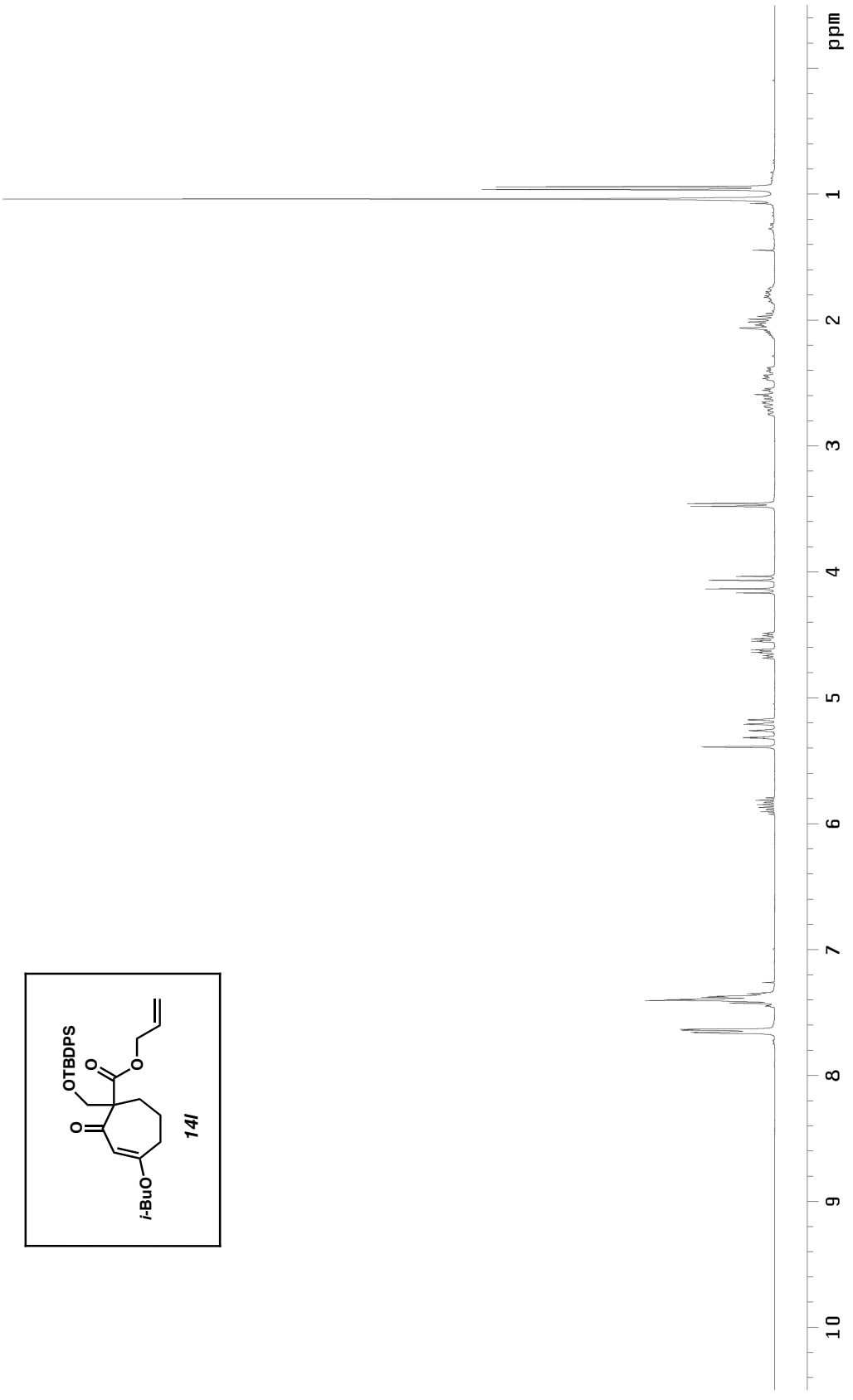


Figure SI-18A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **14l**.

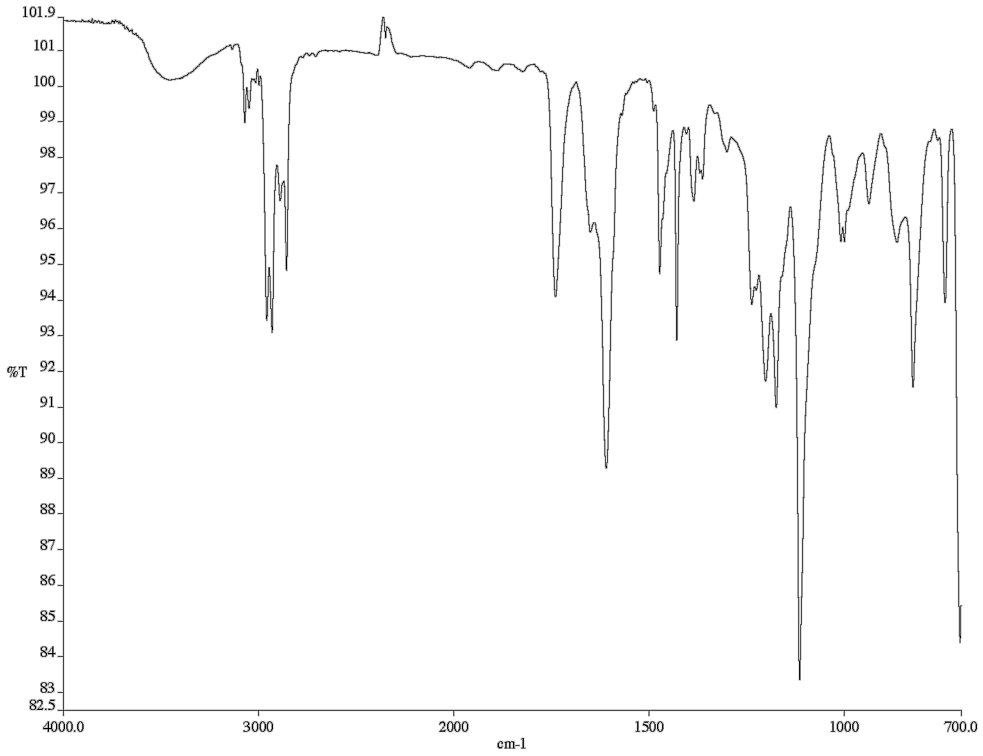


Figure SI-18B. Infrared spectrum (thin film/NaCl) of compound **14l**.

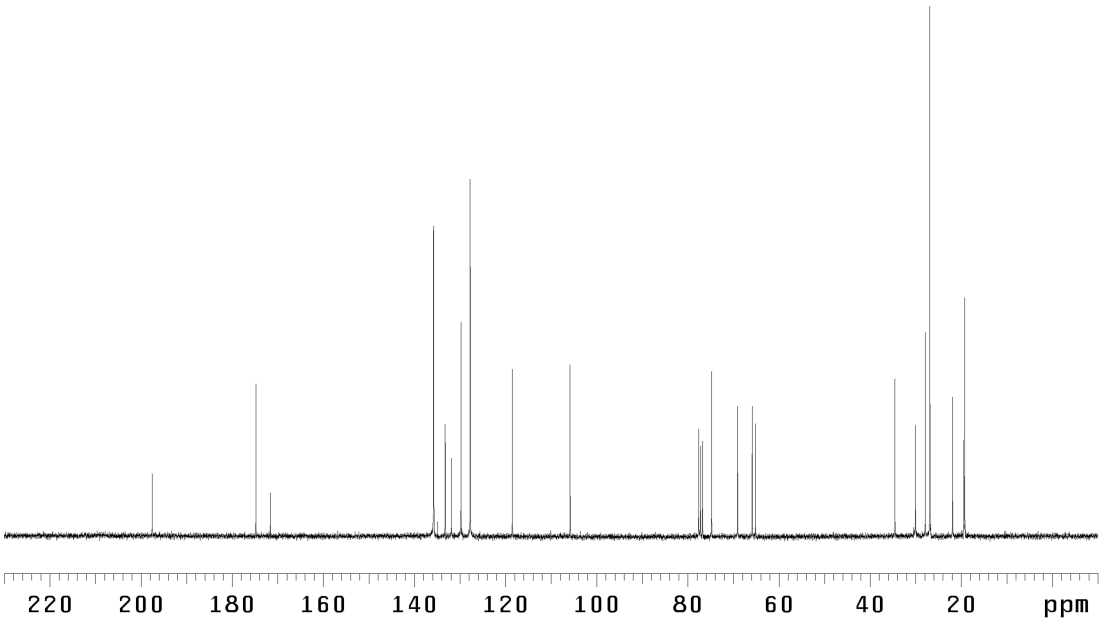


Figure SI-18C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **14l**.

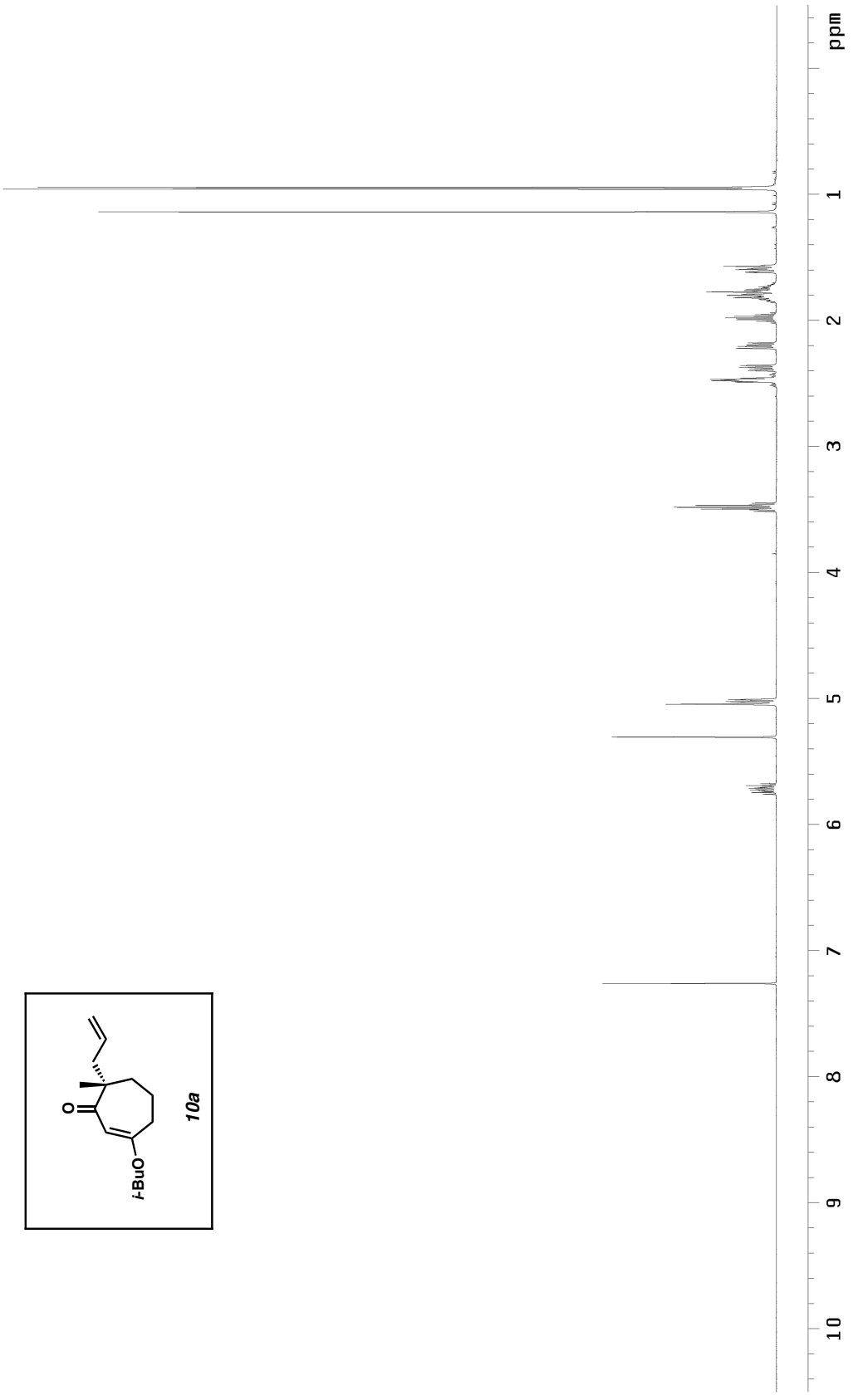


Figure SI-19A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **10a**.

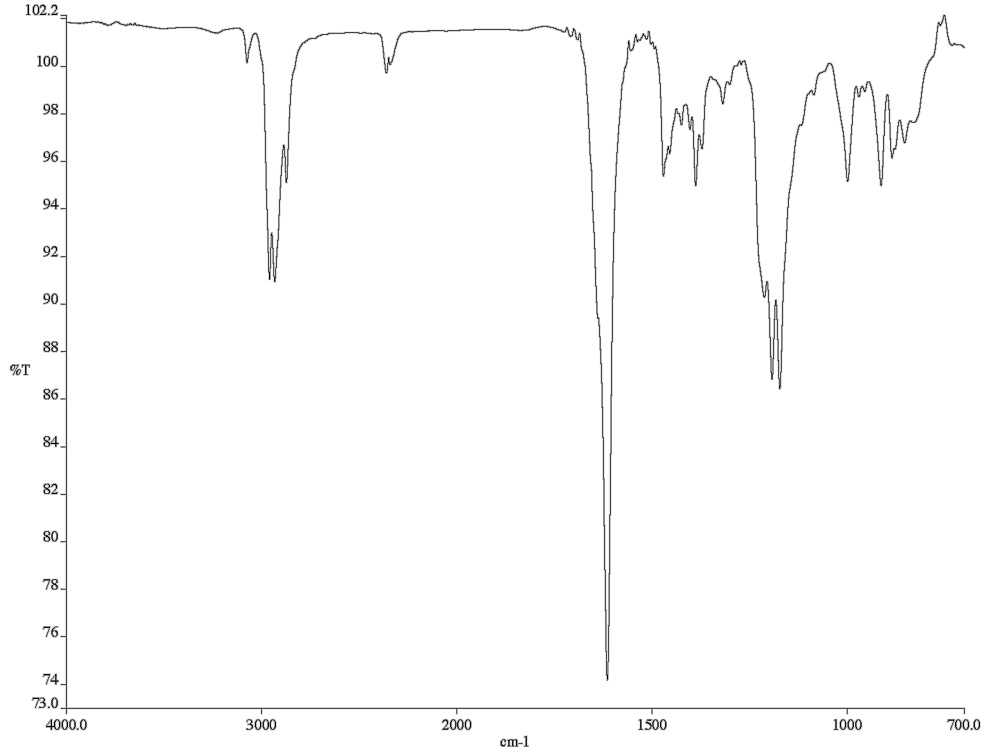


Figure SI-19B. Infrared spectrum (thin film/NaCl) of compound **10a**.

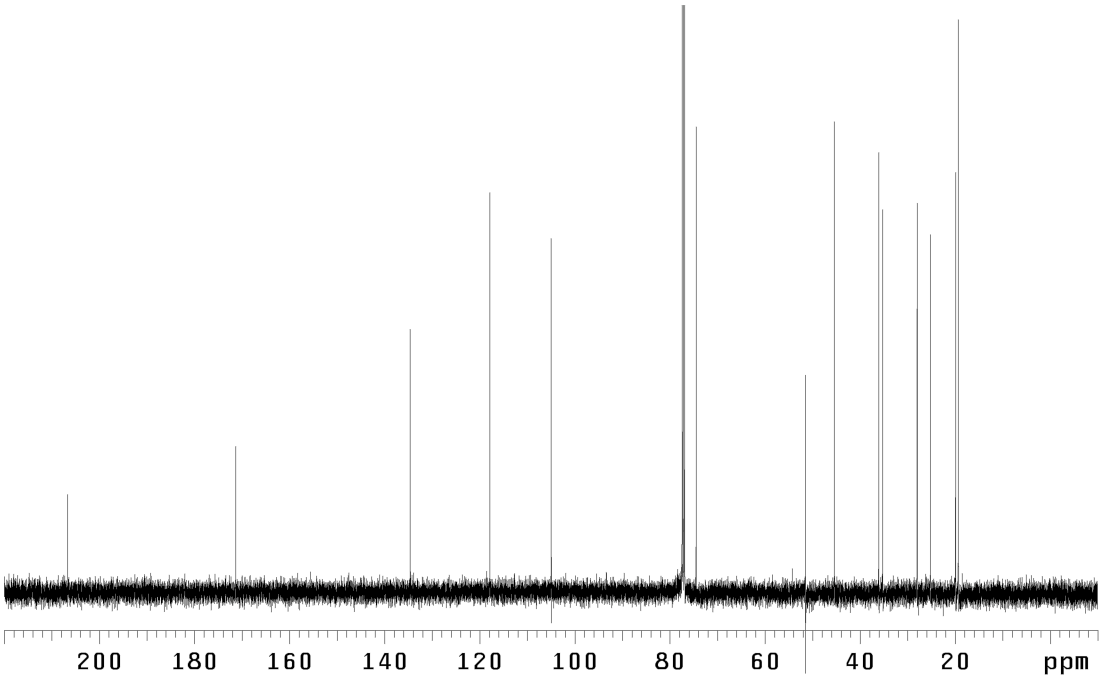


Figure SI-19C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **10a**.

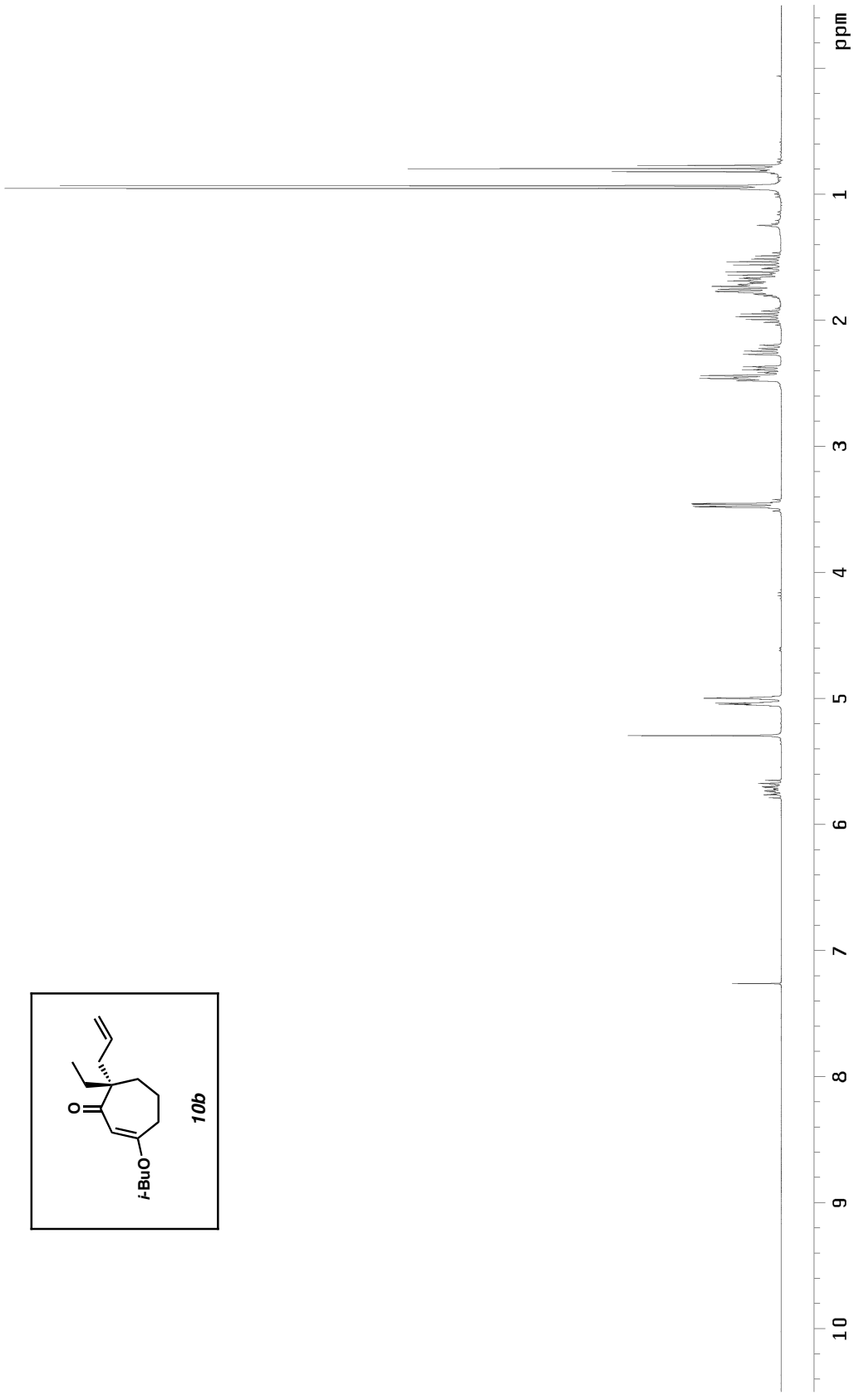


Figure SI-20A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10b**.

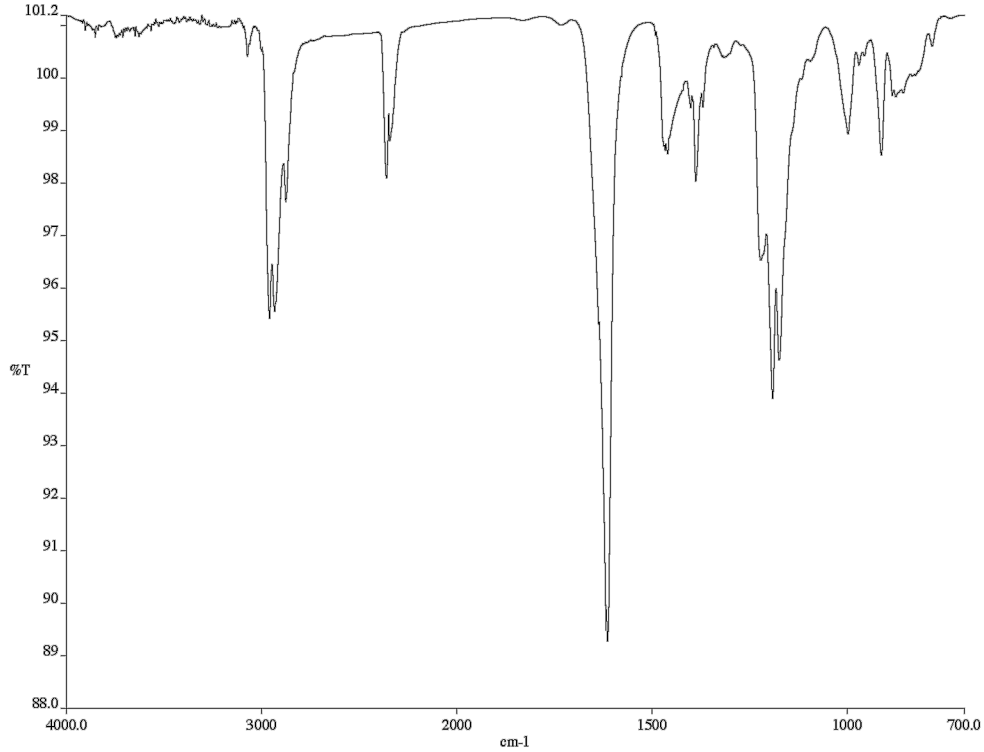


Figure SI-20B. Infrared spectrum (thin film/NaCl) of compound **10b**.

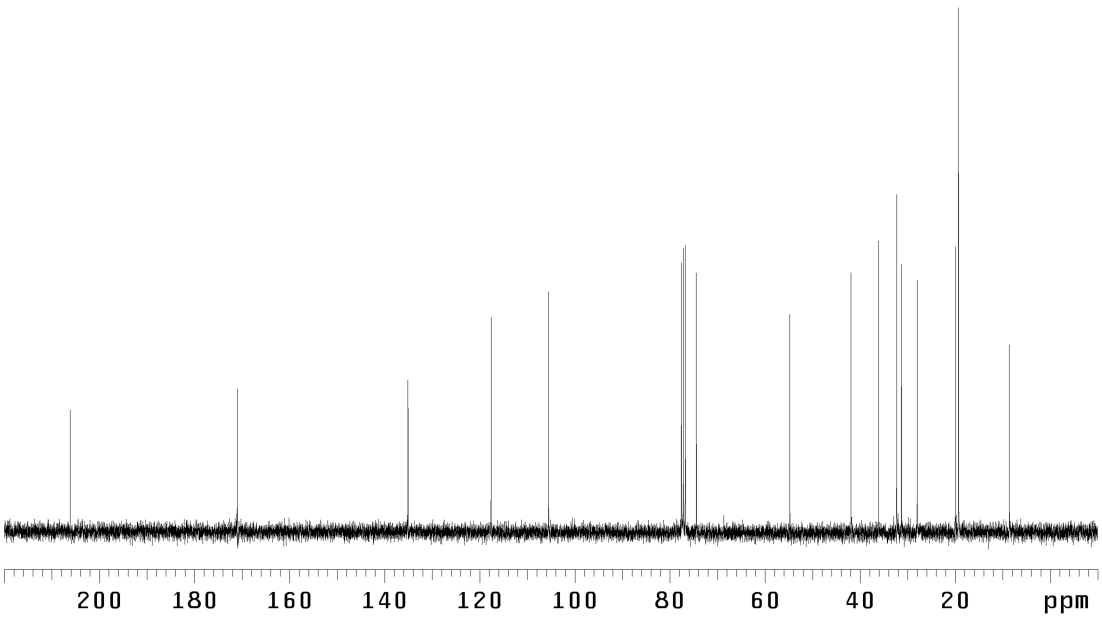


Figure SI-20C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10b**.

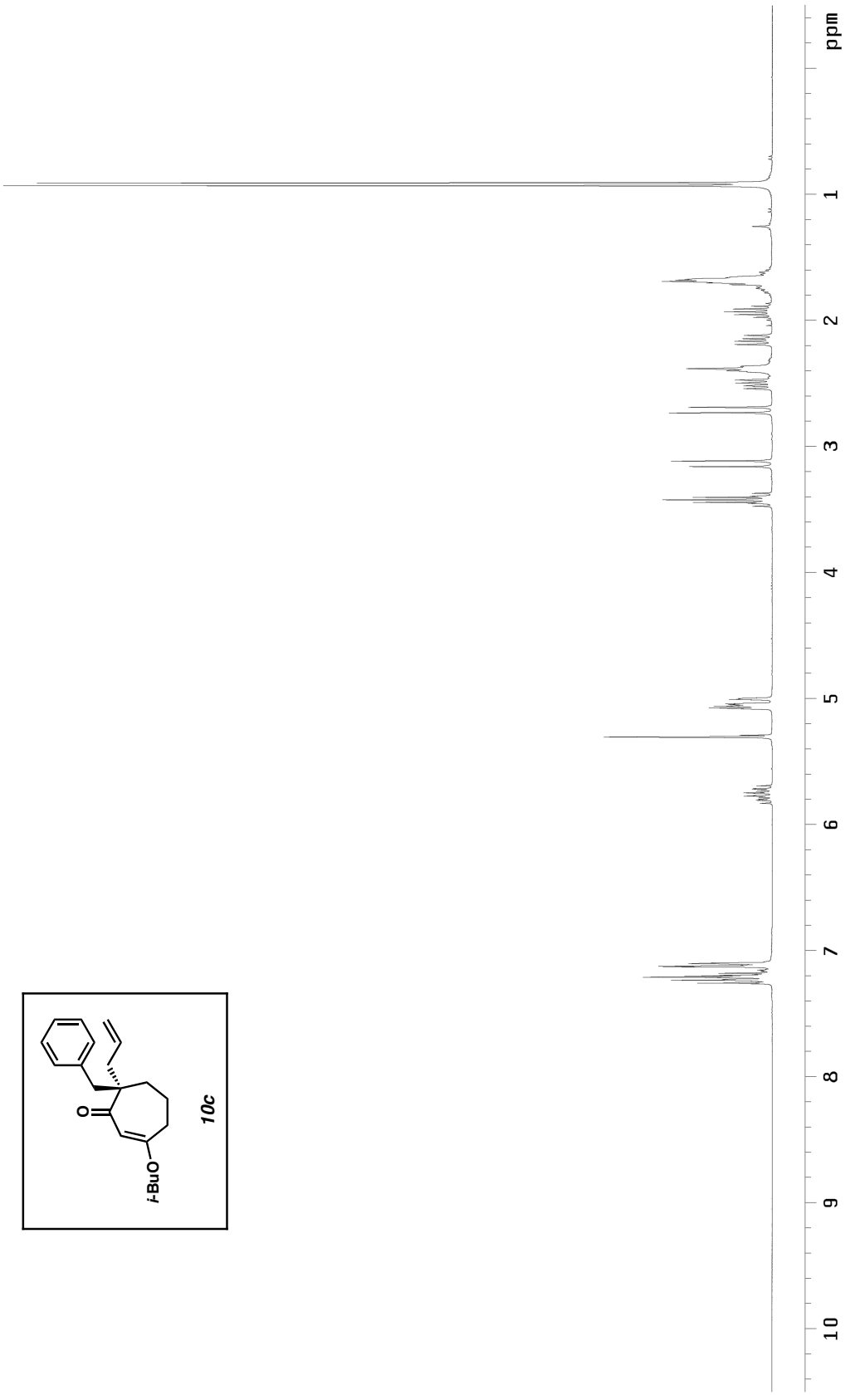


Figure SI-21A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10c**.

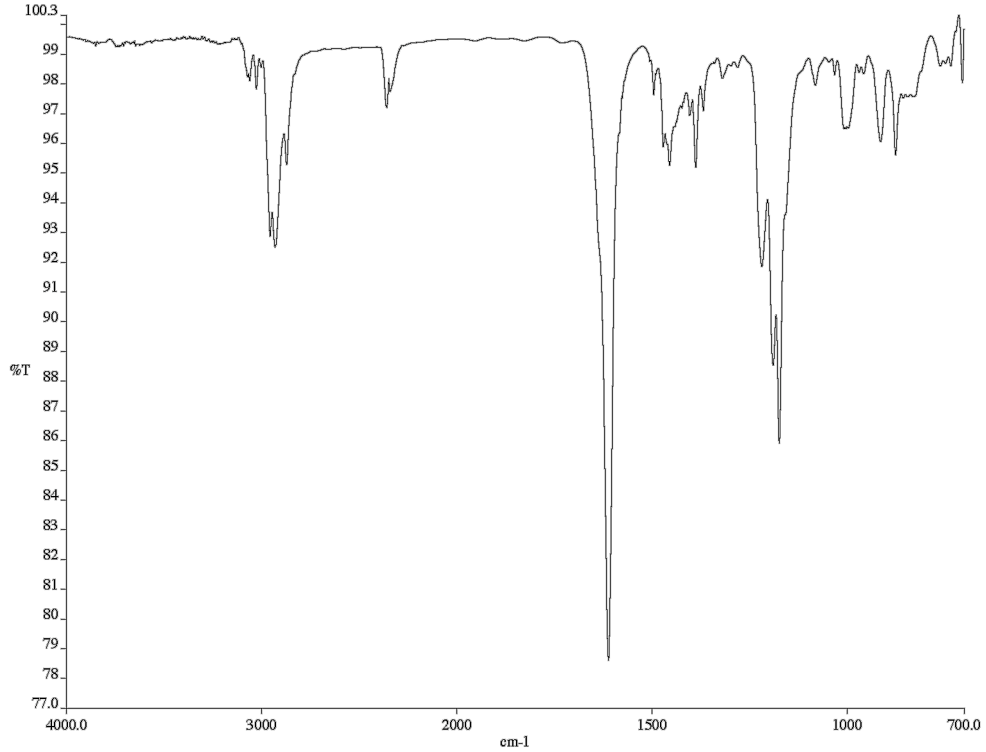


Figure SI-21B. Infrared spectrum (thin film/NaCl) of compound **10c**.

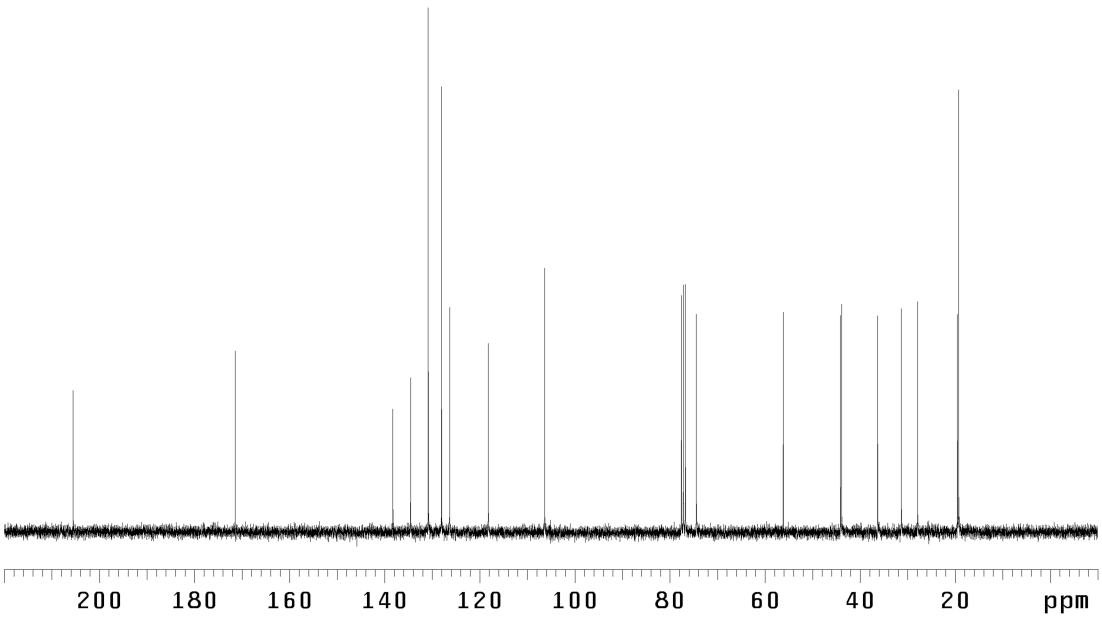


Figure SI-21C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10c**.

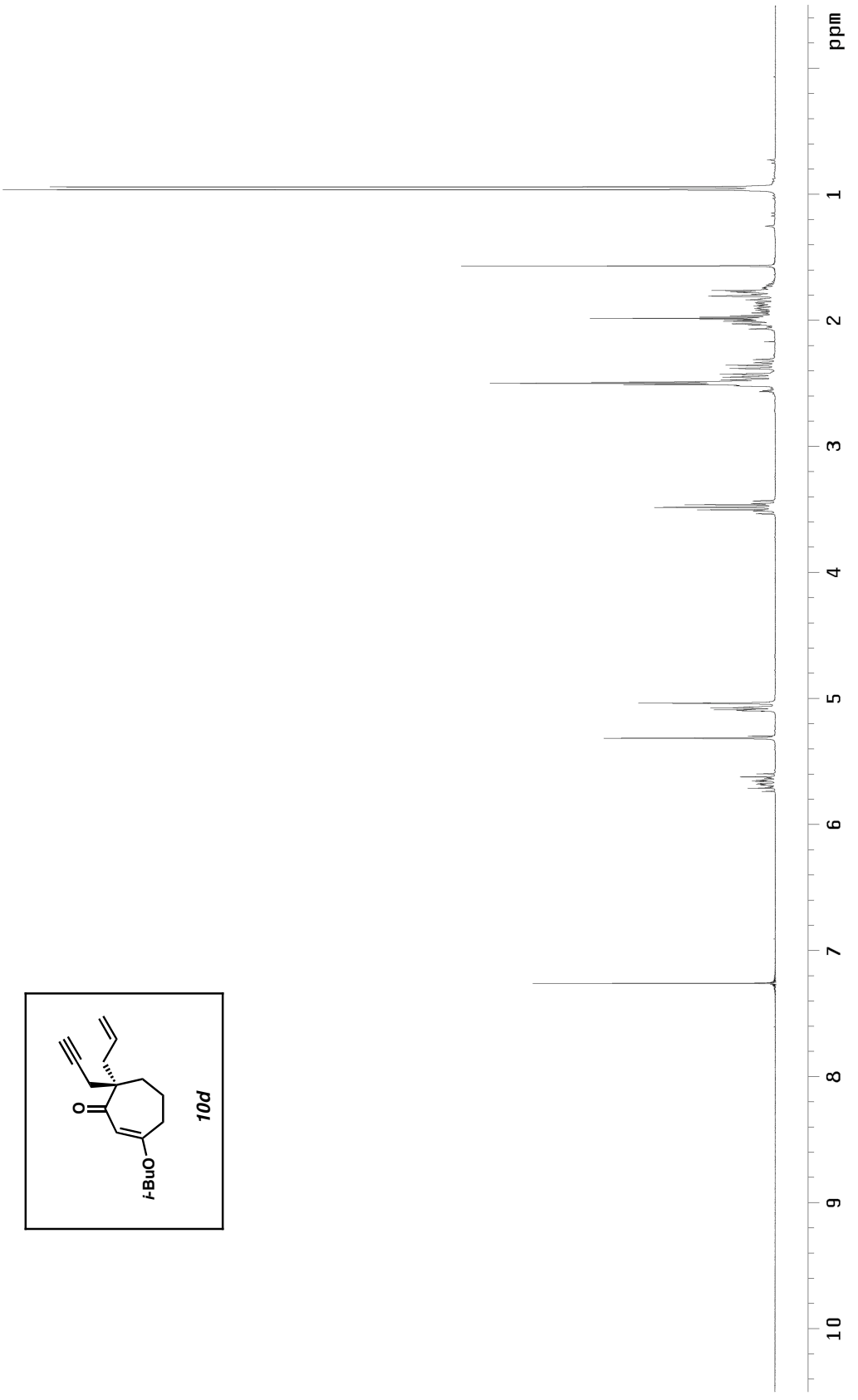


Figure SI-22A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10d**.

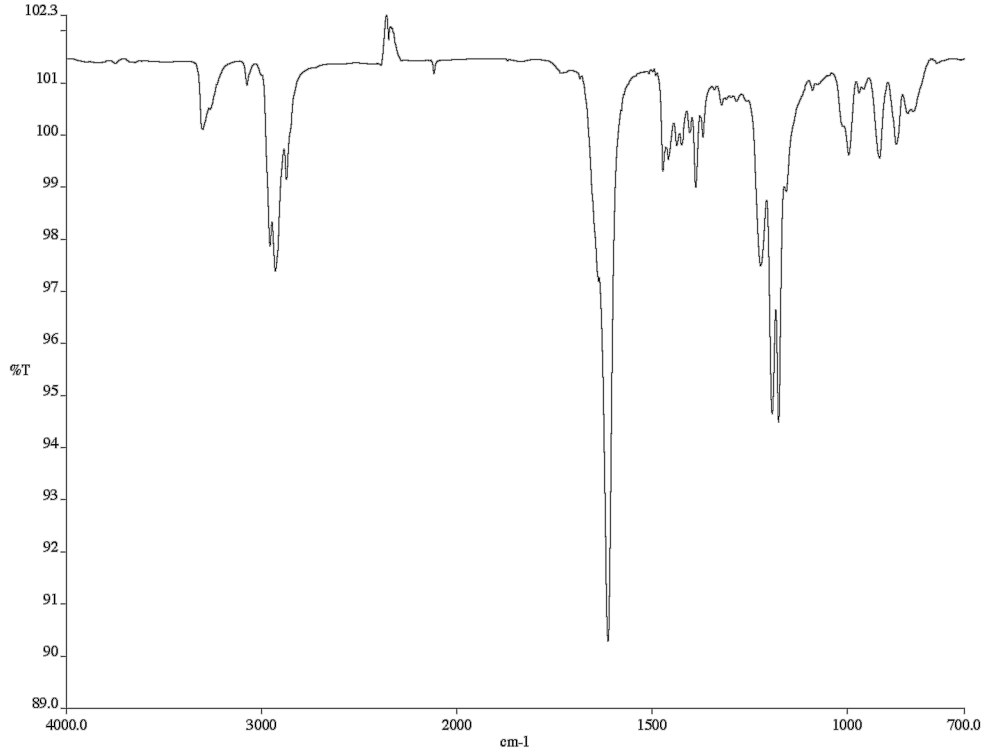


Figure SI-22B. Infrared spectrum (thin film/NaCl) of compound **10d**.

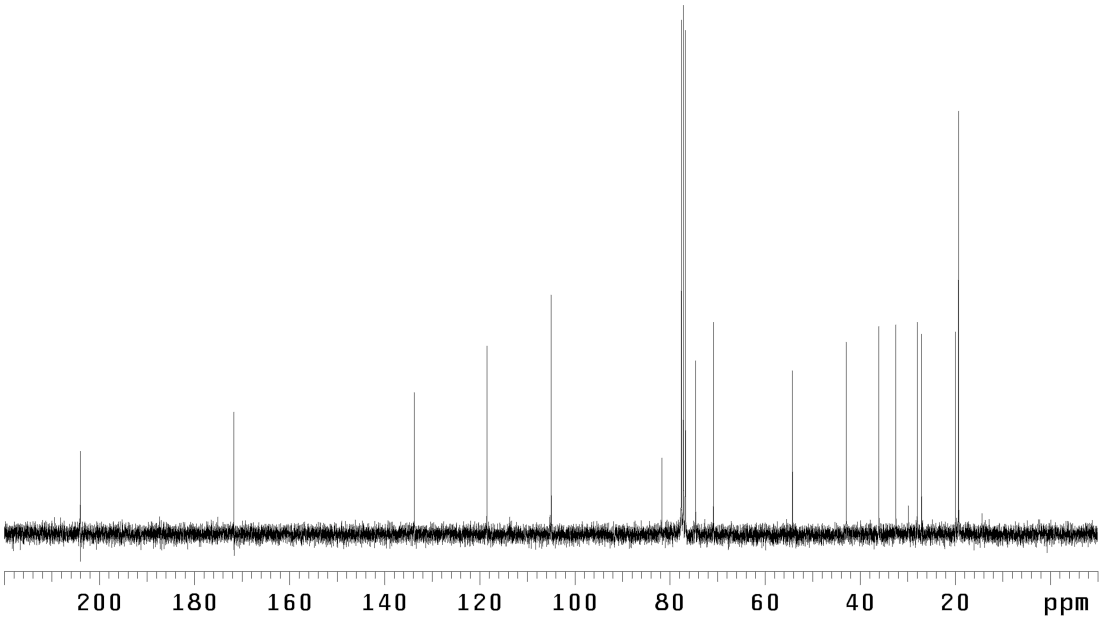


Figure SI-22C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10d**.

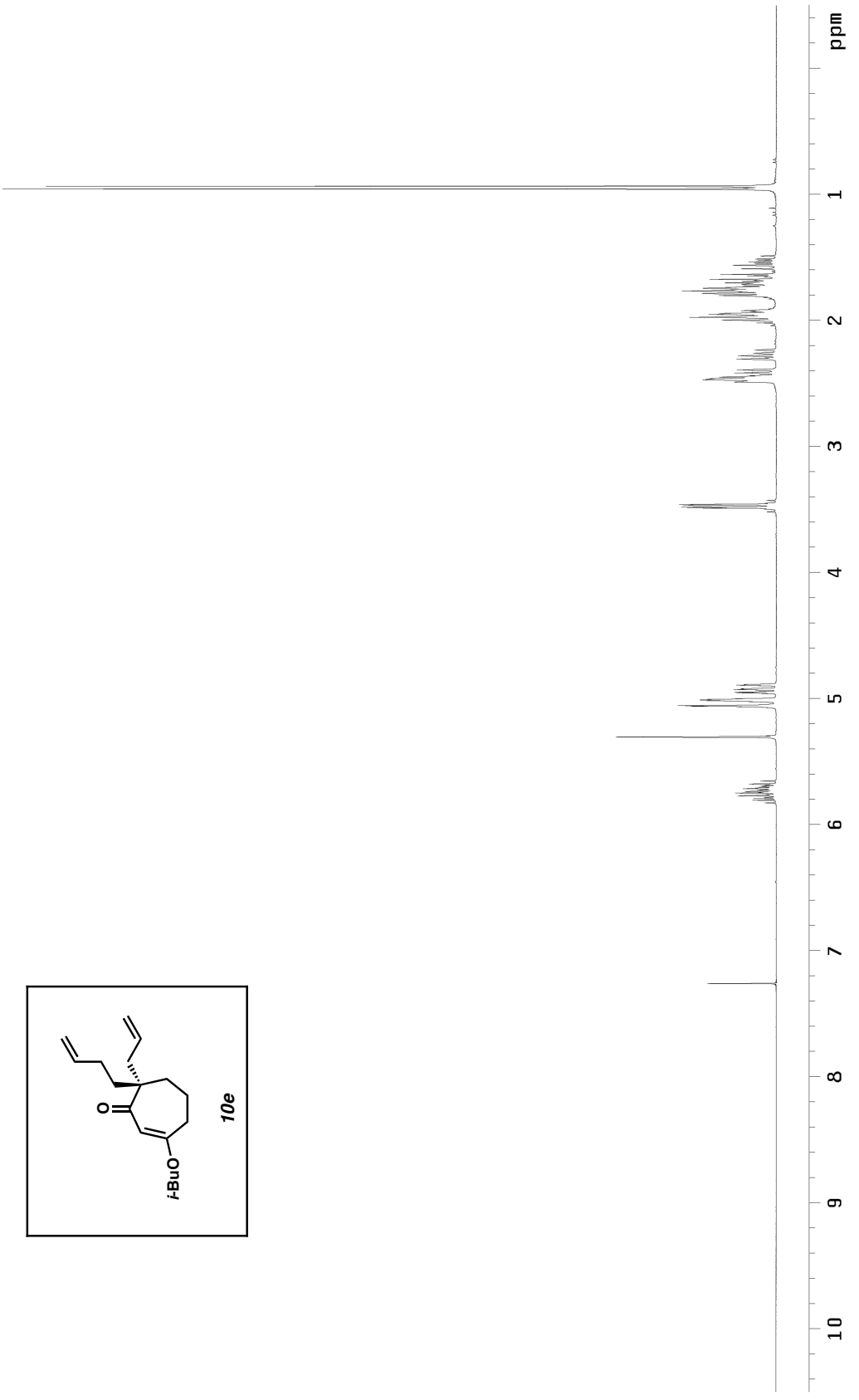


Figure SI-23A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10e**.

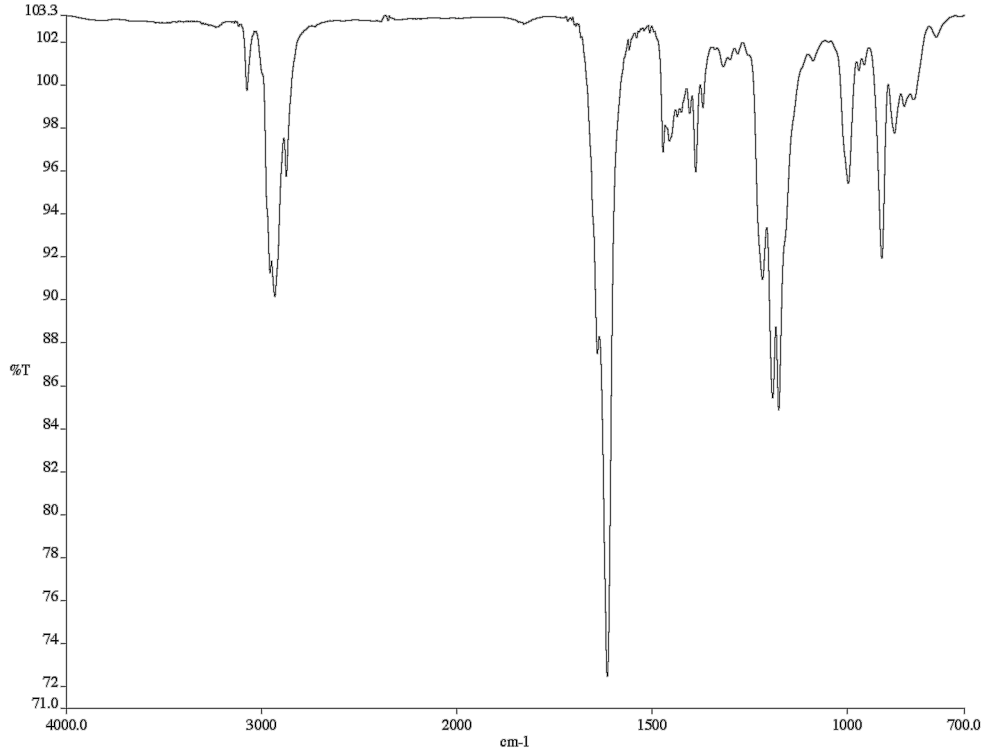


Figure SI-23B. Infrared spectrum (thin film/NaCl) of compound **10e**.

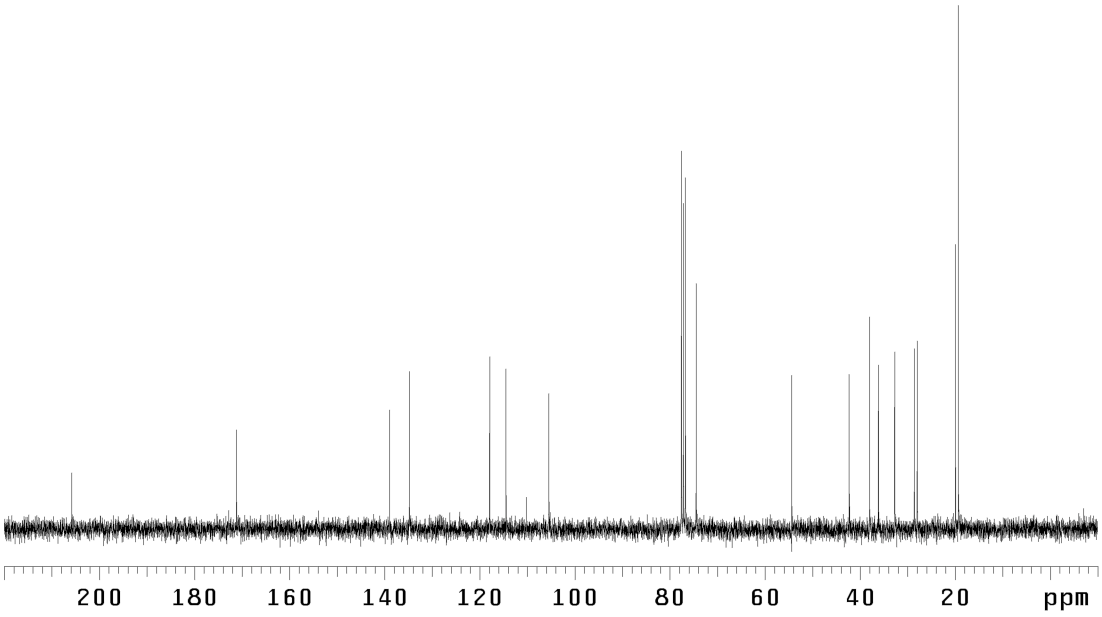


Figure SI-23C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10e**.

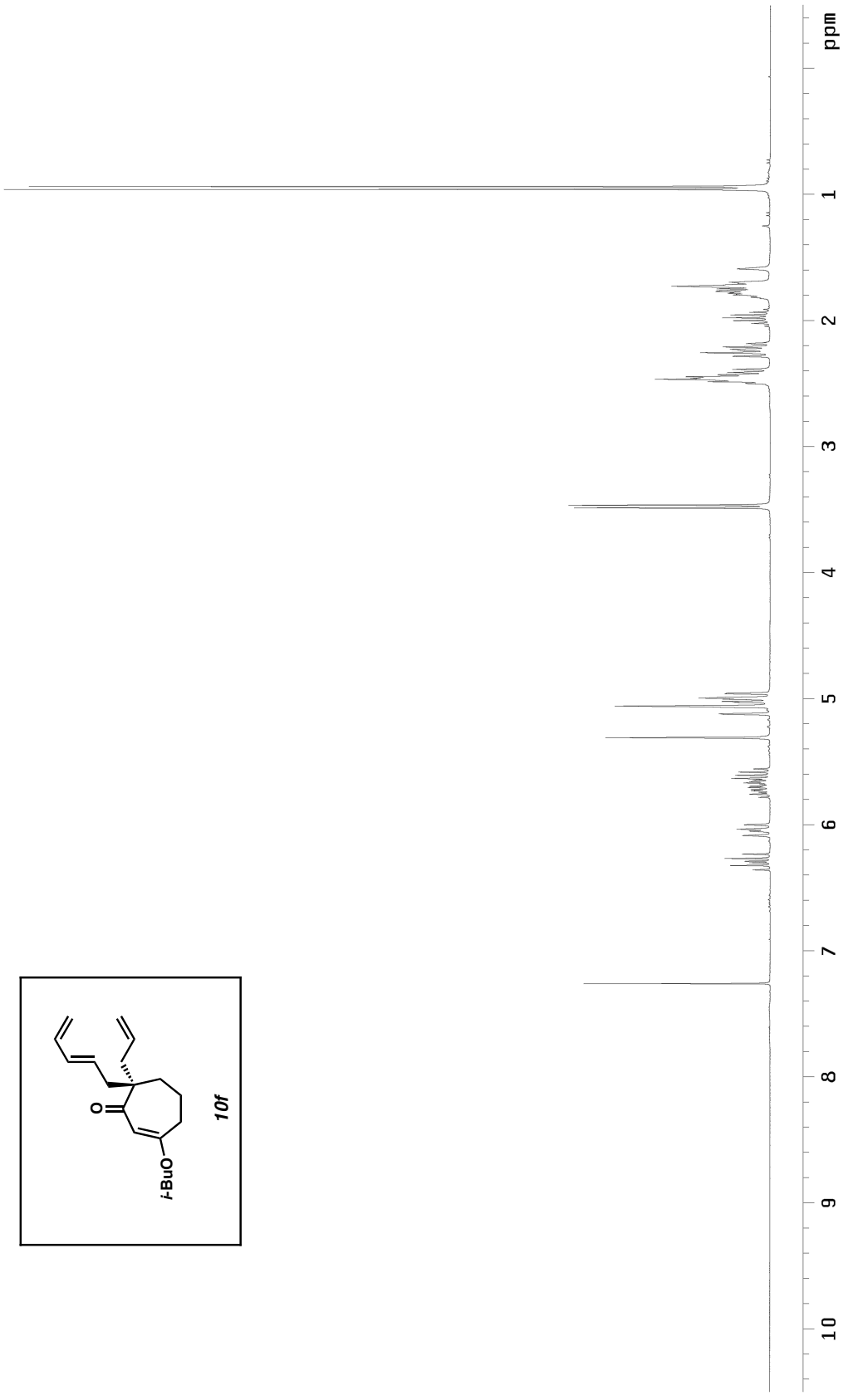


Figure SI-24A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10f**.

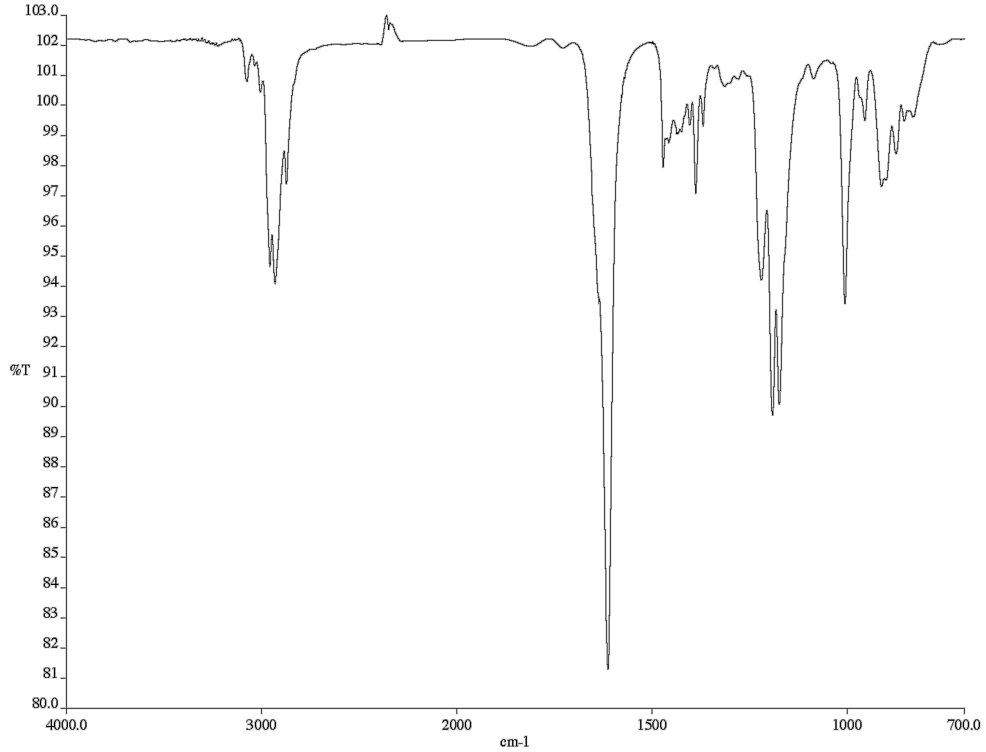


Figure SI-24B. Infrared spectrum (thin film/NaCl) of compound **10f**.

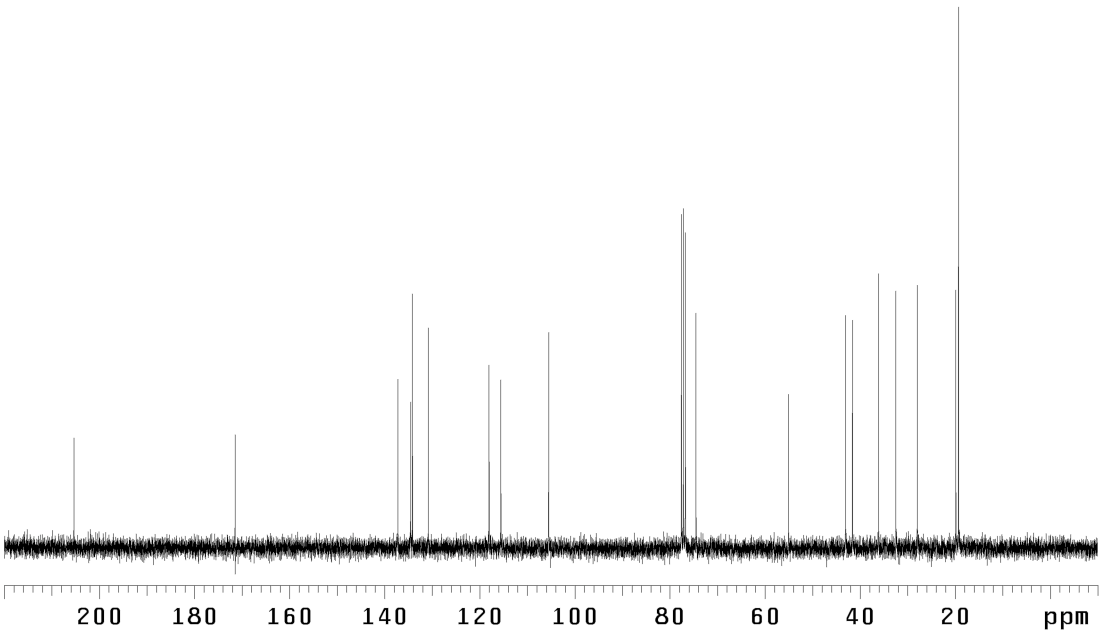


Figure SI-24C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10f**.

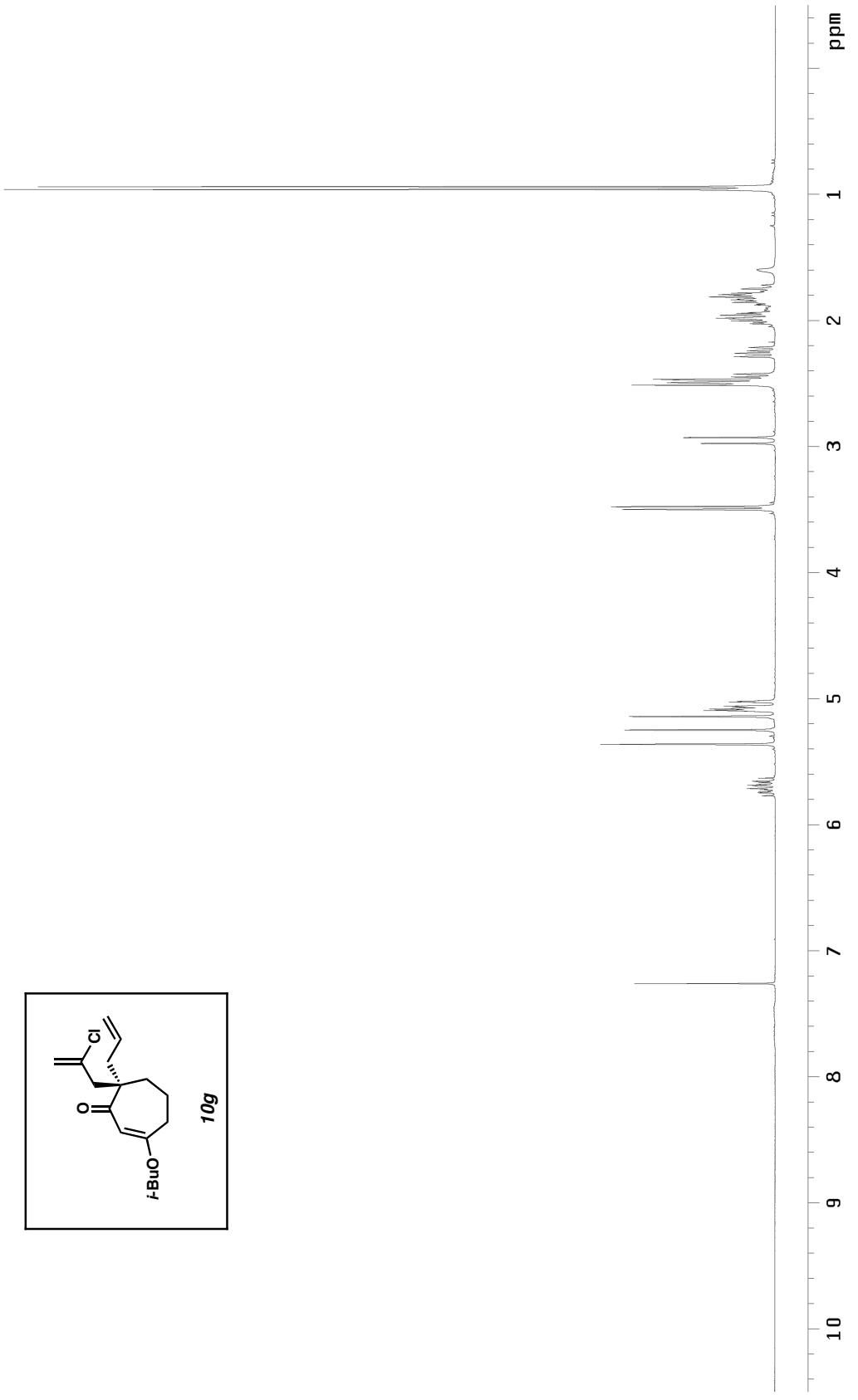


Figure SI-25A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10g**.

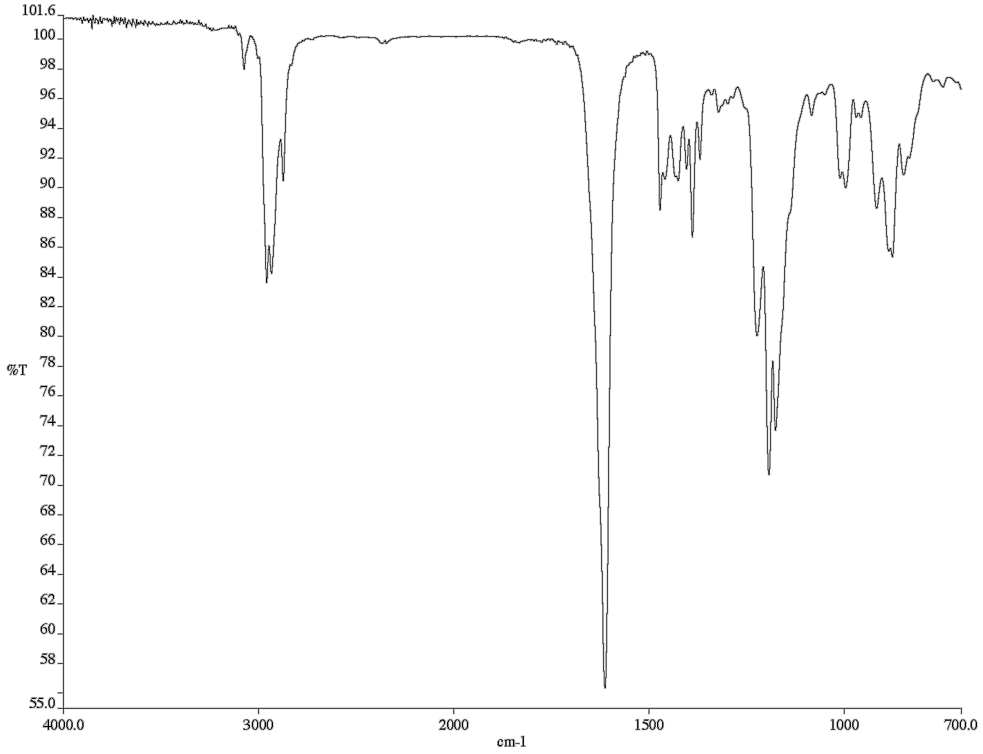


Figure SI-25B. Infrared spectrum (thin film/NaCl) of compound **10g**.

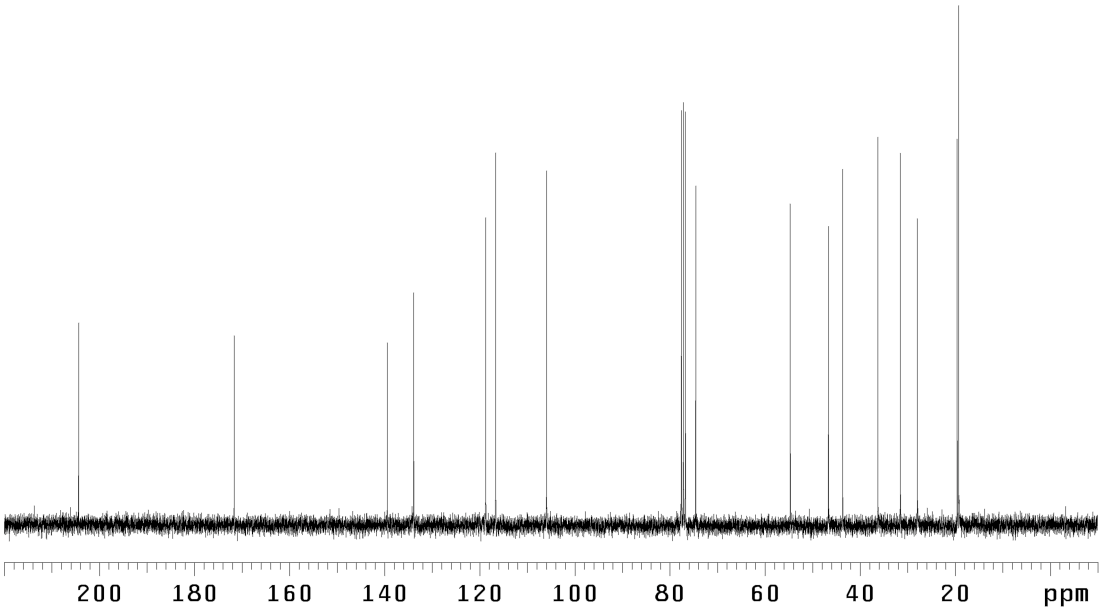


Figure SI-25C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10g**.

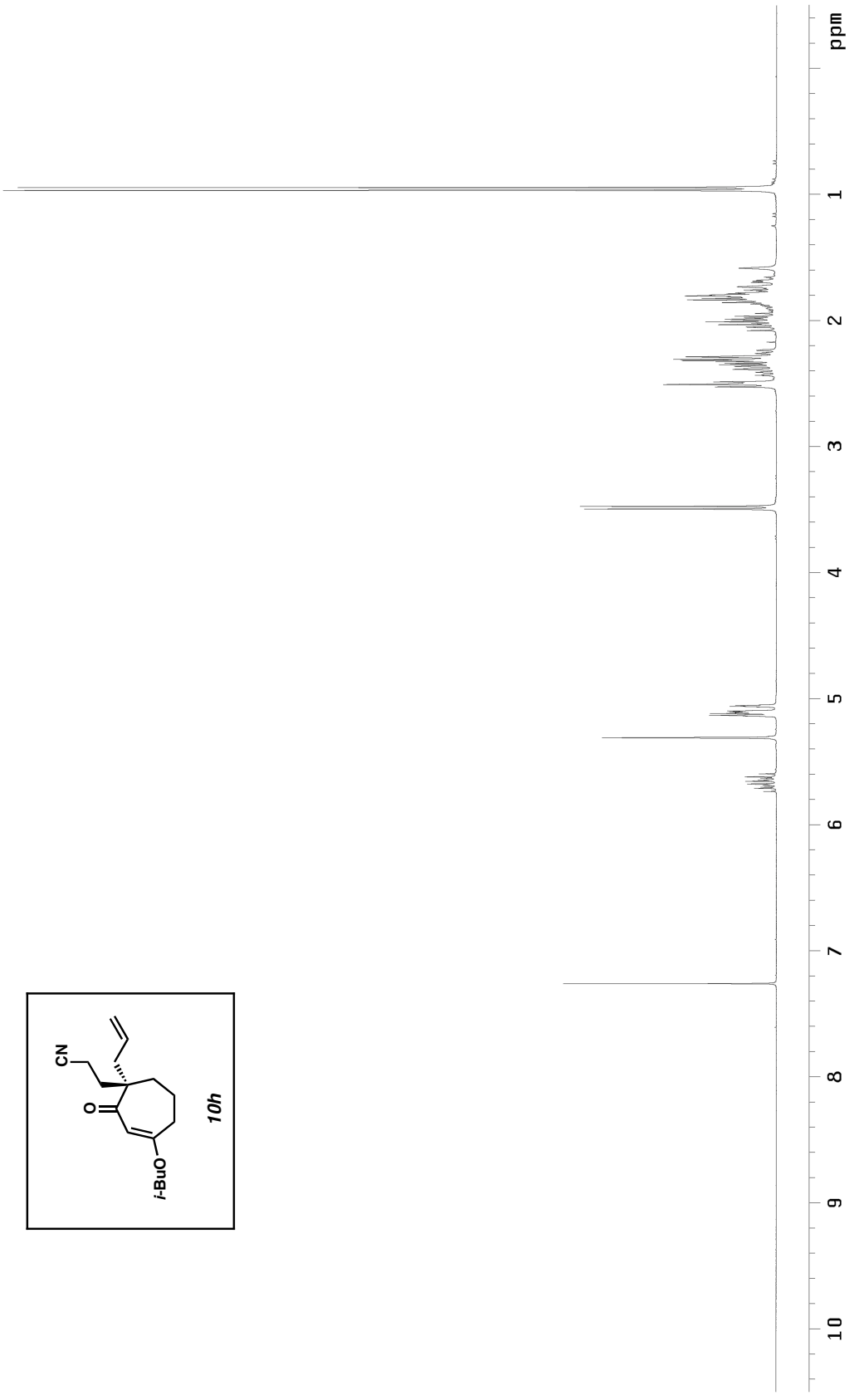


Figure SI-26A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10h**.

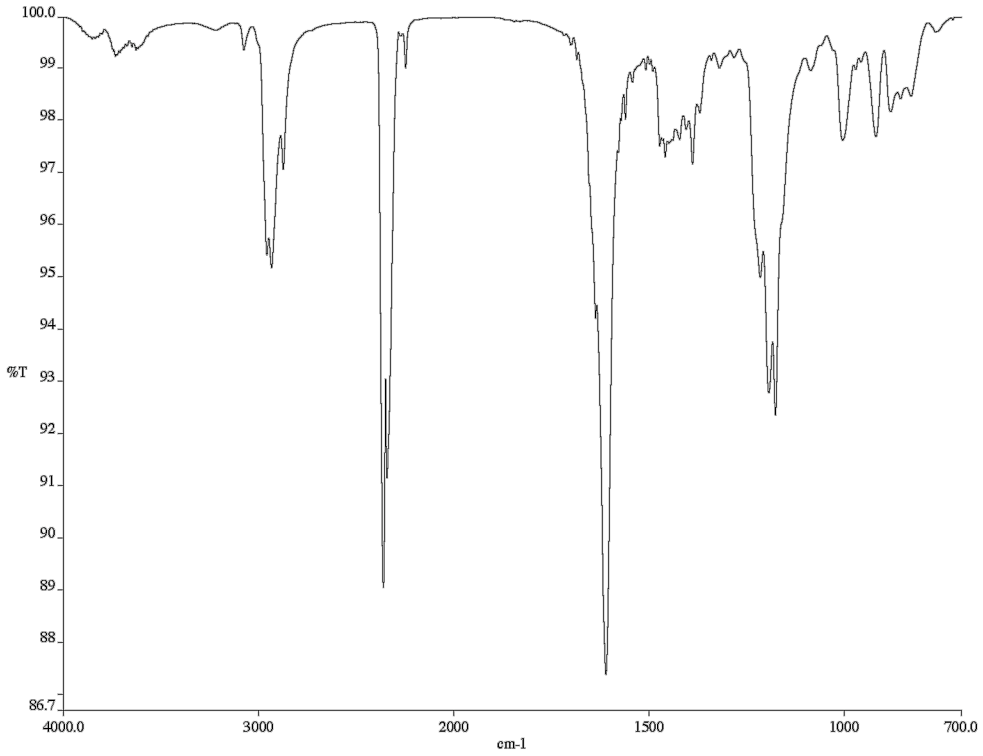


Figure SI-26B. Infrared spectrum (thin film/NaCl) of compound **10h**.

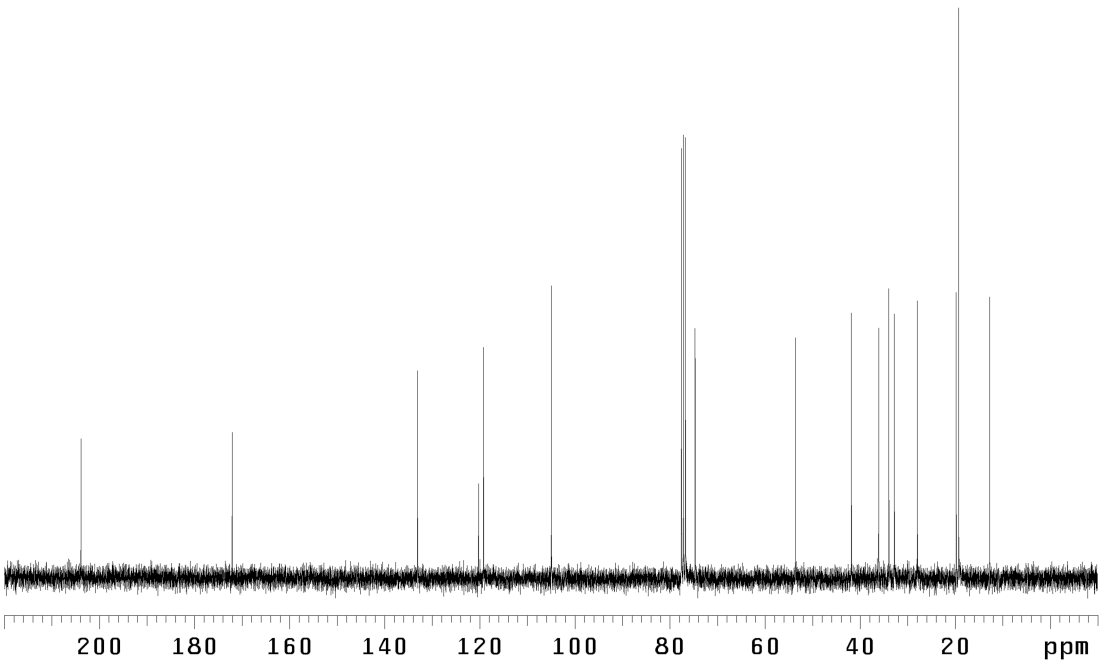


Figure SI-26C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10h**.

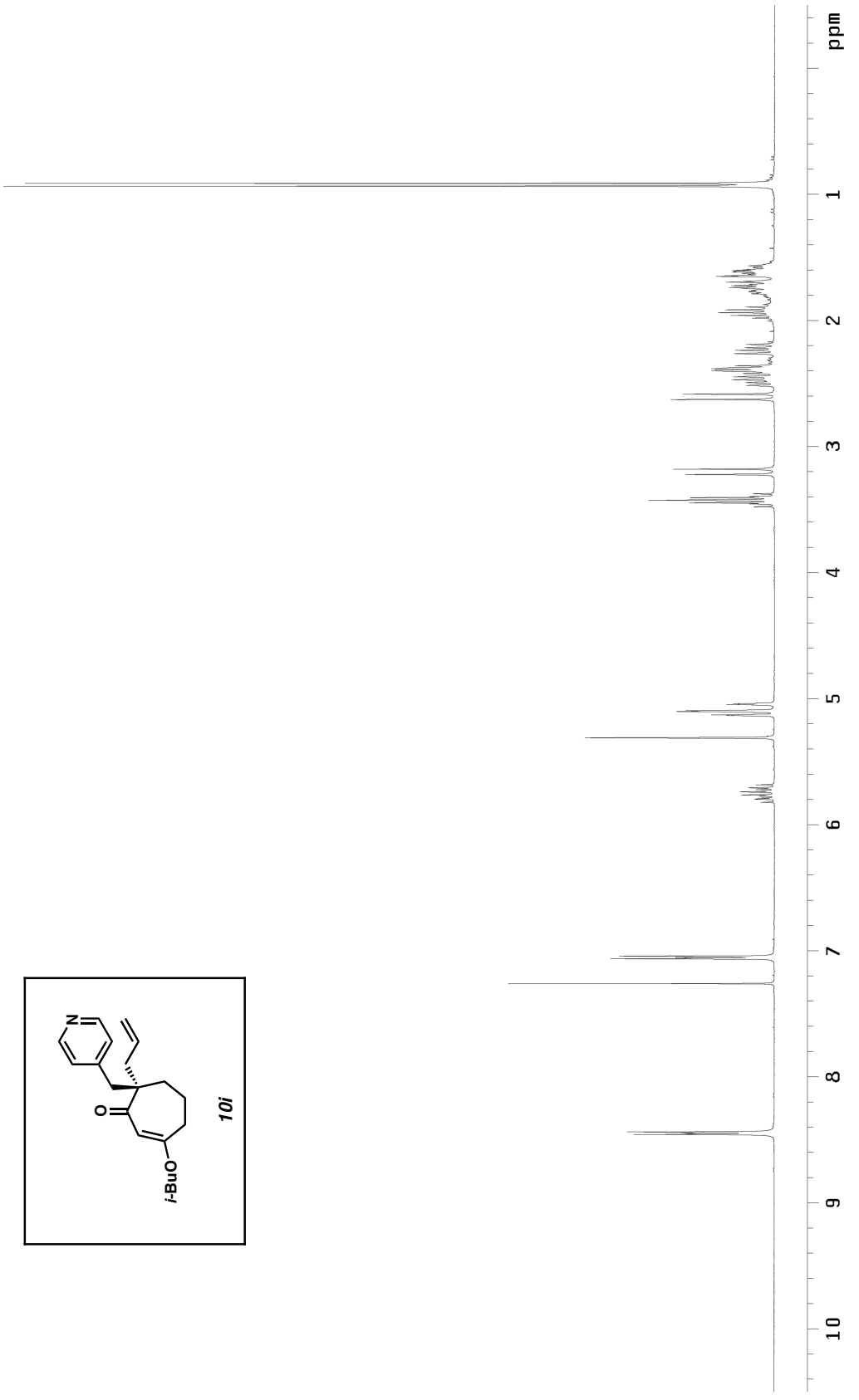


Figure SI-27A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10i**.

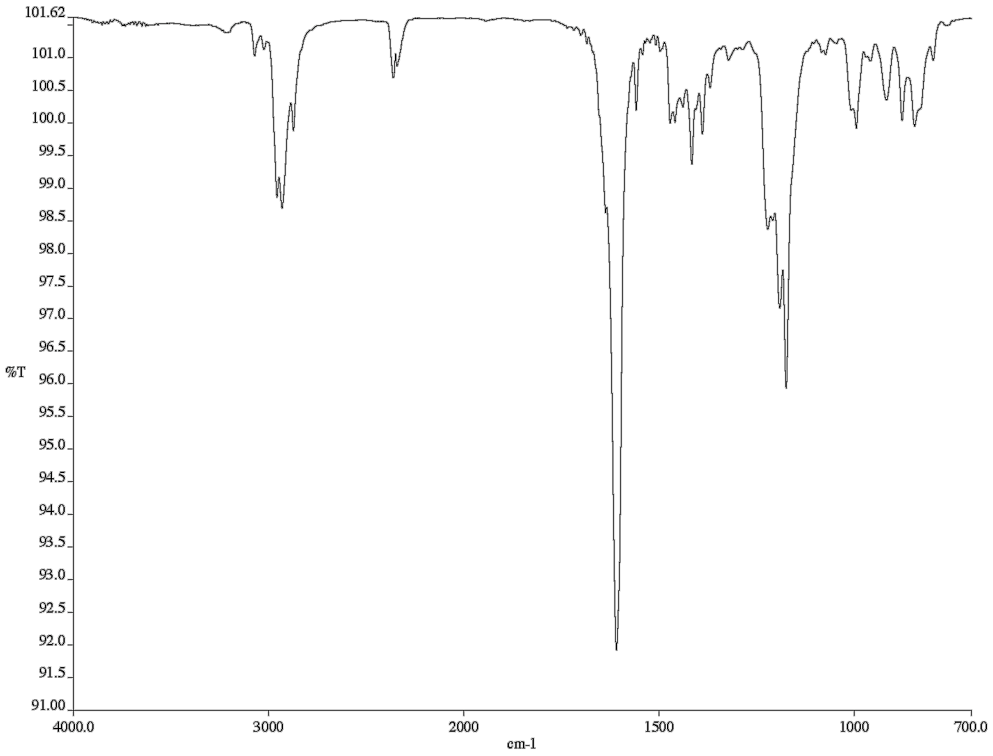


Figure SI-27B. Infrared spectrum (thin film/NaCl) of compound **10i**.

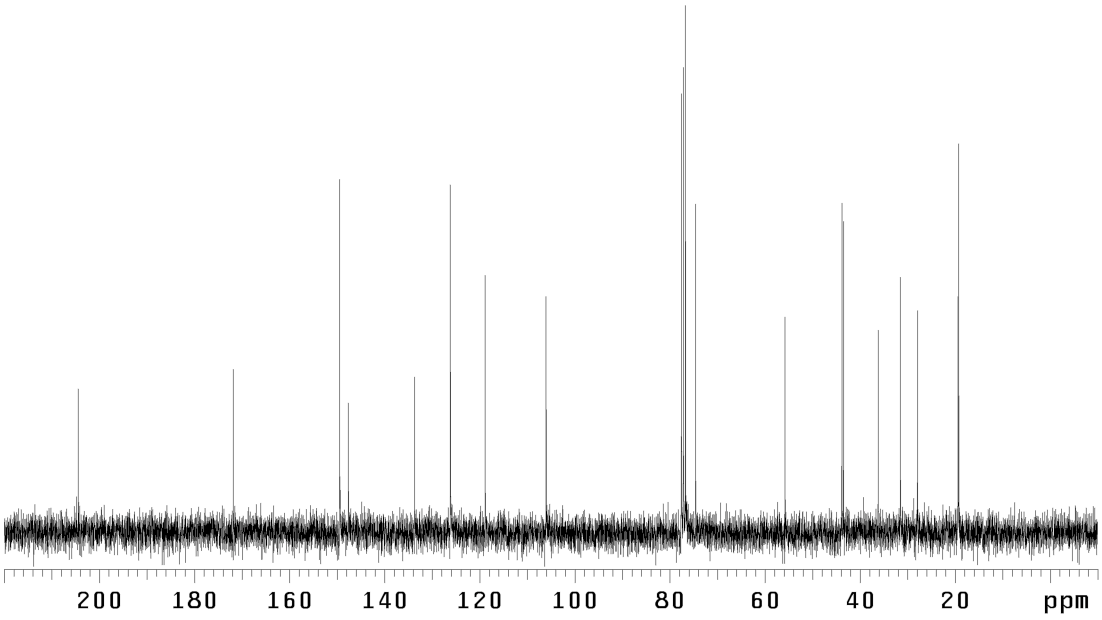


Figure SI-27C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10i**.

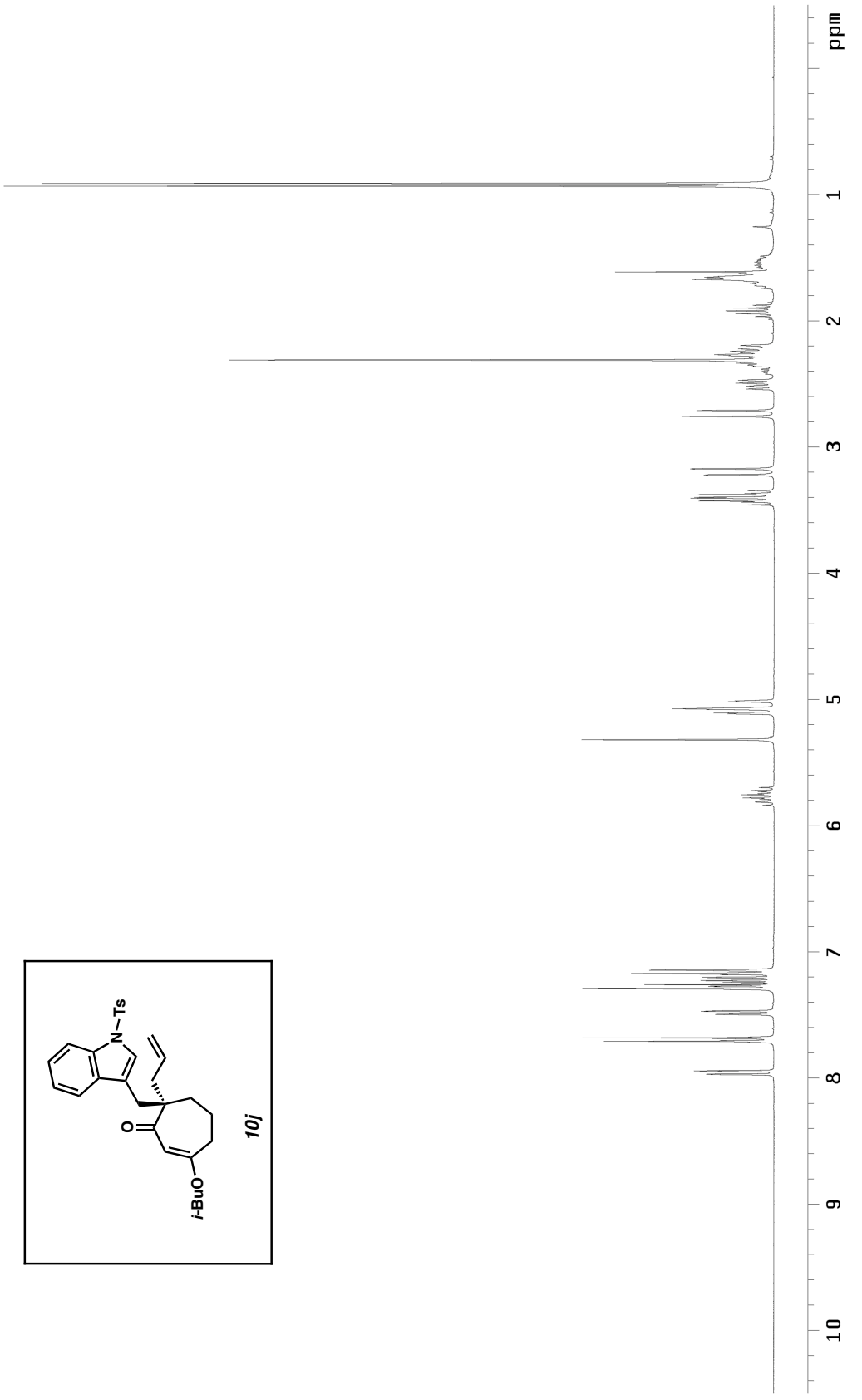


Figure SI-28A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10j**.

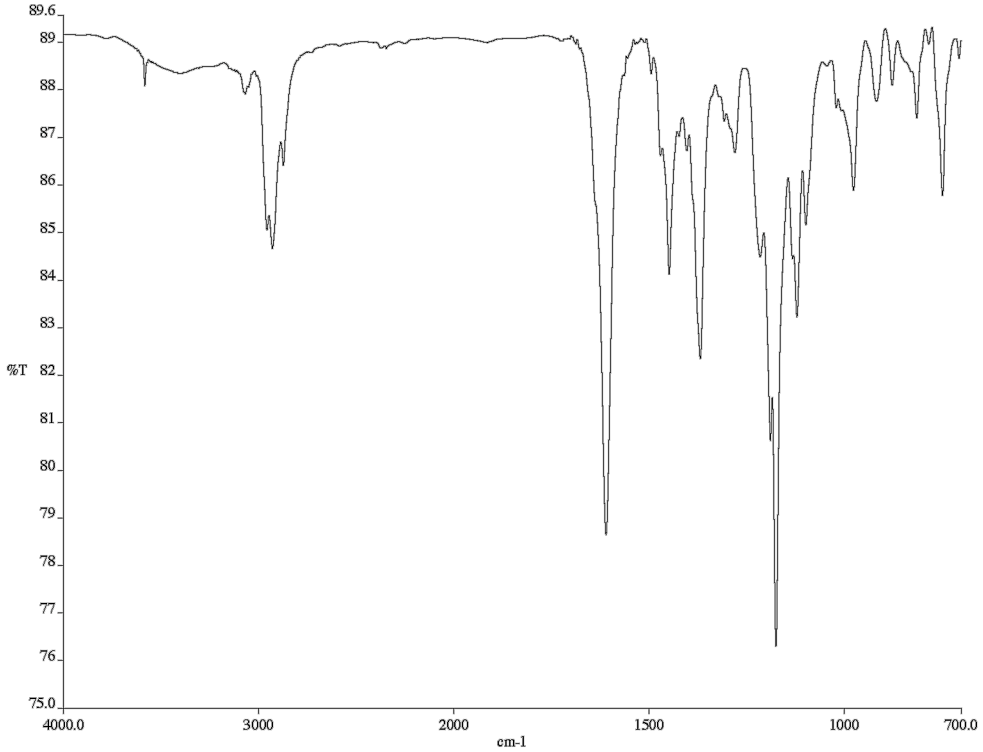


Figure SI-28B. Infrared spectrum (thin film/NaCl) of compound **10j**.

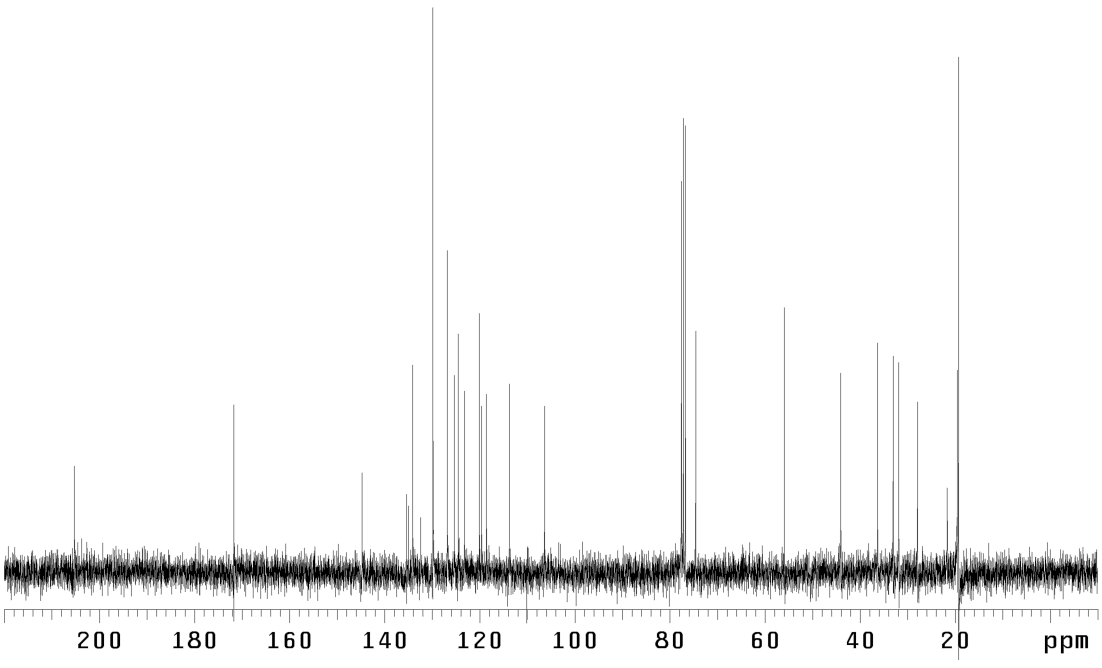


Figure SI-28C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10j**.

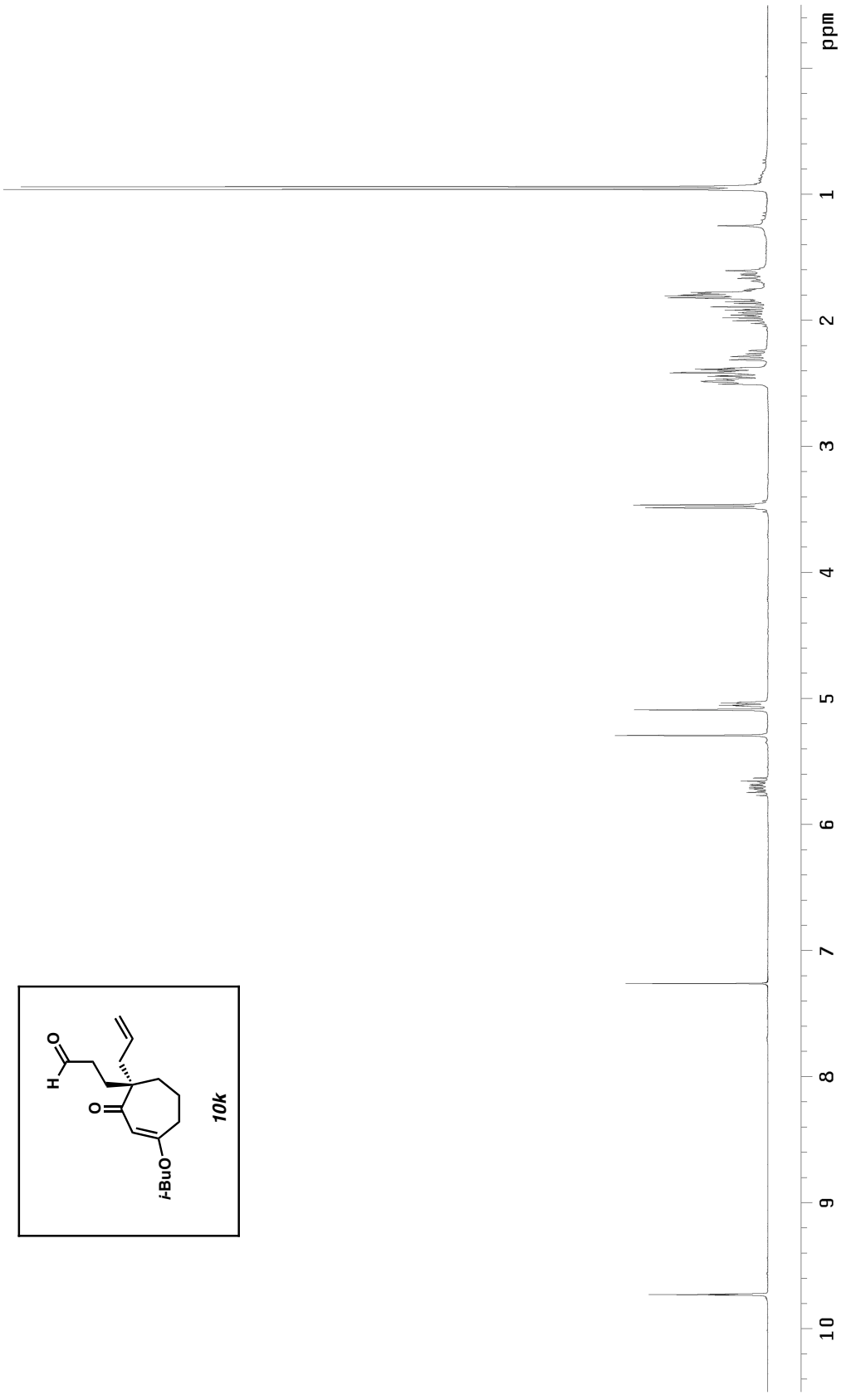


Figure SI-29A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10k**.

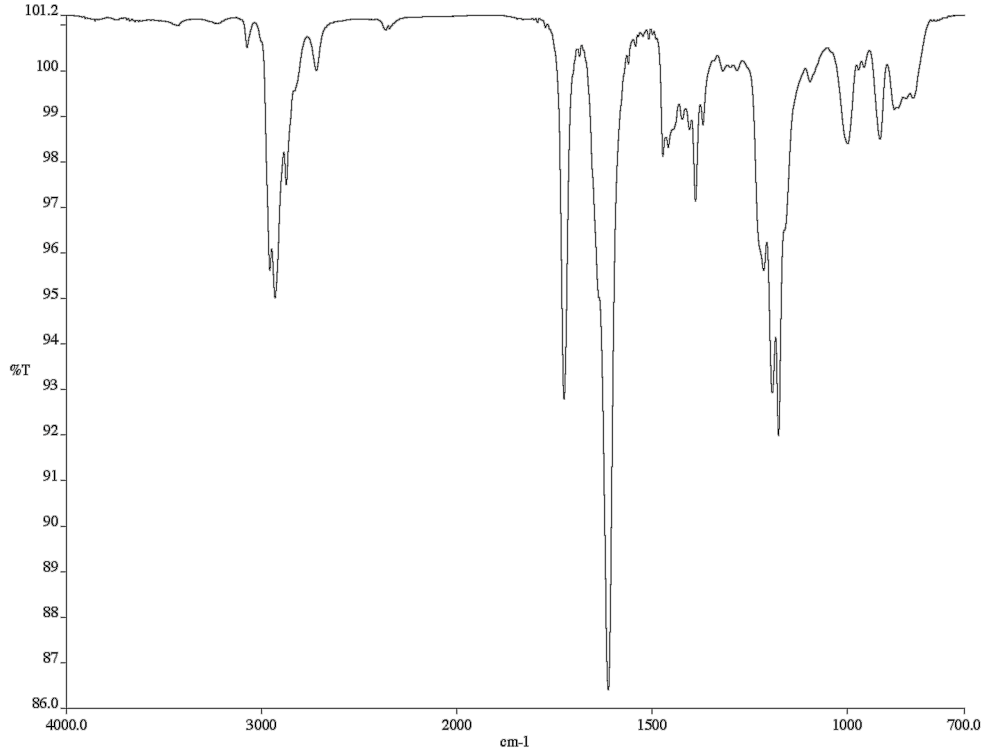


Figure SI-29B. Infrared spectrum (thin film/NaCl) of compound **10k**.

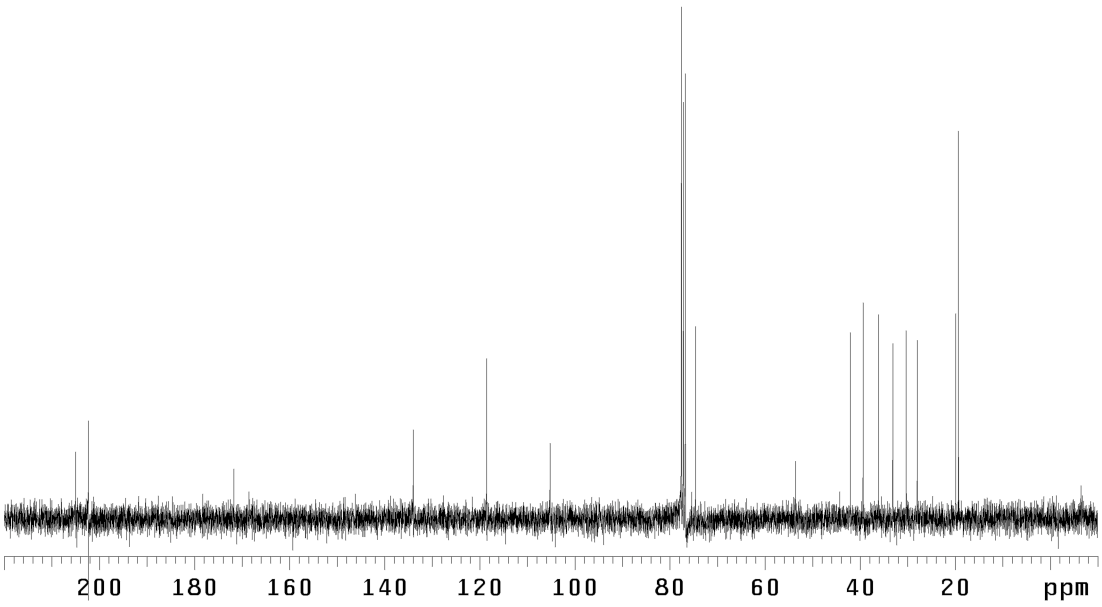


Figure SI-29C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10k**.

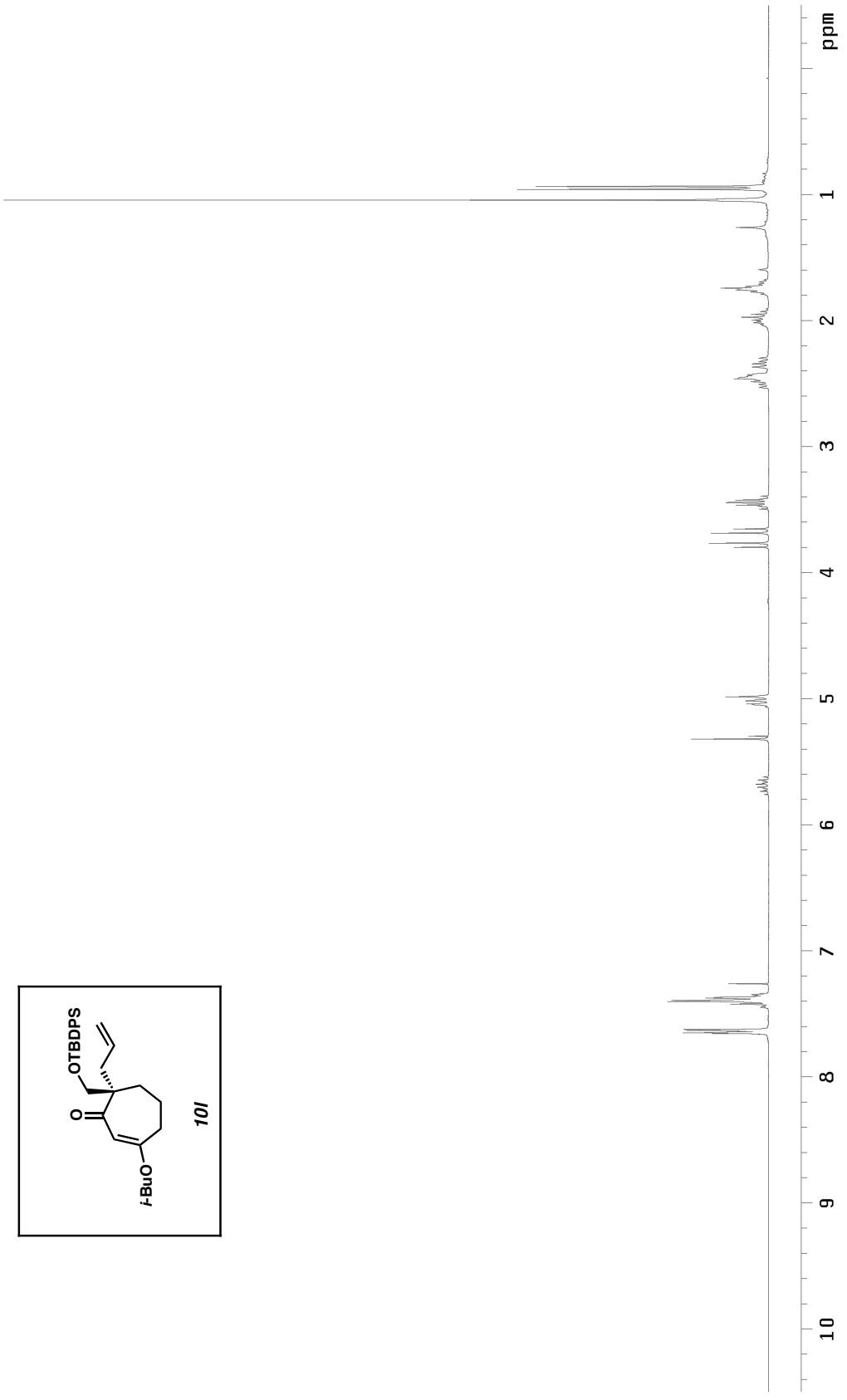


Figure SI-30A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10l**.

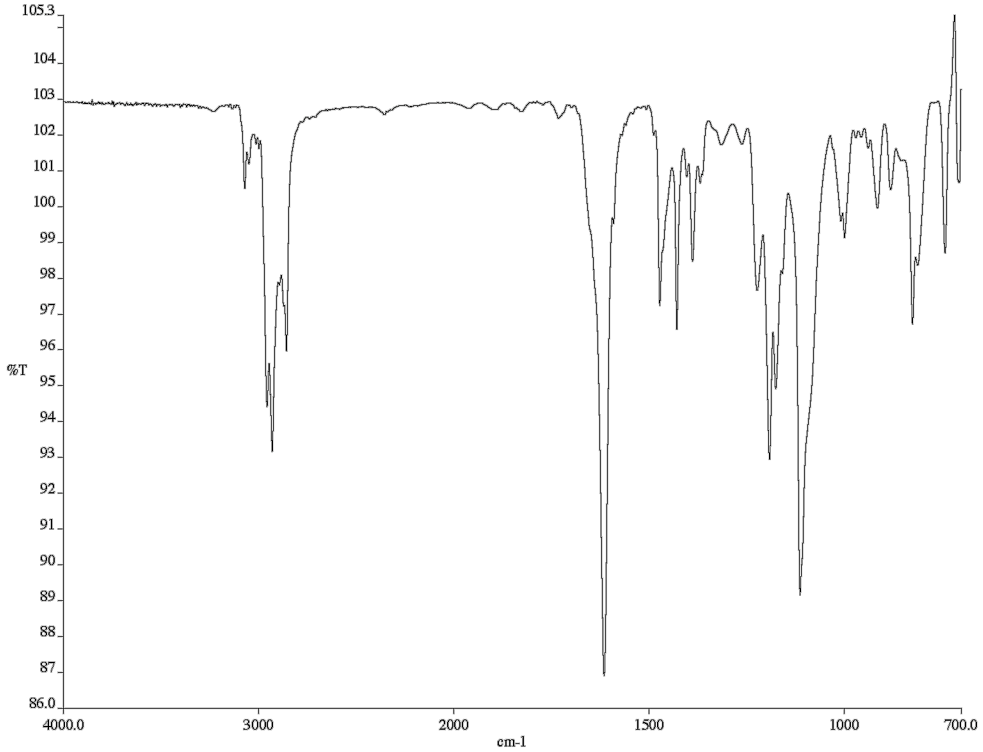


Figure SI-30B. Infrared spectrum (thin film/NaCl) of compound **10l**.

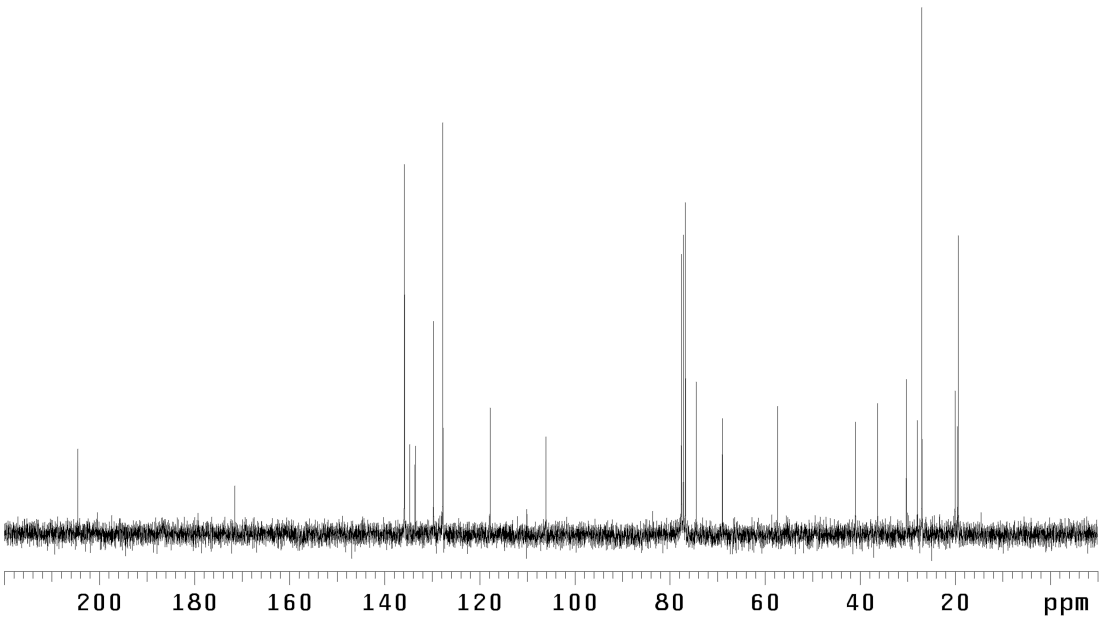


Figure SI-30C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10l**.

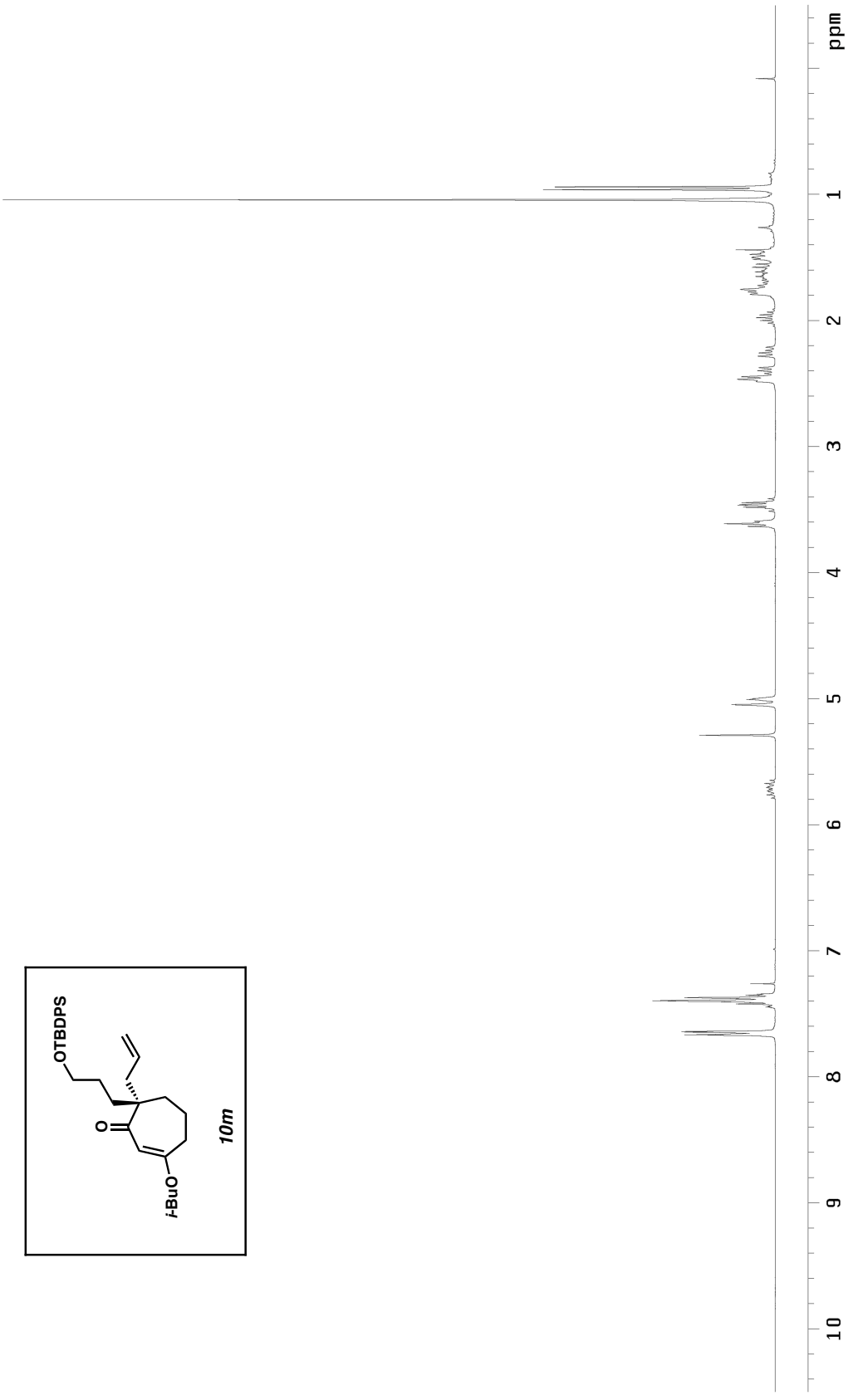


Figure SI-31A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10m**.

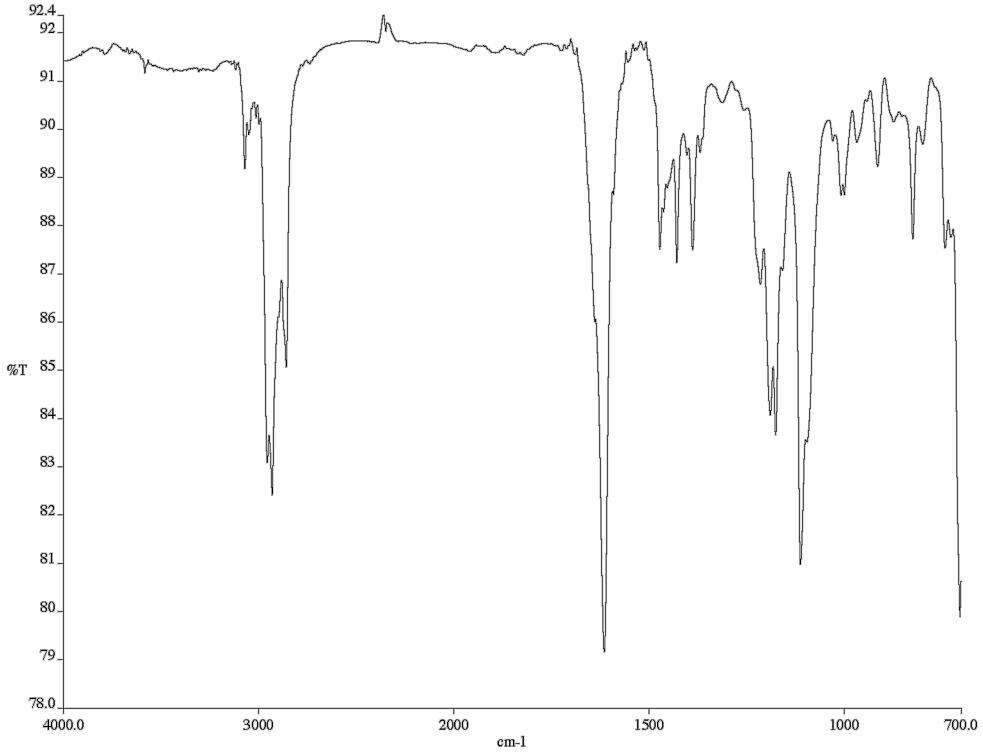


Figure SI-31B. Infrared spectrum (thin film/NaCl) of compound **10m**.

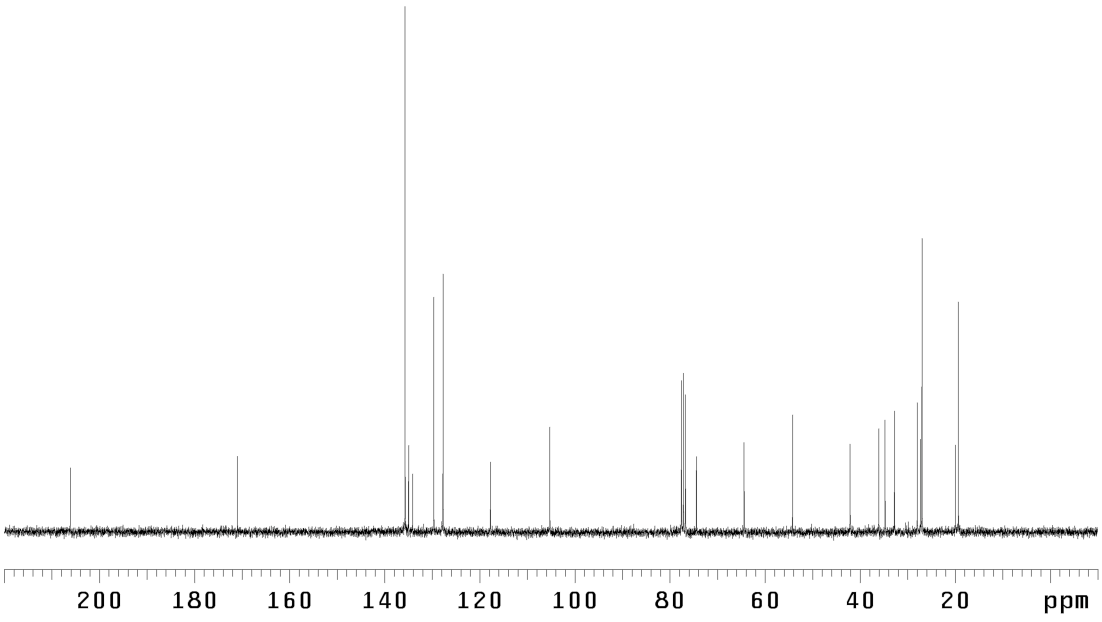


Figure SI-31C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10m**.

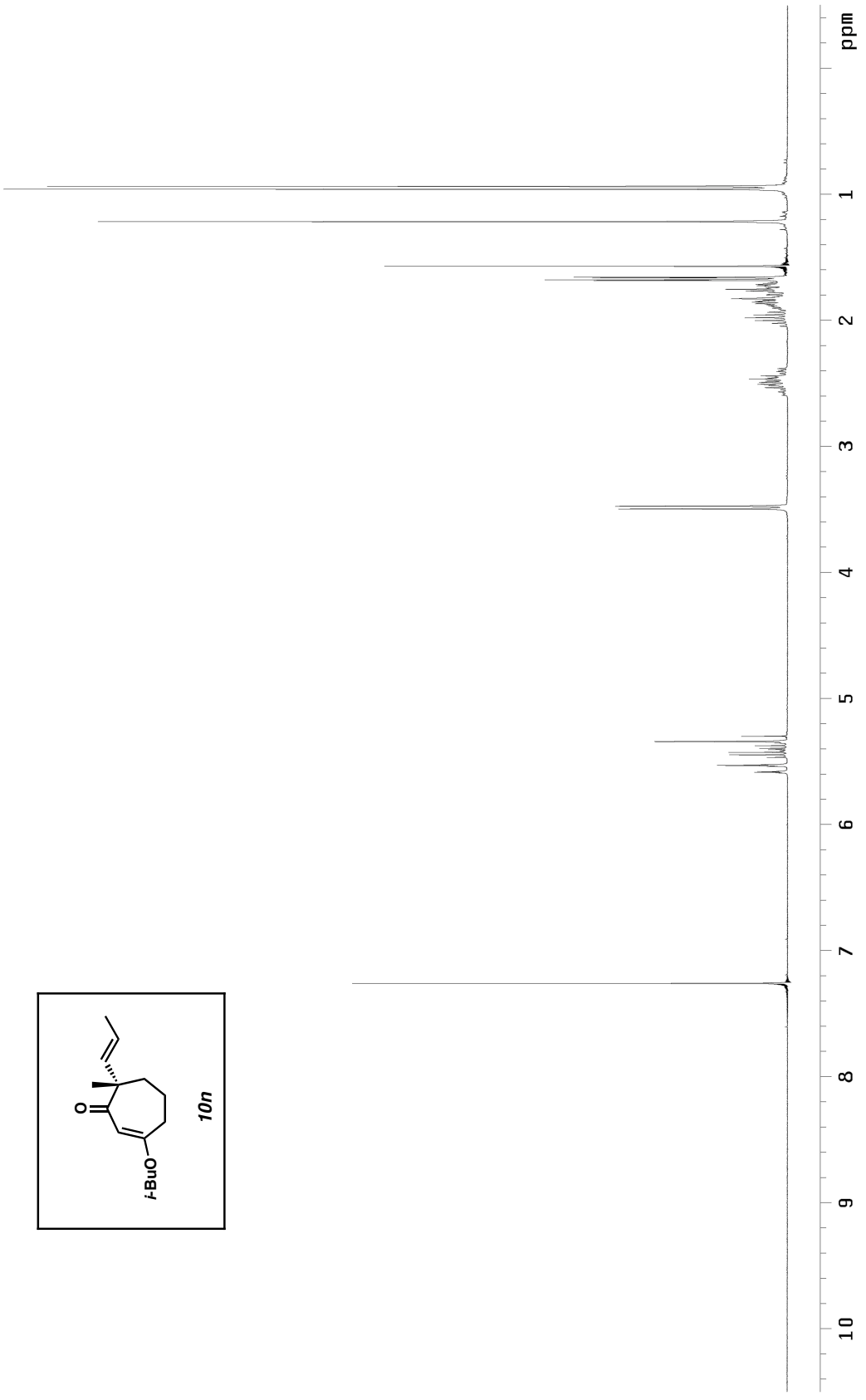


Figure SI-32A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10n**.

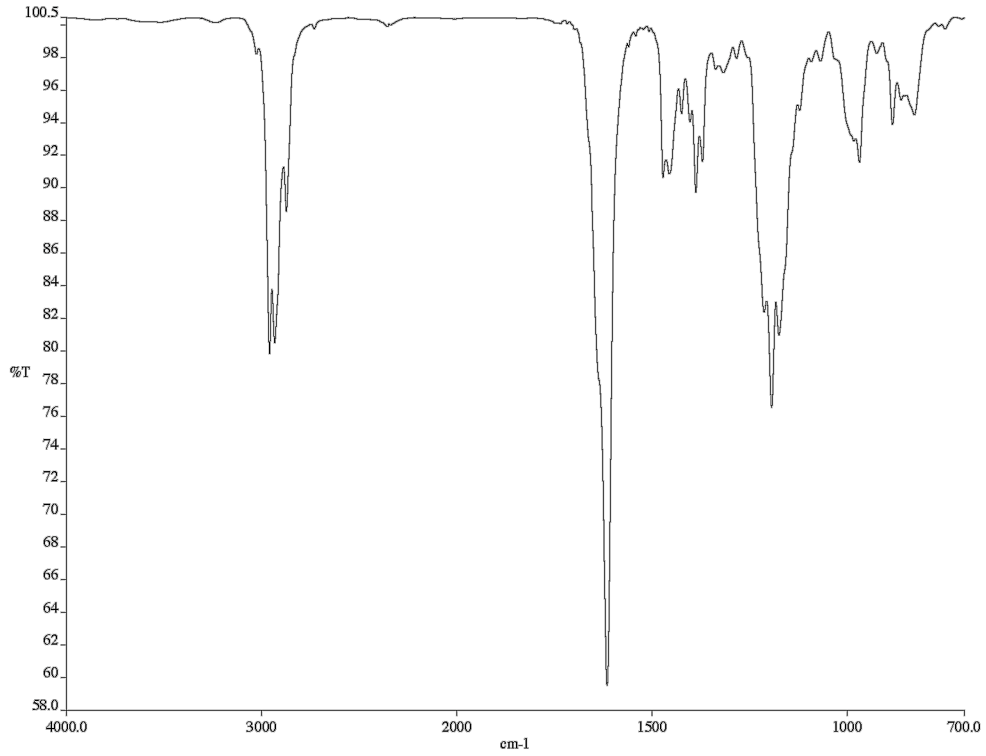


Figure SI-32B. Infrared spectrum (thin film/NaCl) of compound **10n**.

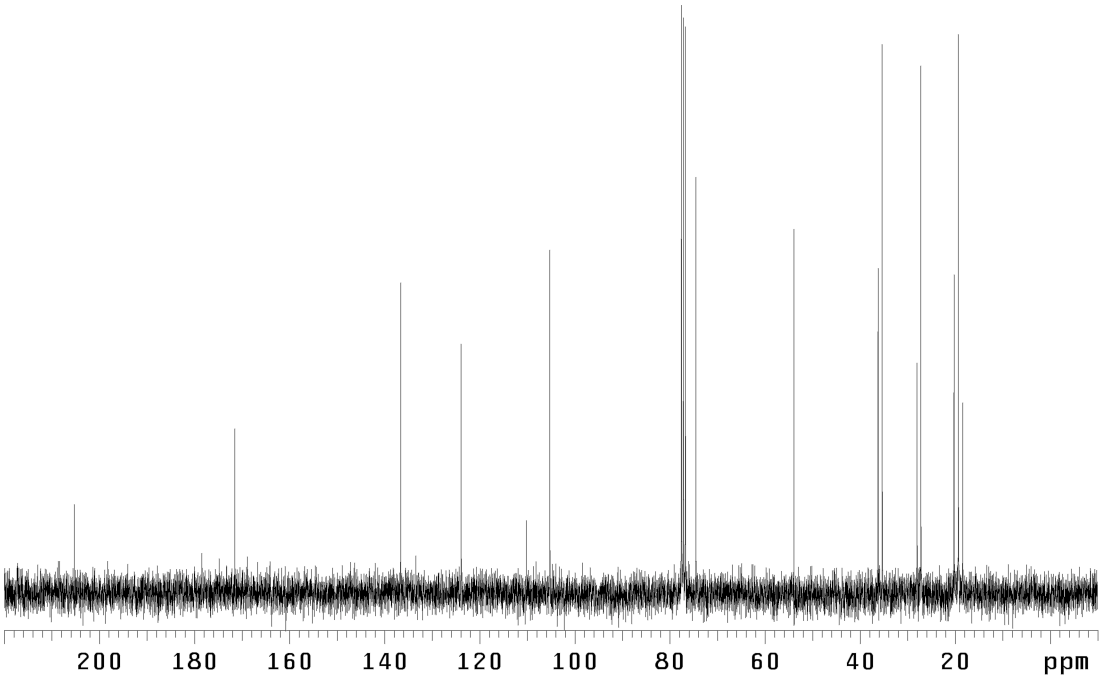


Figure SI-32C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10n**.

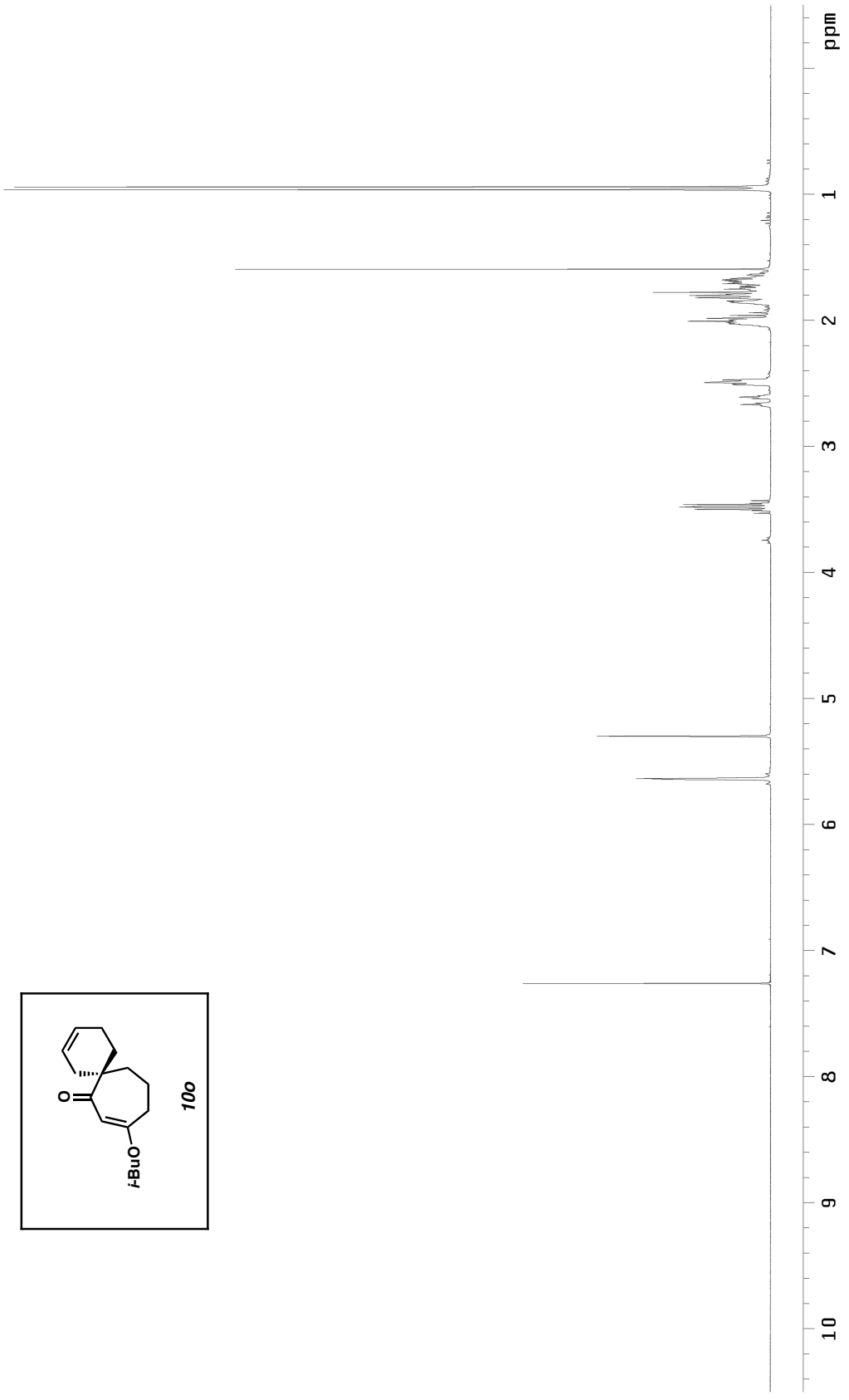


Figure SI-33A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **10o**.

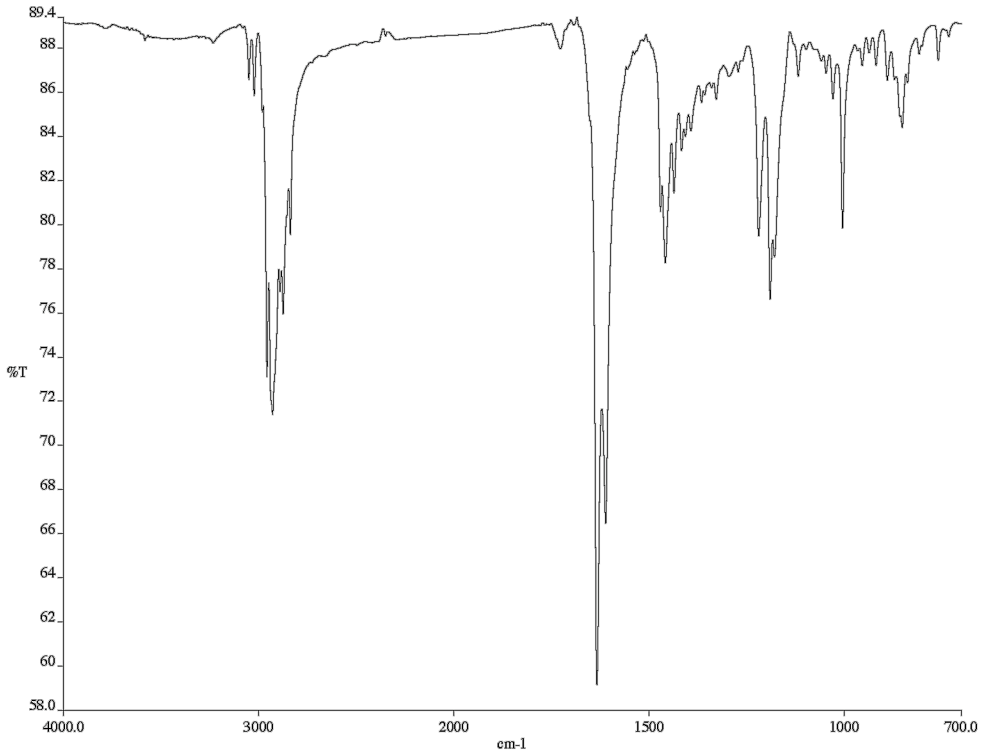


Figure SI-33B. Infrared spectrum (thin film/NaCl) of compound **10o**.

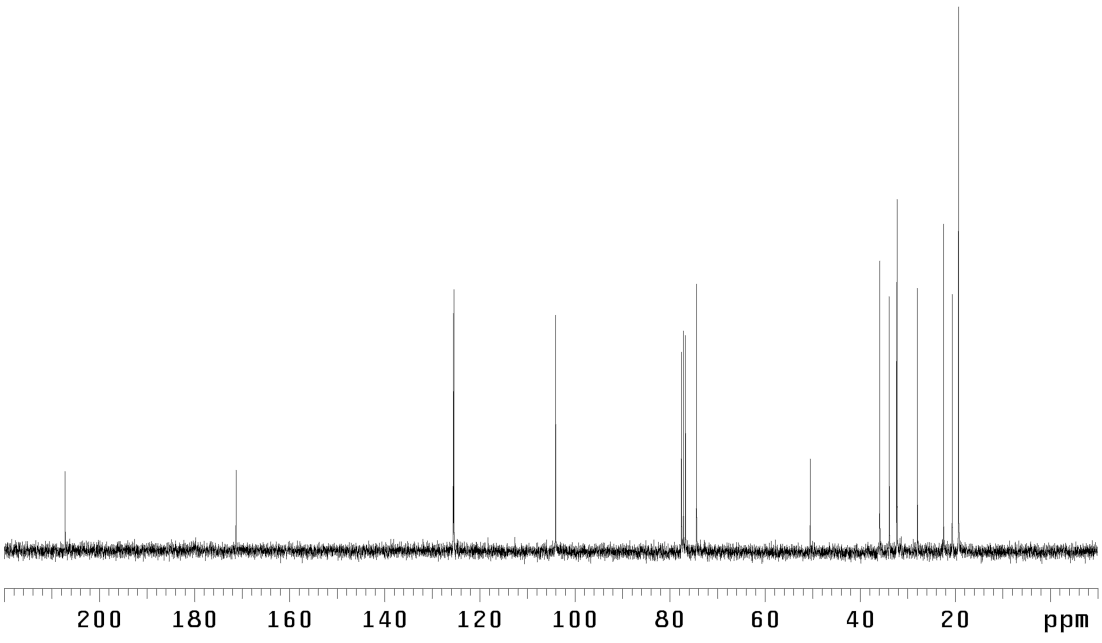


Figure SI-33C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **10o**.

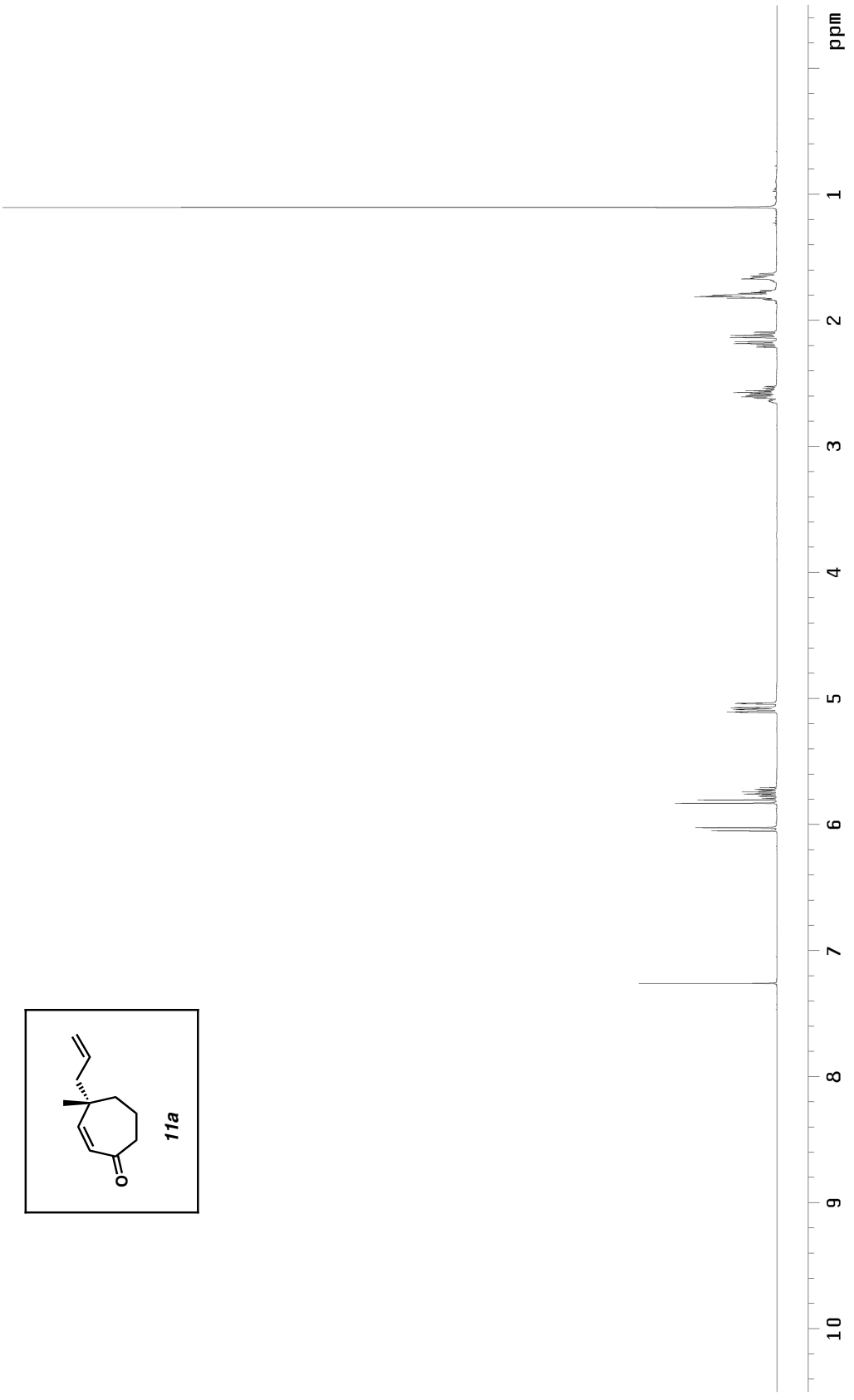


Figure SI-34A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **11a**.

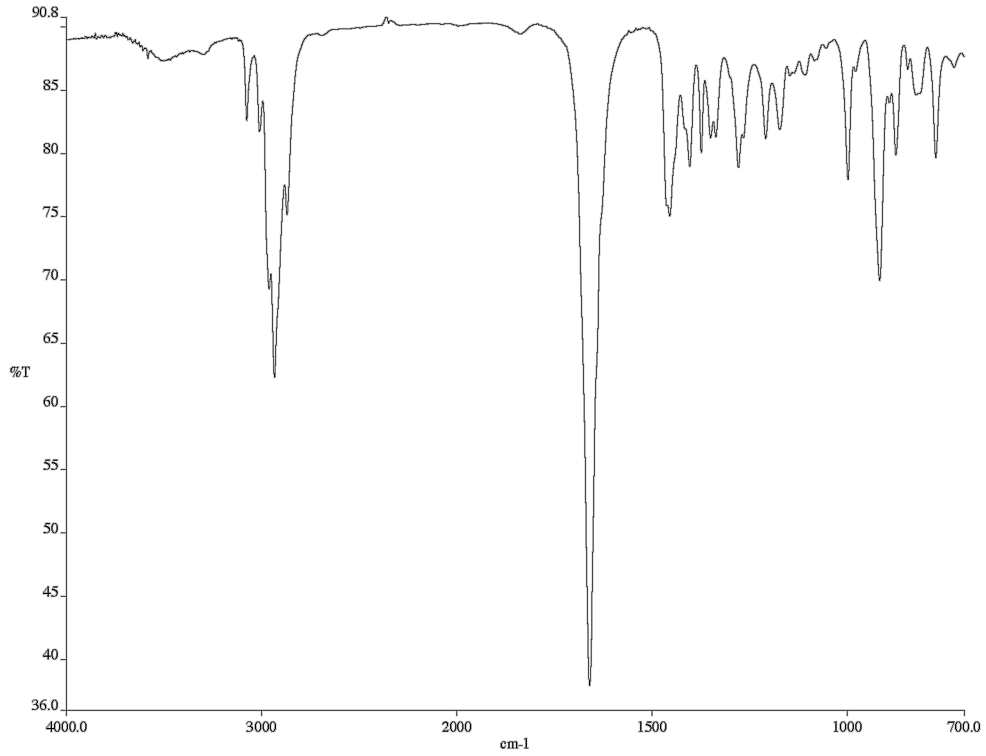


Figure SI-34B. Infrared spectrum (thin film/NaCl) of compound **11a**.

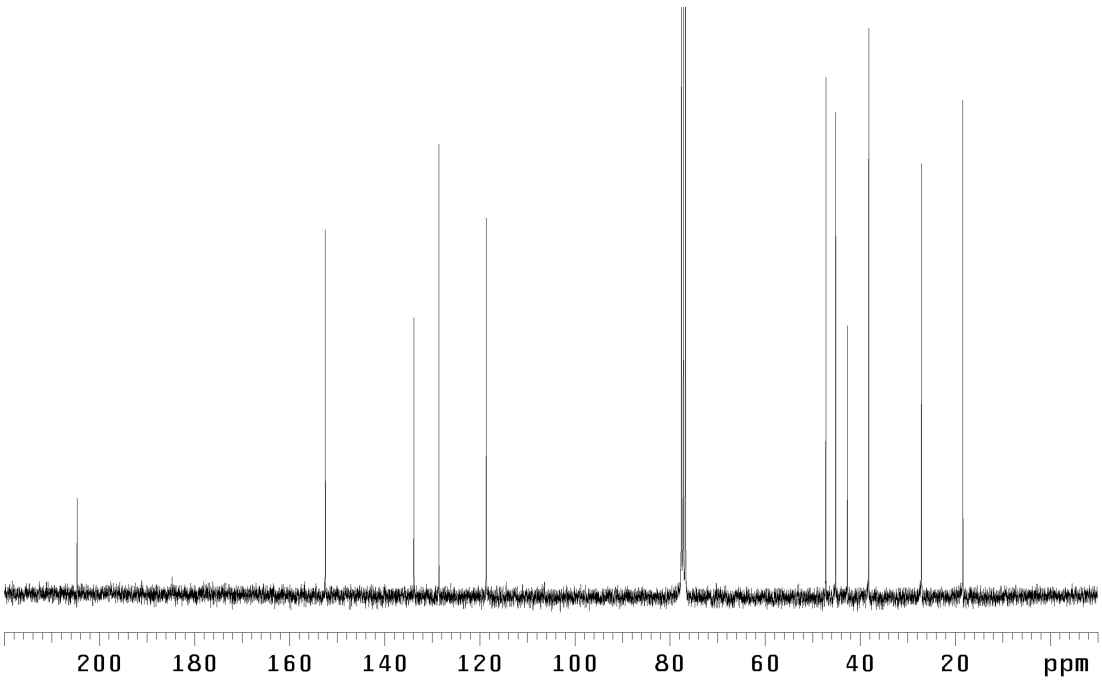


Figure SI-34C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **11a**.

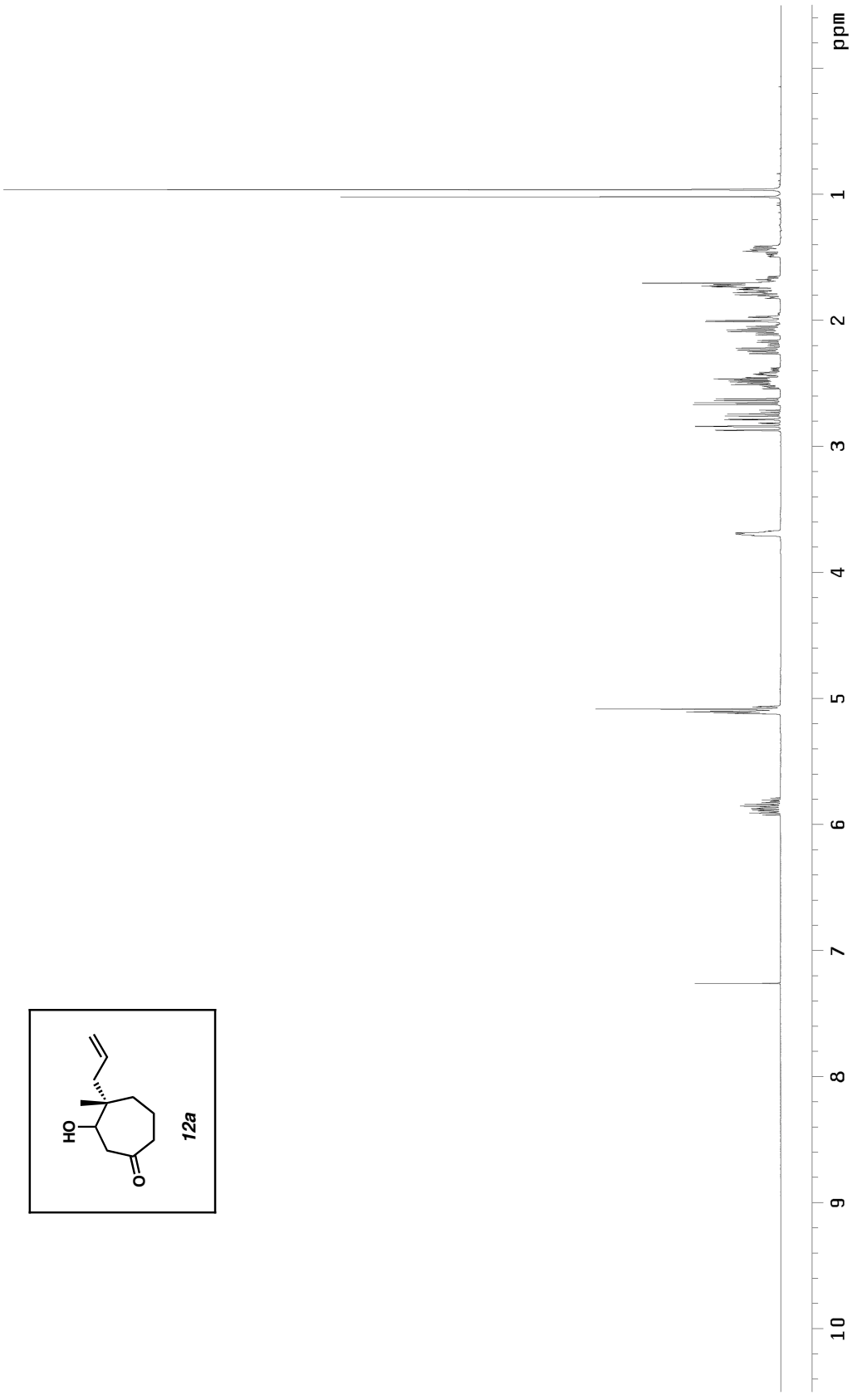


Figure SI-35A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **12a**.

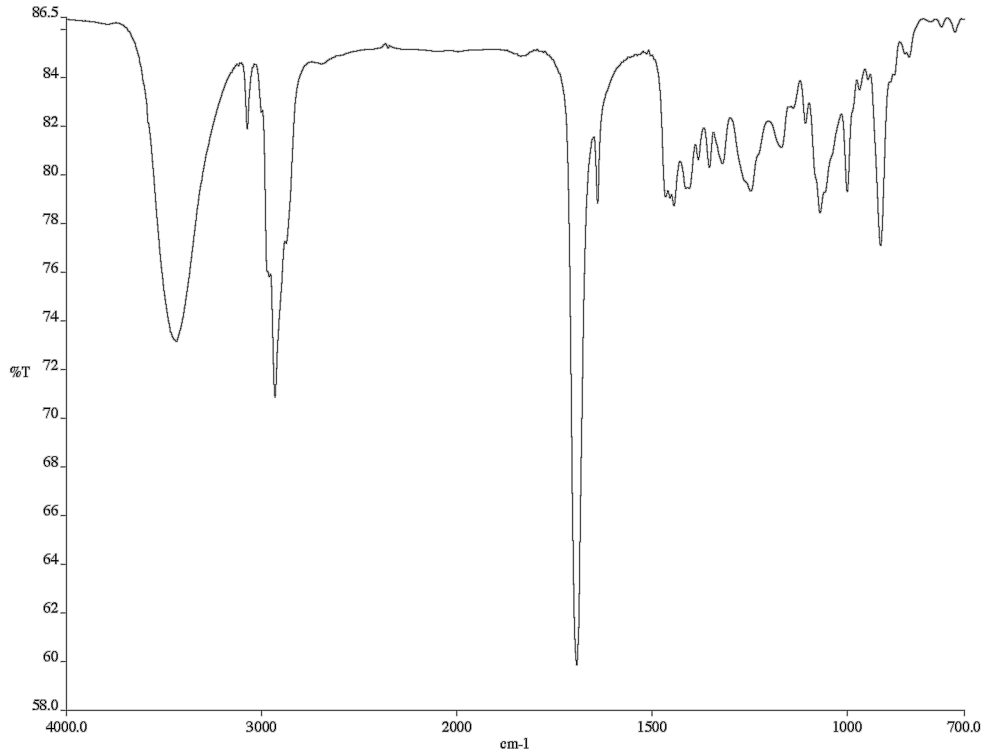


Figure SI-35B. Infrared spectrum (thin film/NaCl) of compound **12a**.

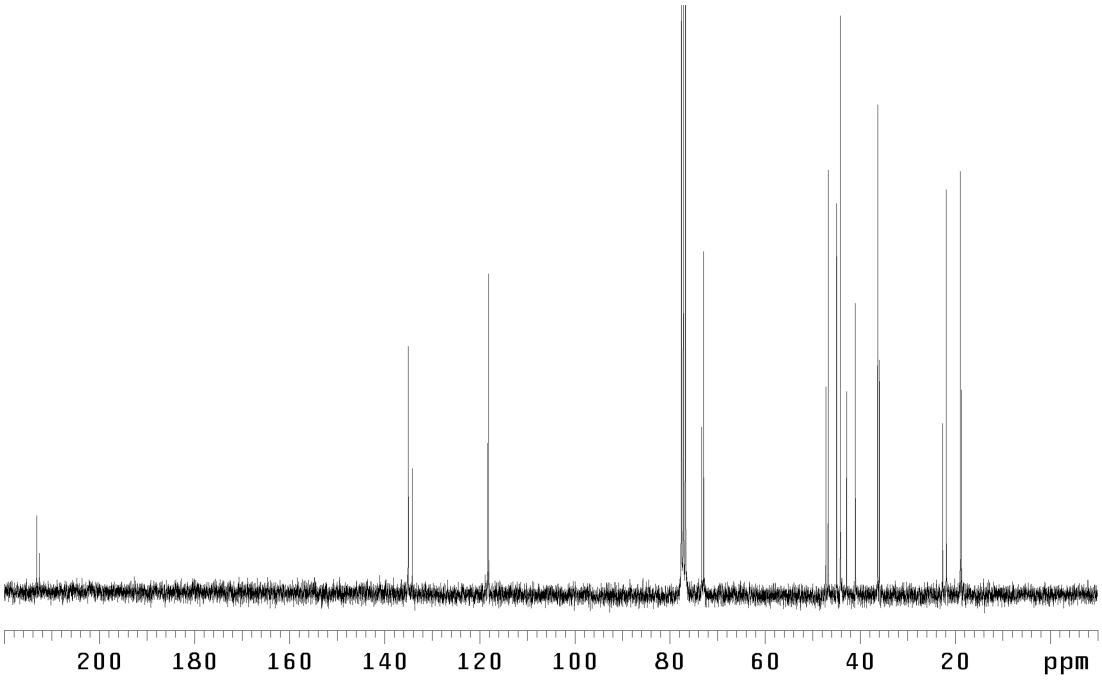


Figure SI-35C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **12a**.

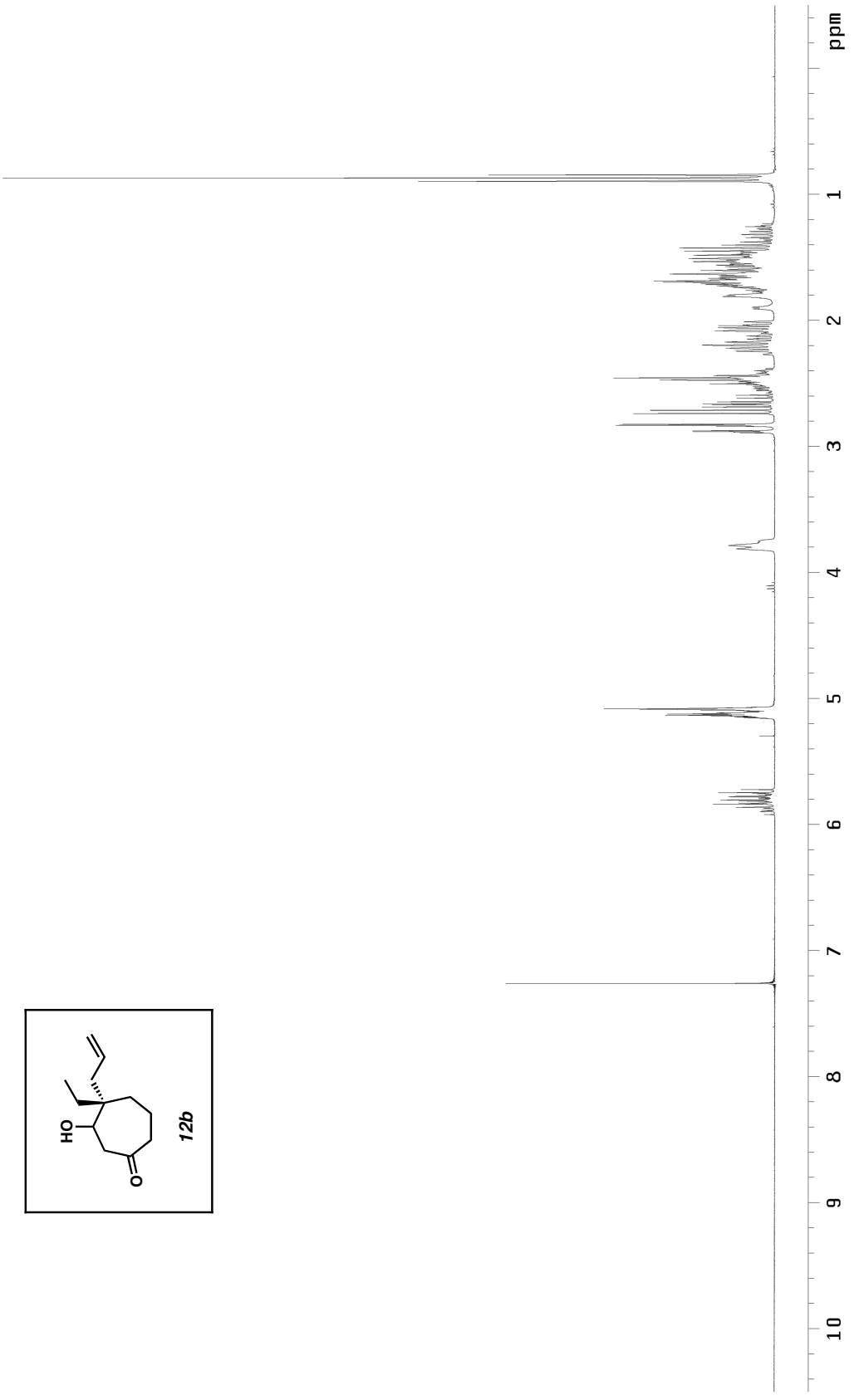


Figure SI-36A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12b**.

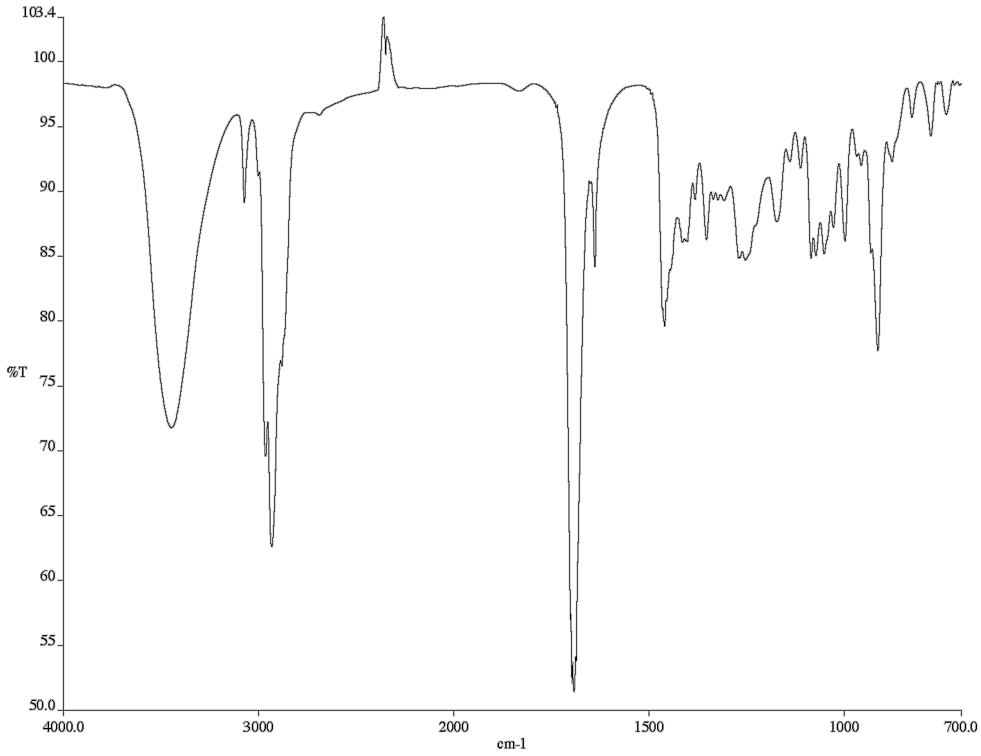


Figure SI-36B. Infrared spectrum (thin film/NaCl) of compound **12b**.

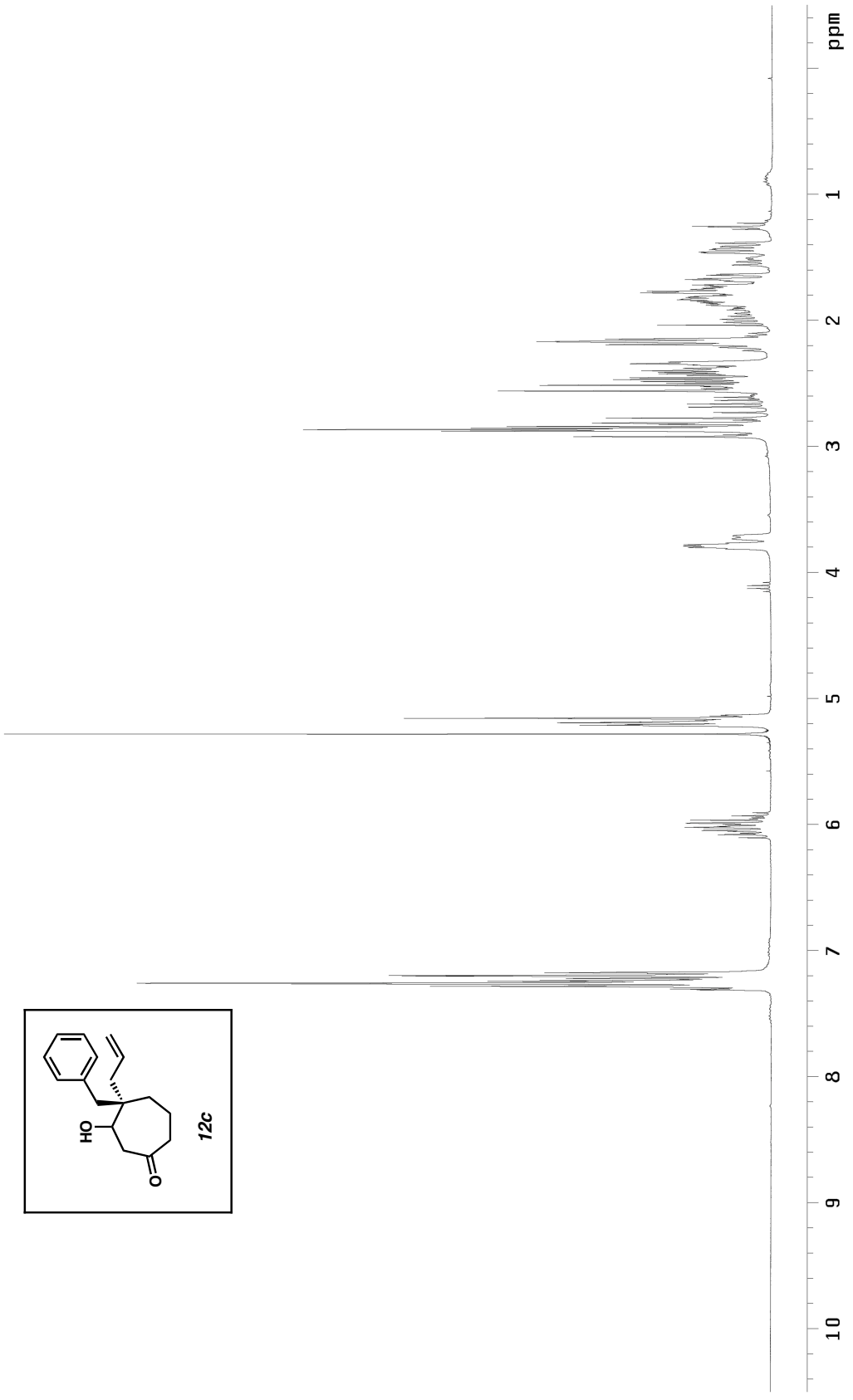


Figure SI-37A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12c**.

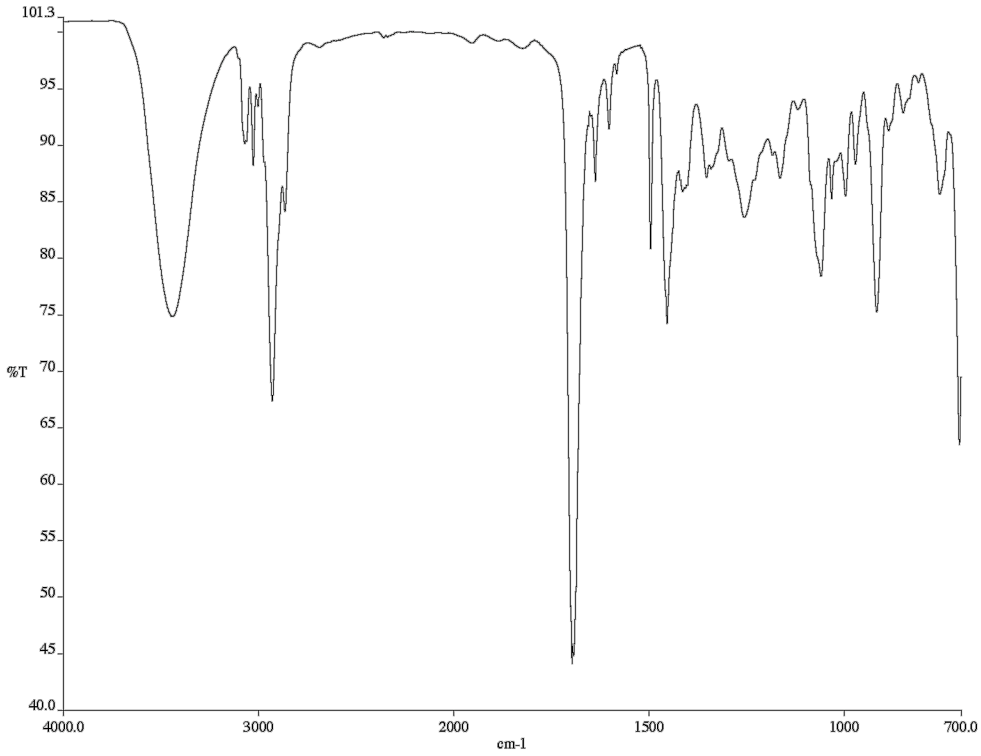


Figure SI-37B. Infrared spectrum (thin film/NaCl) of compound **12c**.

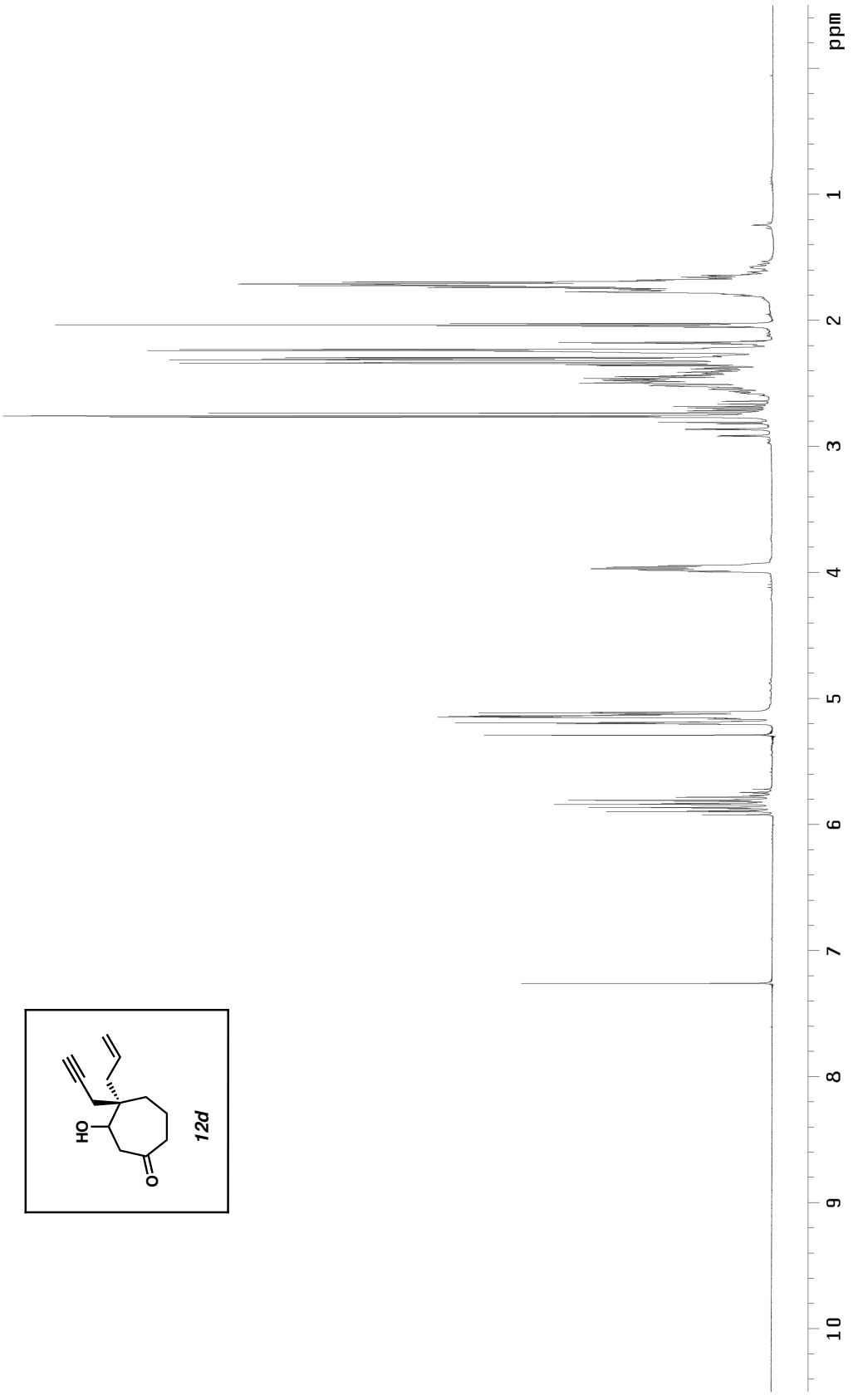


Figure SI-38A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12d**.

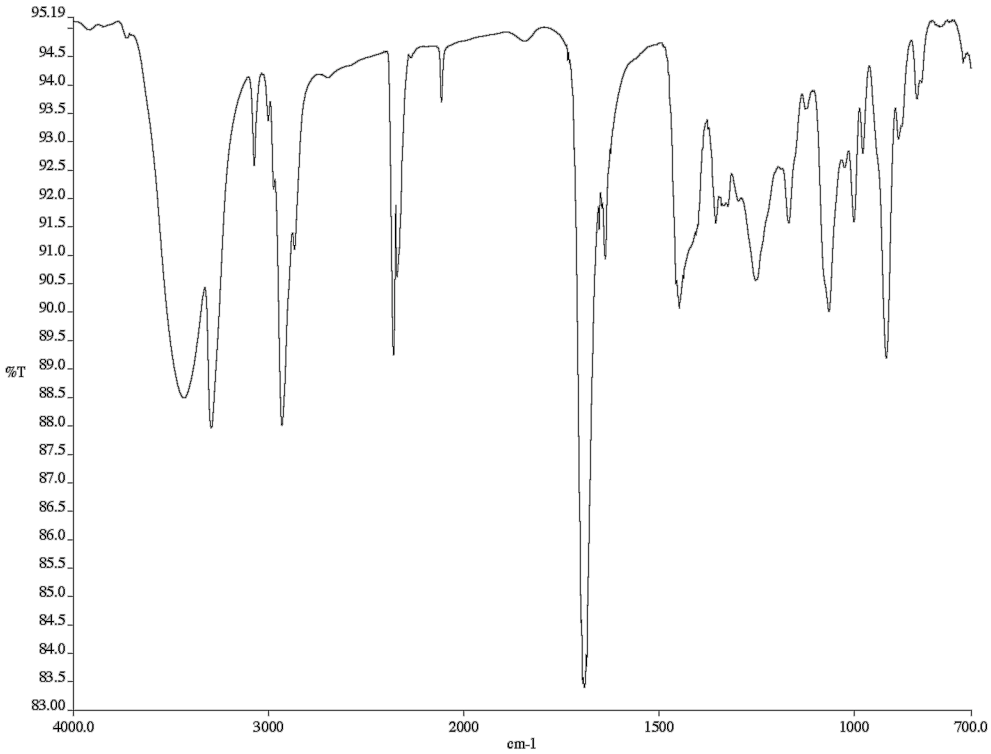


Figure SI-38B. Infrared spectrum (thin film/NaCl) of compound **12d**.

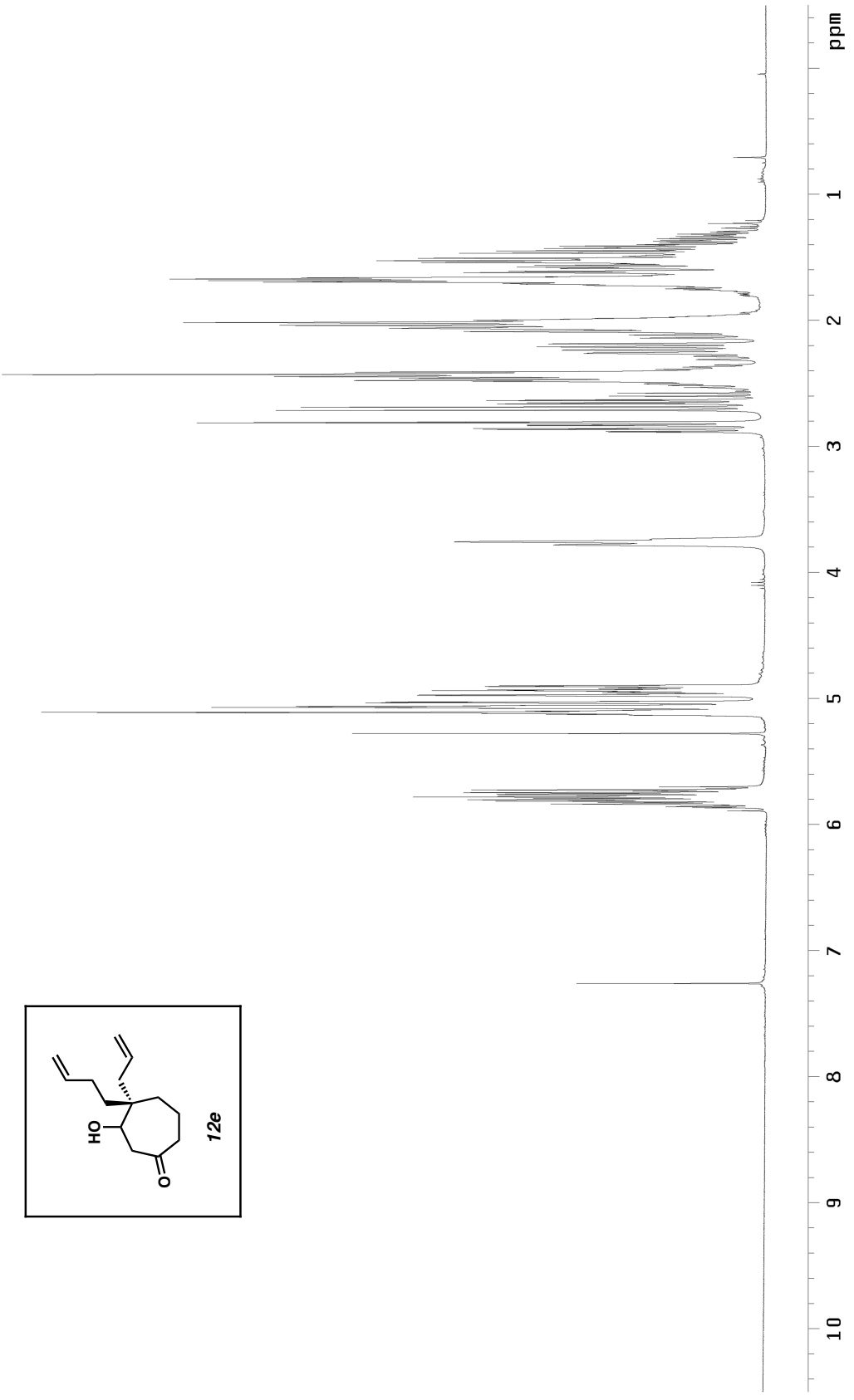


Figure SI-39A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12e**.

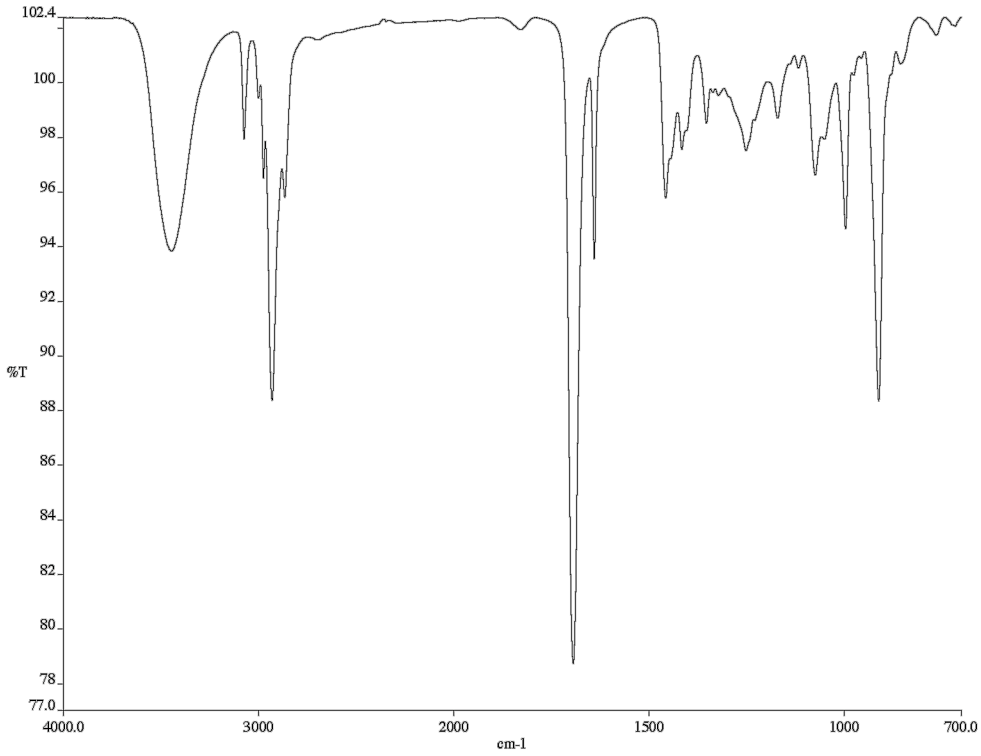


Figure SI-39B. Infrared spectrum (thin film/NaCl) of compound **12e**.

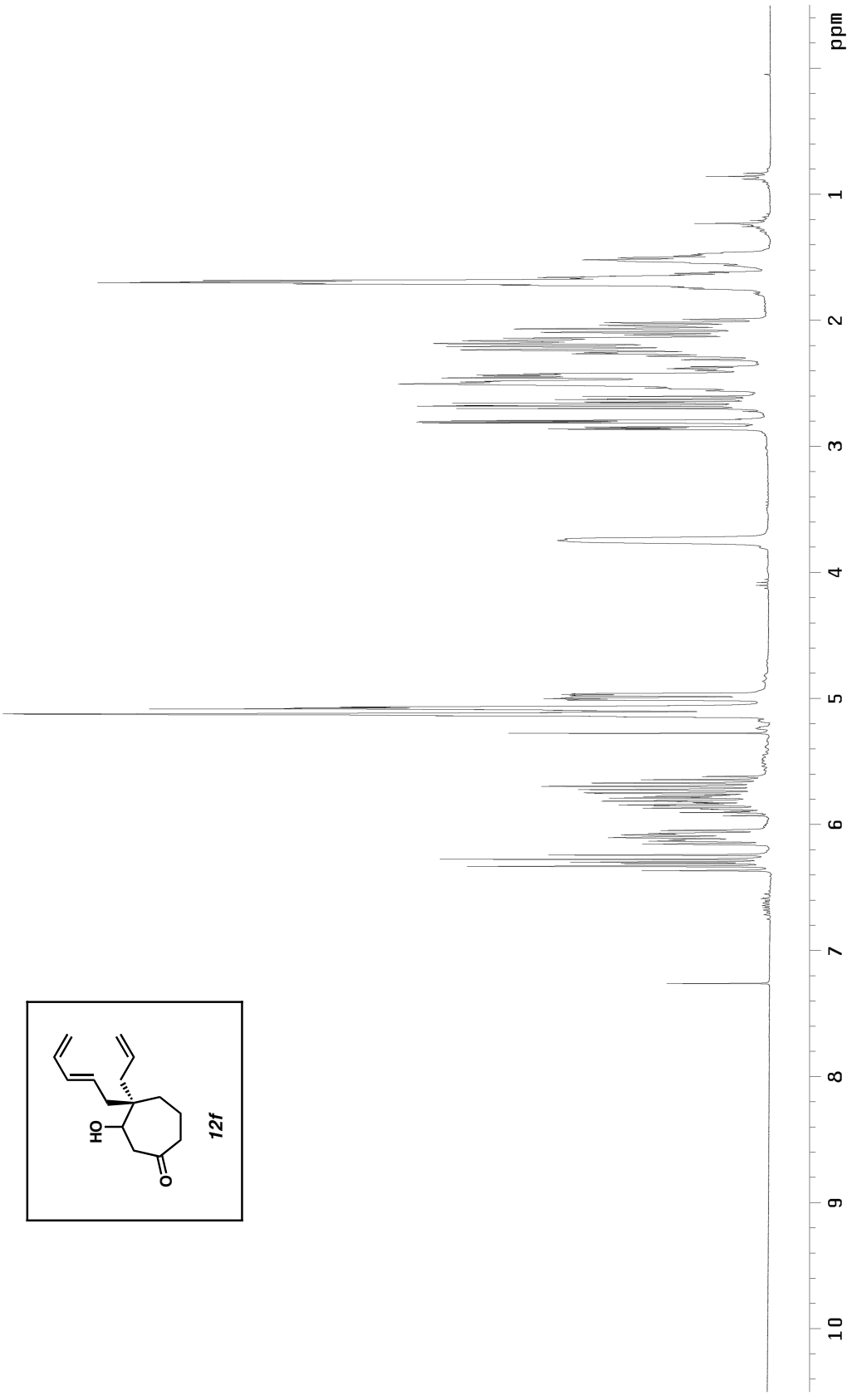


Figure SI-40A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12f**.

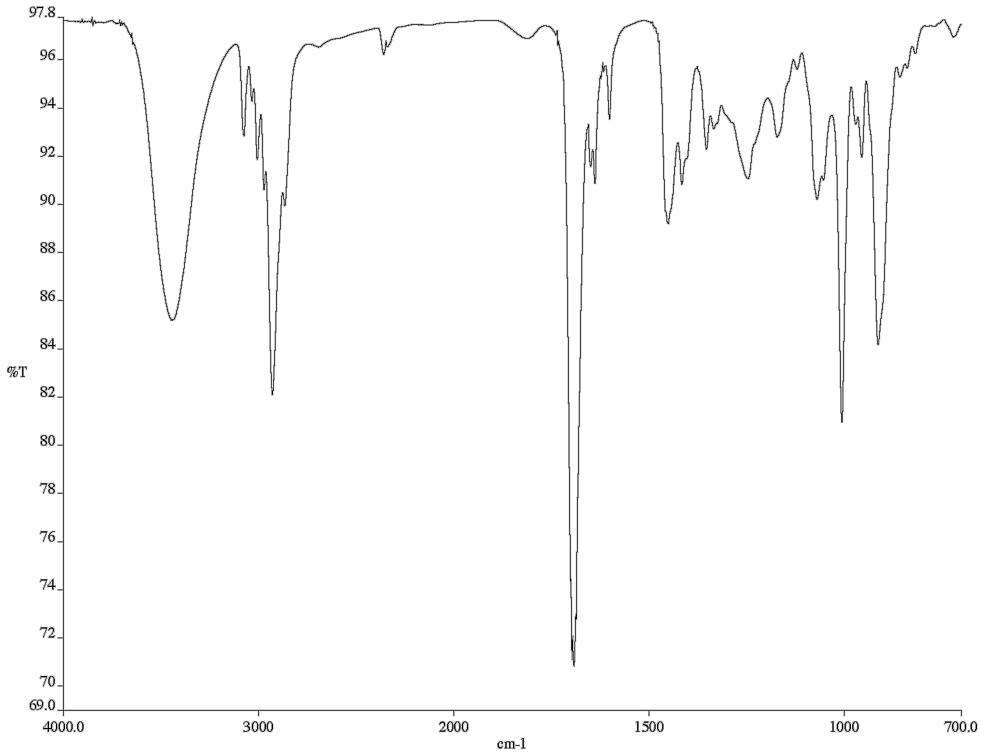


Figure SI-40B. Infrared spectrum (thin film/NaCl) of compound **12f**.

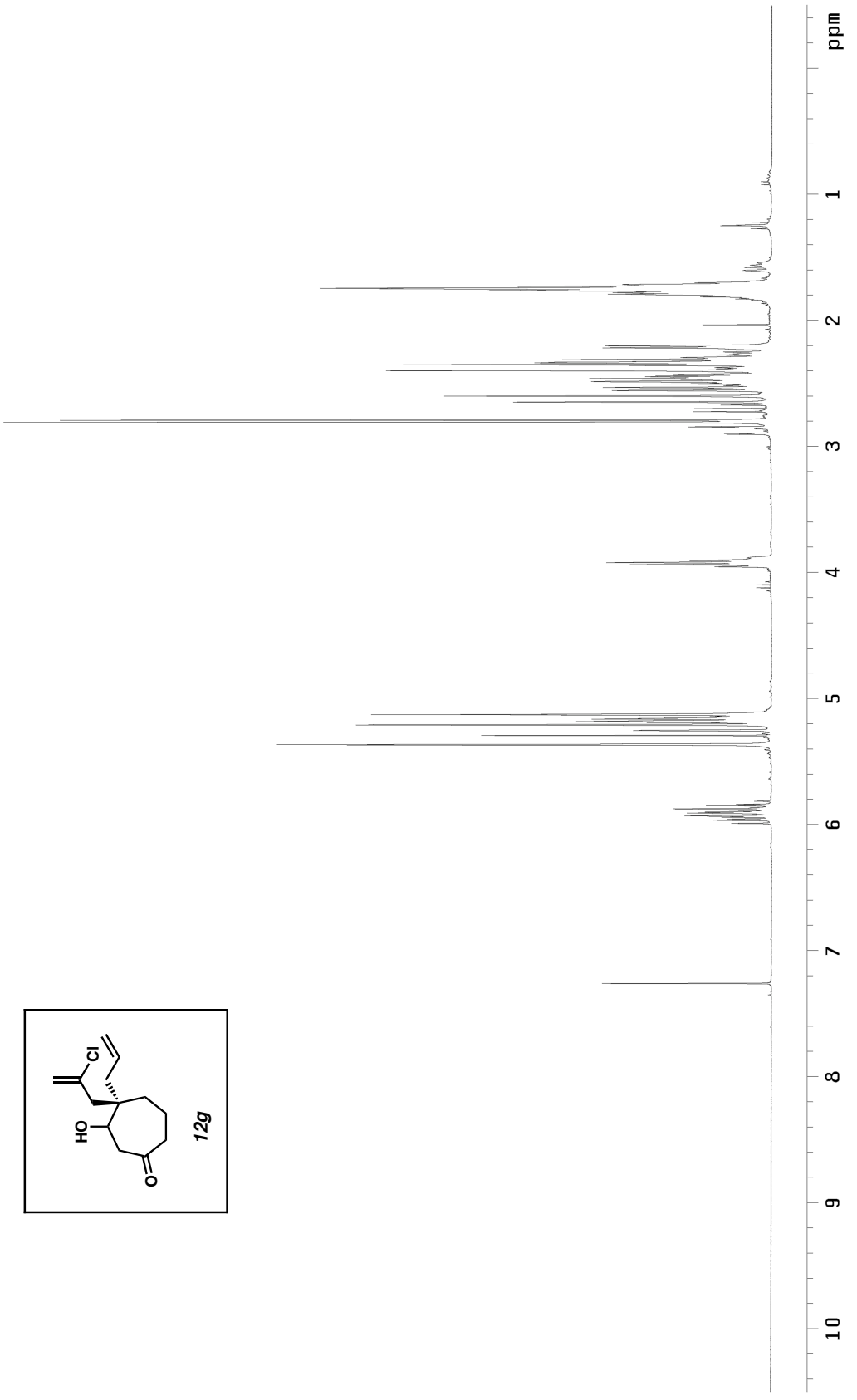


Figure SI-41A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12g**.

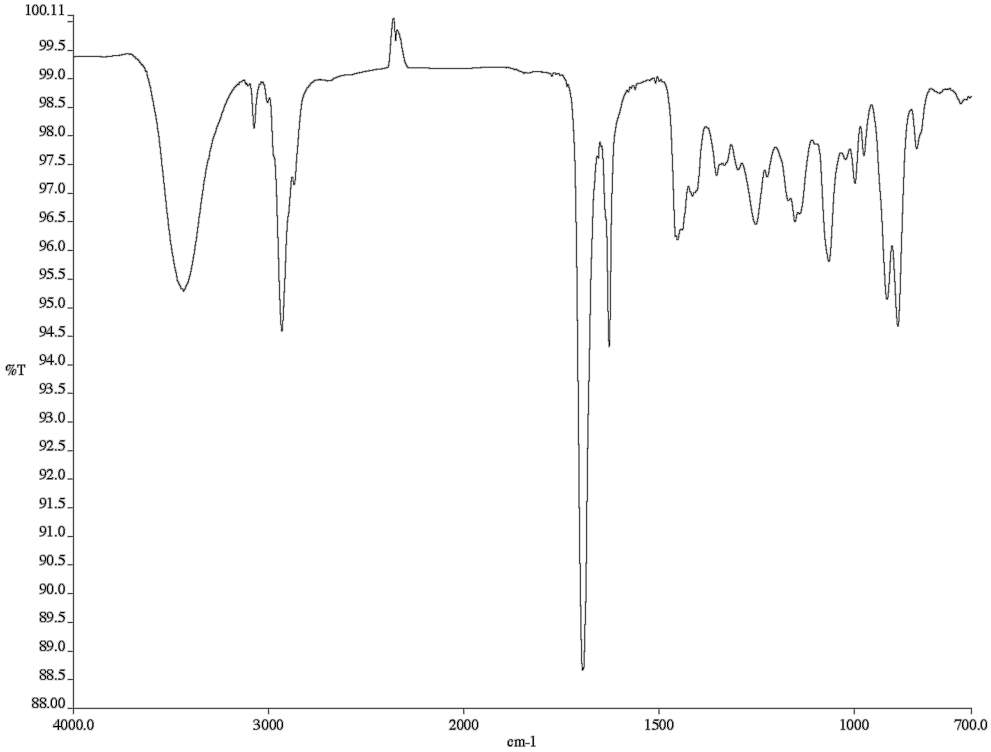


Figure SI-41B. Infrared spectrum (thin film/NaCl) of compound **12g**.

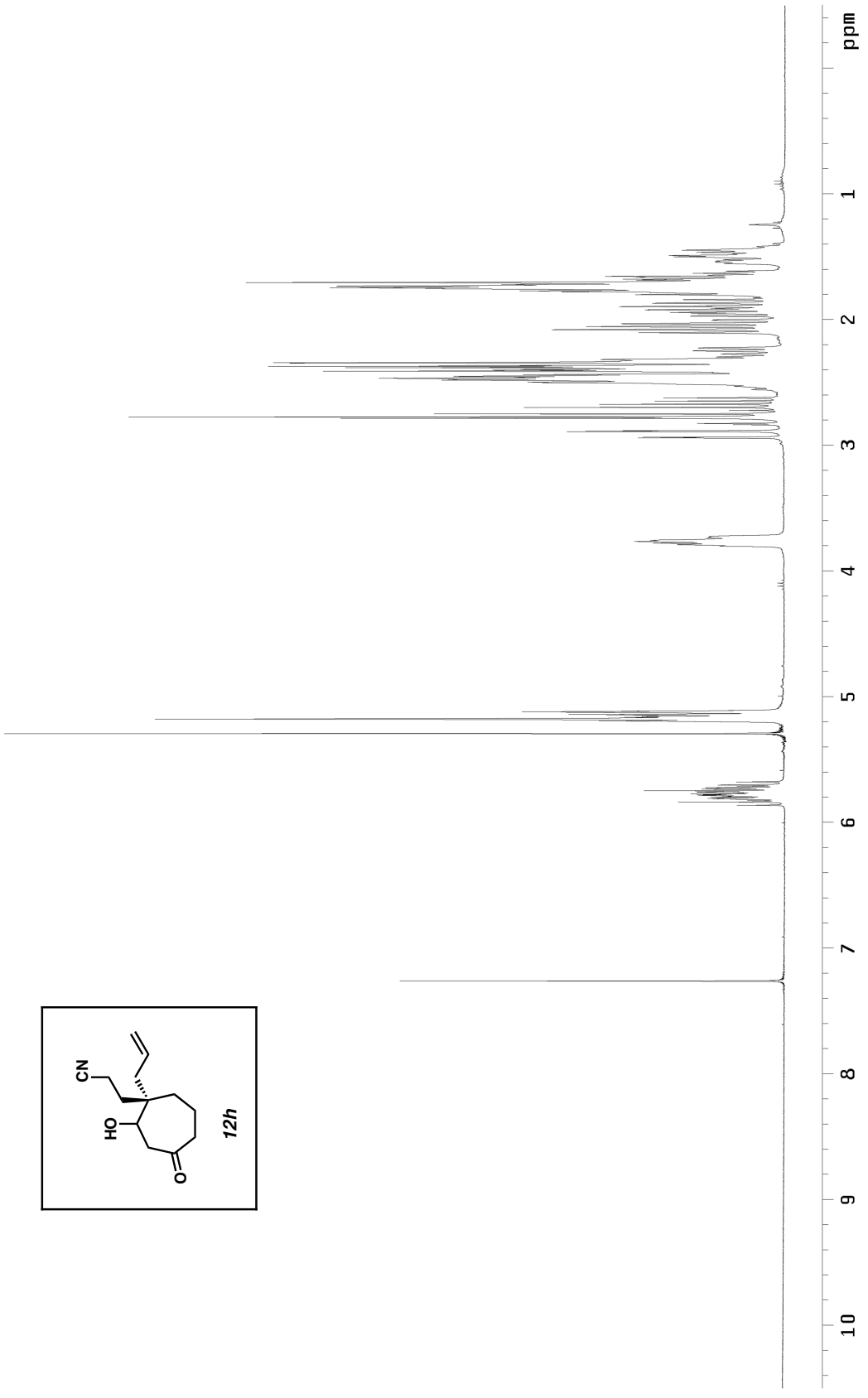


Figure SI-42A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12h**.

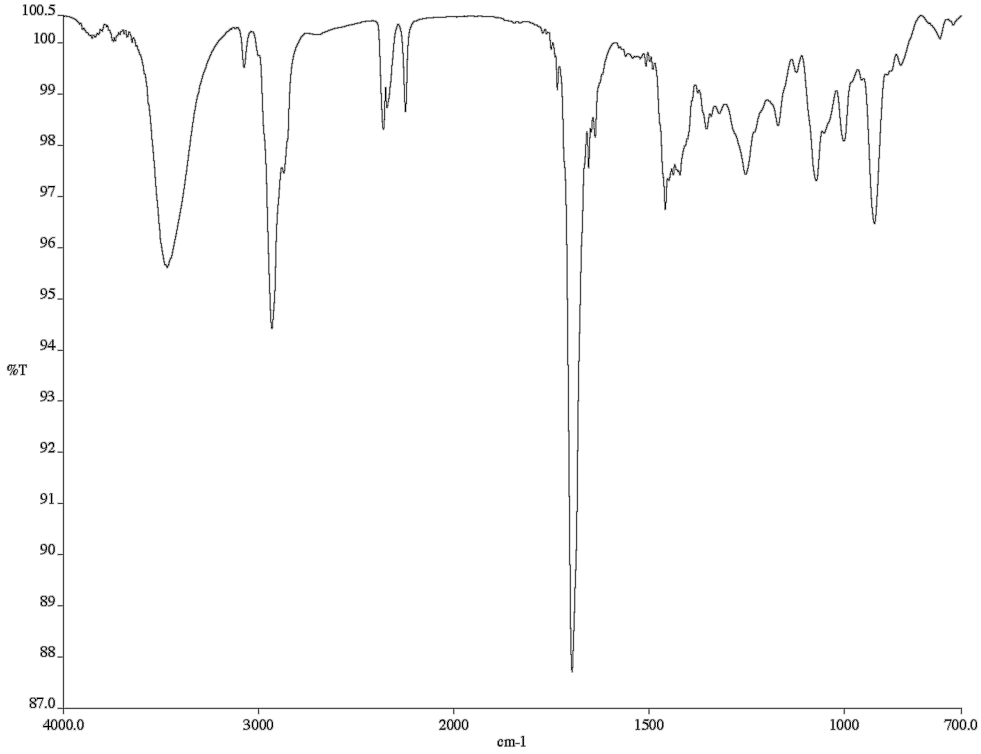


Figure SI-42B. Infrared spectrum (thin film/NaCl) of compound **12h**.

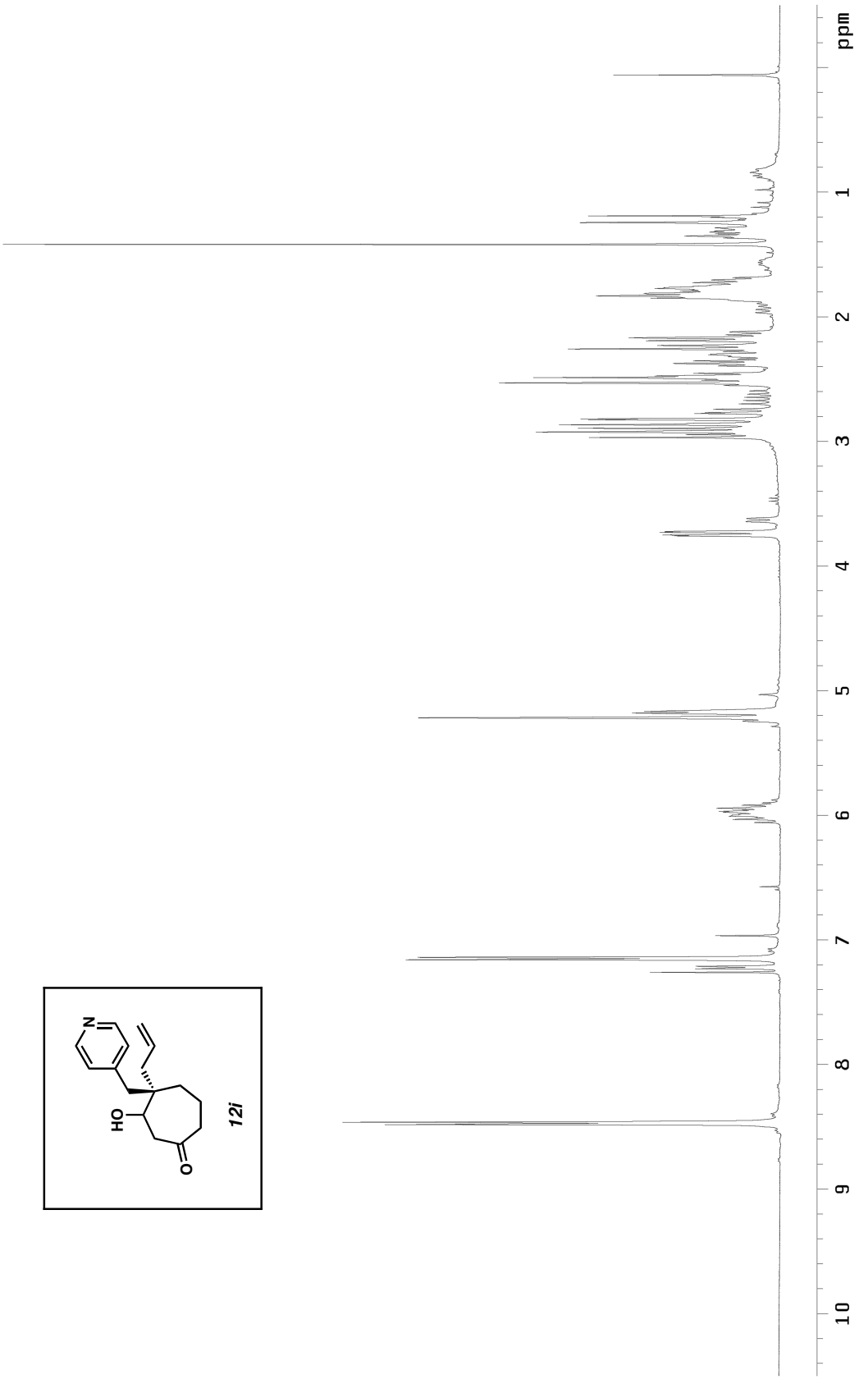


Figure SI-43A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12i**.

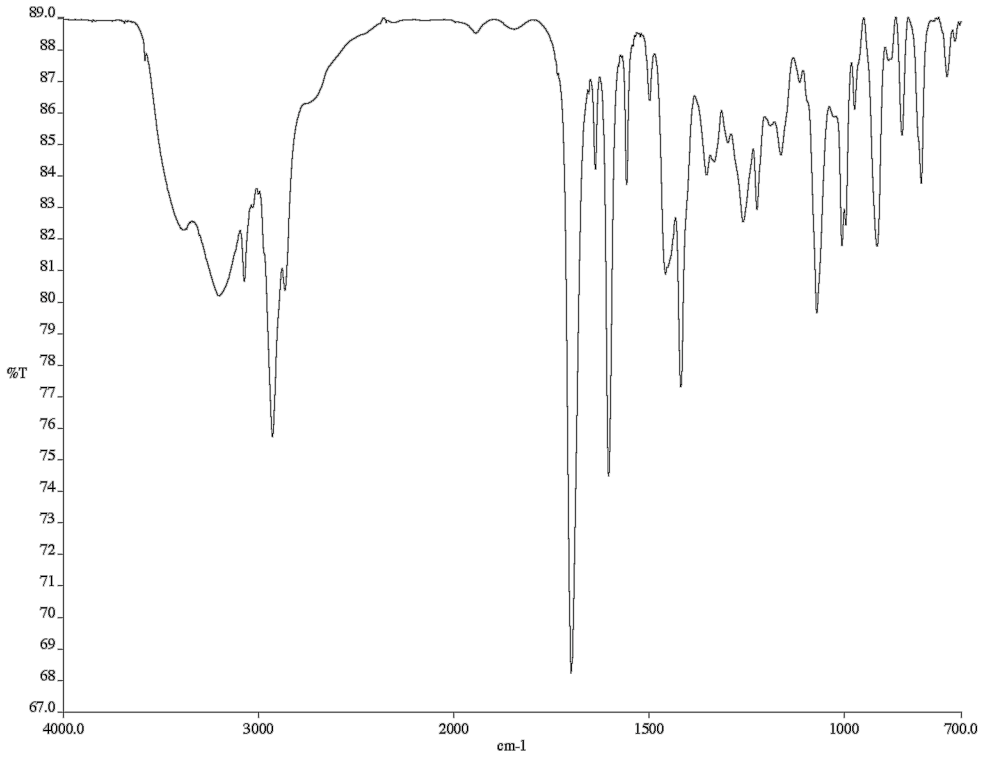


Figure SI-43B. Infrared spectrum (thin film/NaCl) of compound **12i**.

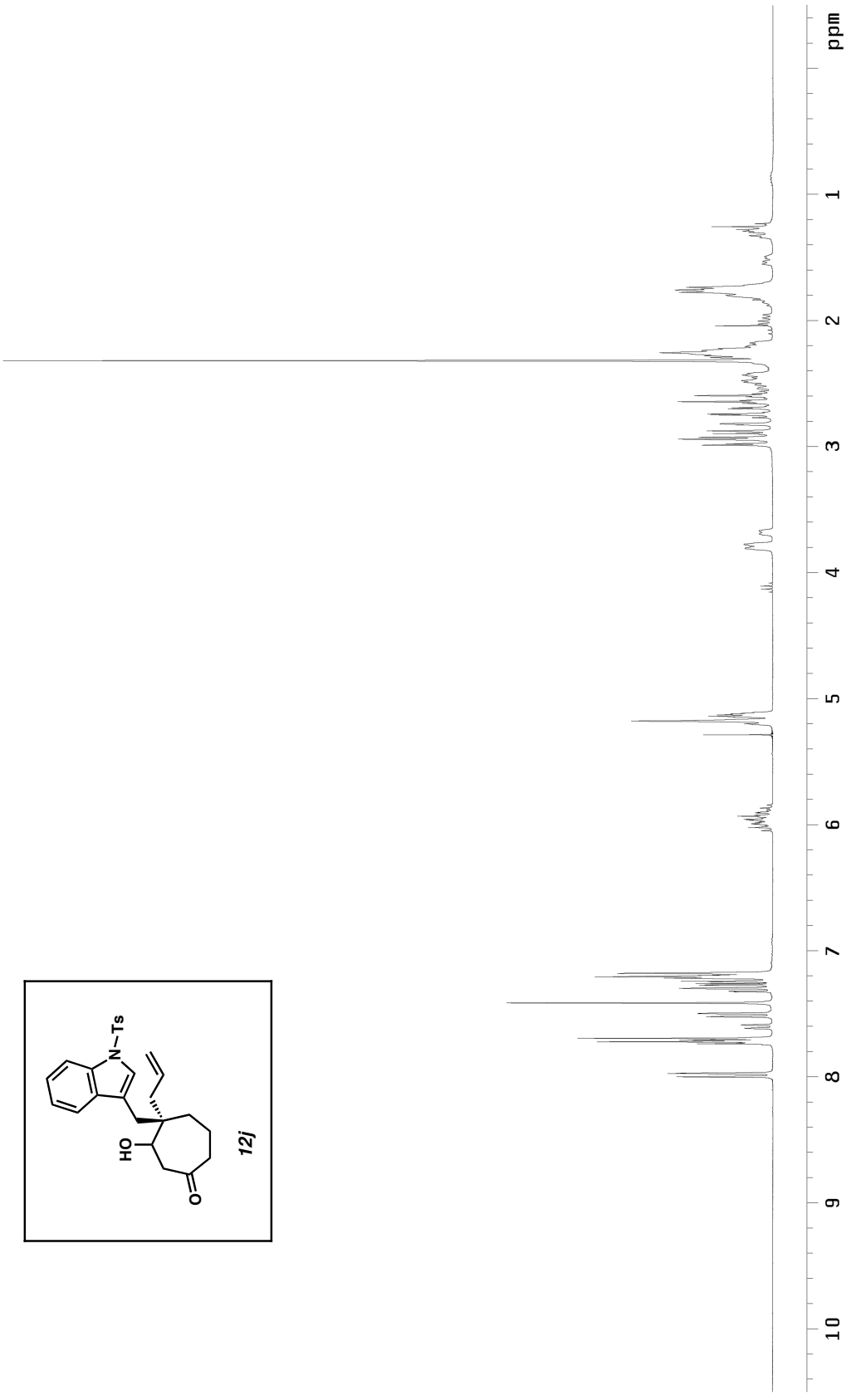


Figure SI-44A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12j**.

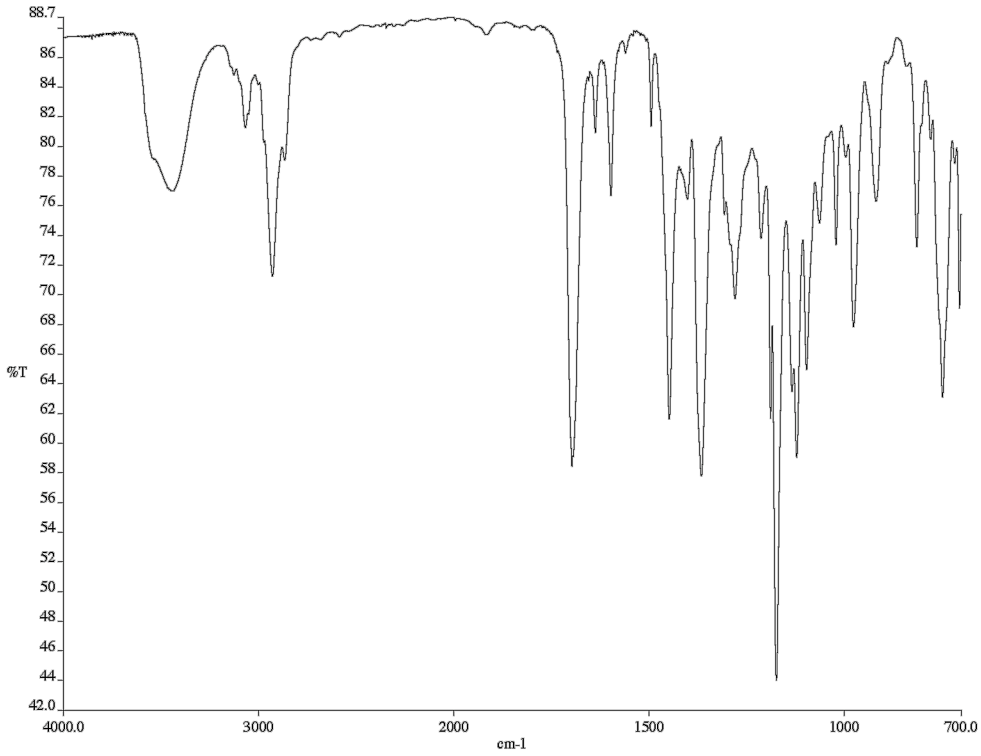


Figure SI-44B. Infrared spectrum (thin film/NaCl) of compound **12j**.

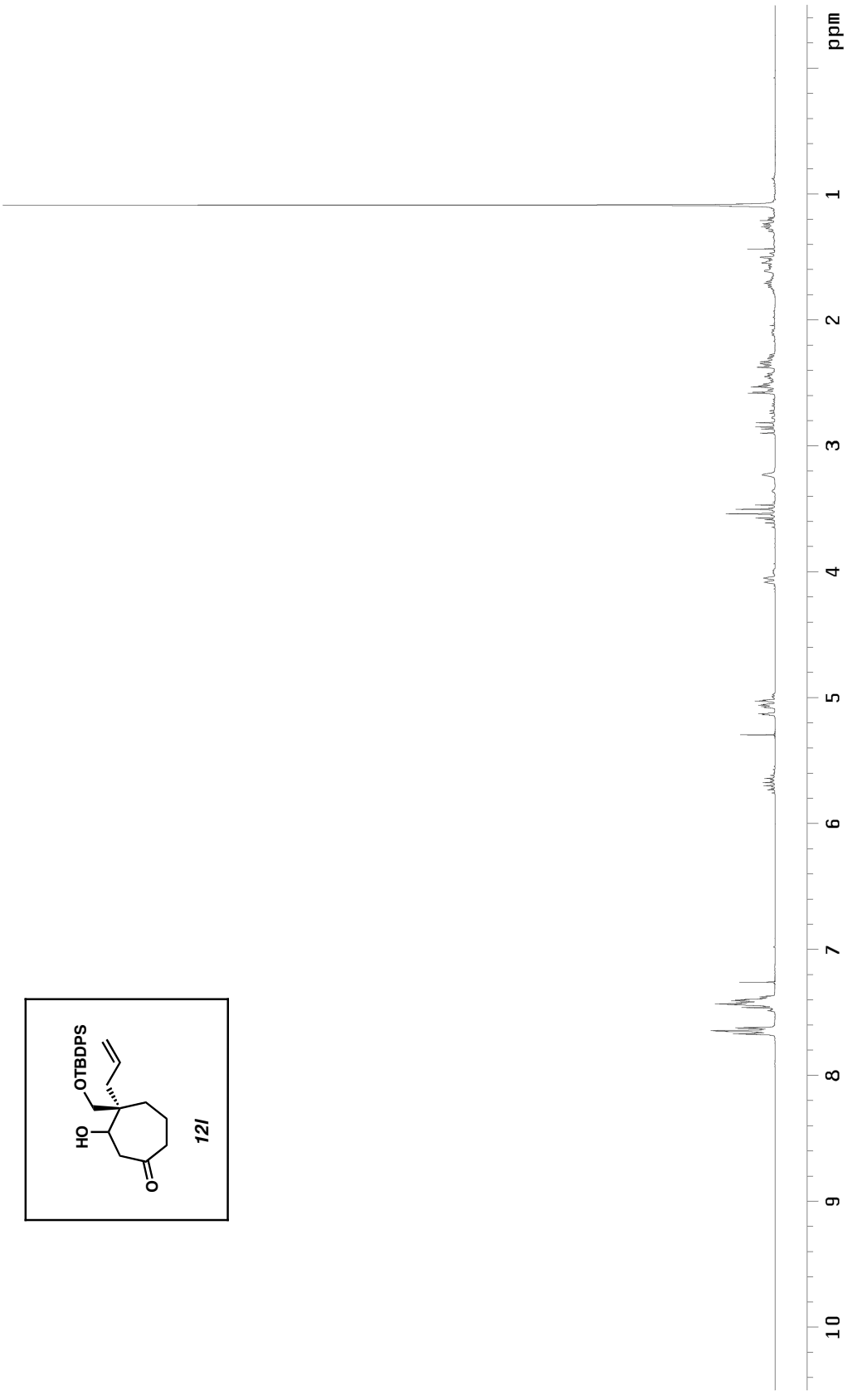


Figure SI-45A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12l**.

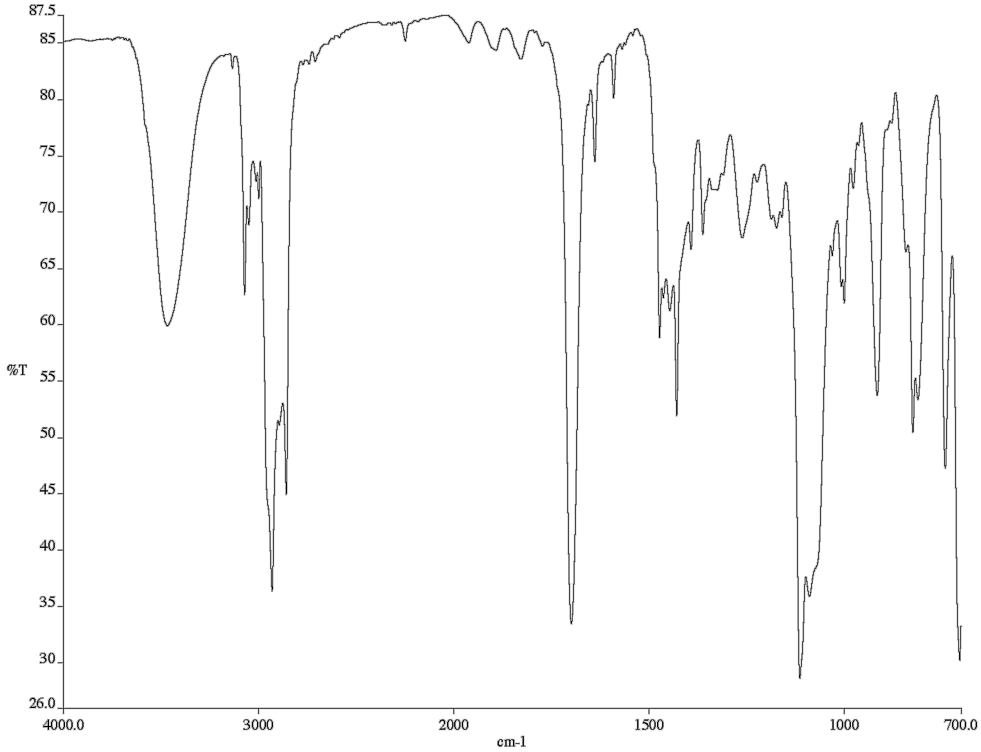


Figure SI-45B. Infrared spectrum (thin film/NaCl) of compound **12l**.

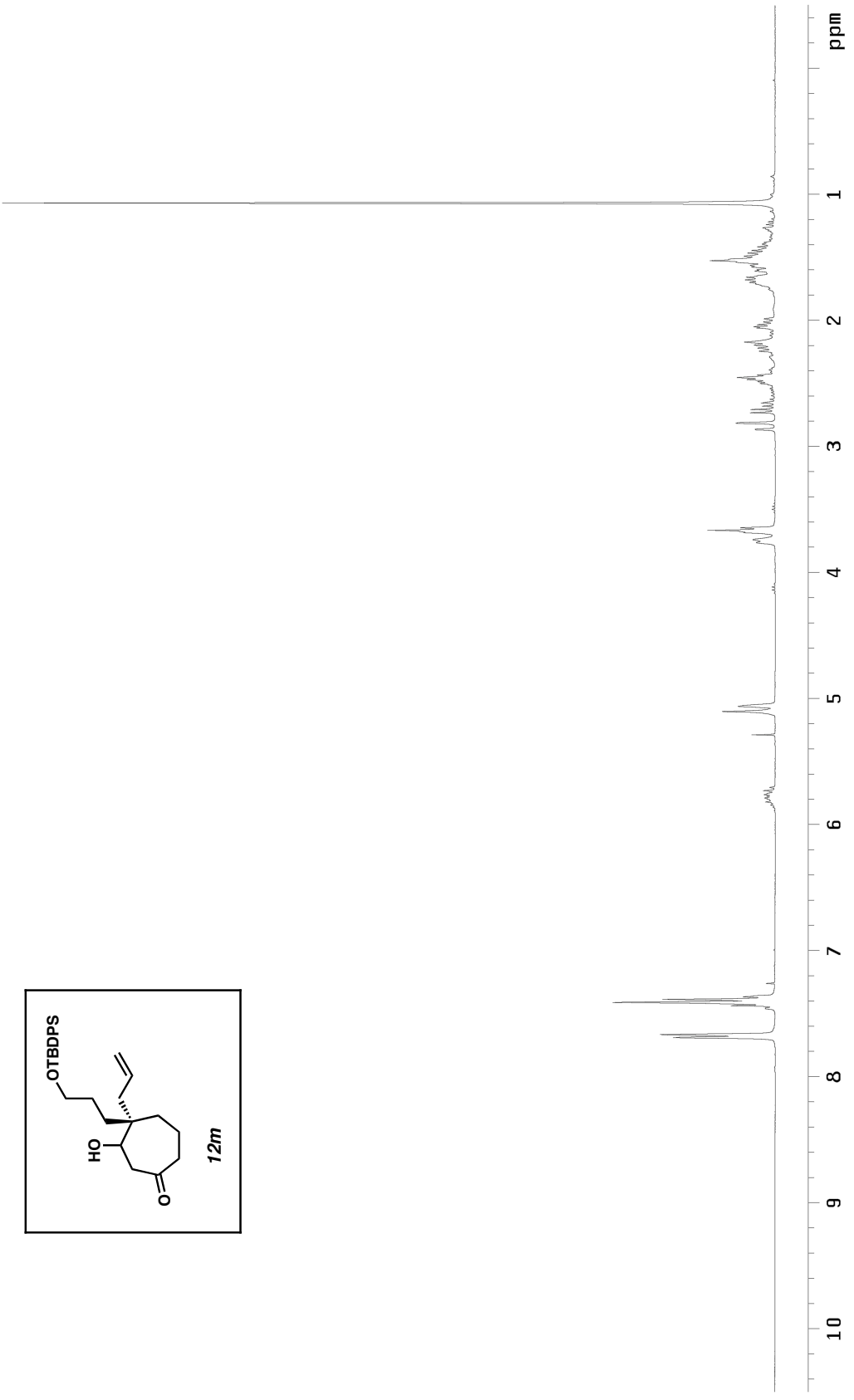


Figure SI-46A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12m**.

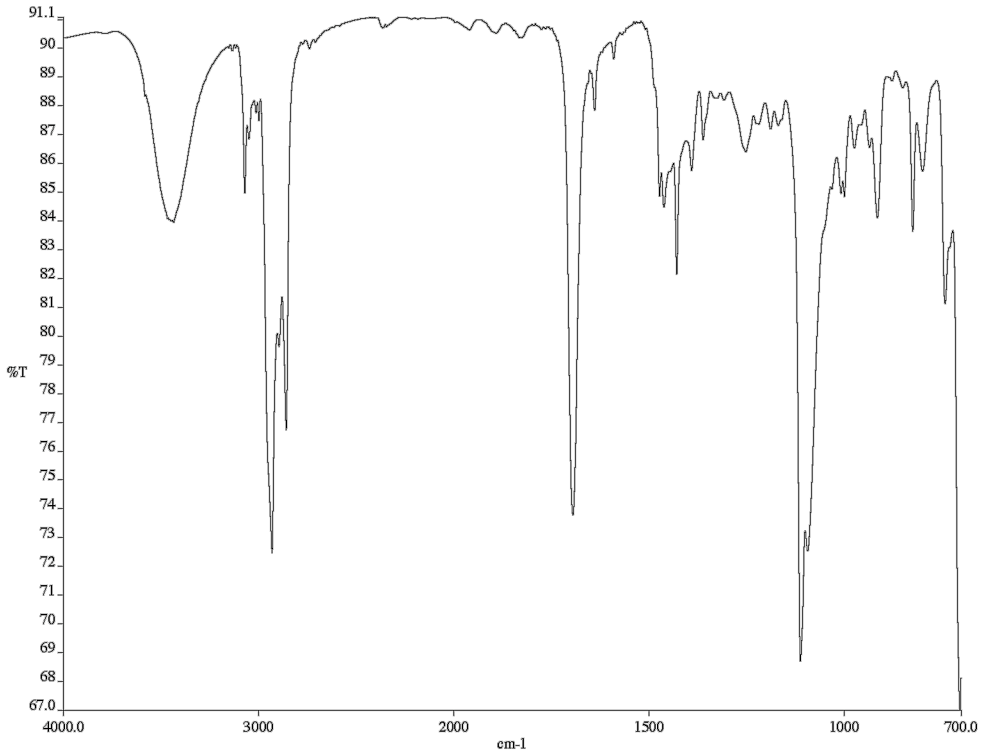


Figure SI-46B. Infrared spectrum (thin film/NaCl) of compound **12m**.

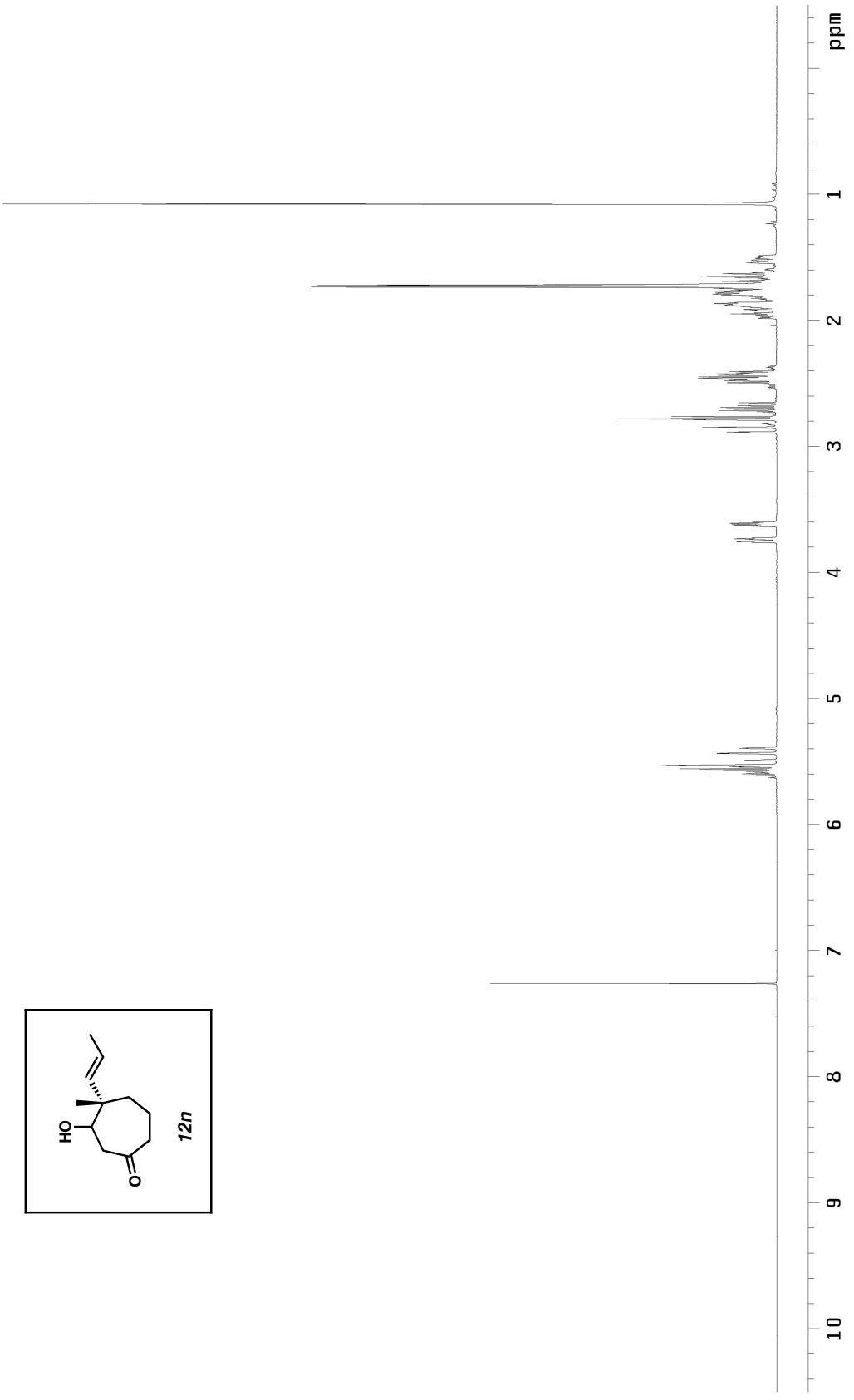


Figure SI-47A. ^{1}H NMR (400 MHz, $CDCl_3$) of compound **12n**.

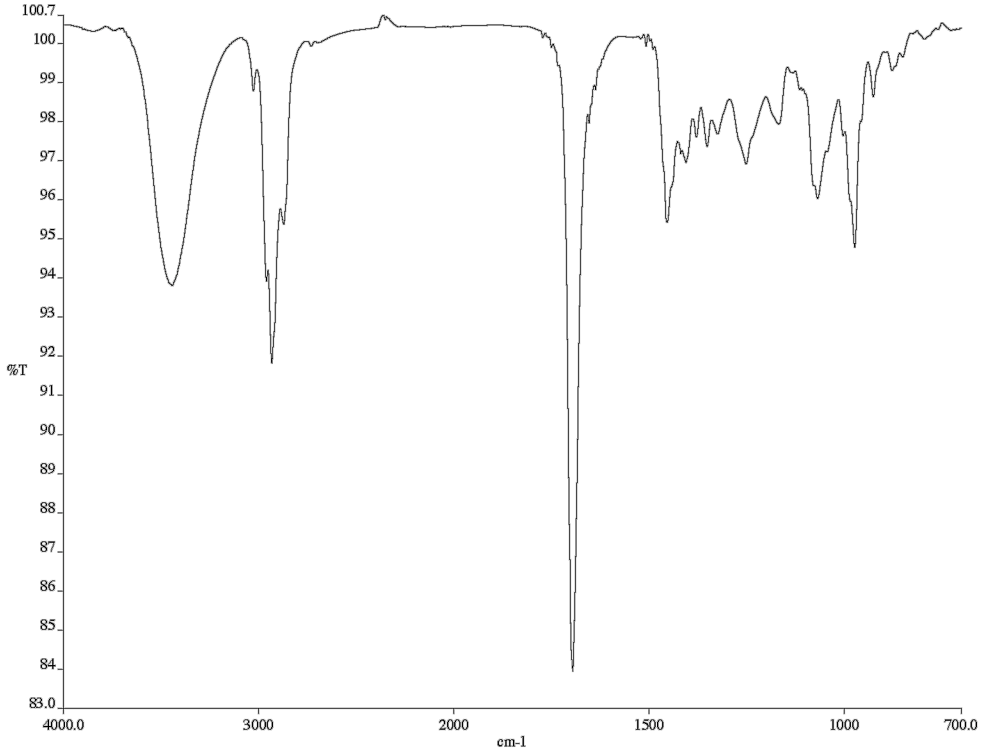


Figure SI-47B. Infrared spectrum (thin film/NaCl) of compound **12n**.

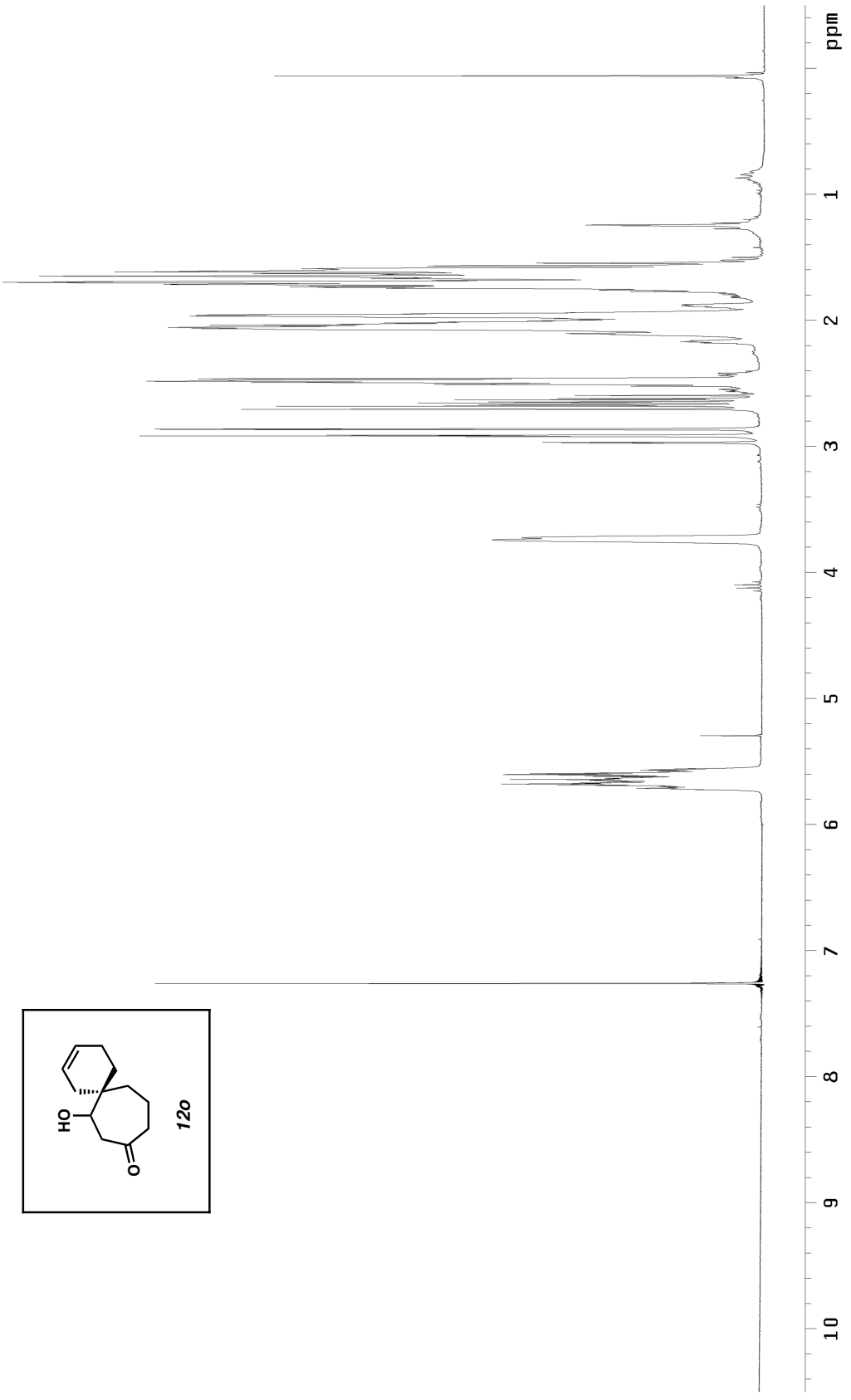


Figure SI-48A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **12o**.

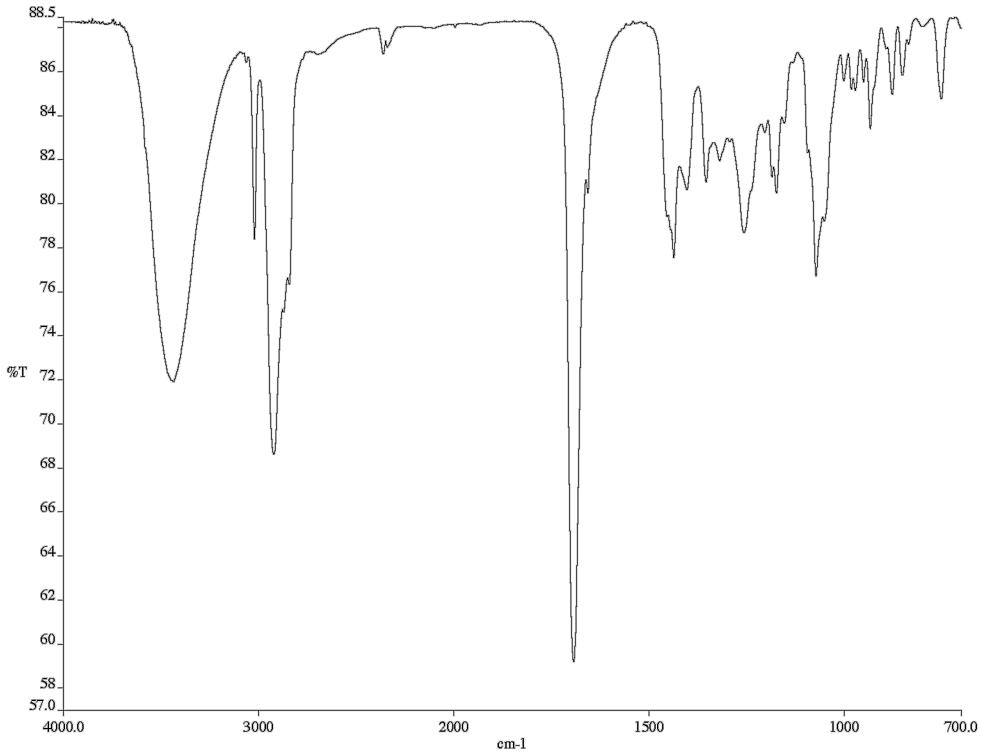


Figure SI-48B. Infrared spectrum (thin film/NaCl) of compound **12o**.

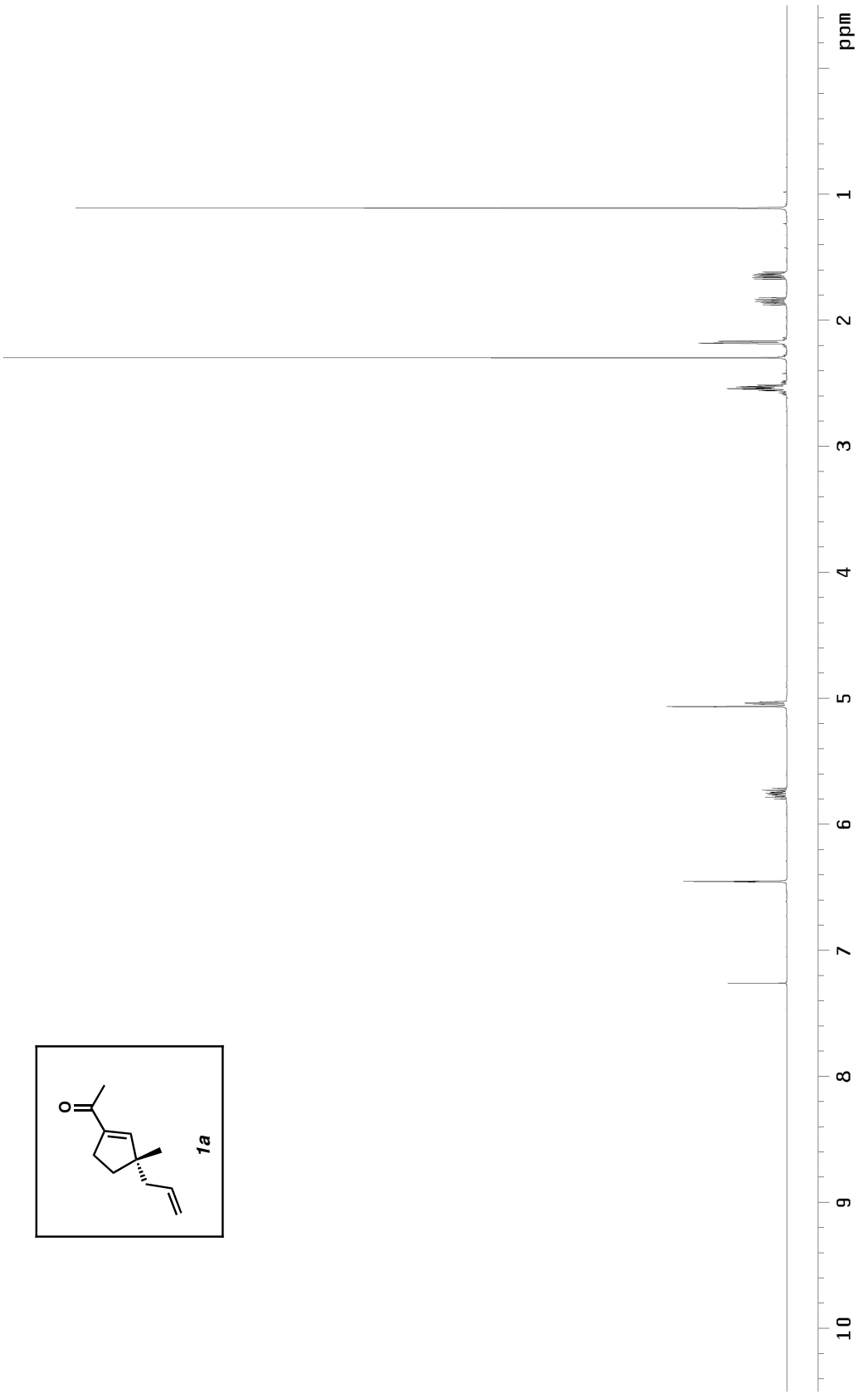


Figure SI-49A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **1a**.

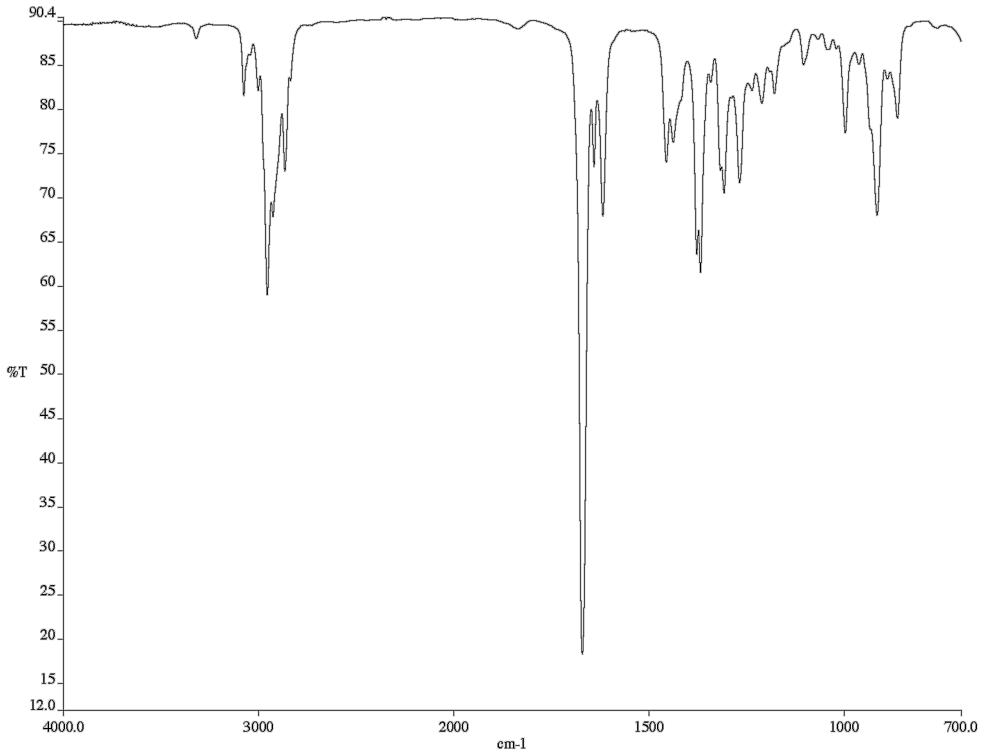


Figure SI-49B. Infrared spectrum (thin film/NaCl) of compound **1a**.

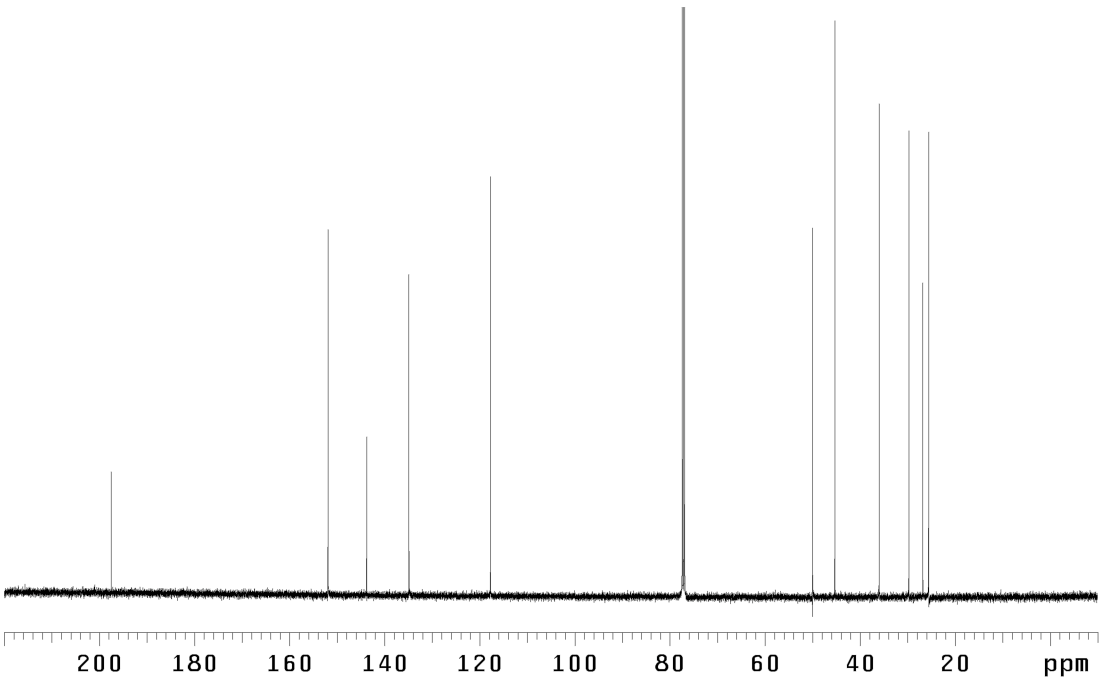


Figure SI-49C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **1a**.

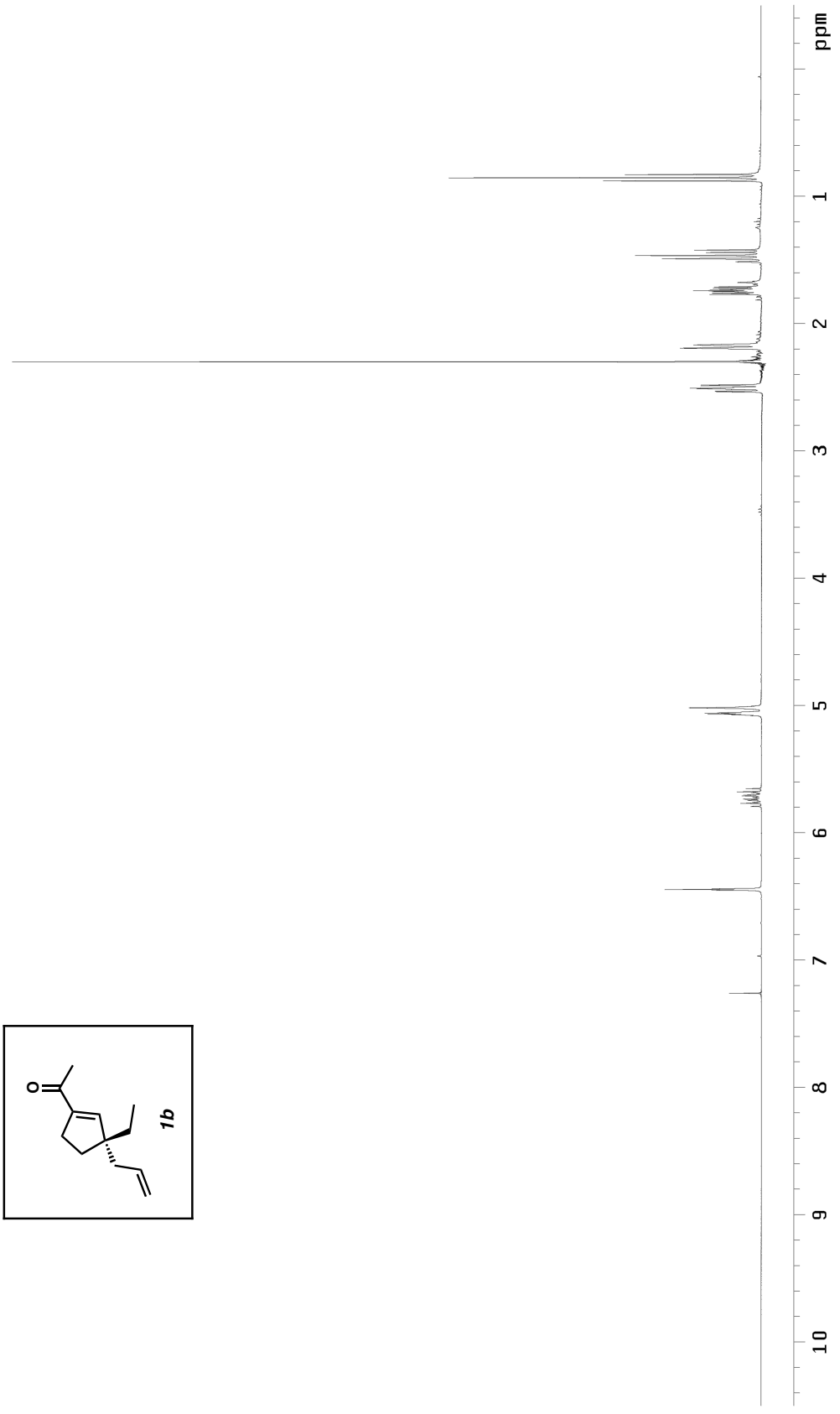


Figure SI-50A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1b**.

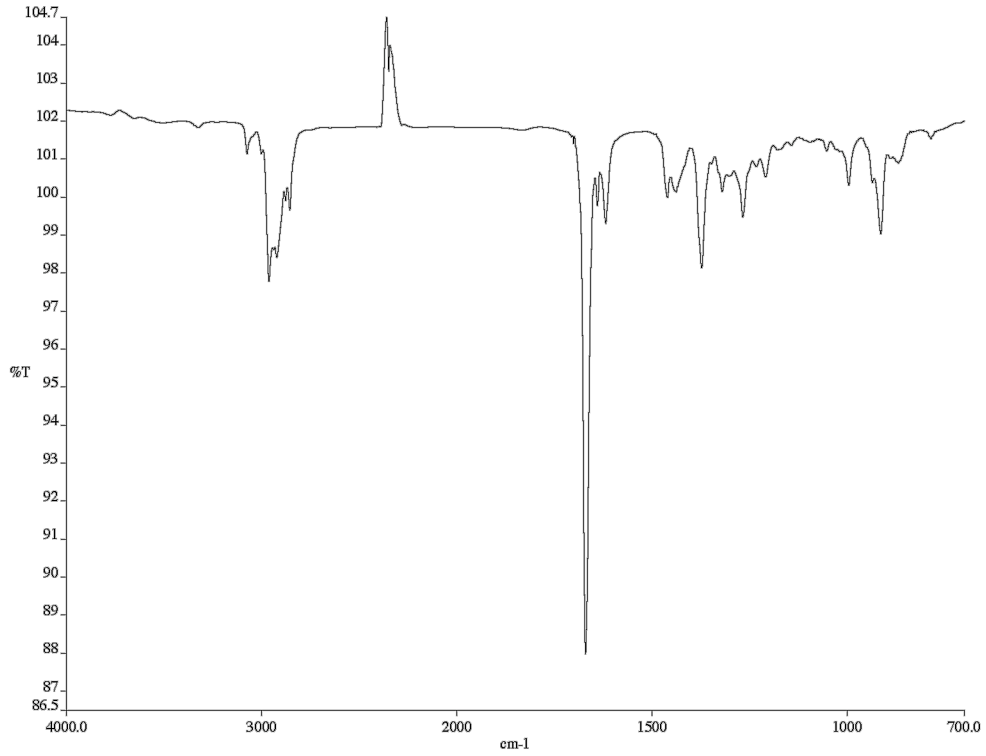


Figure SI-50B. Infrared spectrum (thin film/NaCl) of compound **1b**.

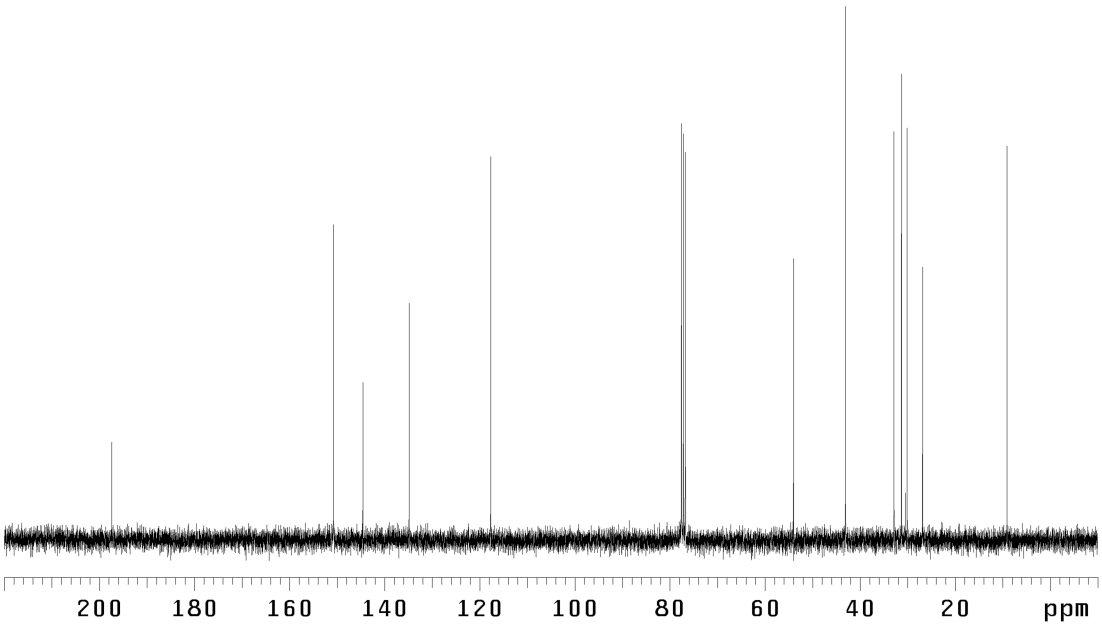


Figure SI-50C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1b**.

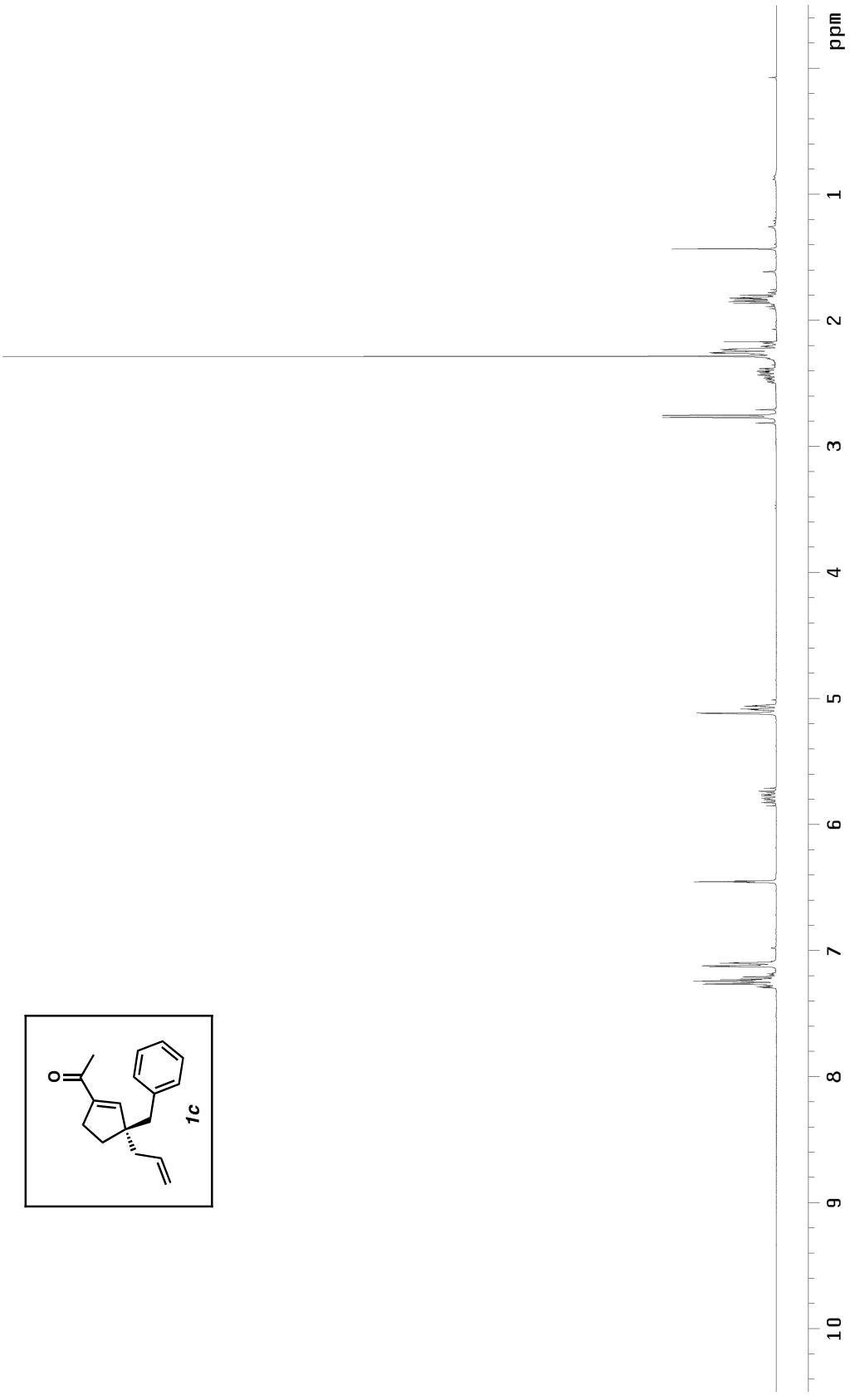


Figure SI-51A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1c**.

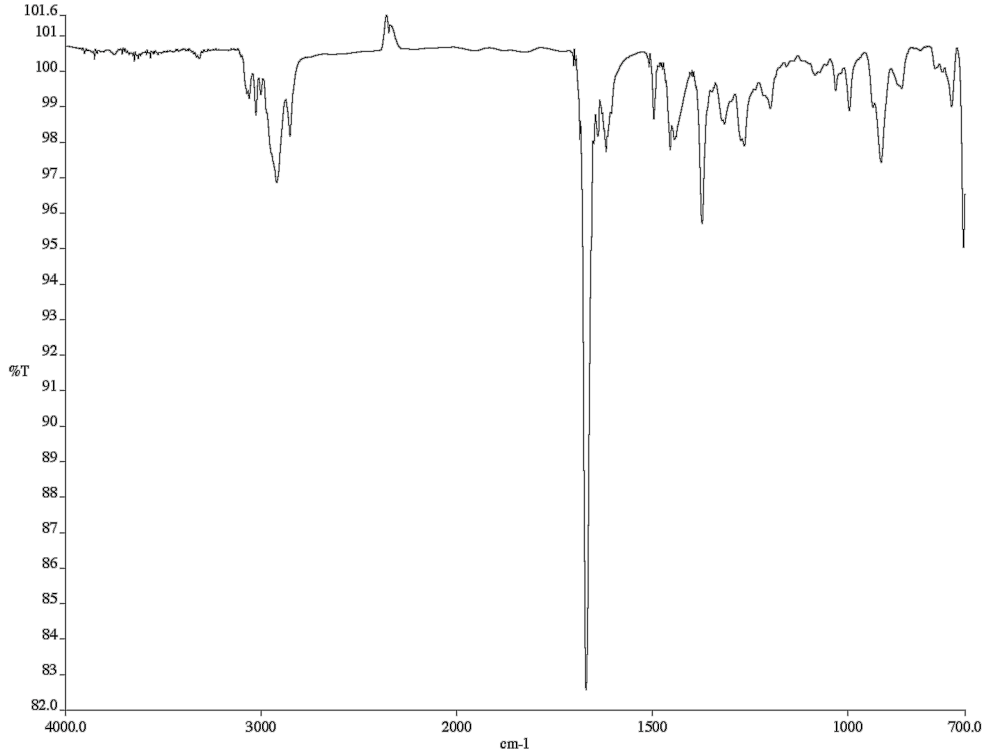


Figure SI-51B. Infrared spectrum (thin film/NaCl) of compound **1c**.

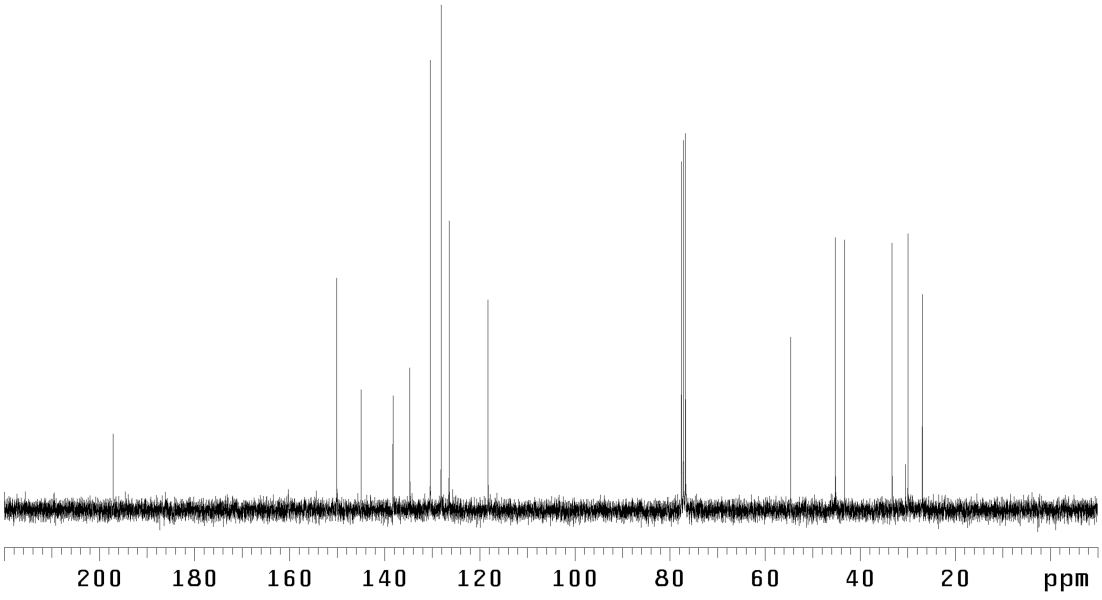


Figure SI-51C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1c**.

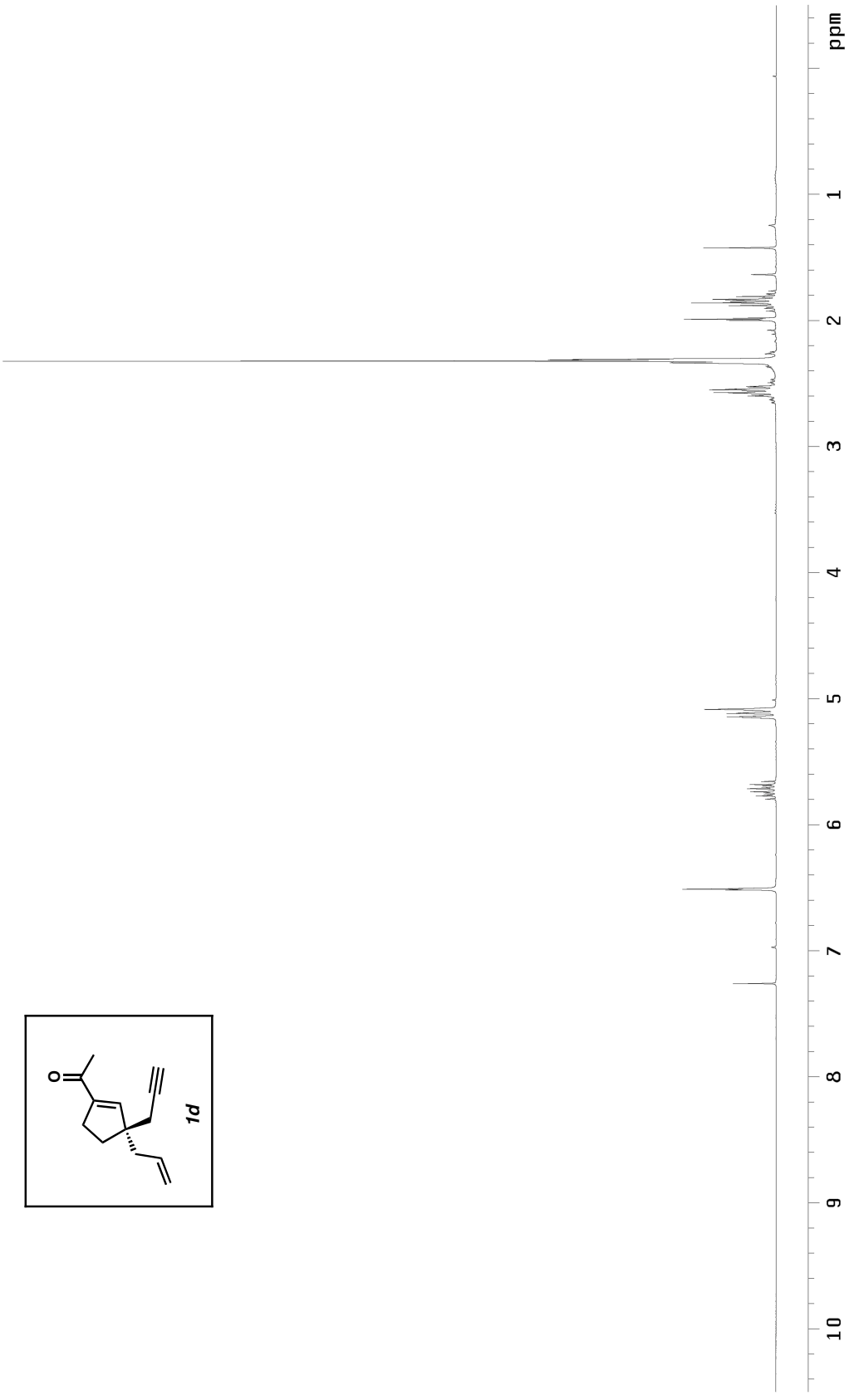


Figure SI-52A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1d**.

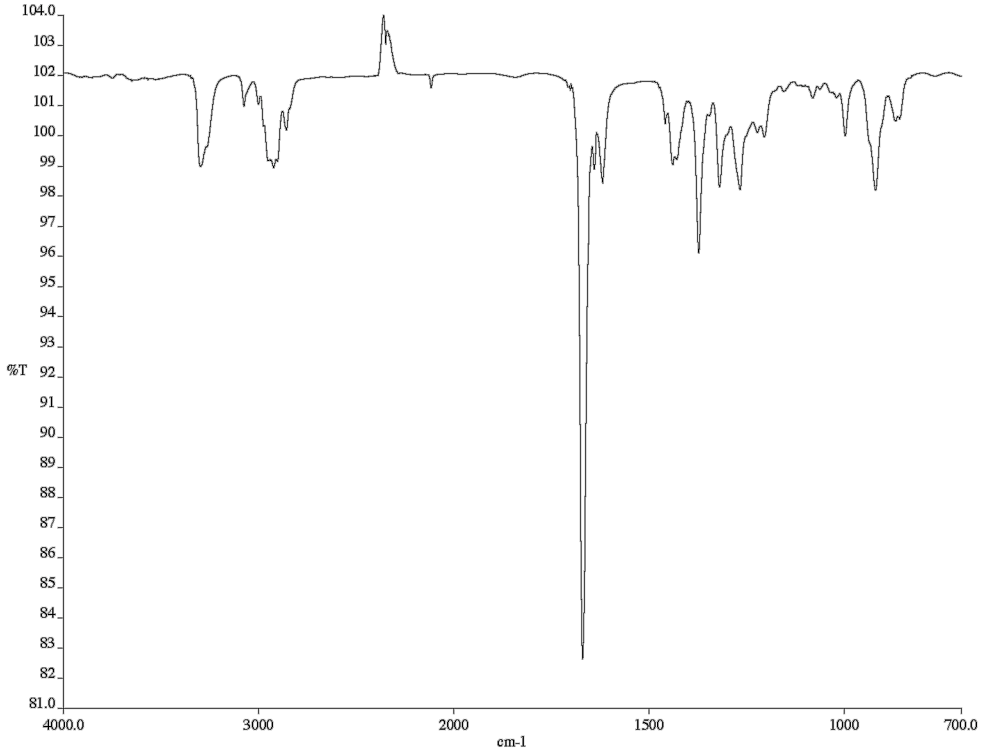


Figure SI-52B. Infrared spectrum (thin film/NaCl) of compound **1d**.

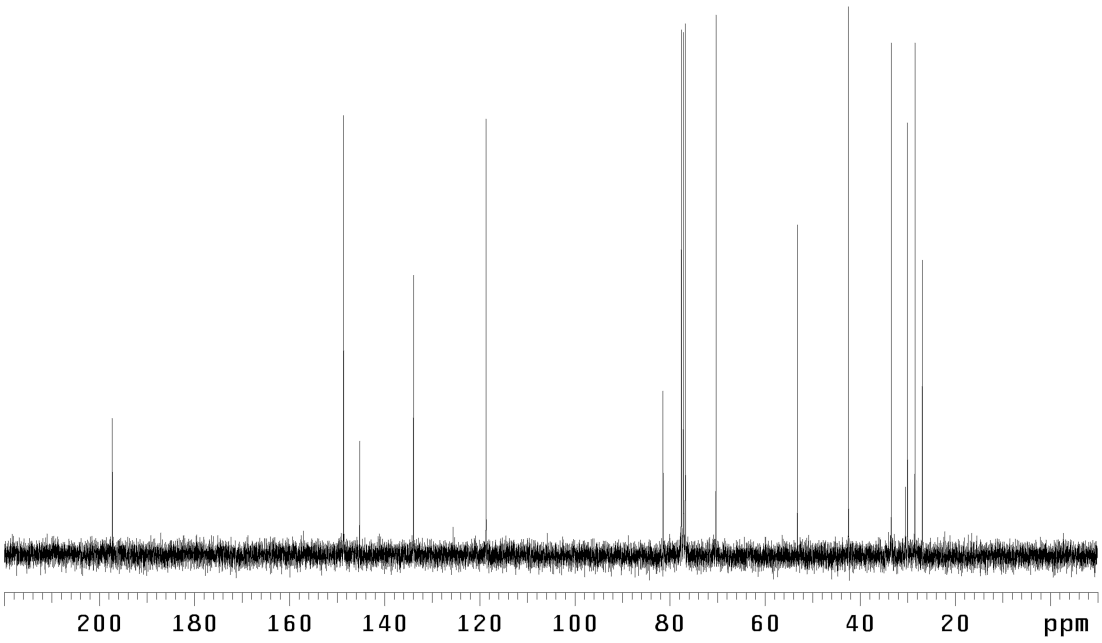


Figure SI-52C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1d**.

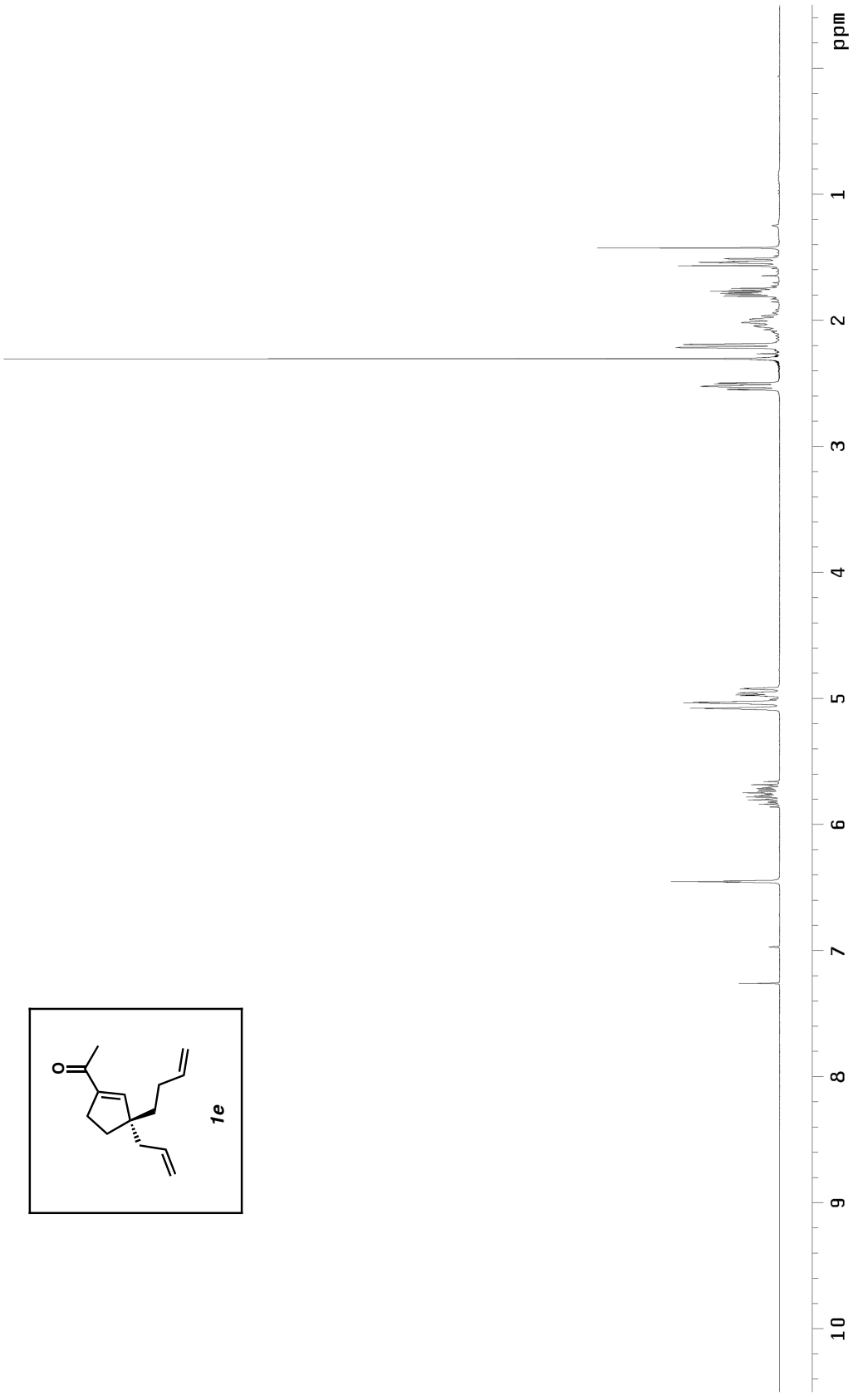


Figure SI-53A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1e**.

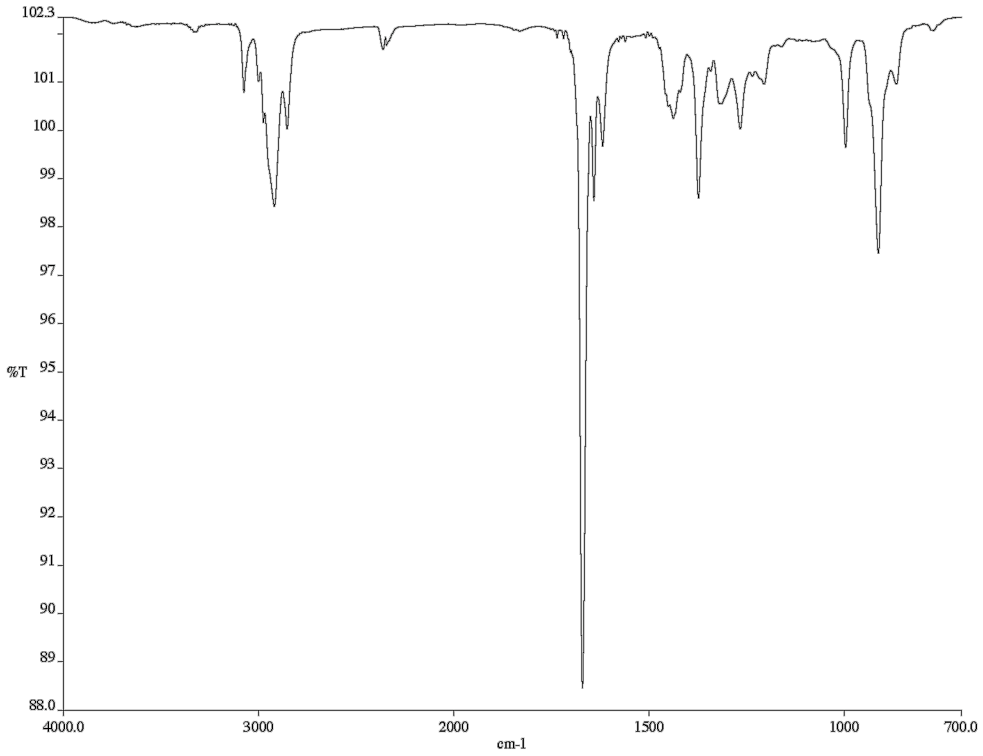


Figure SI-53B. Infrared spectrum (thin film/NaCl) of compound **1e**.

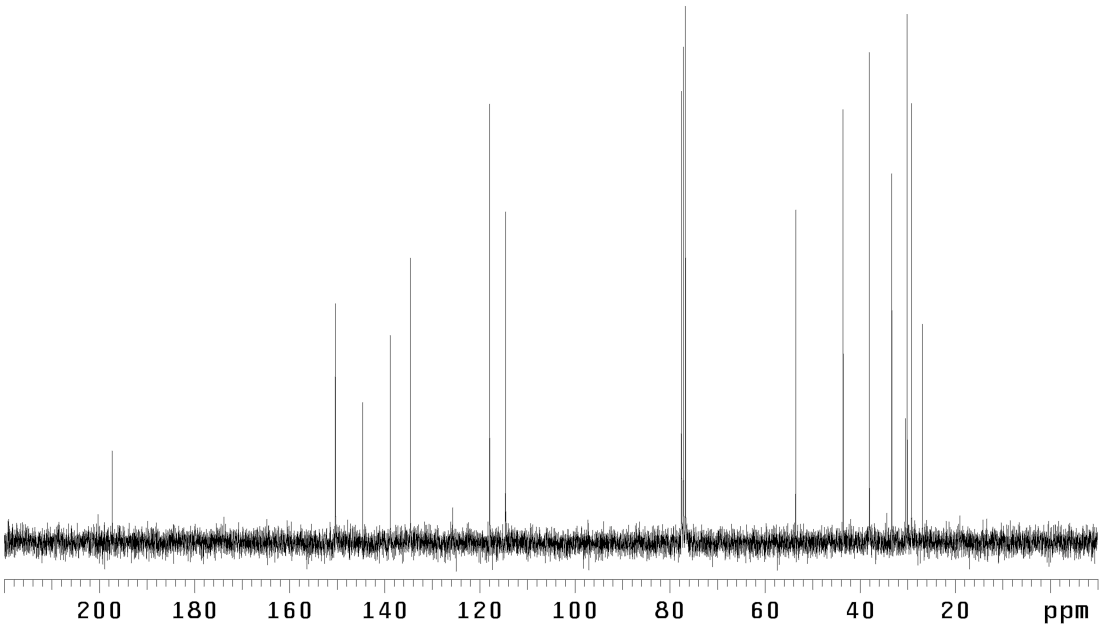


Figure SI-53C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1e**.

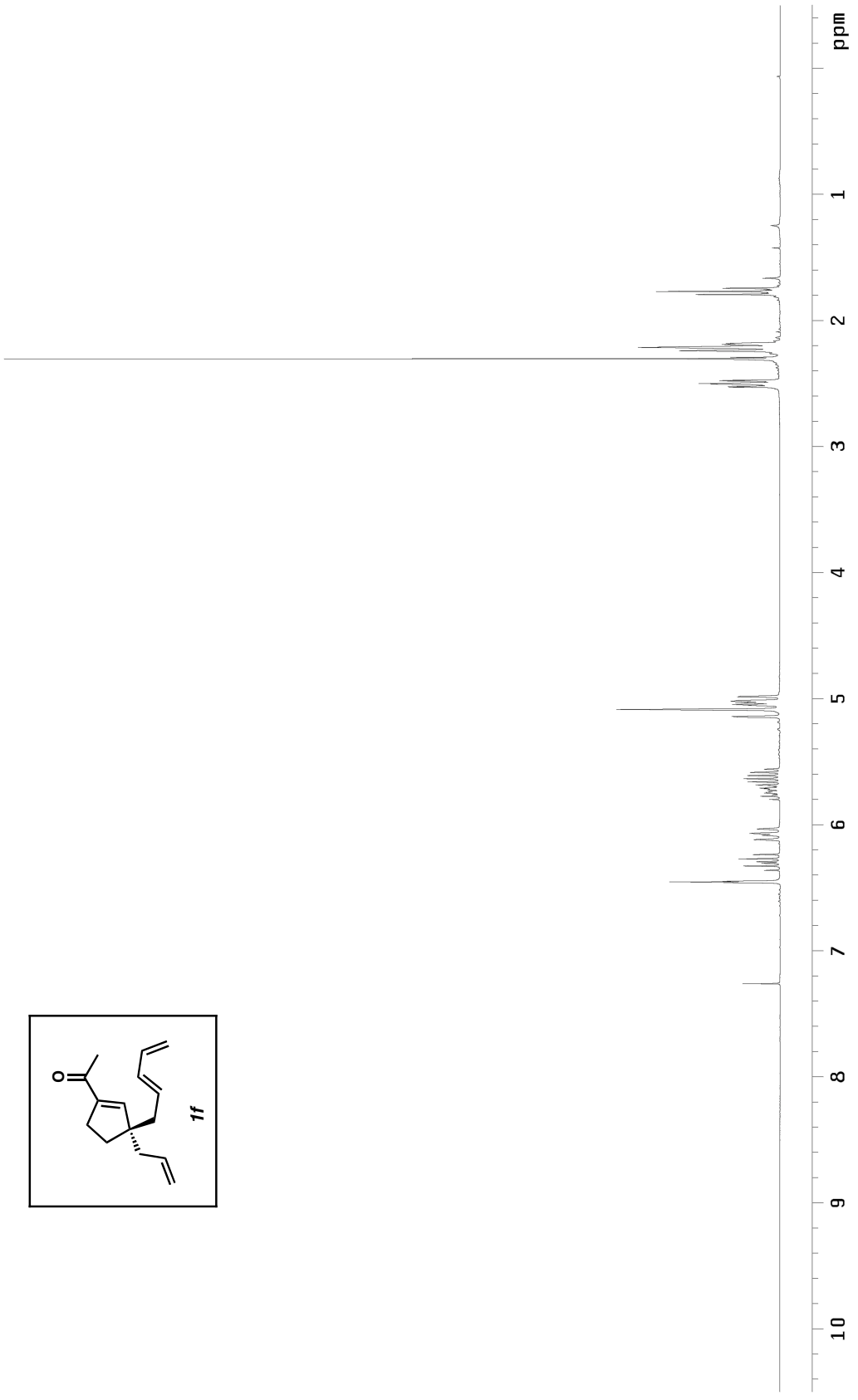


Figure SI-54A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1f**.

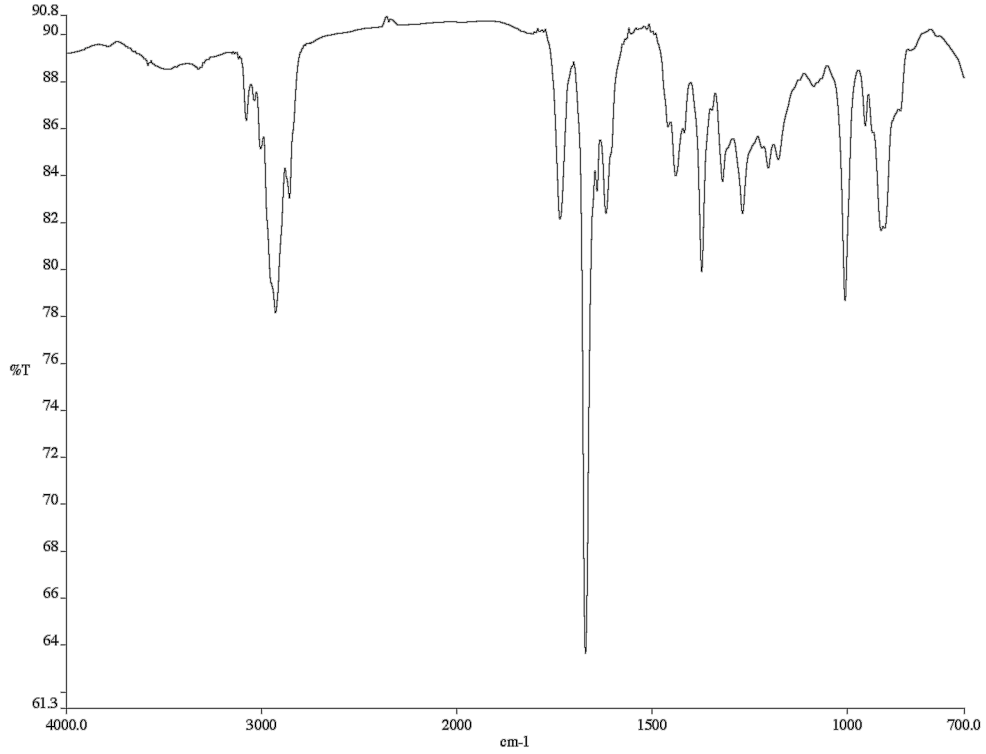


Figure SI-54B. Infrared spectrum (thin film/NaCl) of compound **1f**.

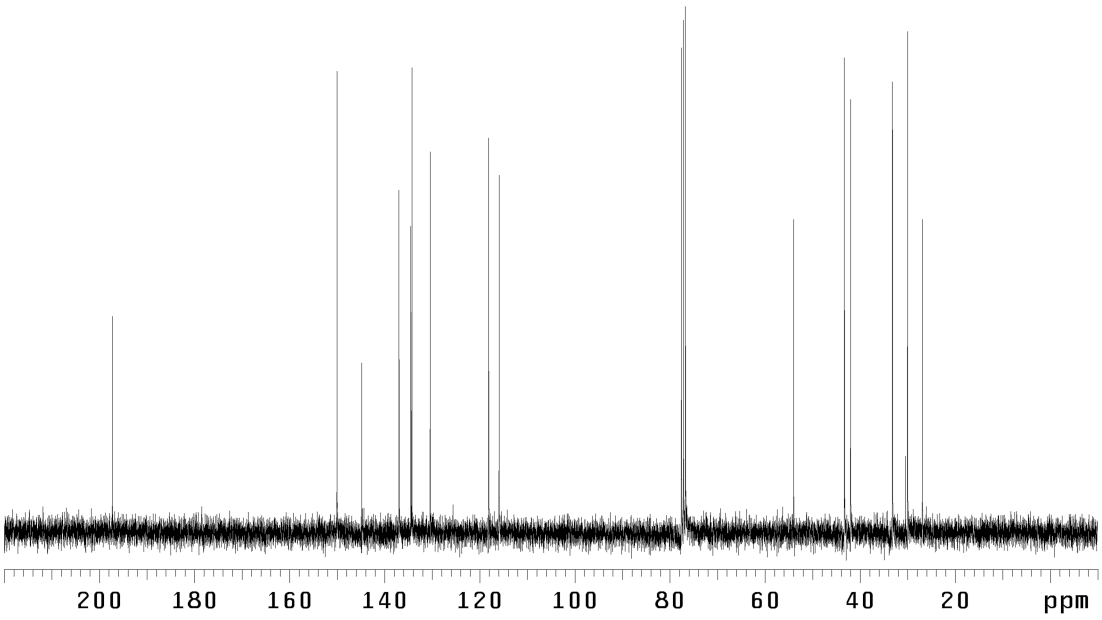


Figure SI-54C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1f**.

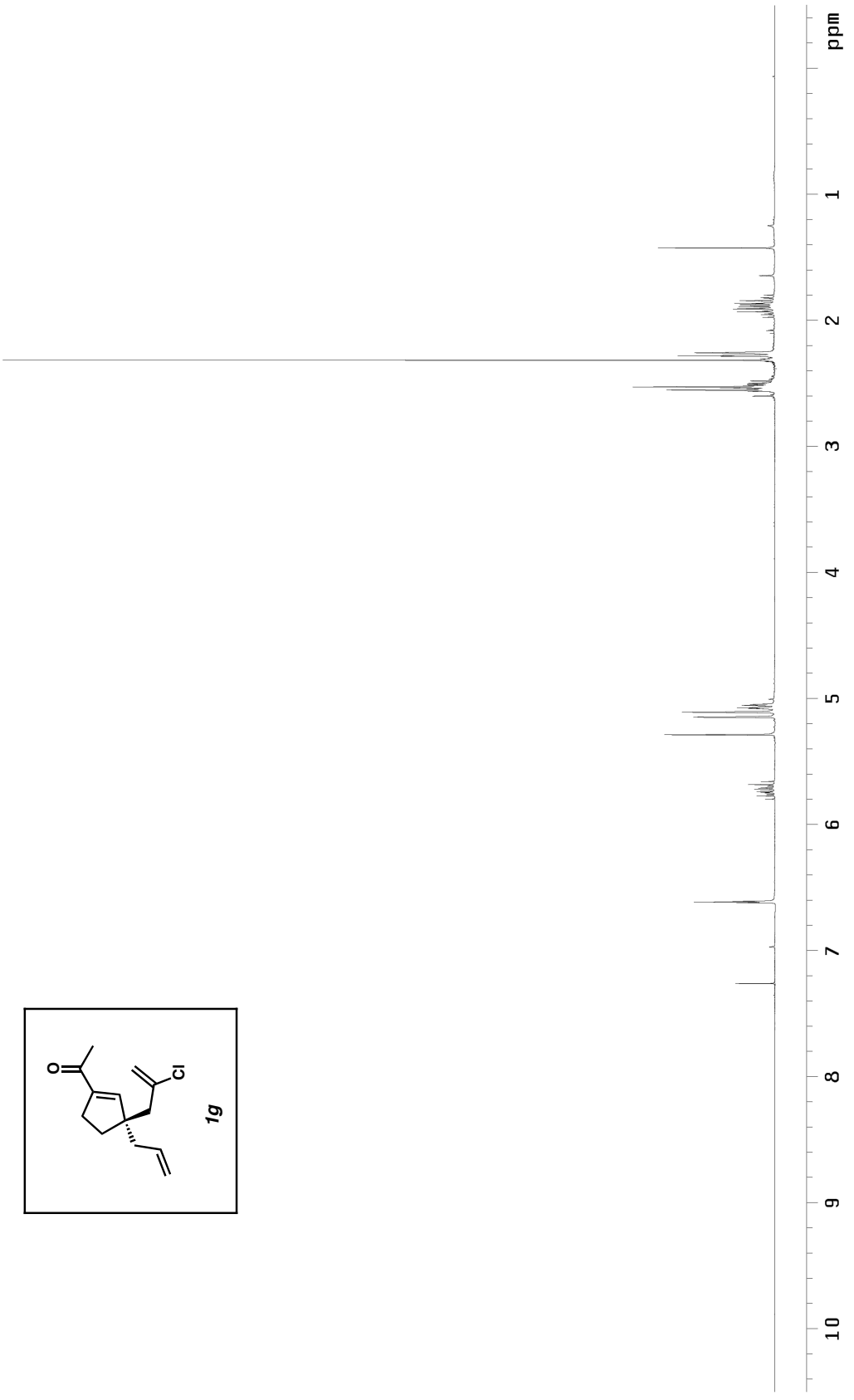


Figure SI-55A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1g**.

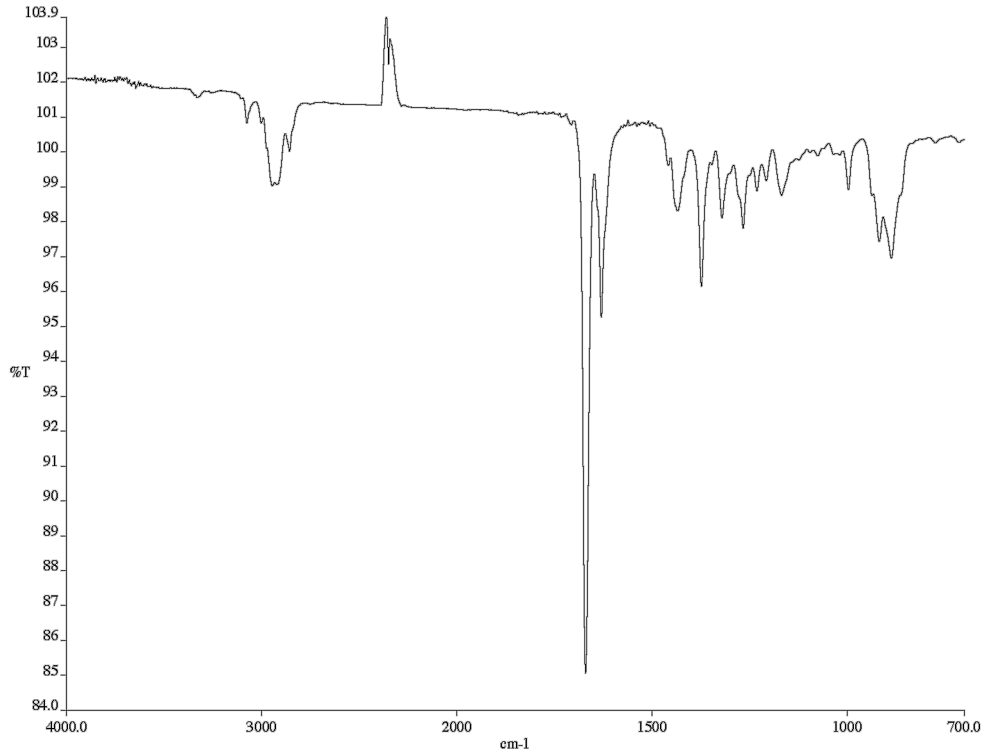


Figure SI-55B. Infrared spectrum (thin film/NaCl) of compound **1g**.

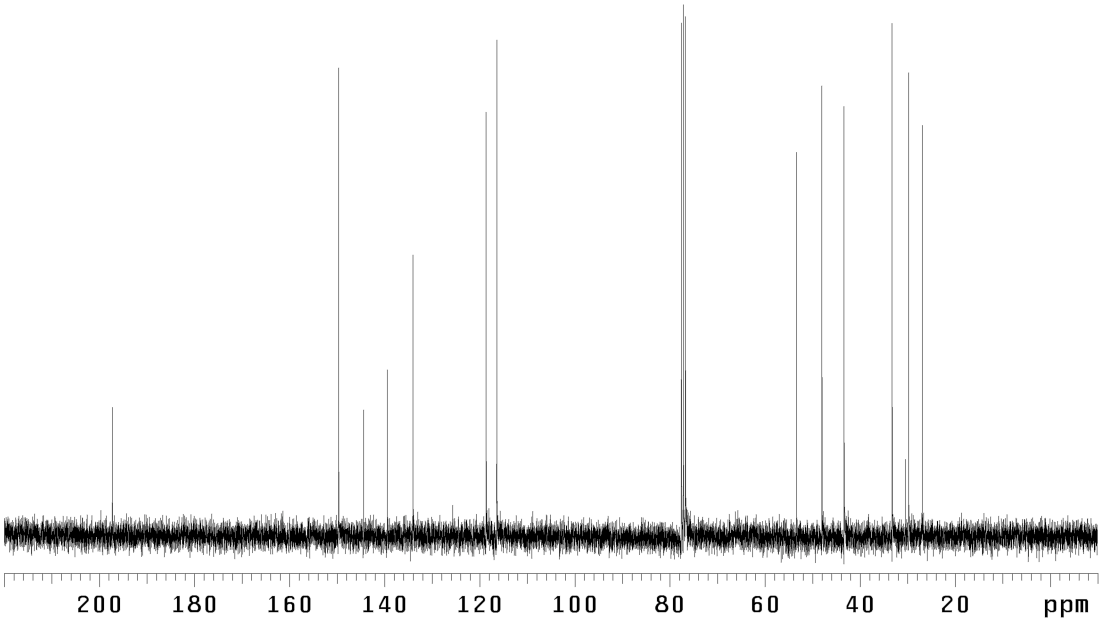


Figure SI-55C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1g**.

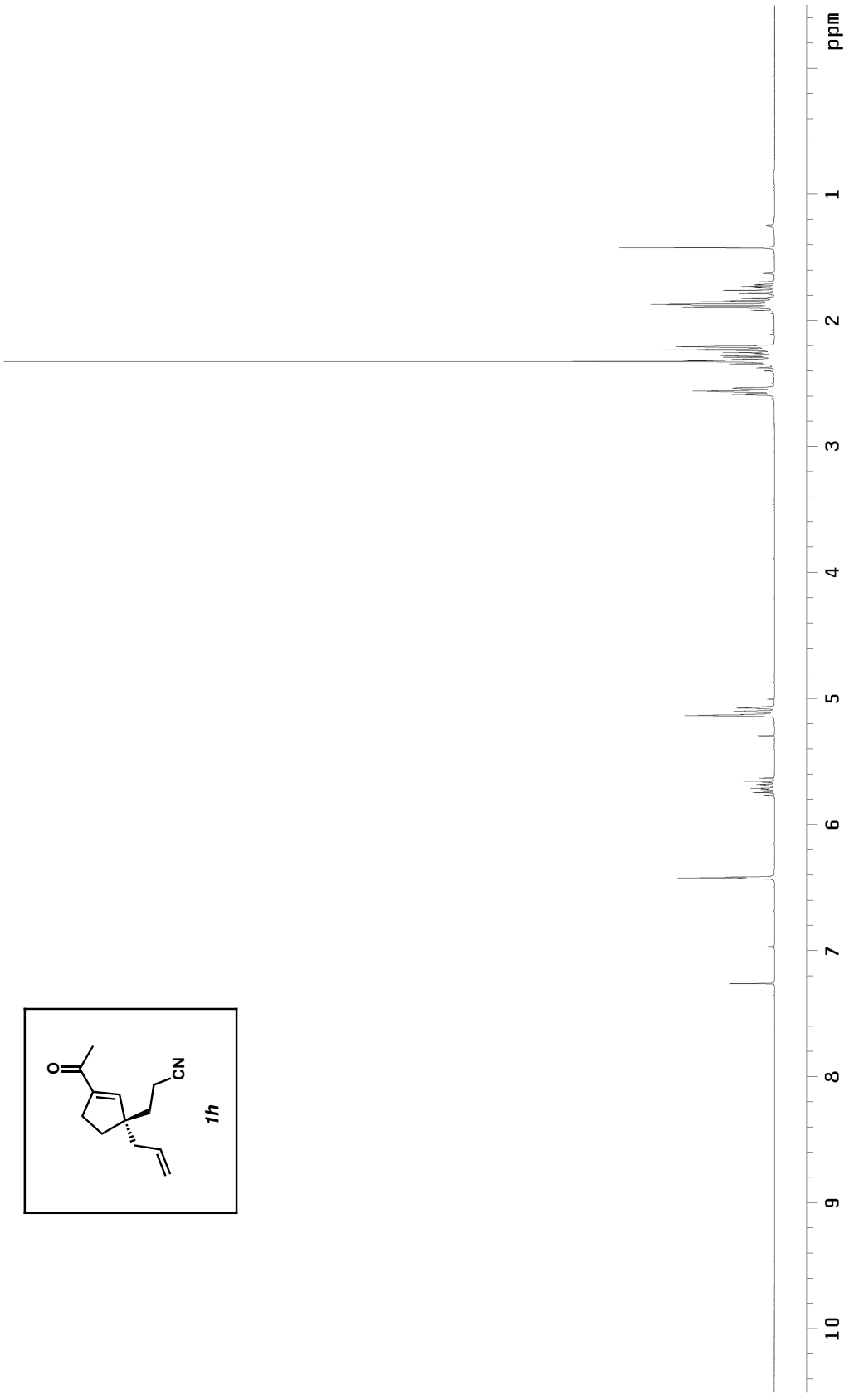


Figure SI-56A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1h**.

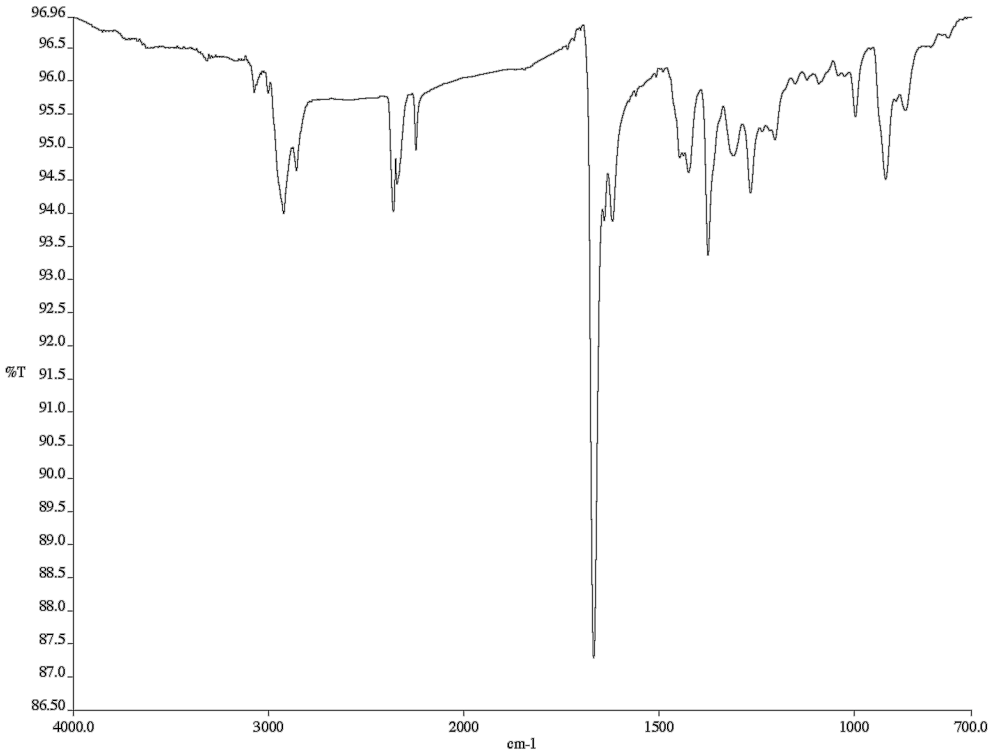


Figure SI-56B. Infrared spectrum (thin film/NaCl) of compound **1h**.

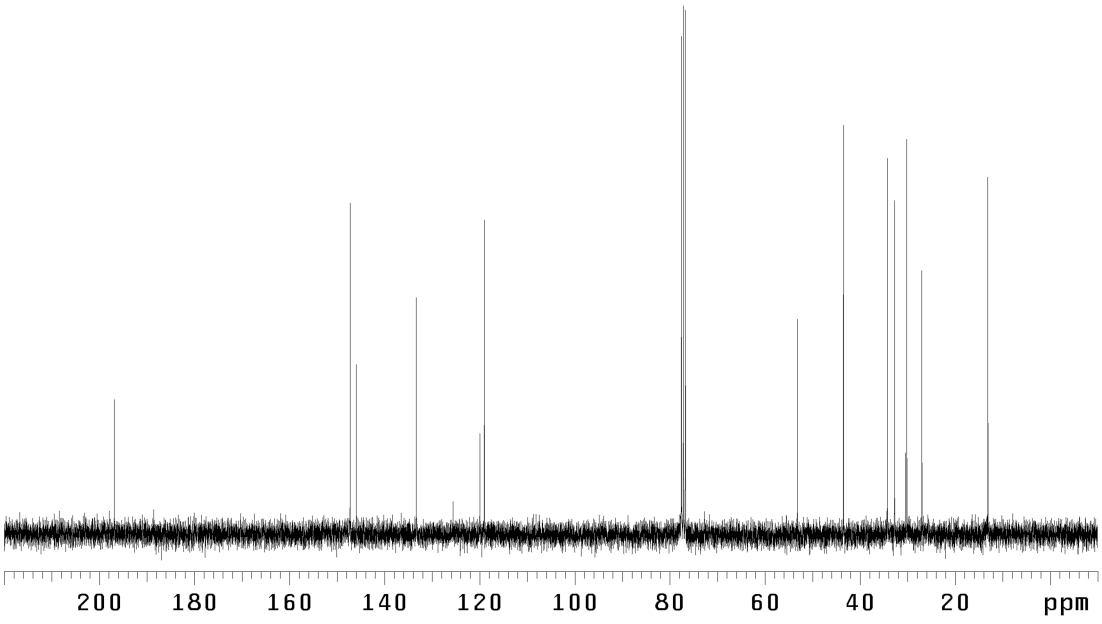


Figure SI-56C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1h**.

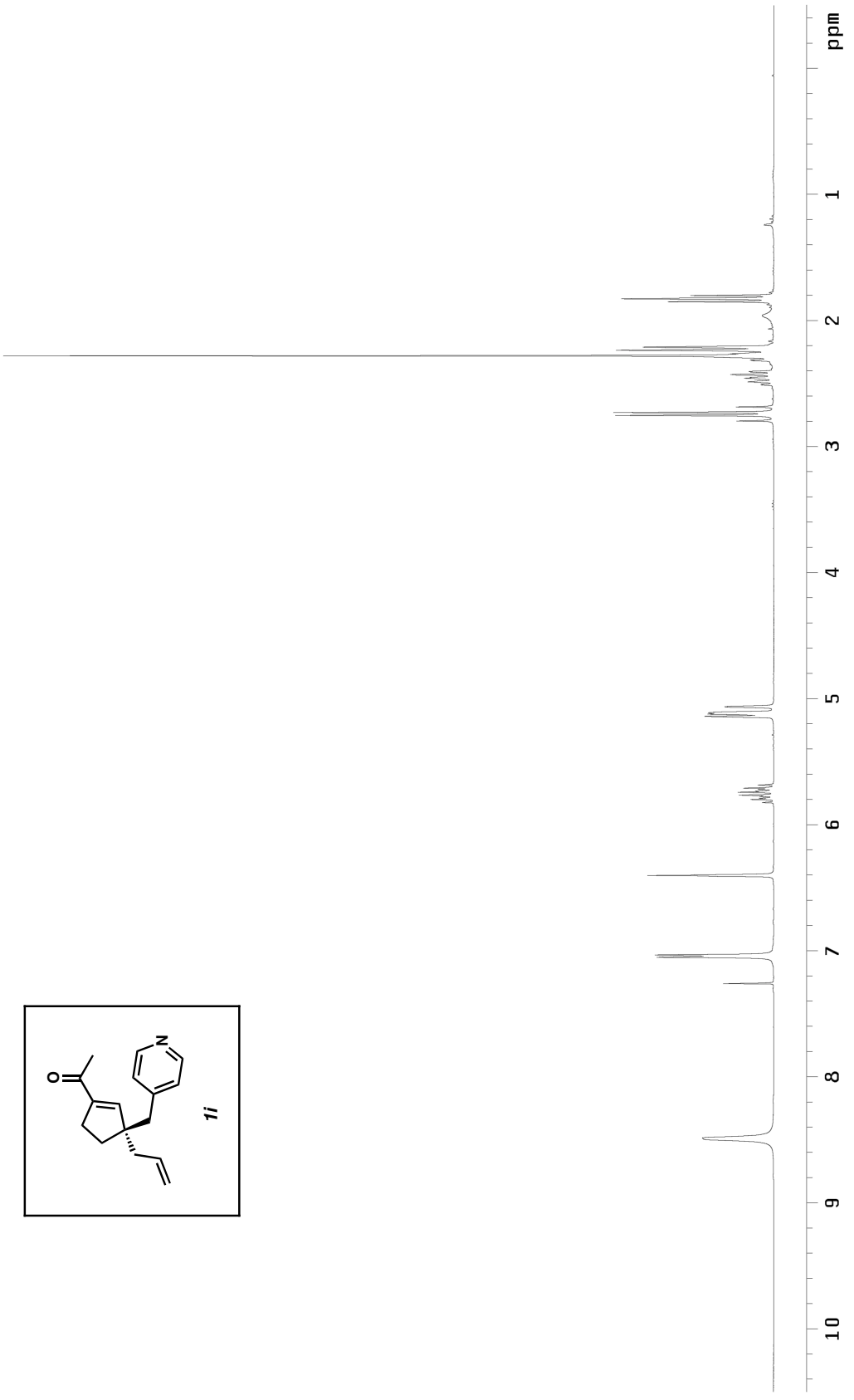


Figure SI-57A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1i**.

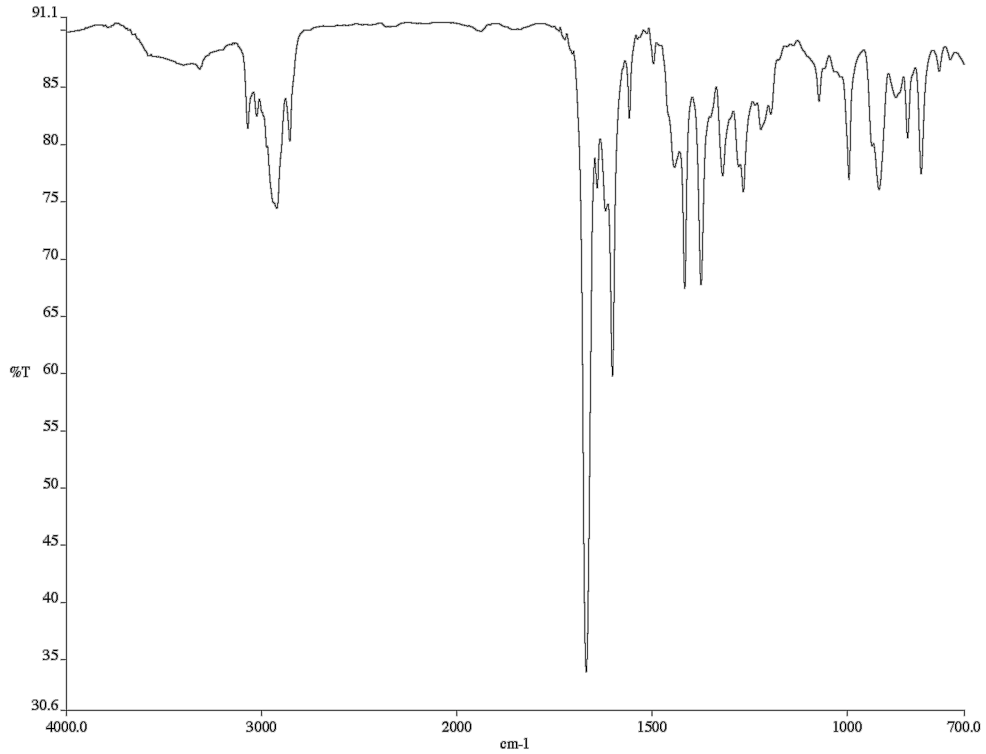


Figure SI-57B. Infrared spectrum (thin film/NaCl) of compound **1i**.

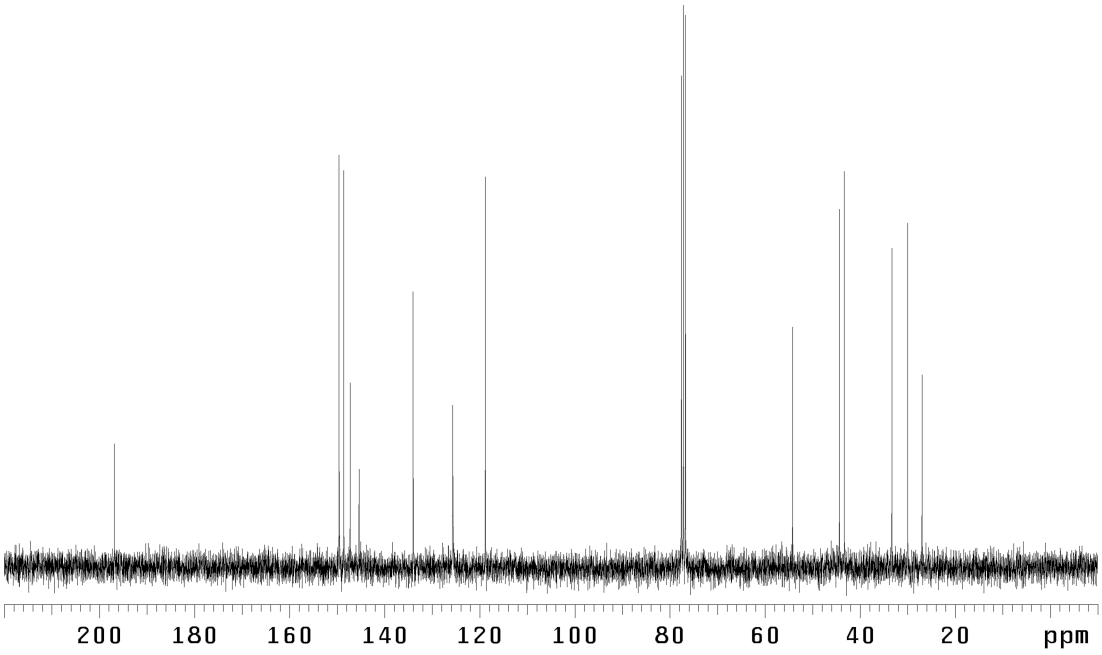


Figure SI-57C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1i**.

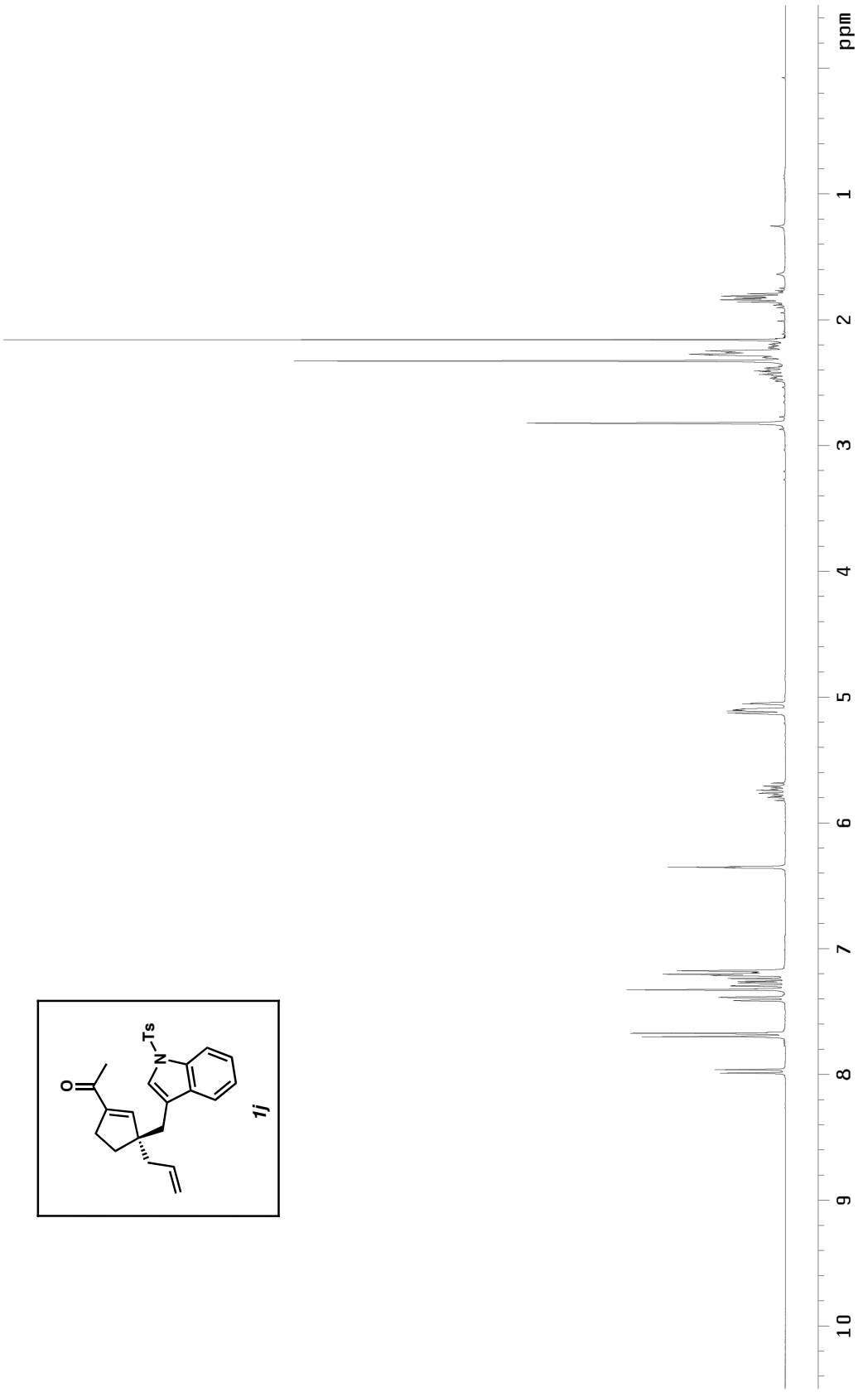


Figure SI-58A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1j**.

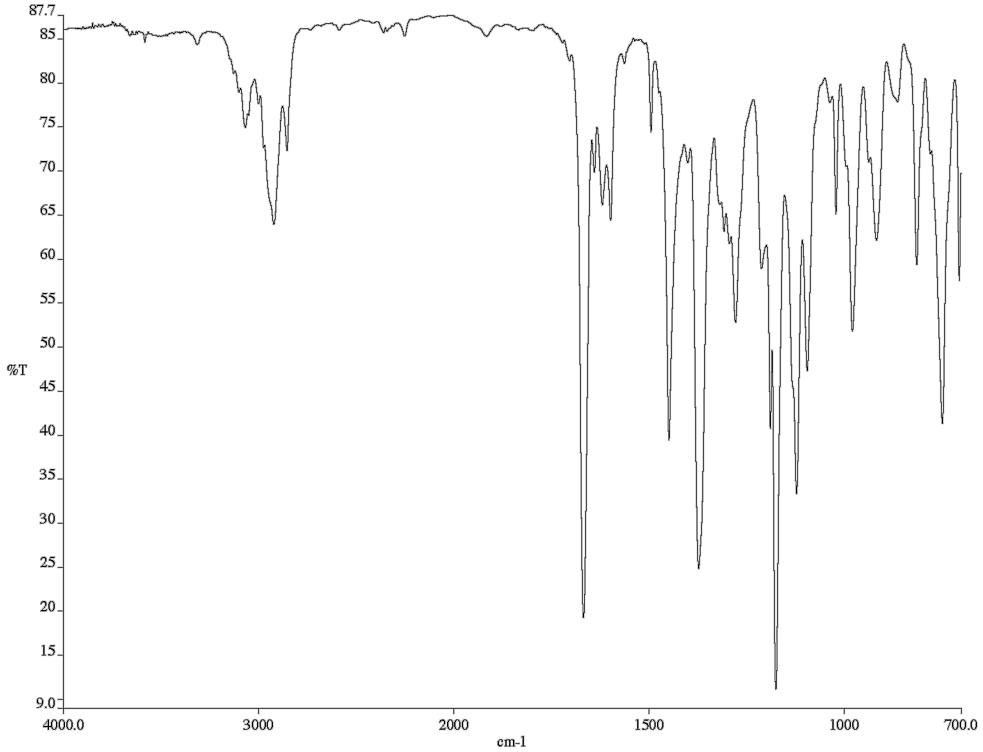


Figure SI-58B. Infrared spectrum (thin film/NaCl) of compound **1j**.

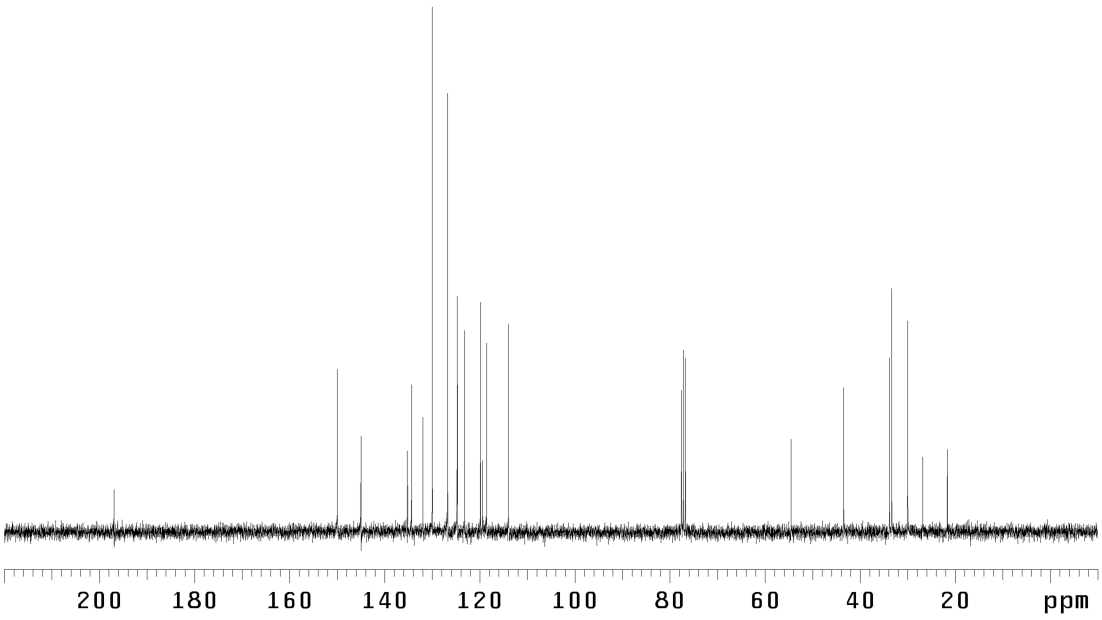


Figure SI-58C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1j**.

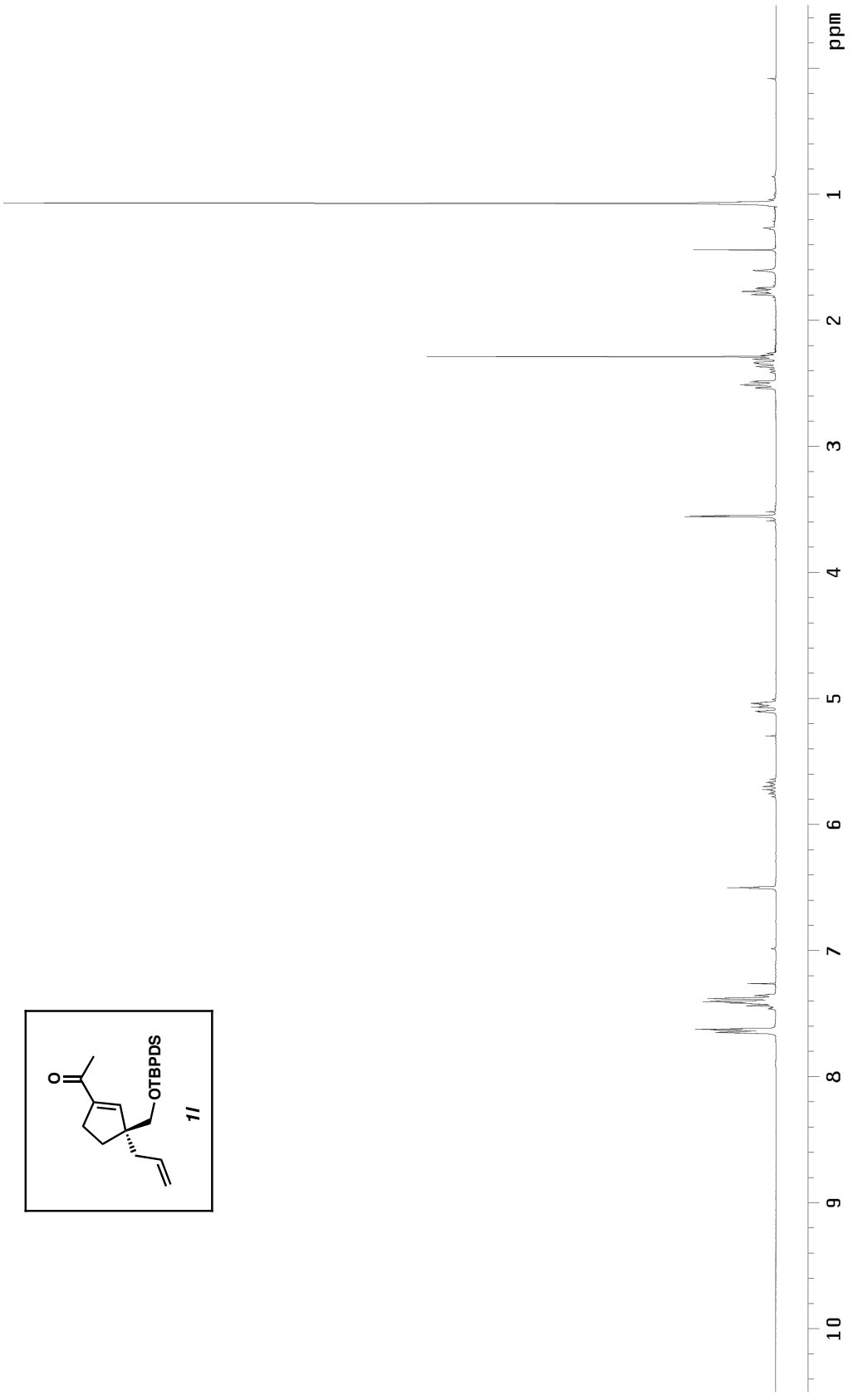


Figure SI-59A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **11**.

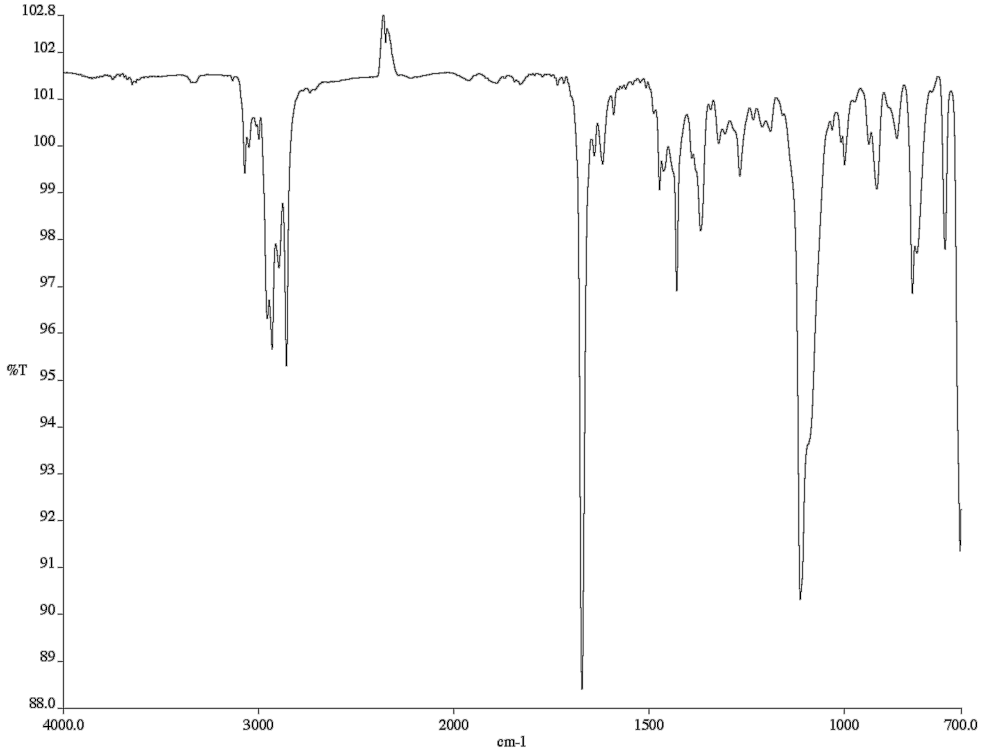


Figure SI-59B. Infrared spectrum (thin film/NaCl) of compound **1l**.

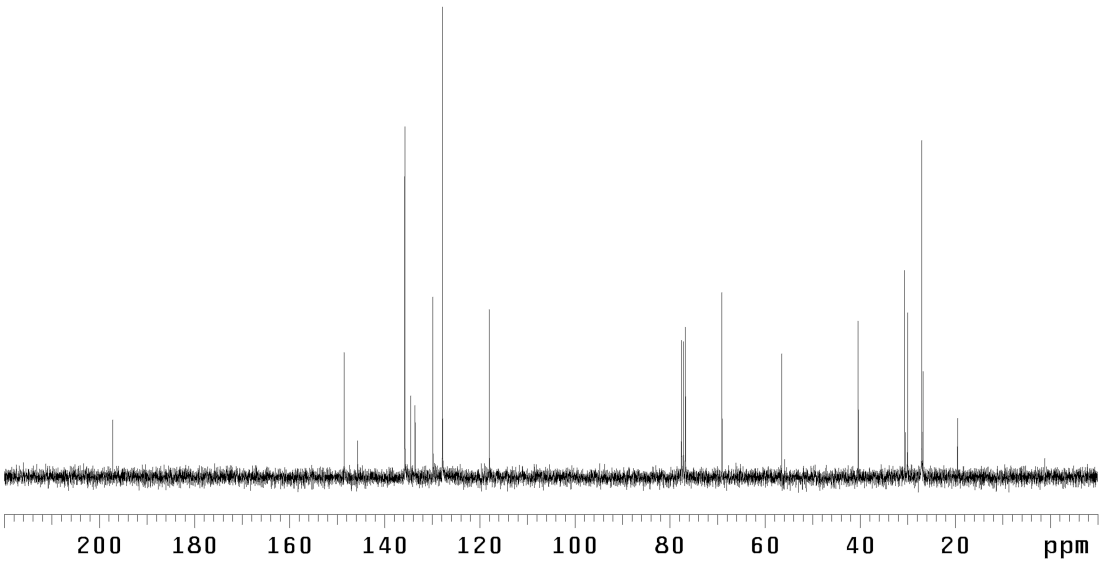


Figure SI-59C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1l**.

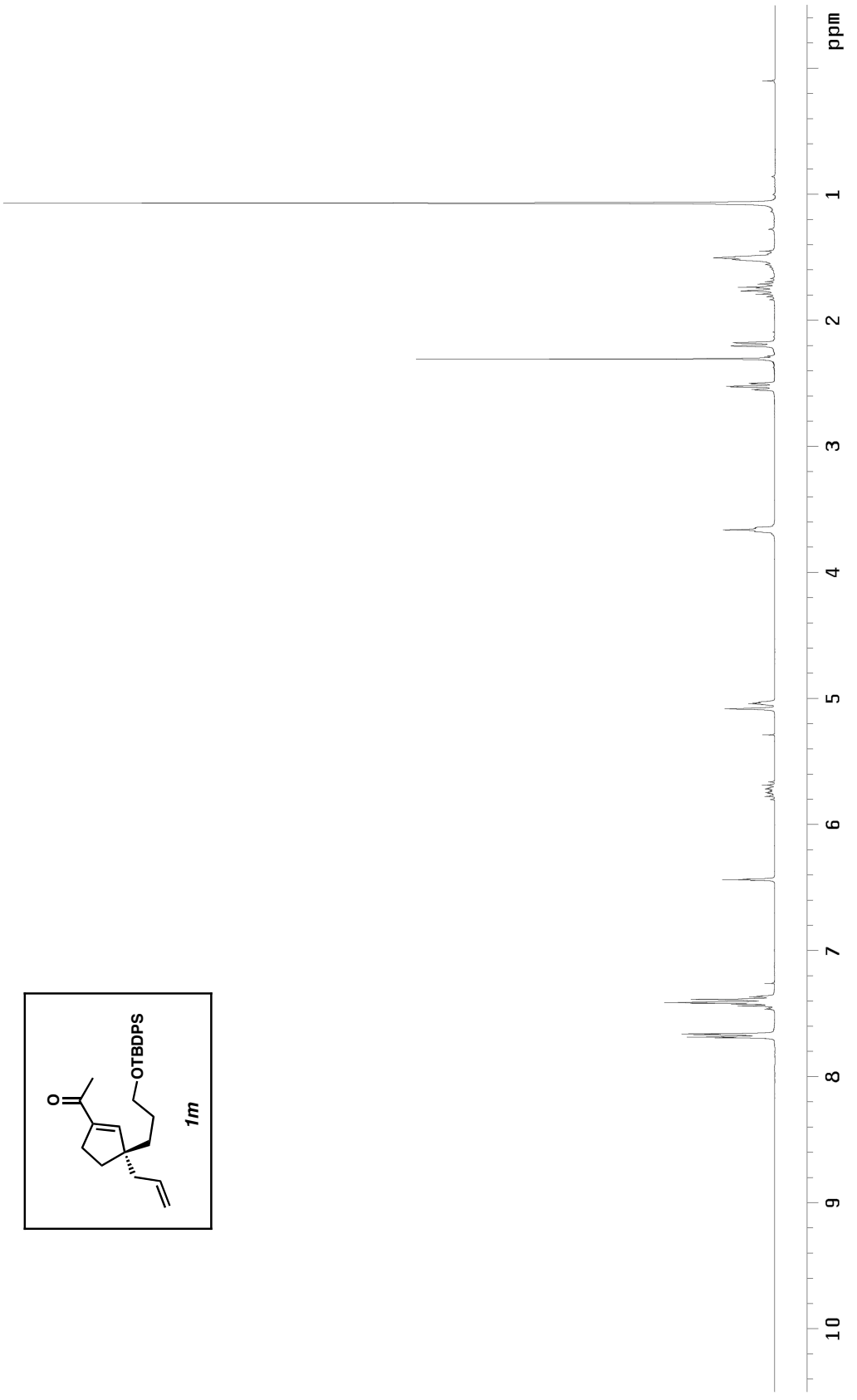


Figure SI-60A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1m**.

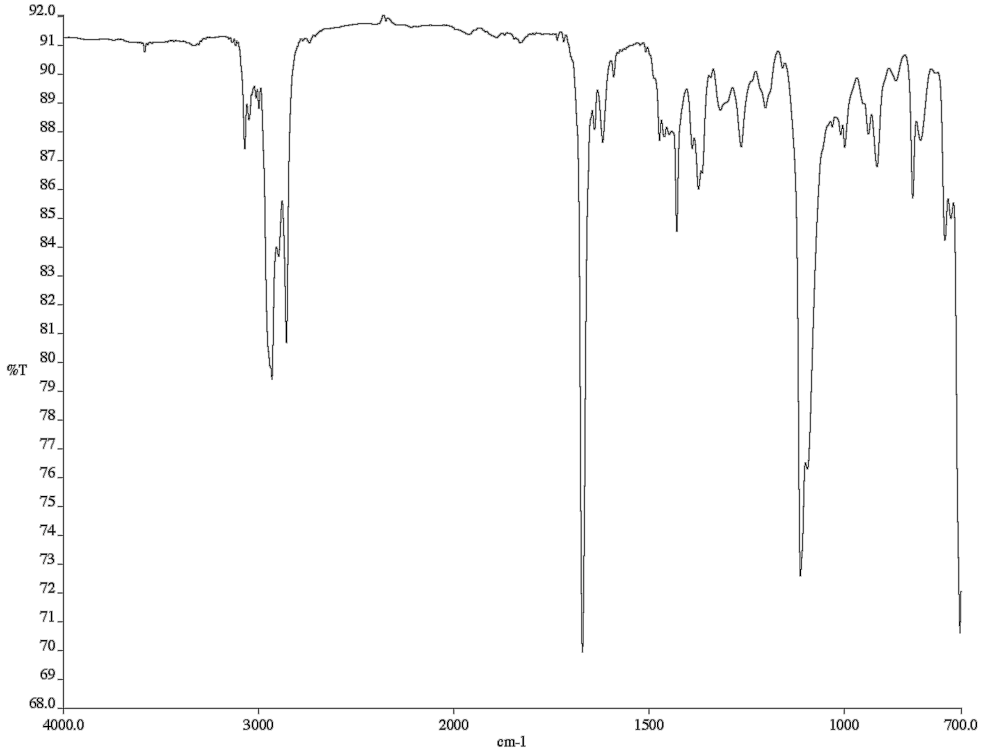


Figure SI-60B. Infrared spectrum (thin film/NaCl) of compound **1m**.

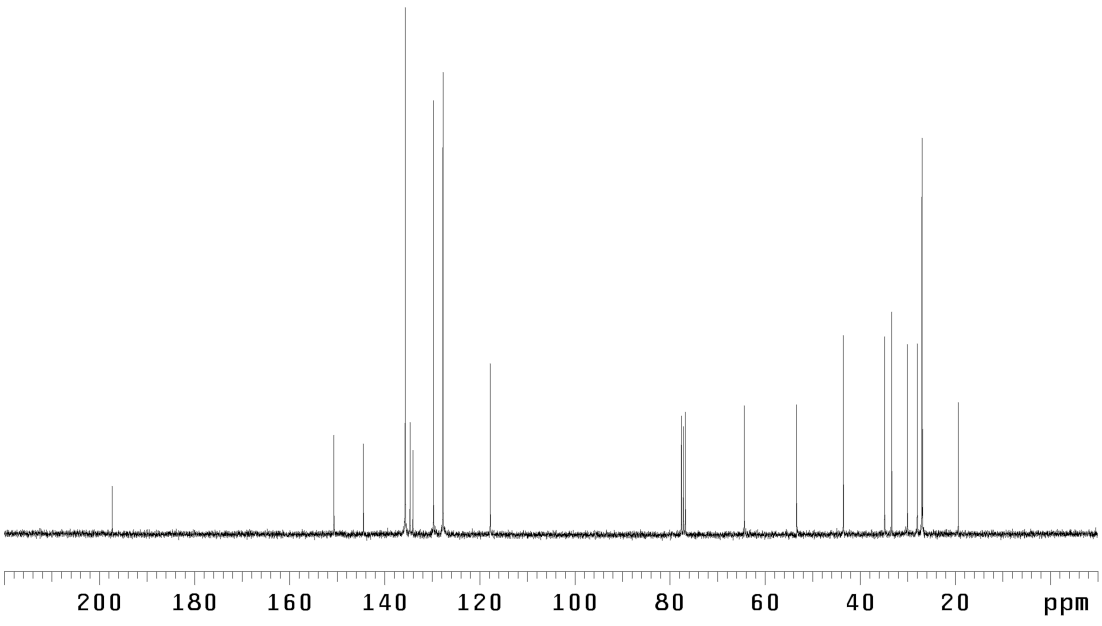


Figure SI-60C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1m**.

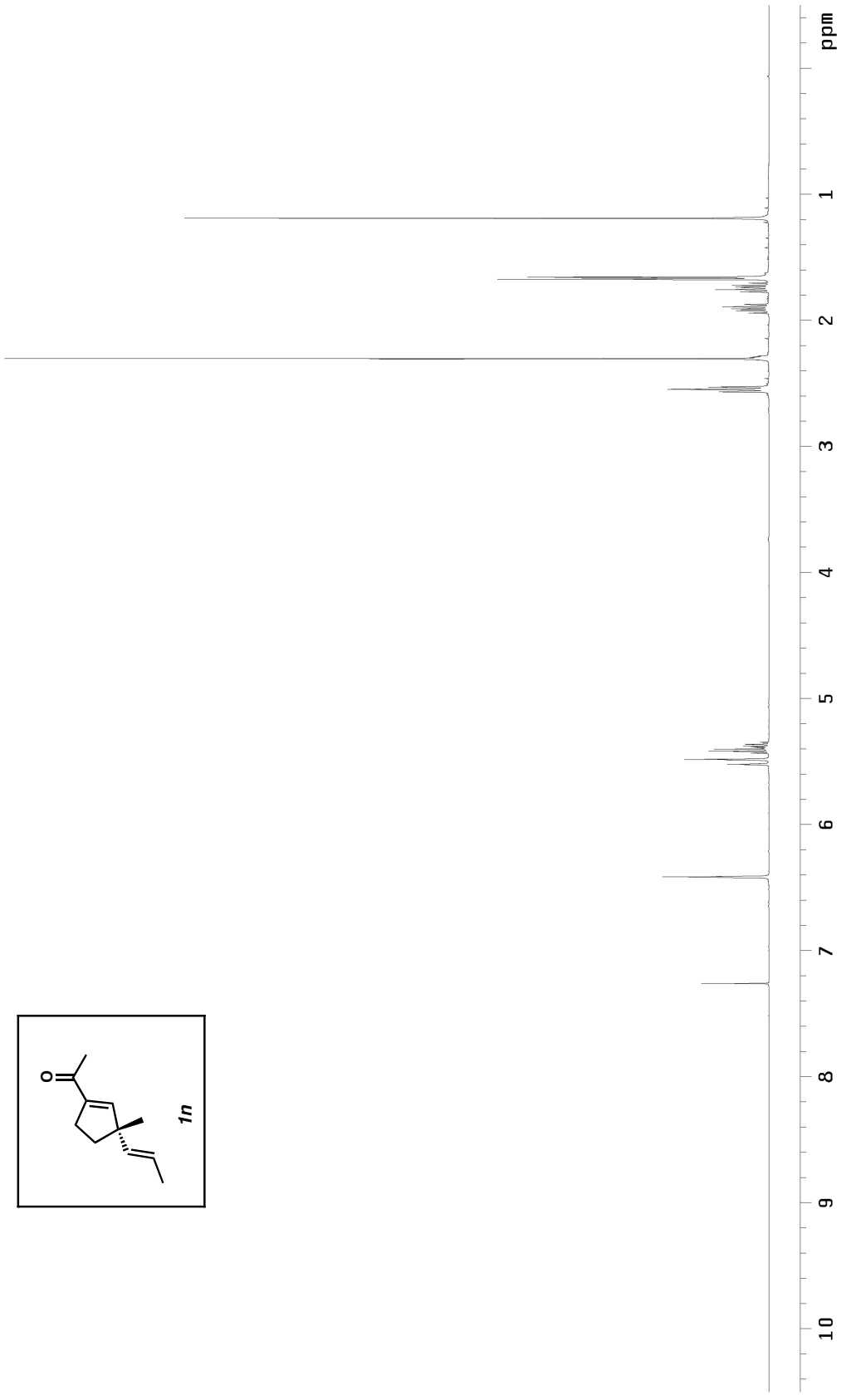


Figure SI-61A. ^{1}H NMR (400 MHz, $CDCl_3$) of compound **1n**.

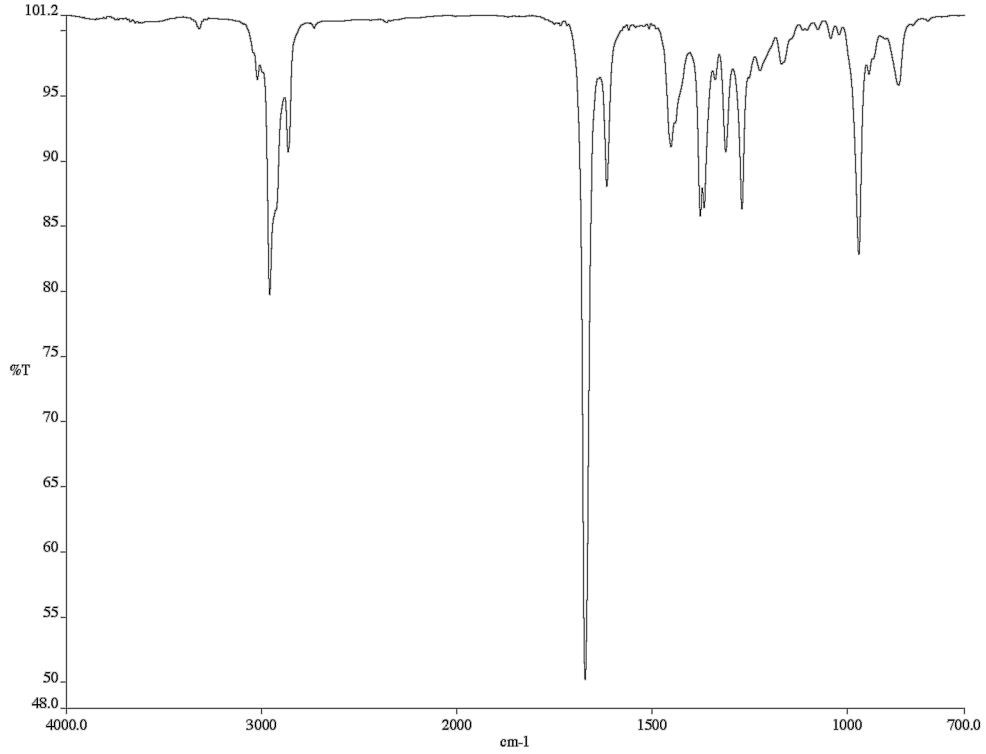


Figure SI-61B. Infrared spectrum (thin film/NaCl) of compound **1n**.

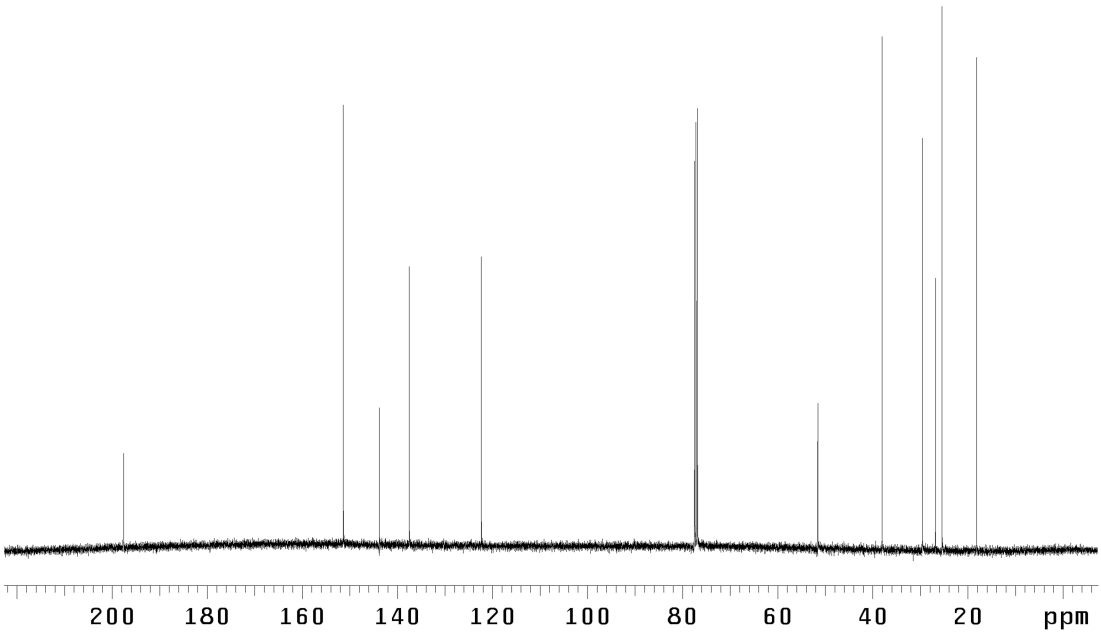


Figure SI-61C. ^{13}C NMR (100 MHz, $CDCl_3$) of compound **1n**.

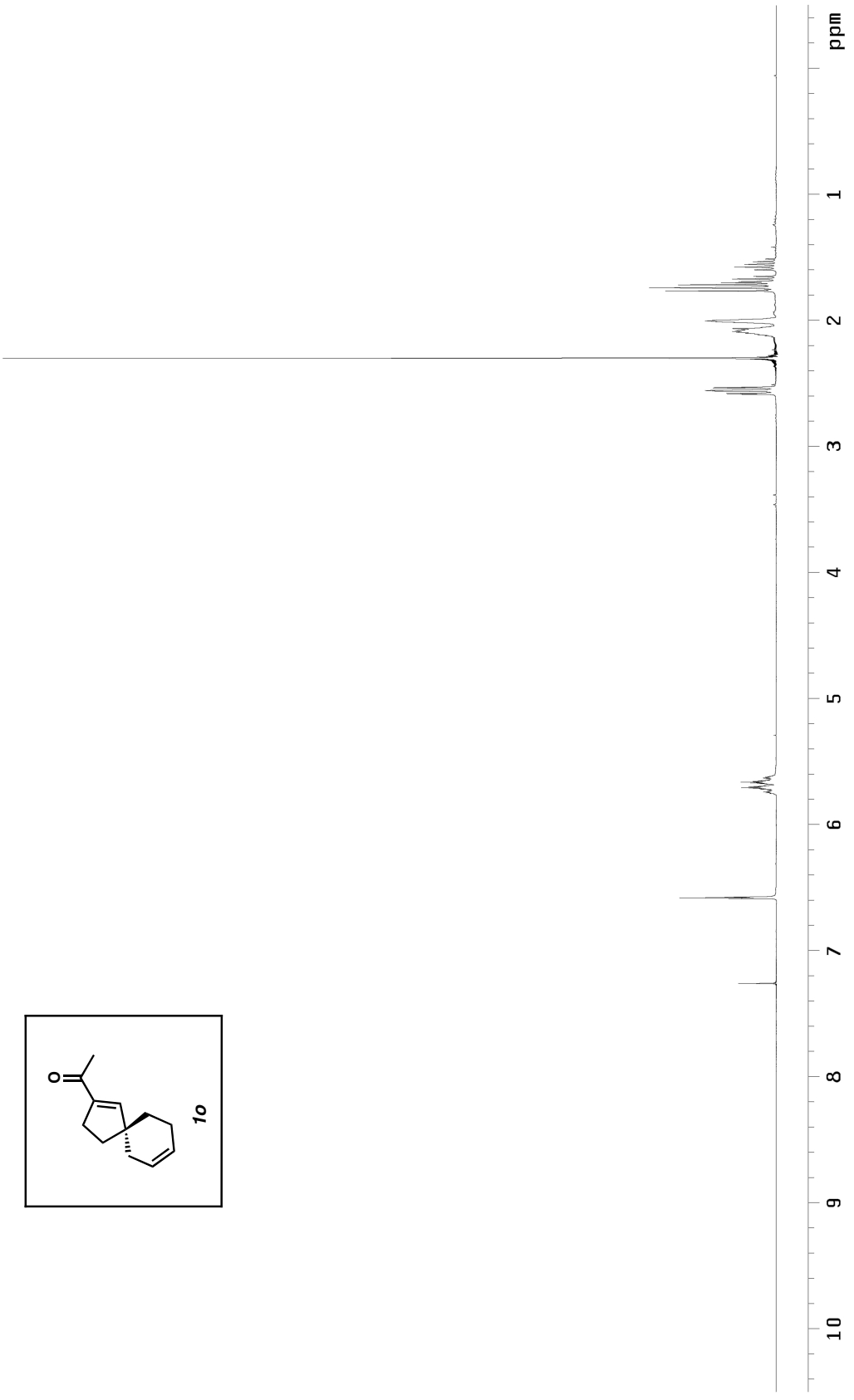


Figure SI-62A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **1o**.

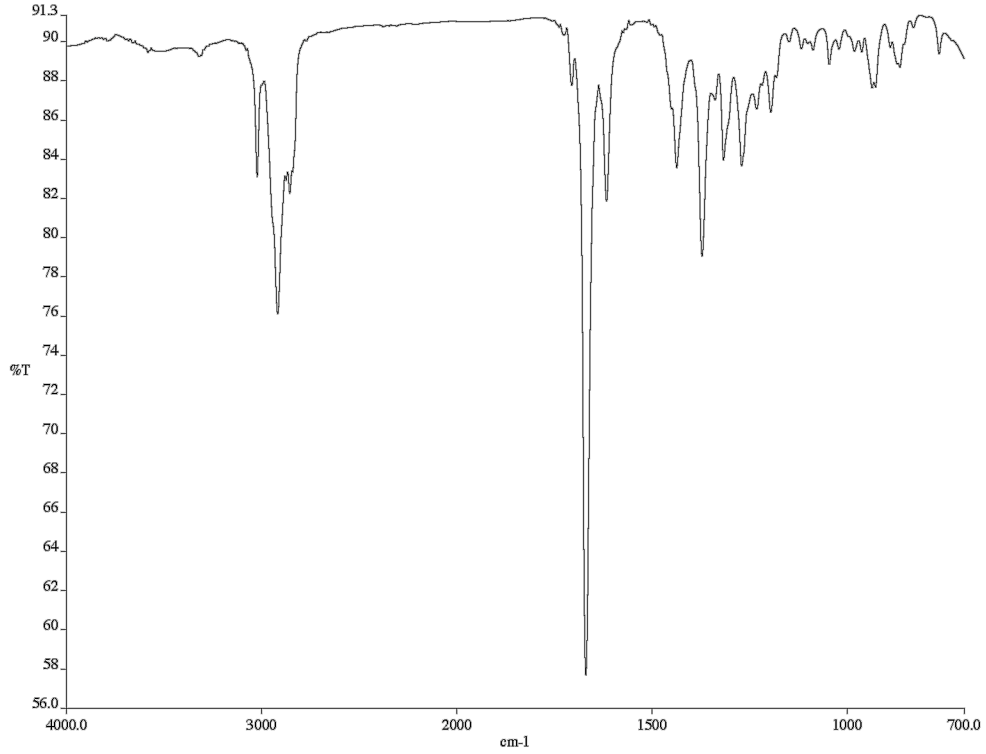


Figure SI-62B. Infrared spectrum (thin film/NaCl) of compound **1o**.

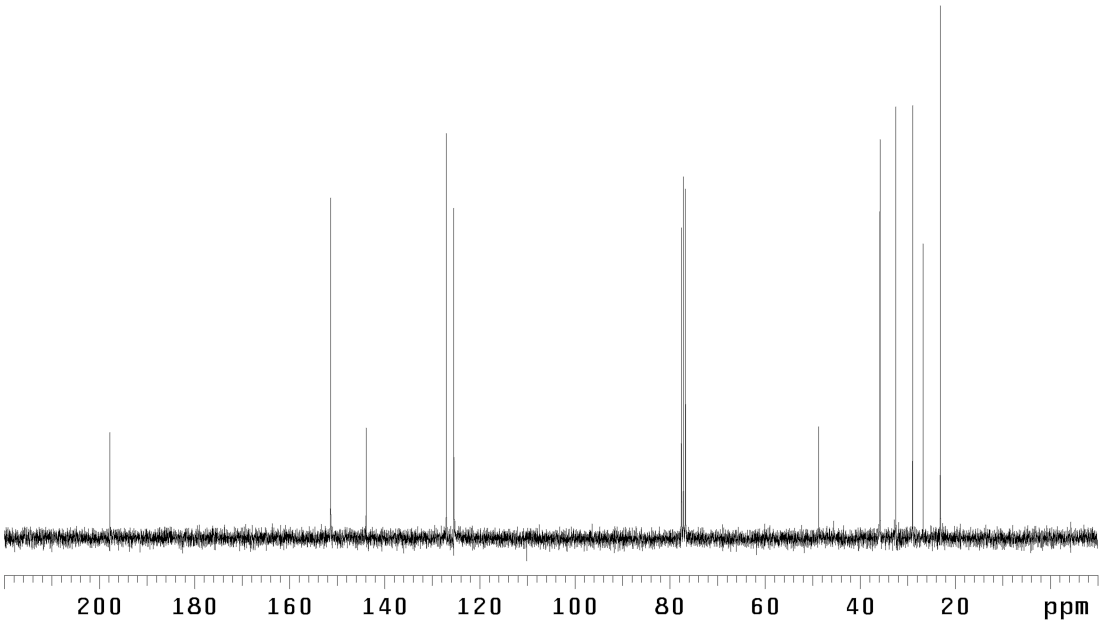


Figure SI-62C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **1o**.

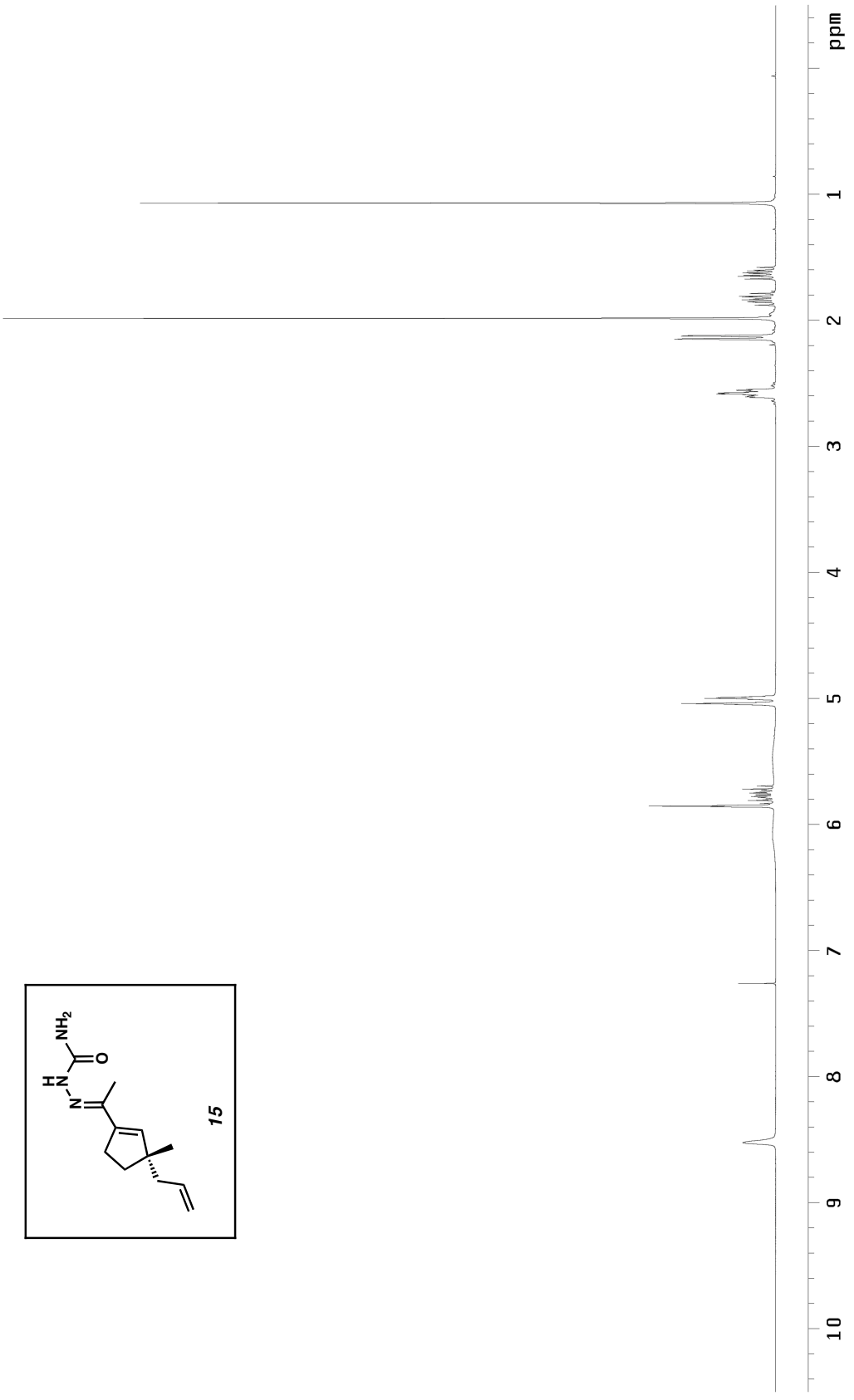


Figure SI-63A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **15**.

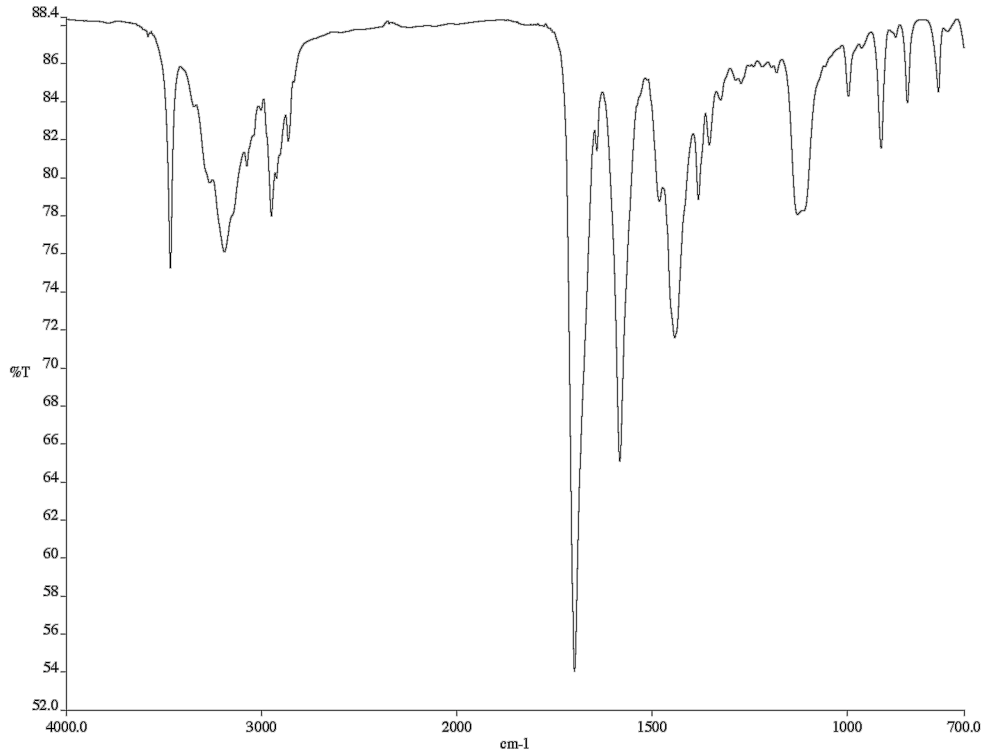


Figure SI-63B. Infrared spectrum (thin film/NaCl) of compound **15**.

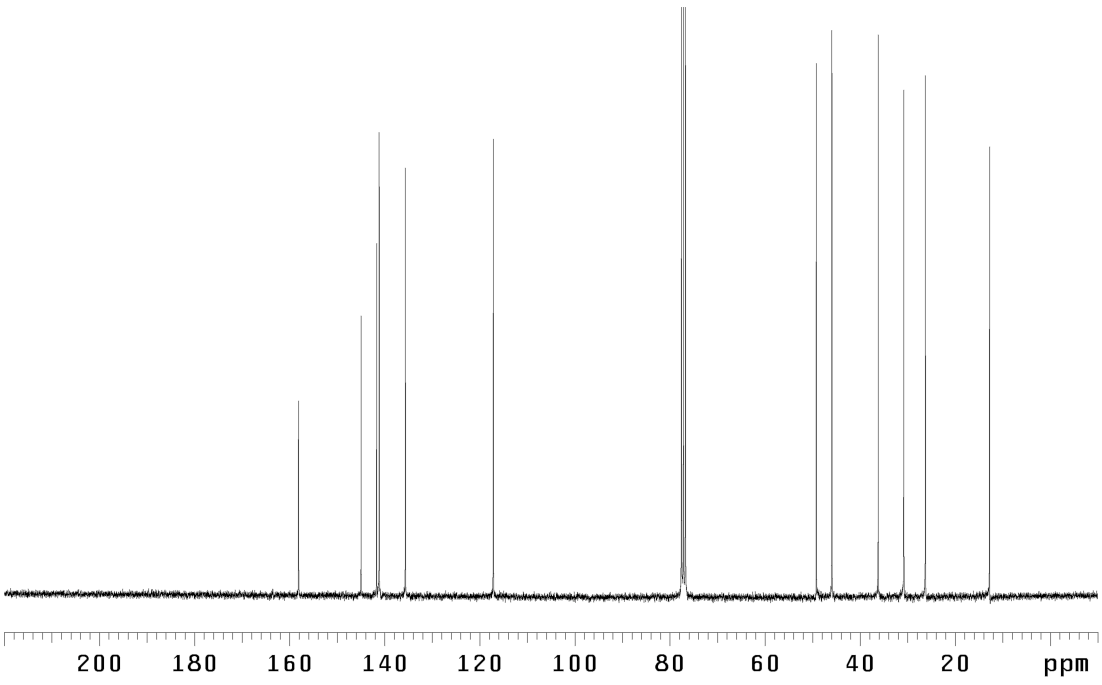


Figure SI-63C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **15**.

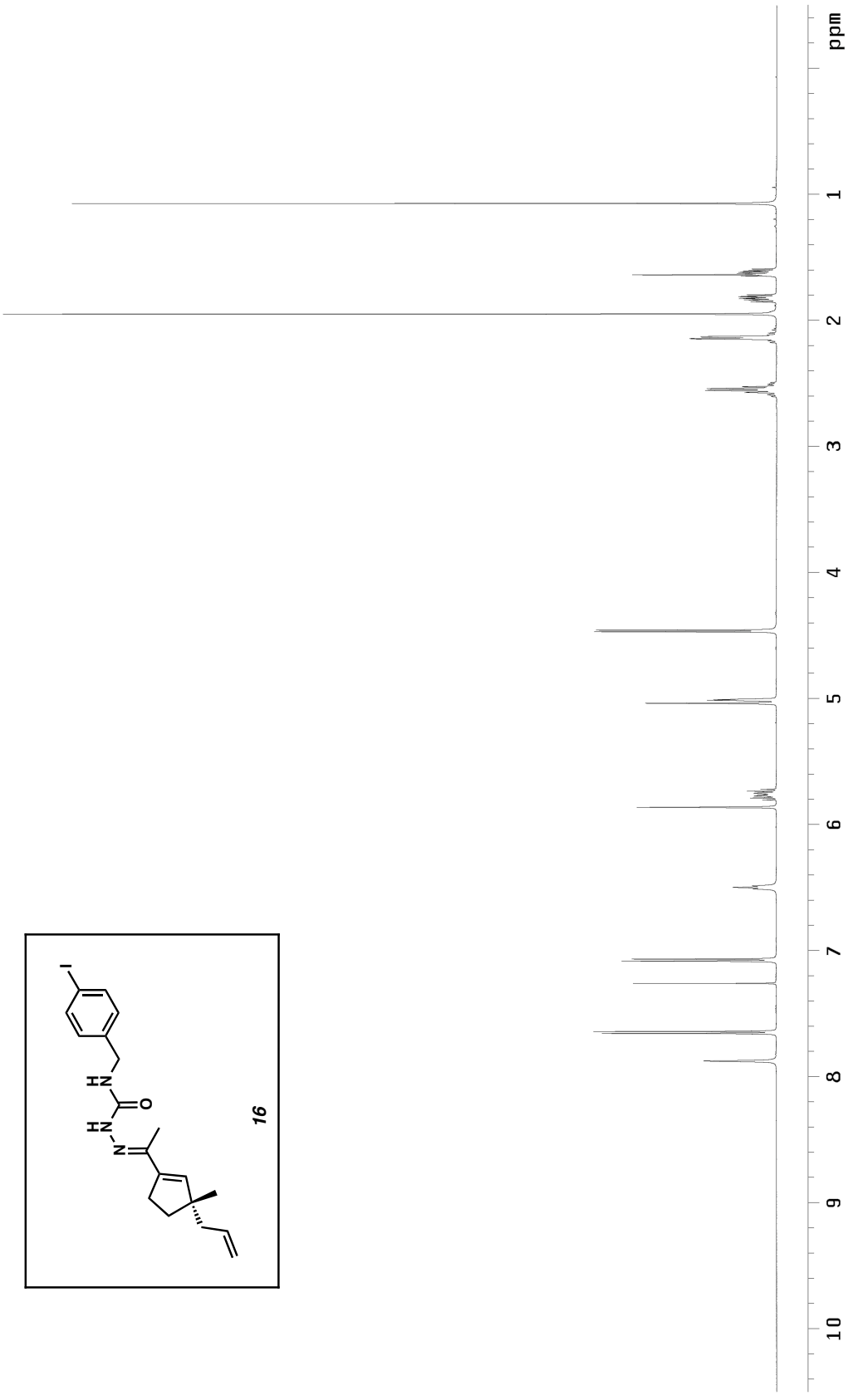


Figure SI-64A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **16**.

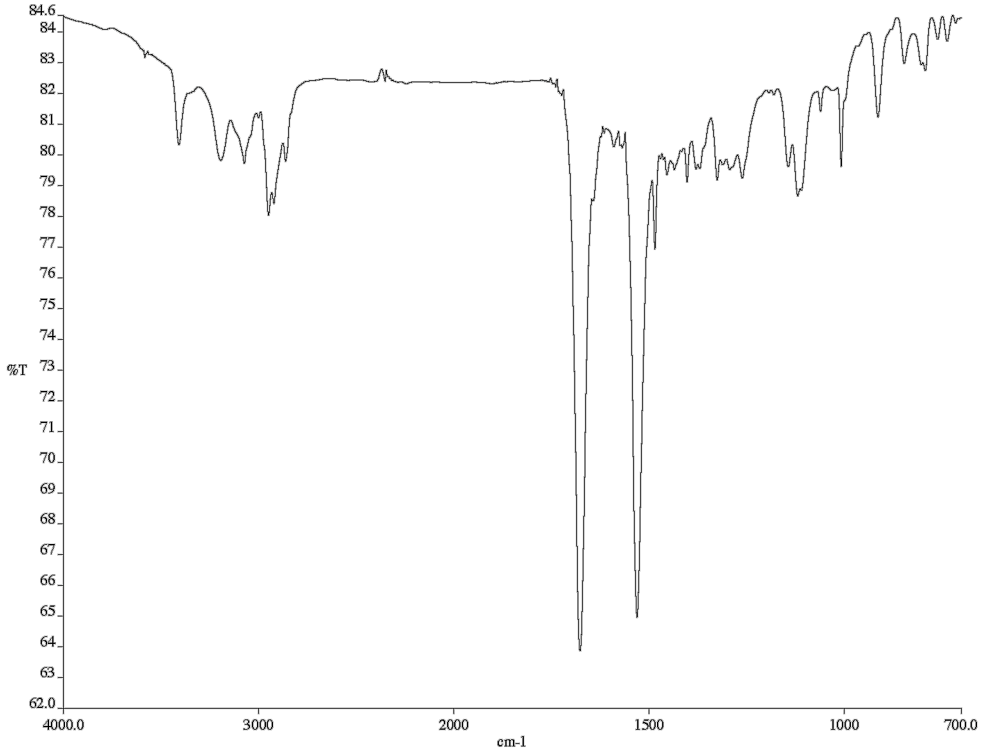


Figure SI-64B. Infrared spectrum (thin film/NaCl) of compound **16**.

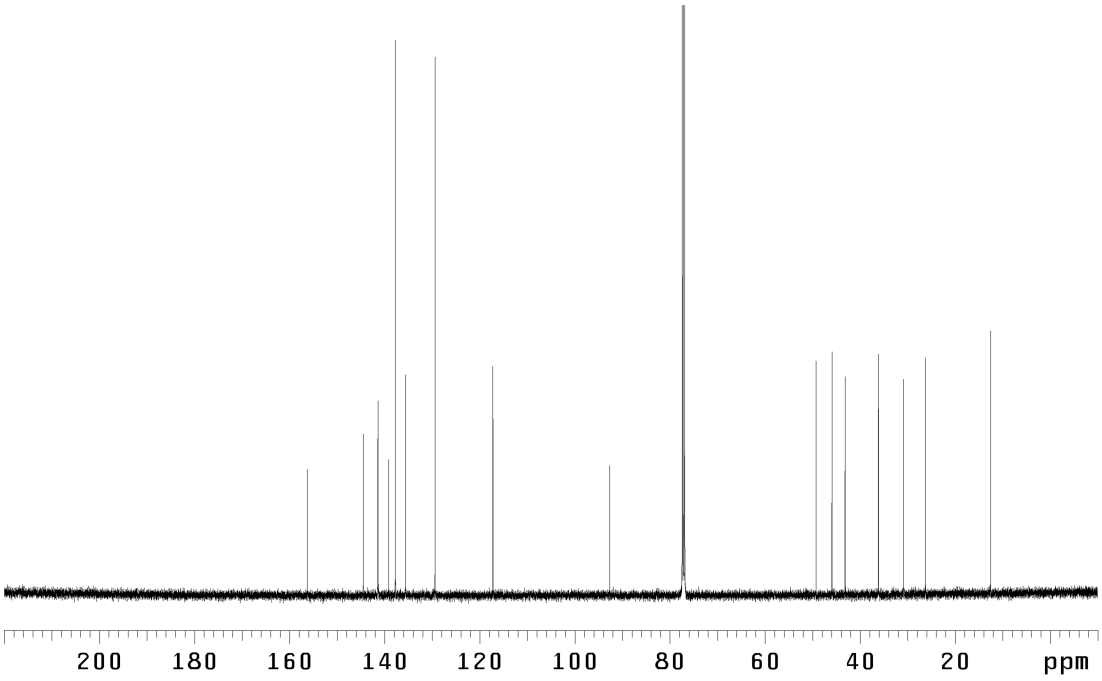


Figure SI-64C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **16**.

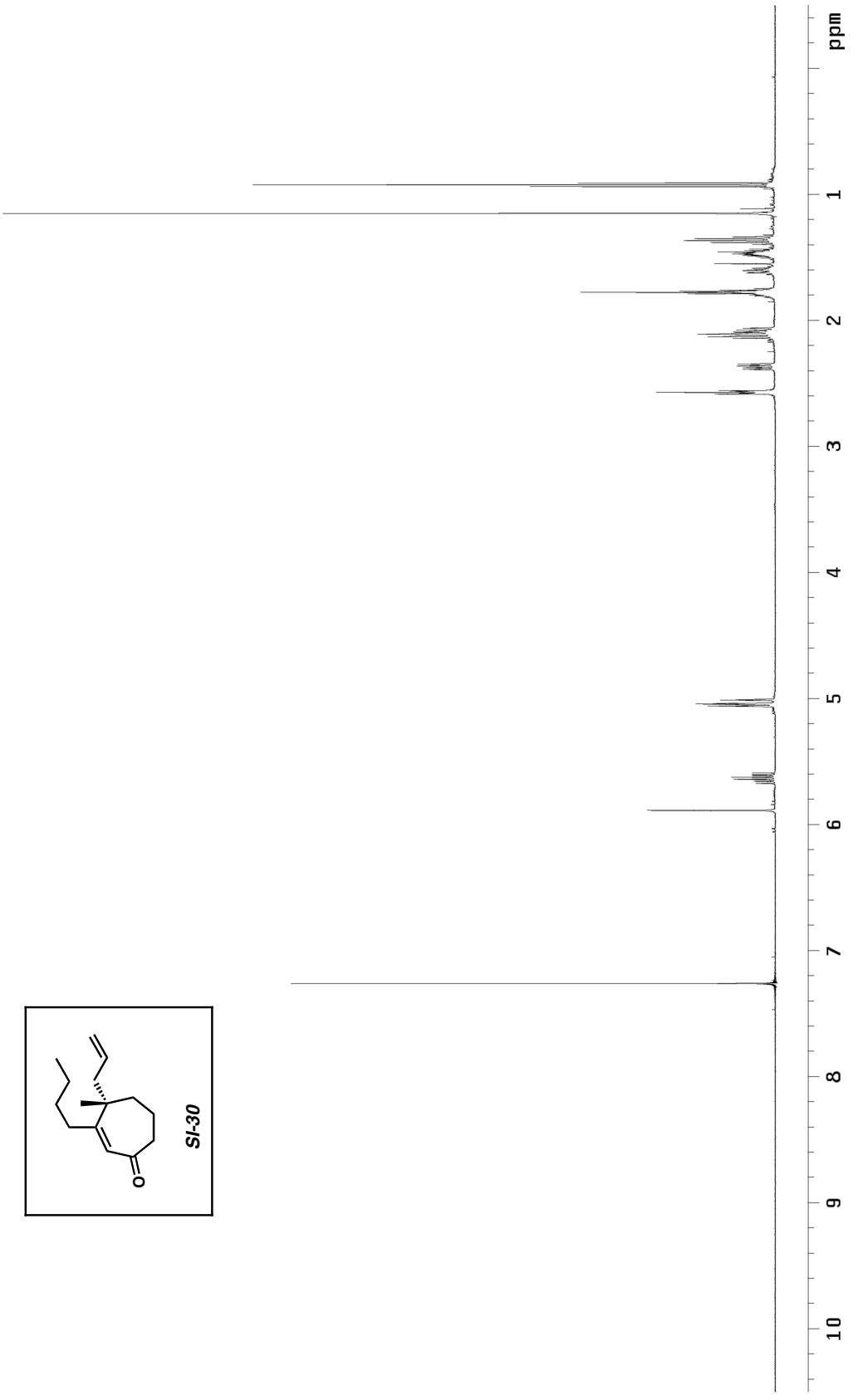


Figure SI-65A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-30**.

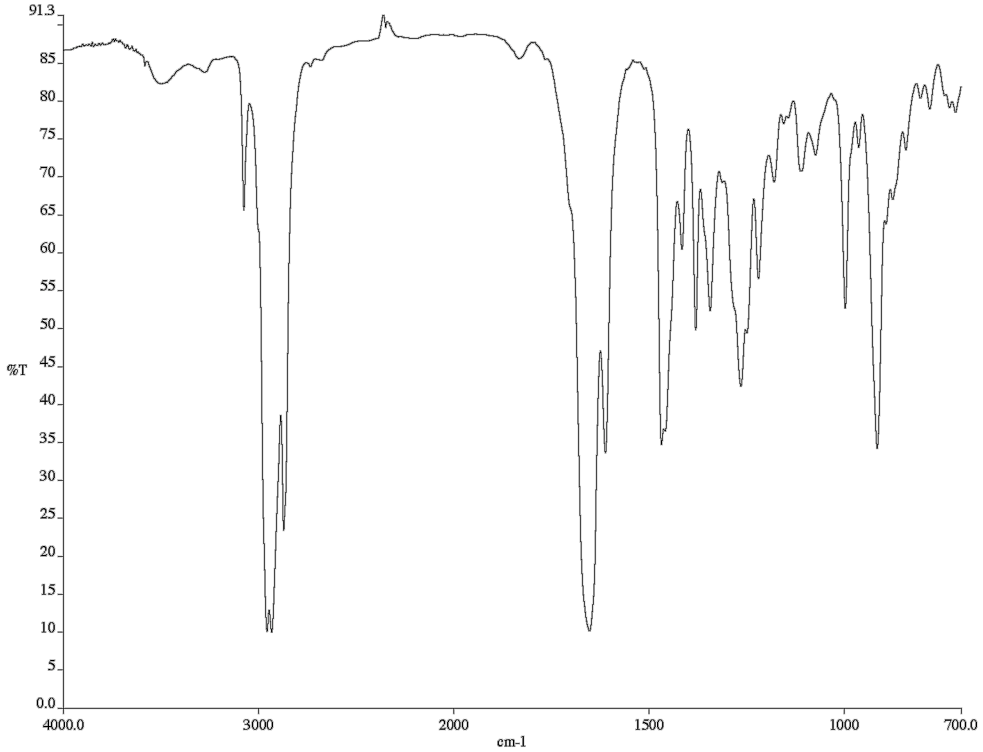


Figure SI-65B. Infrared spectrum (thin film/NaCl) of compound **SI-30**.

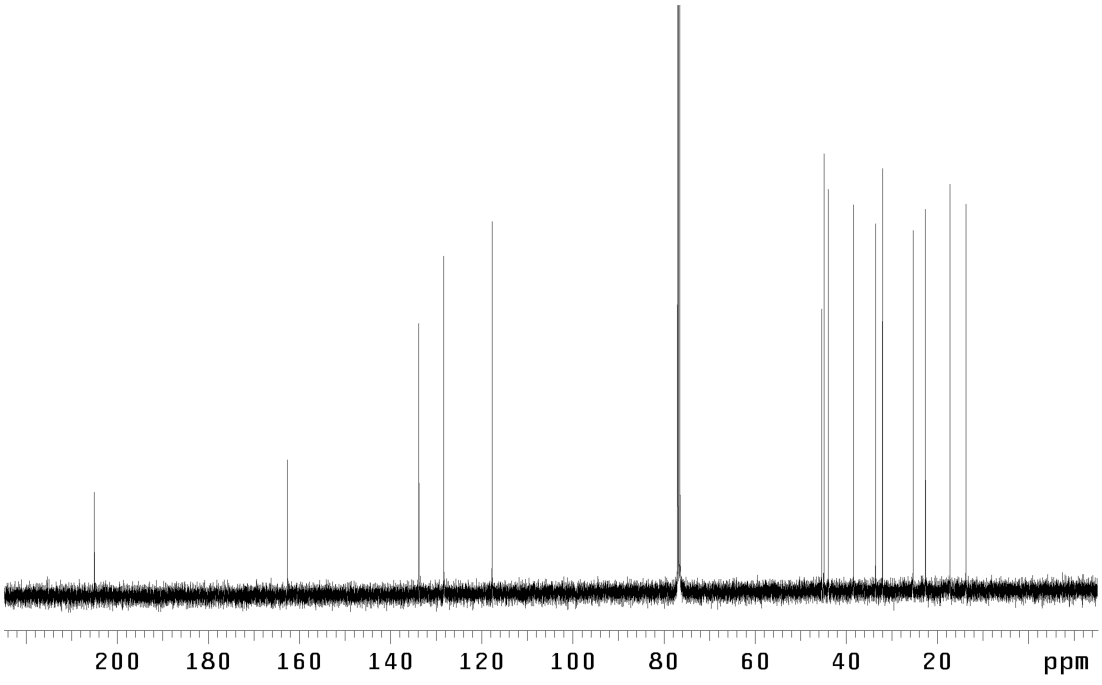


Figure SI-65C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **SI-30**.

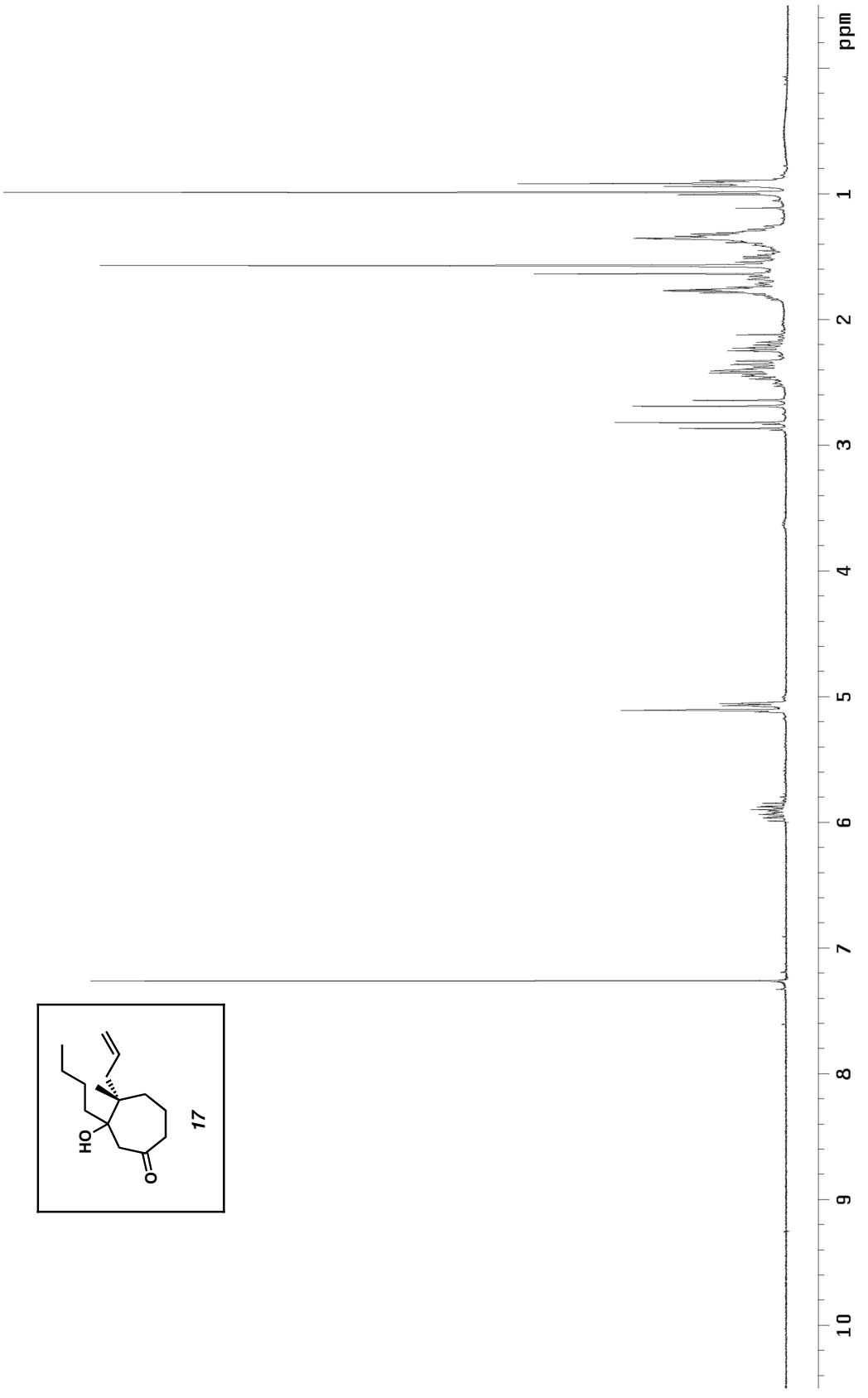


Figure SI-66A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **17**.

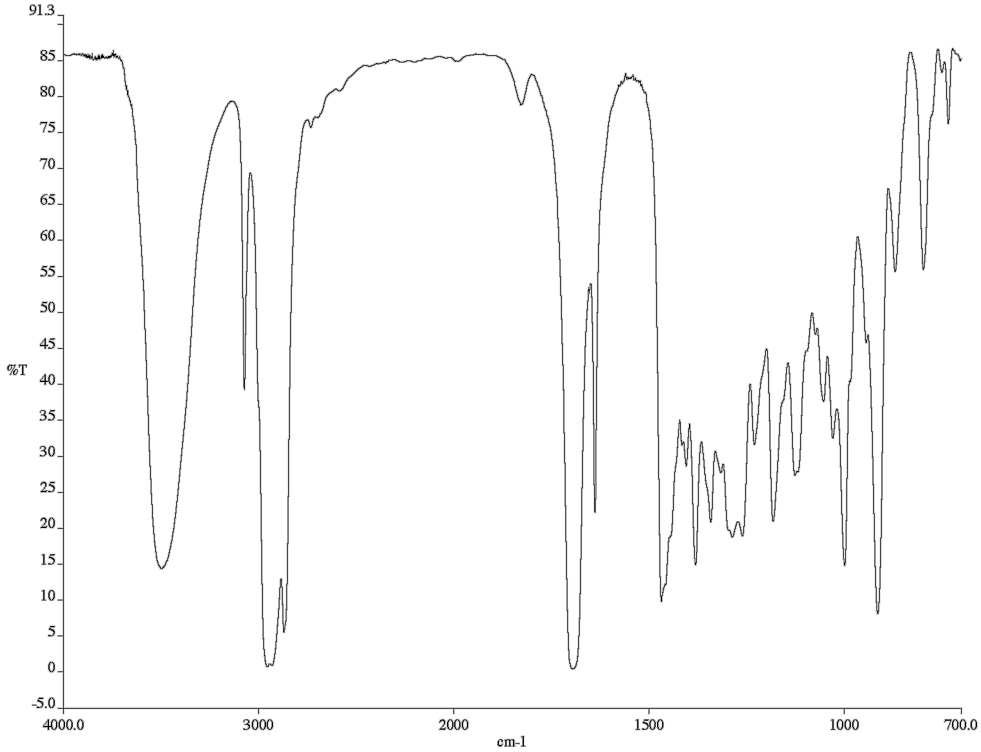


Figure SI-66B. Infrared spectrum (thin film/NaCl) of compound **17**.

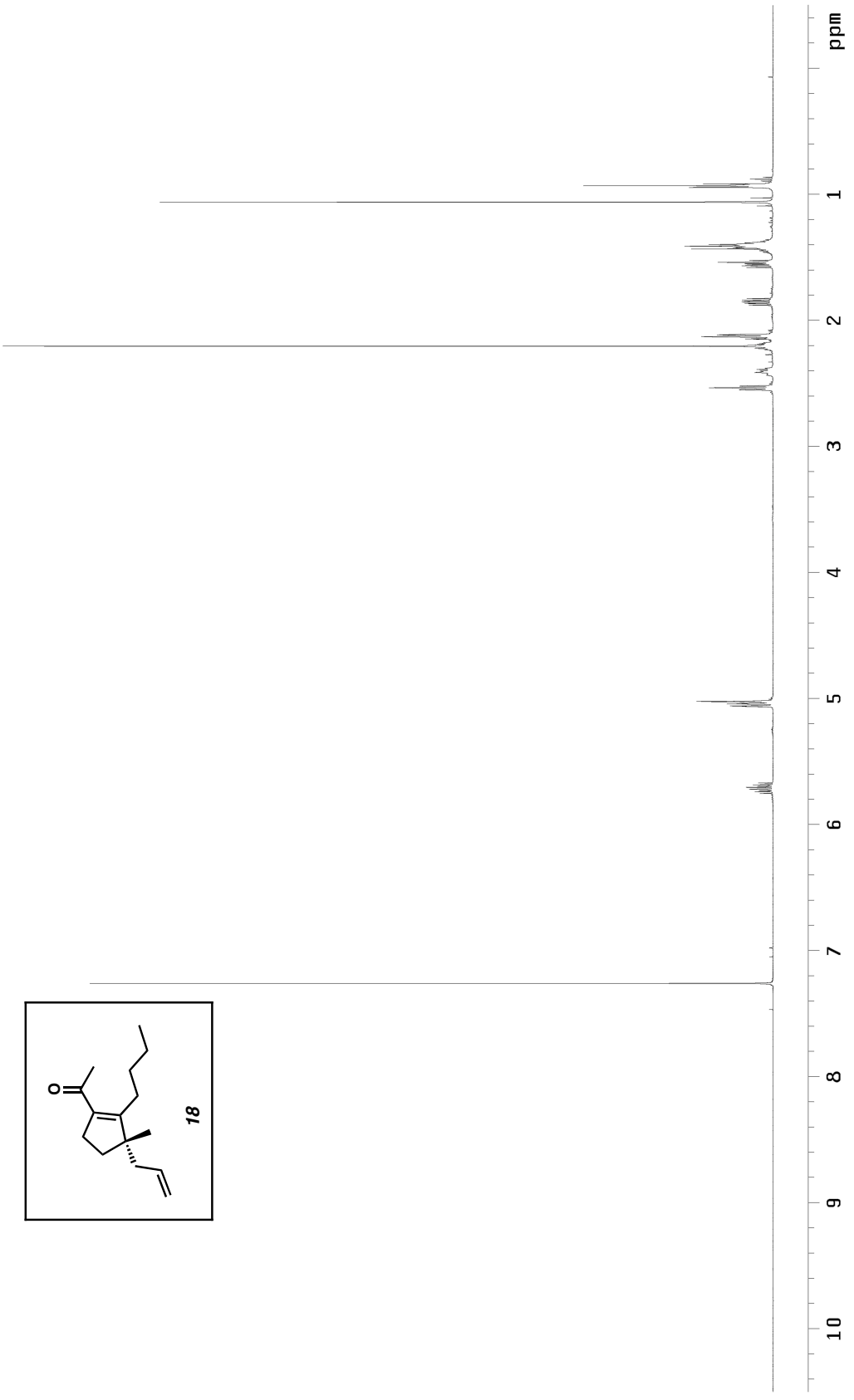


Figure SI-67A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **18**.

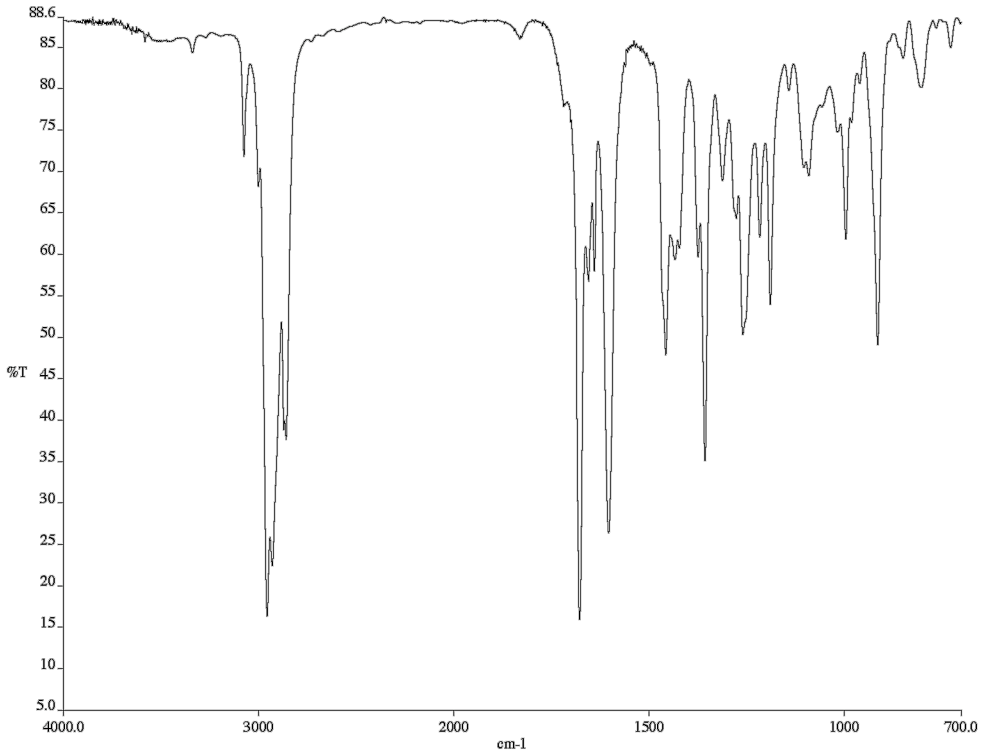


Figure SI-67B. Infrared spectrum (thin film/NaCl) of compound **18**.

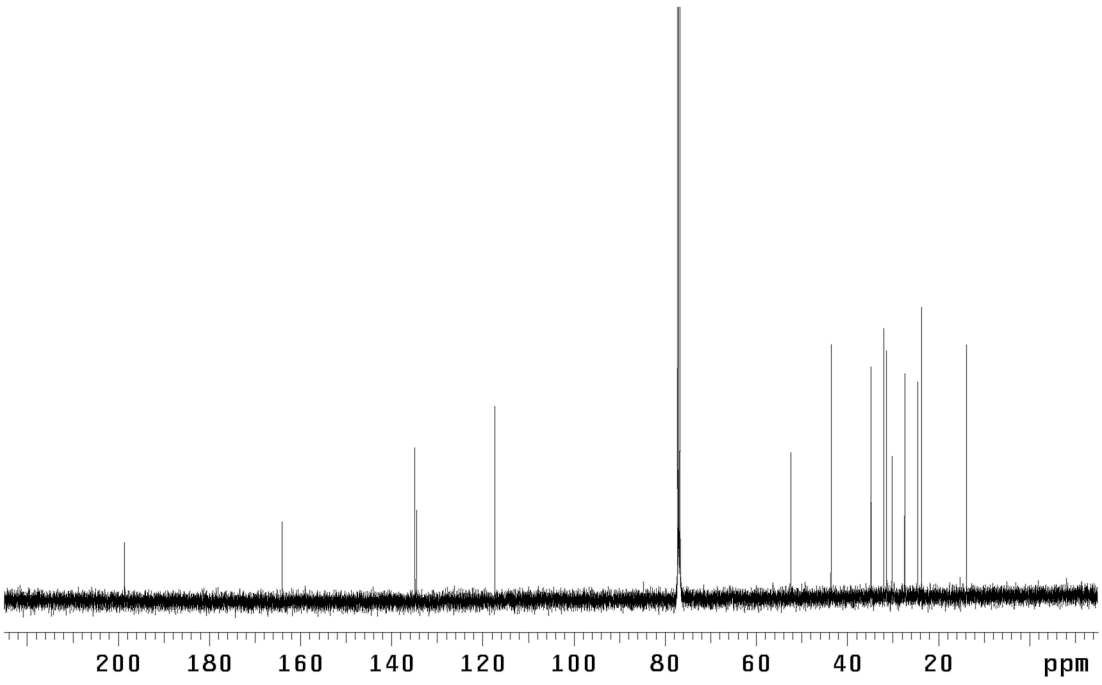


Figure SI-67C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **18**.

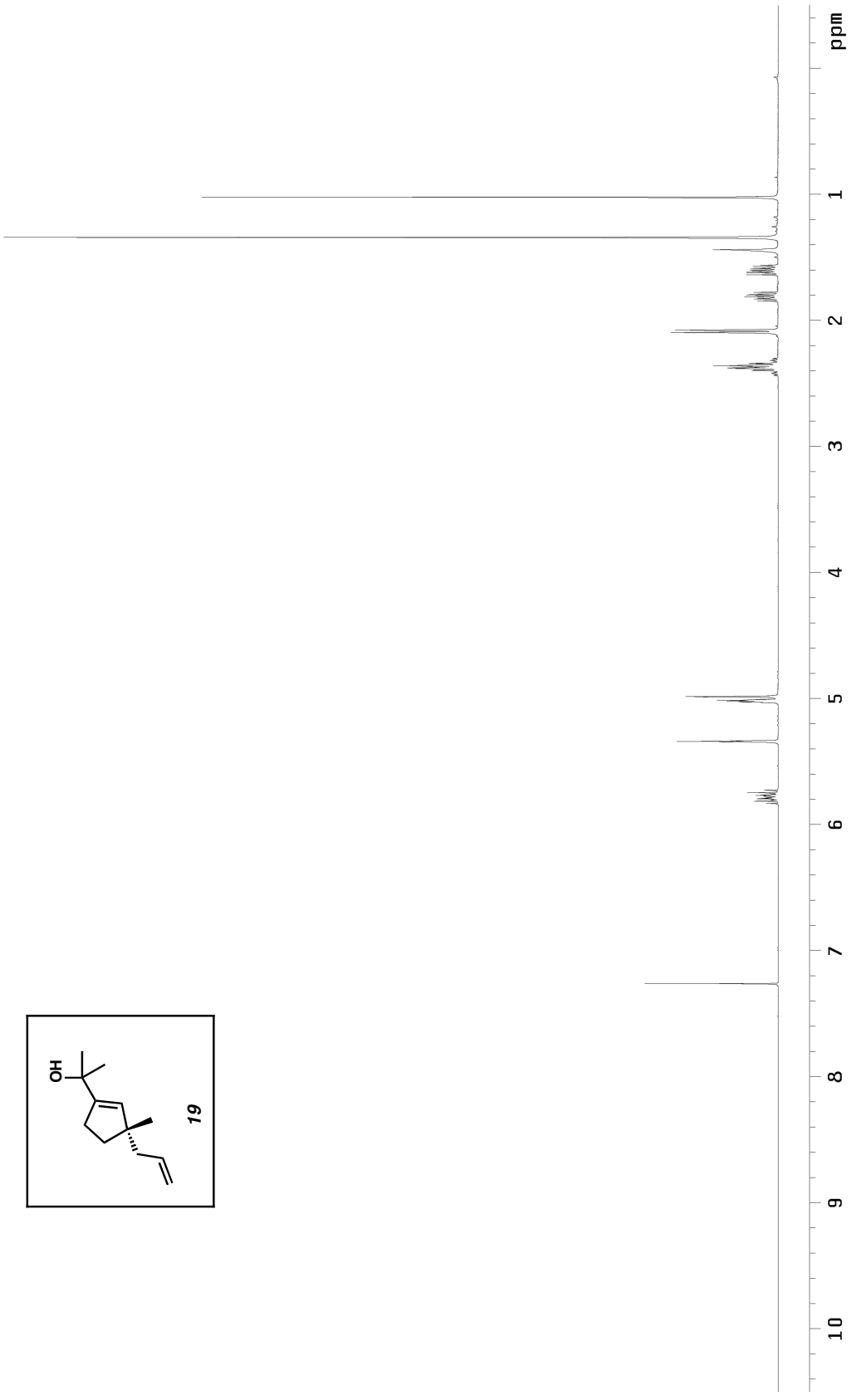


Figure SI-68A. ^{1}H NMR (400 MHz, $CDCl_3$) of compound **19**.

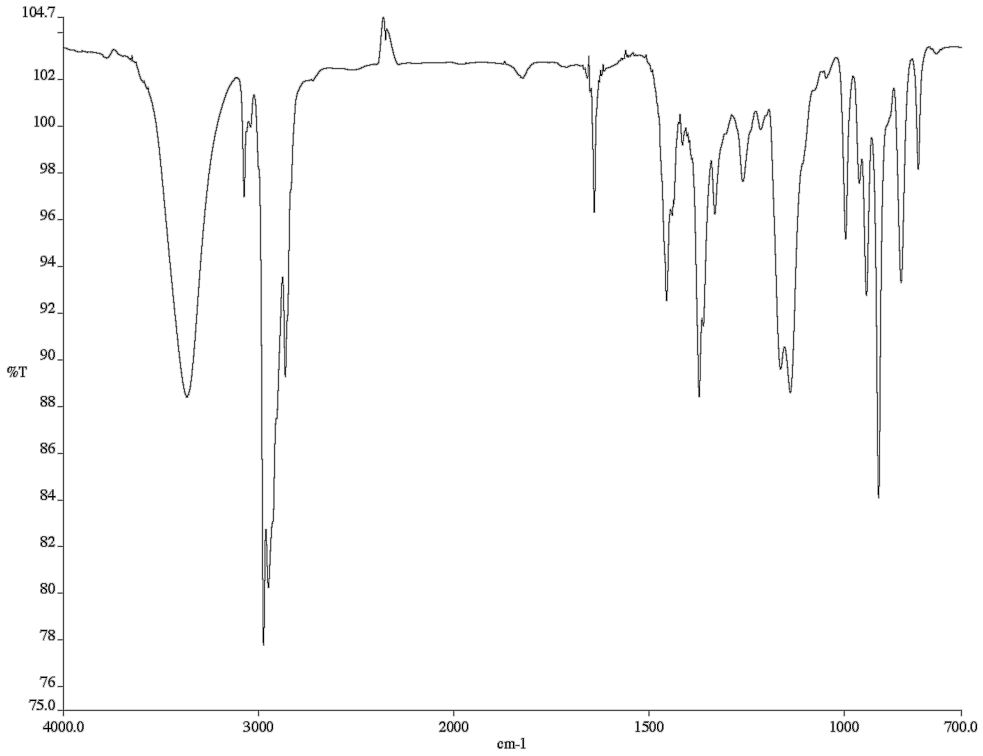


Figure SI-68B. Infrared spectrum (thin film/NaCl) of compound **19**.

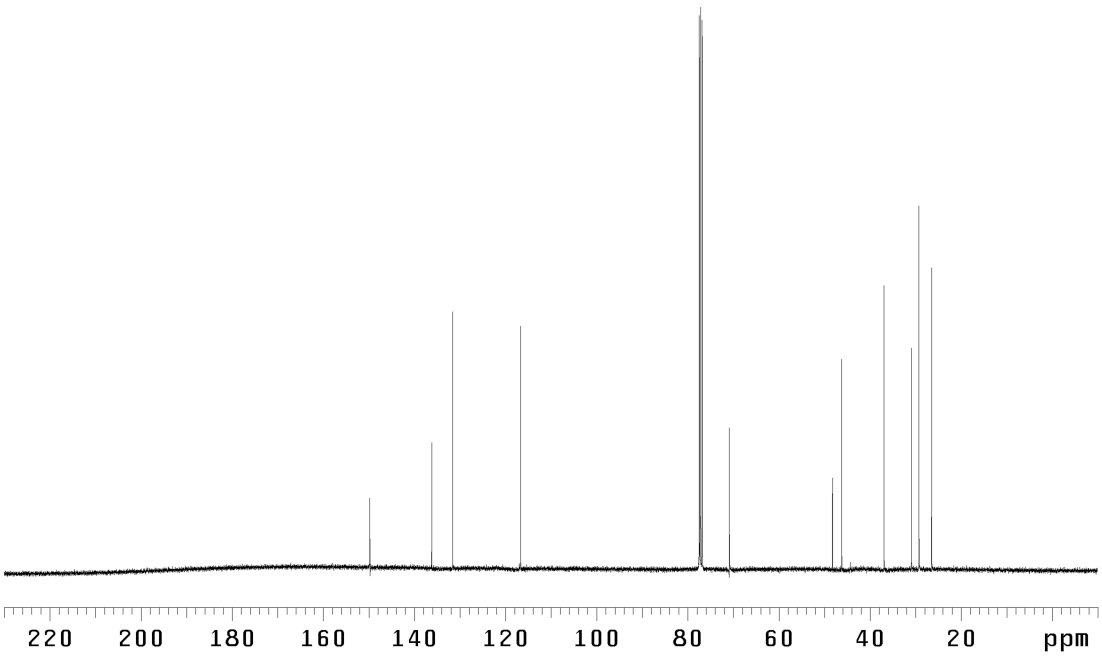


Figure SI-68C. ^{13}C NMR (100 MHz, $CDCl_3$) of compound **19**.

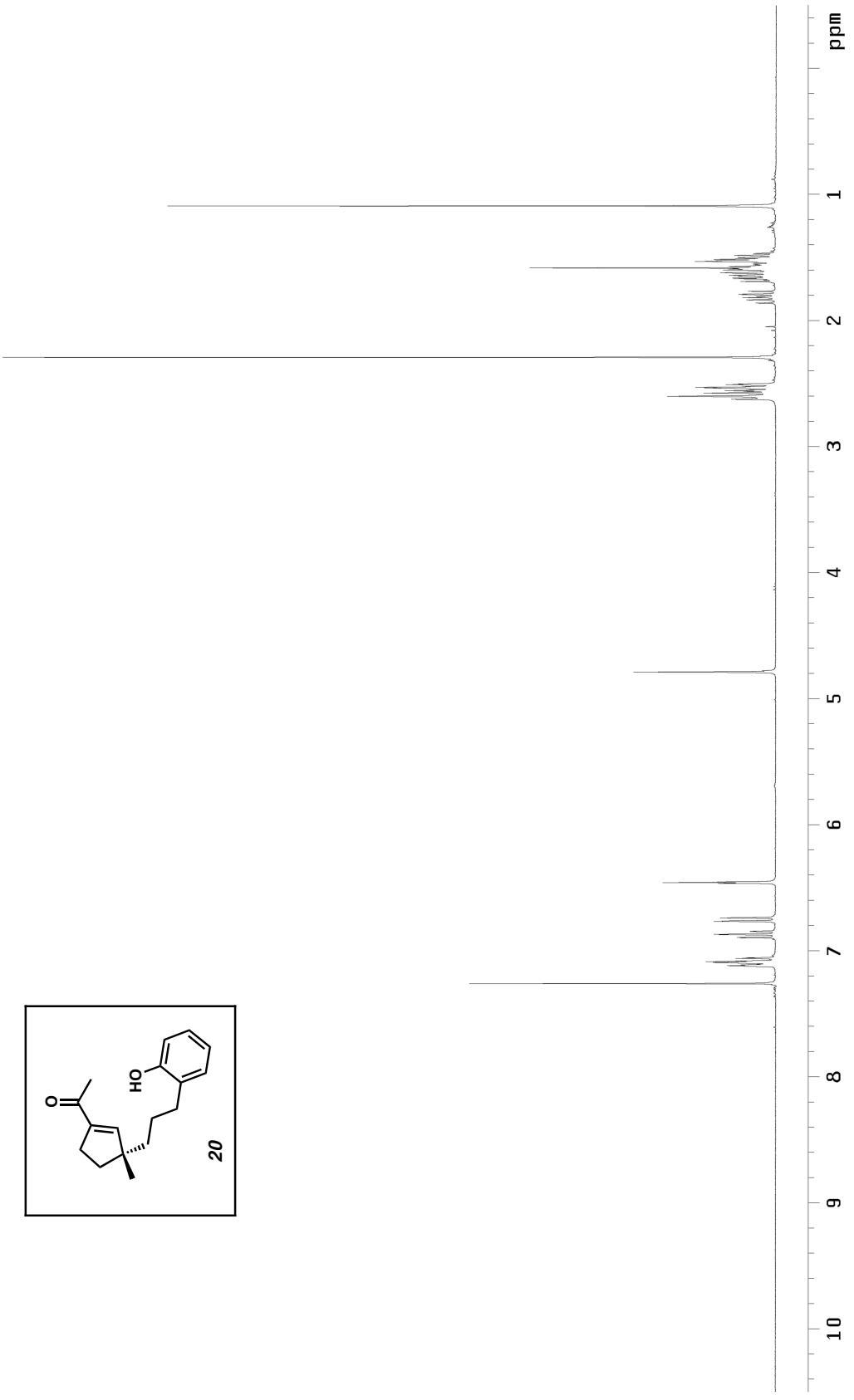


Figure SI-69A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **20**.

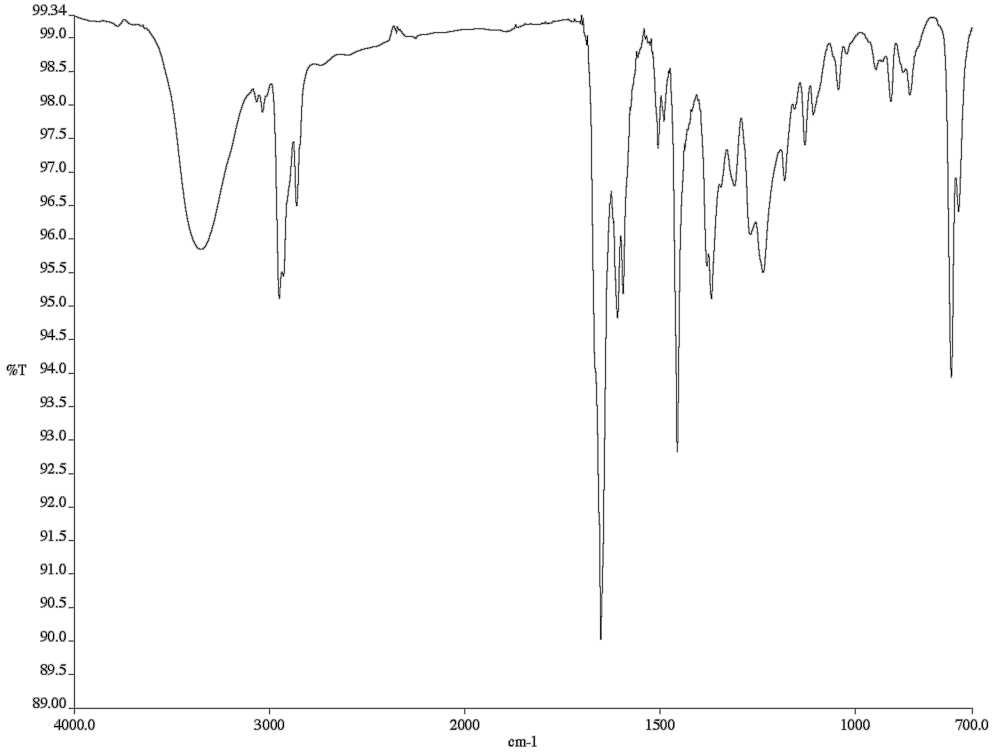


Figure SI-69B. Infrared spectrum (thin film/NaCl) of compound **20**.

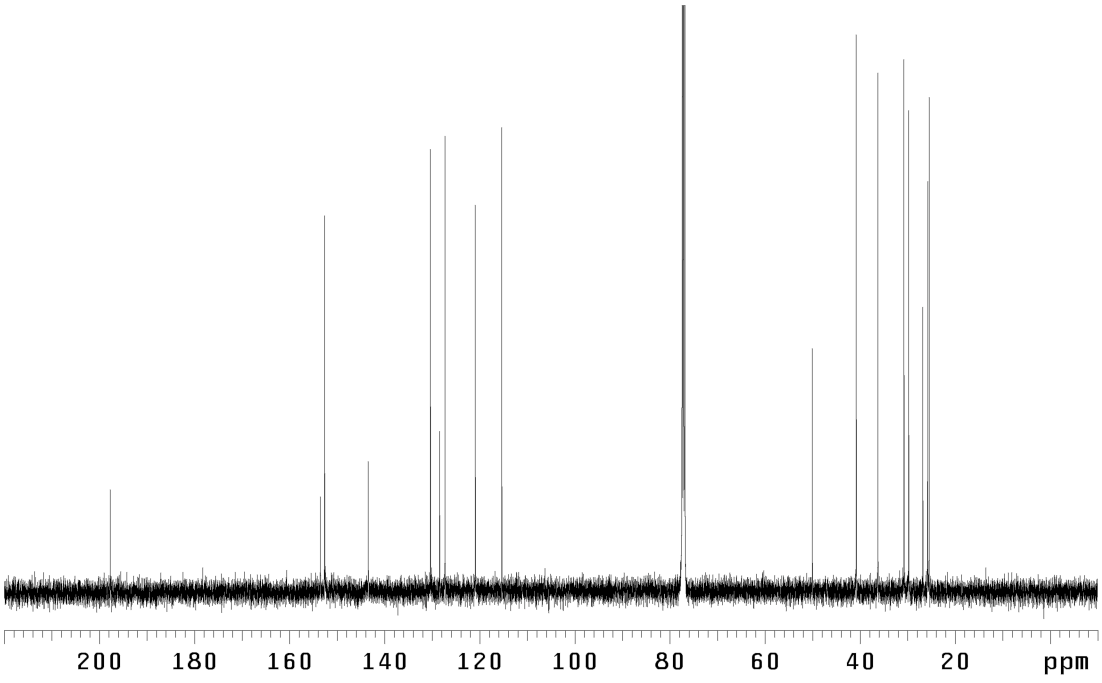


Figure SI-69C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **20**.

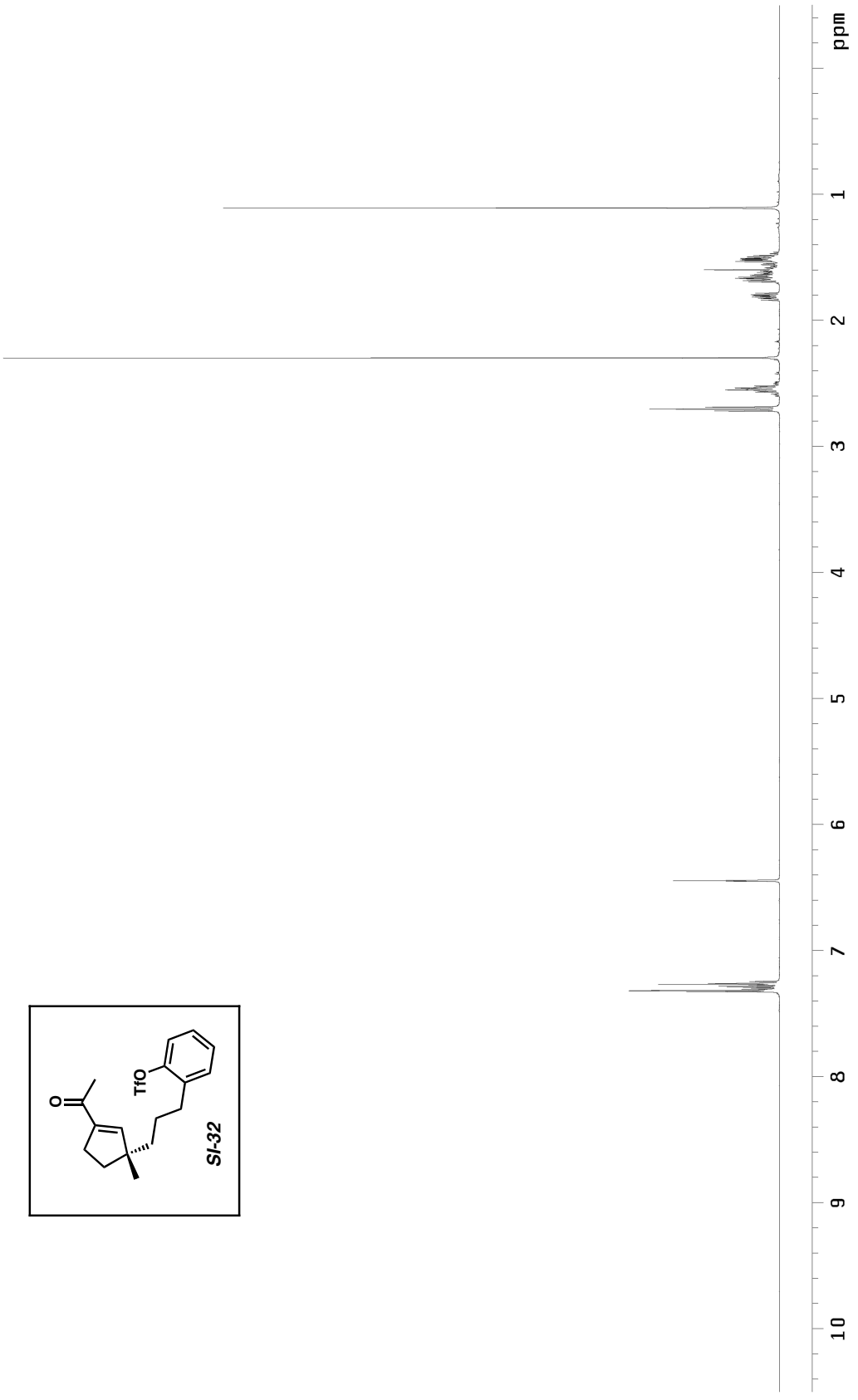


Figure SI-70A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-32**.

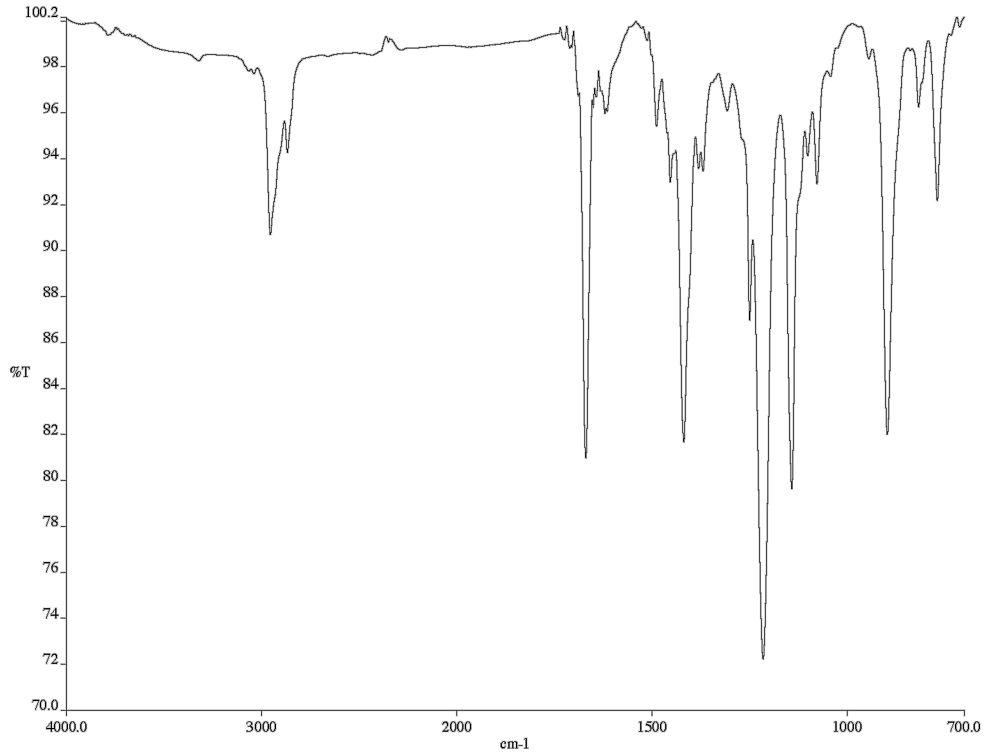


Figure SI-70B. Infrared spectrum (thin film/NaCl) of compound **SI-32**.

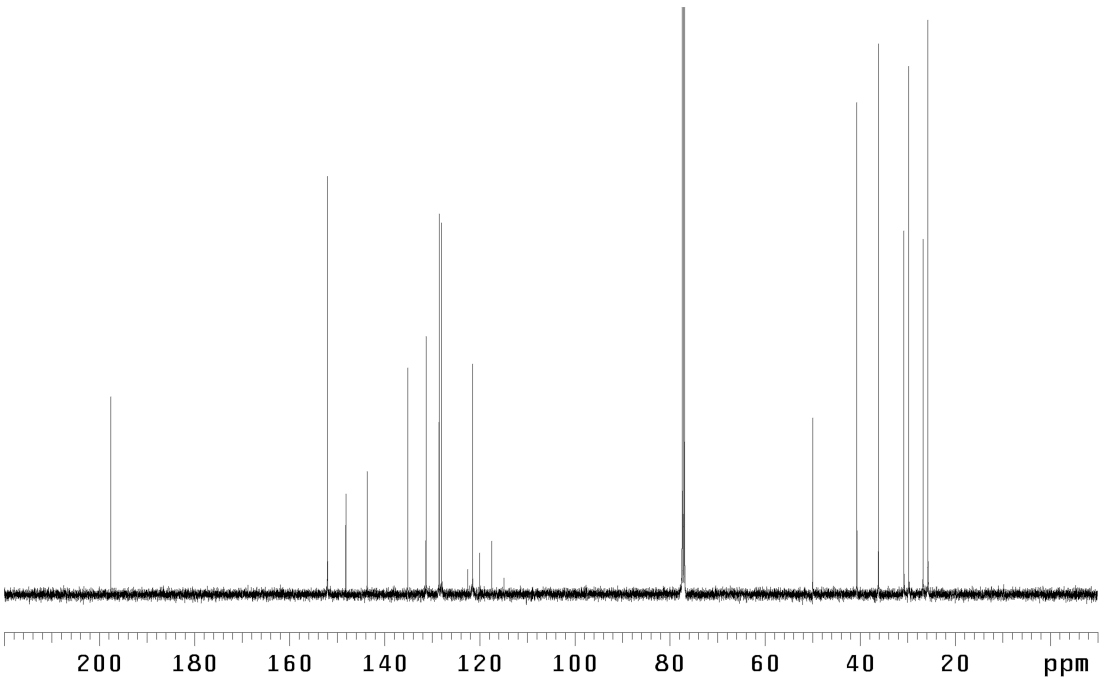


Figure SI-70C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **SI-32**.

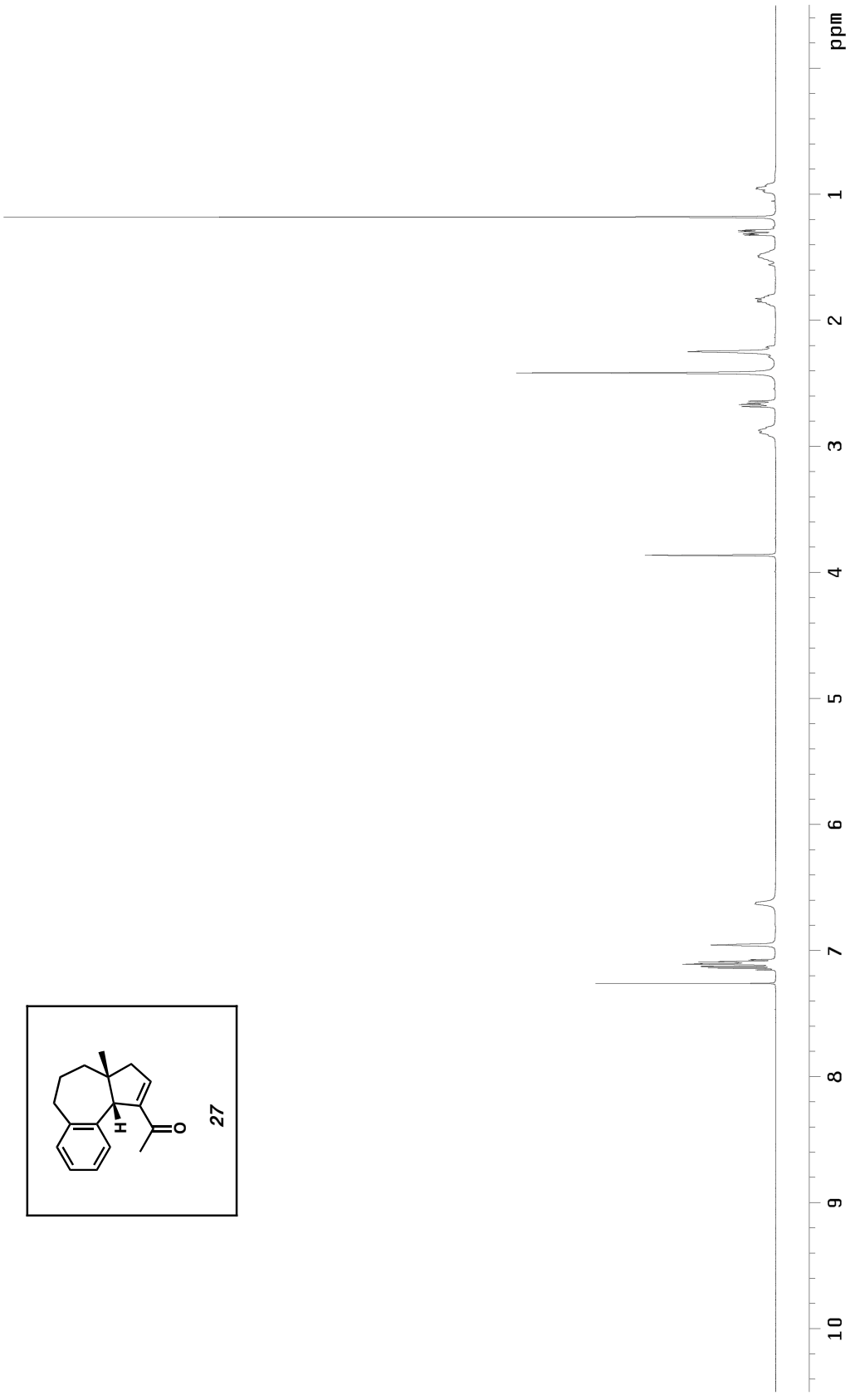


Figure SI-71A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **27**.

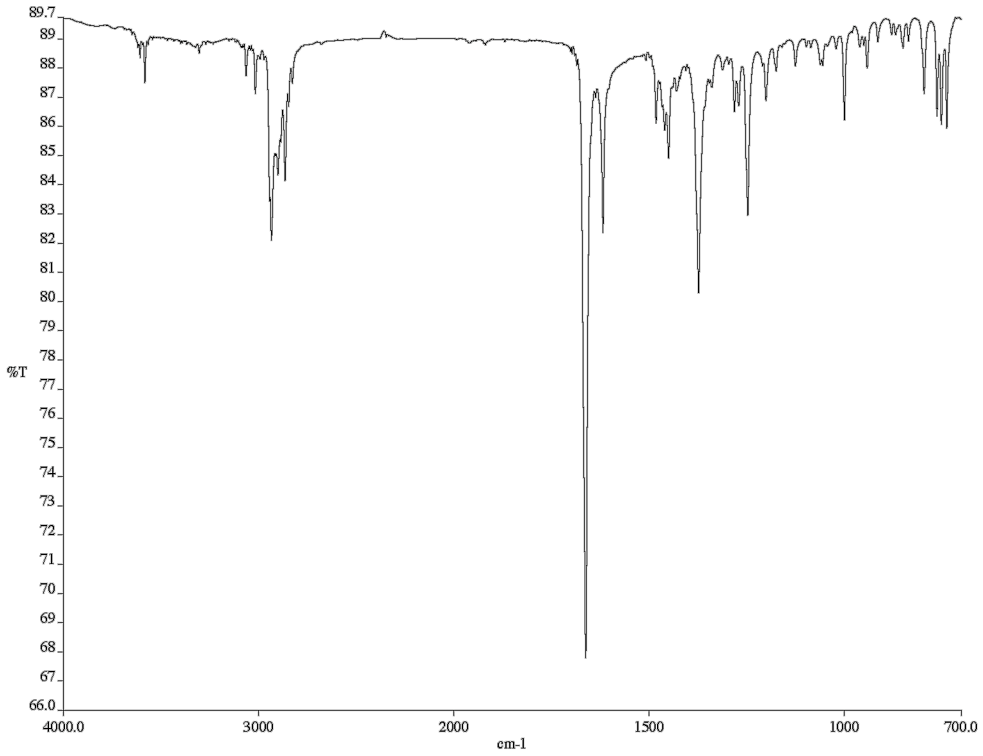


Figure SI-71B. Infrared spectrum (thin film/NaCl) of compound **27**.

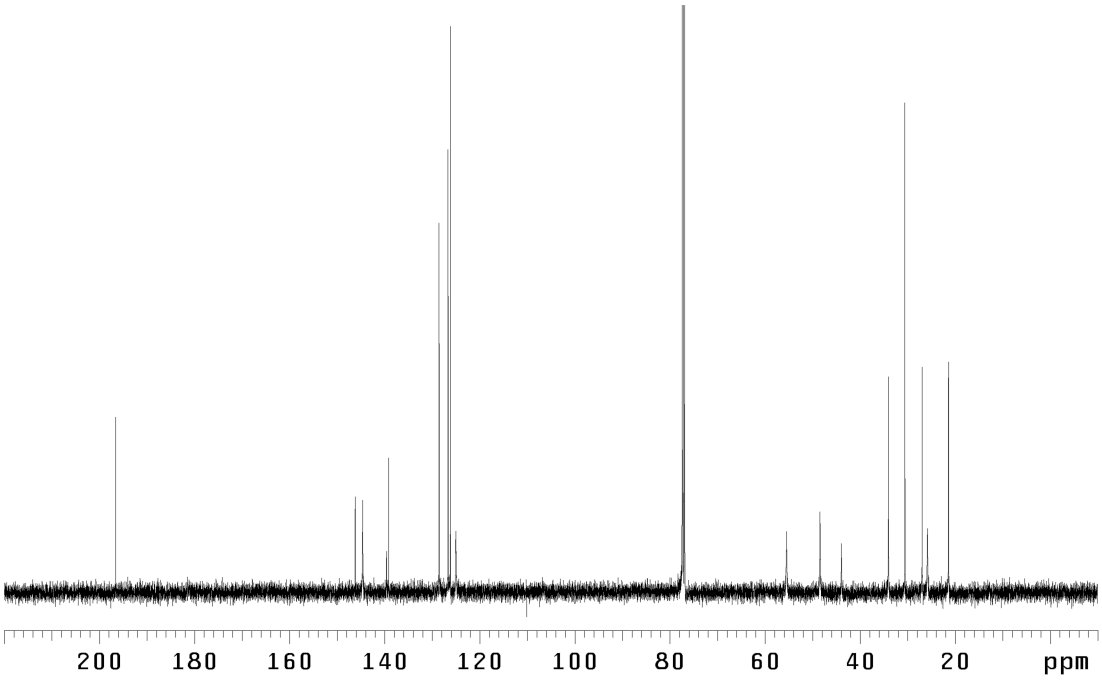


Figure SI-71C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **27**.

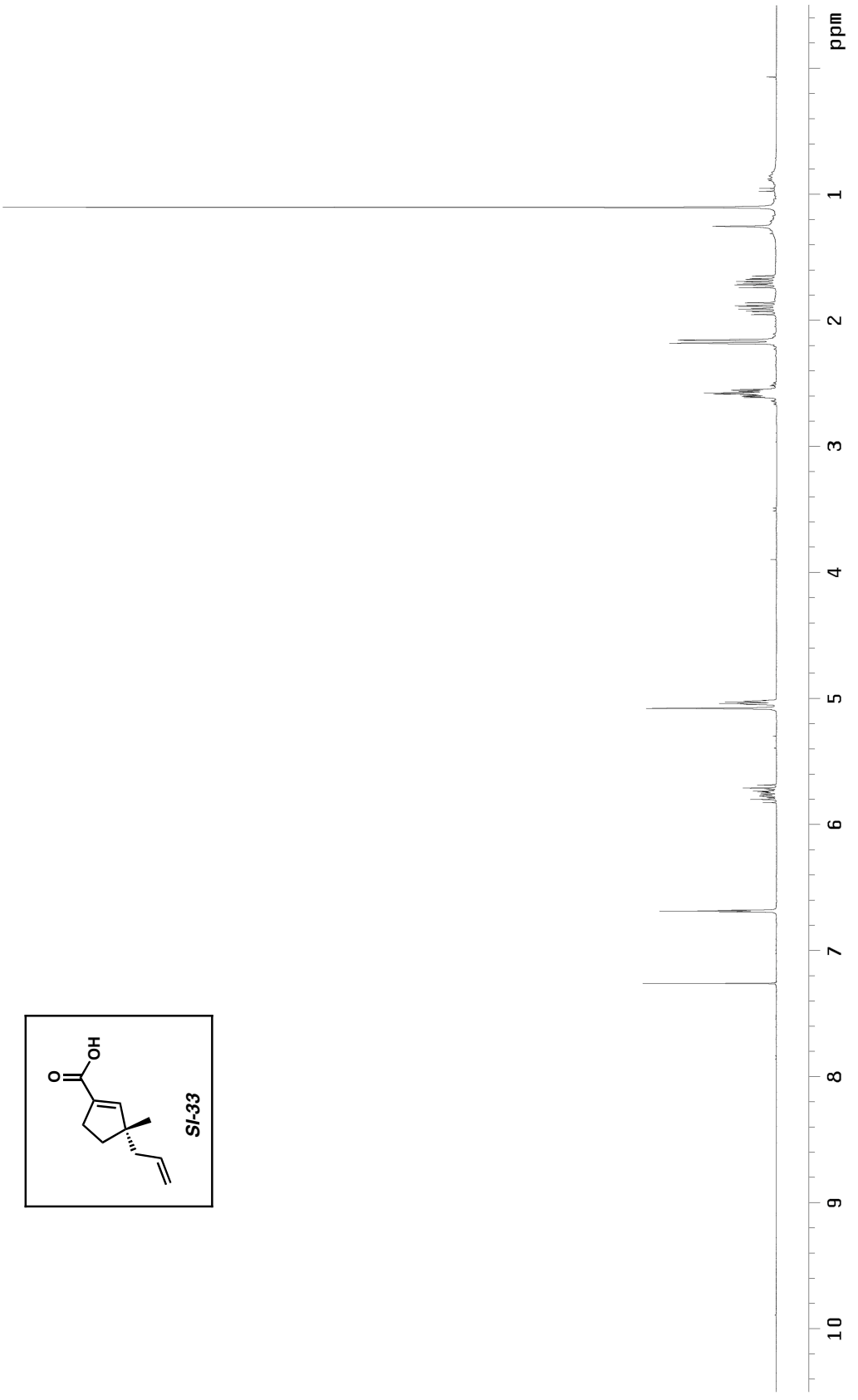


Figure SI-72A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **SI-33**.

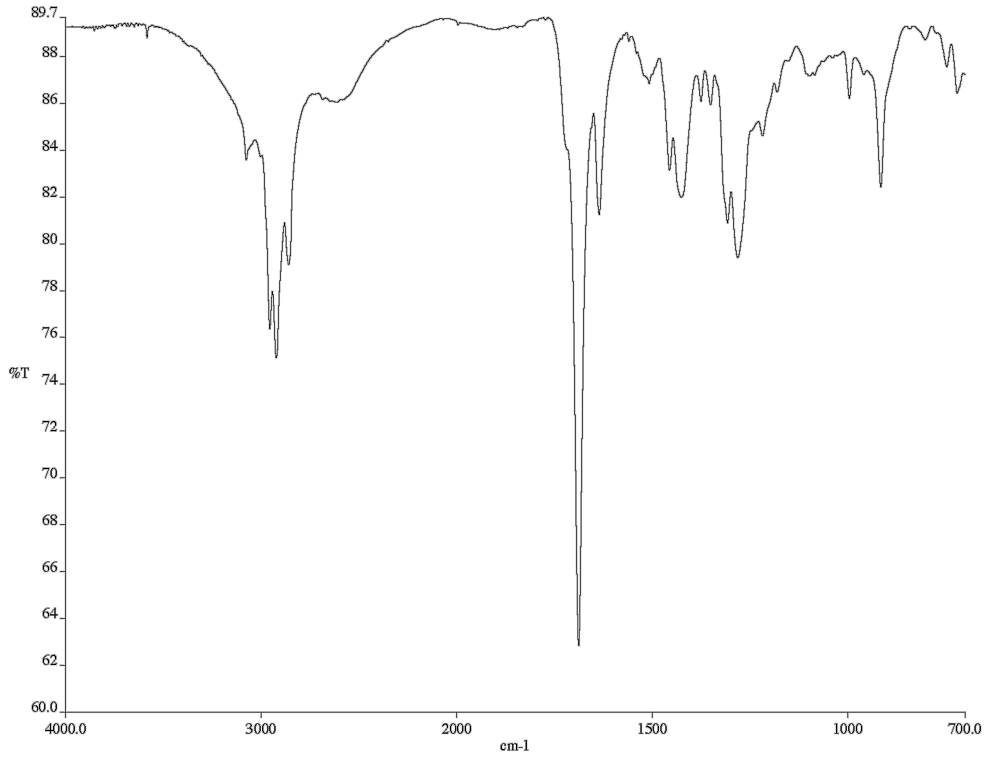


Figure SI-72B. Infrared spectrum (thin film/NaCl) of compound **SI-33**.

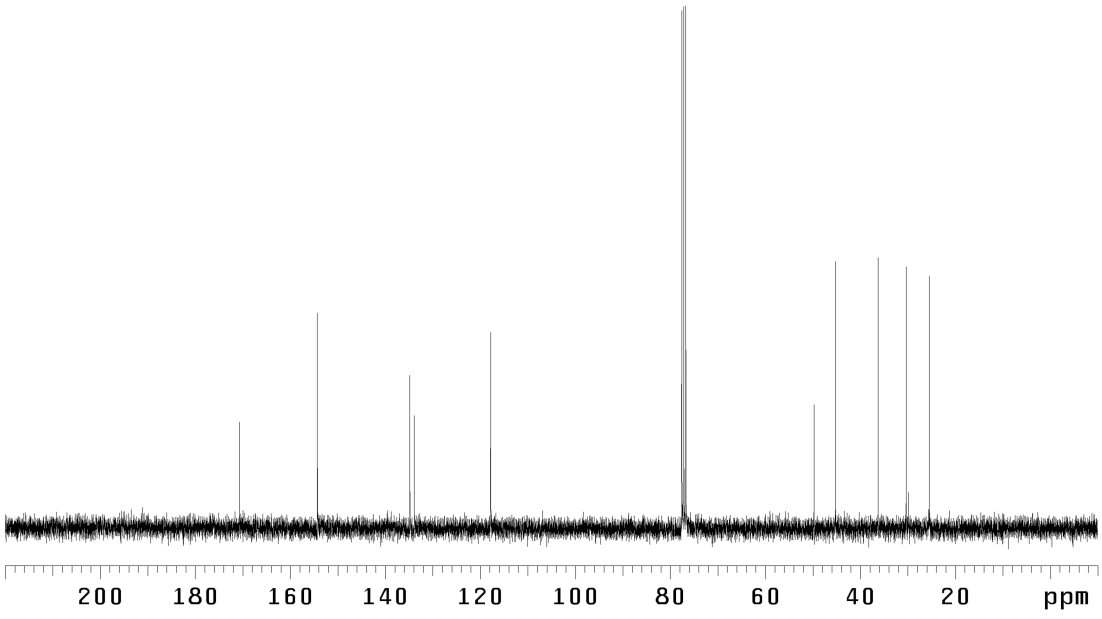


Figure SI-72C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **SI-33**.

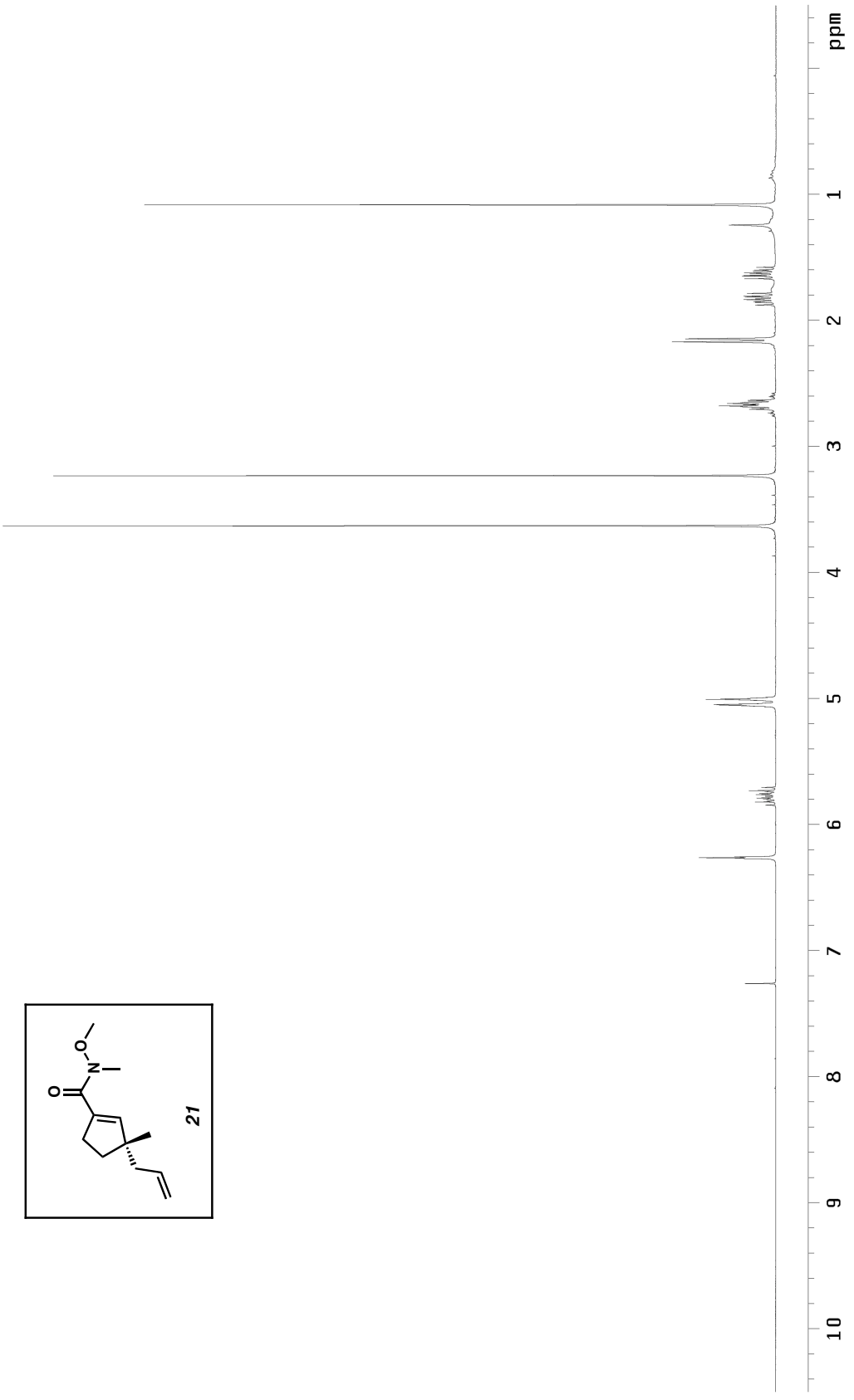


Figure SI-73A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **21**.

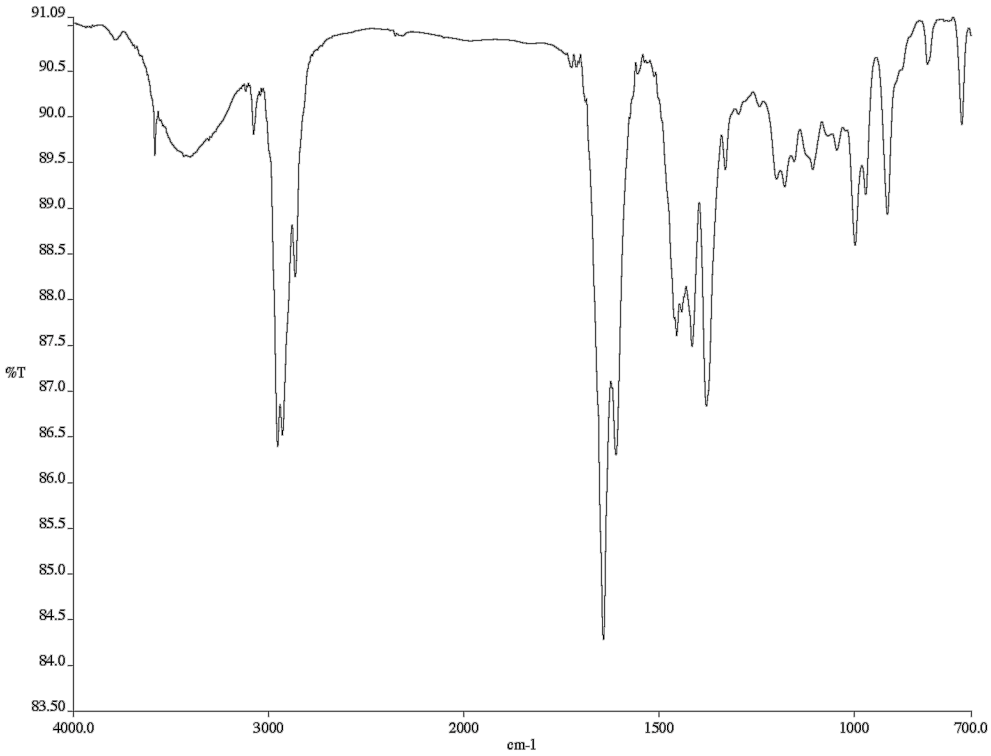


Figure SI-73B. Infrared spectrum (thin film/NaCl) of compound **21**.

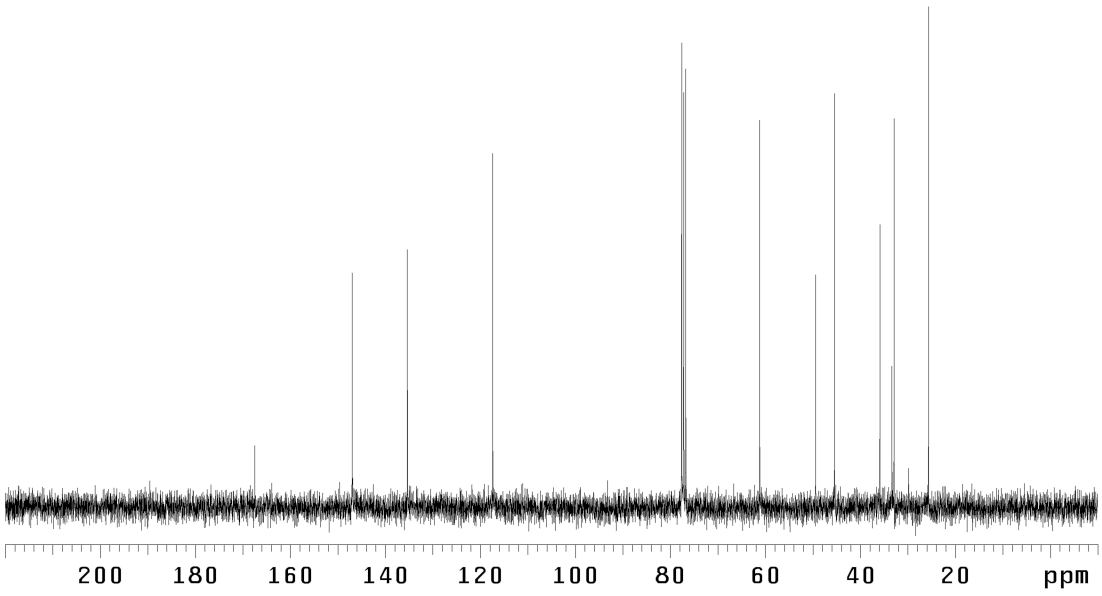


Figure SI-73C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **21**.

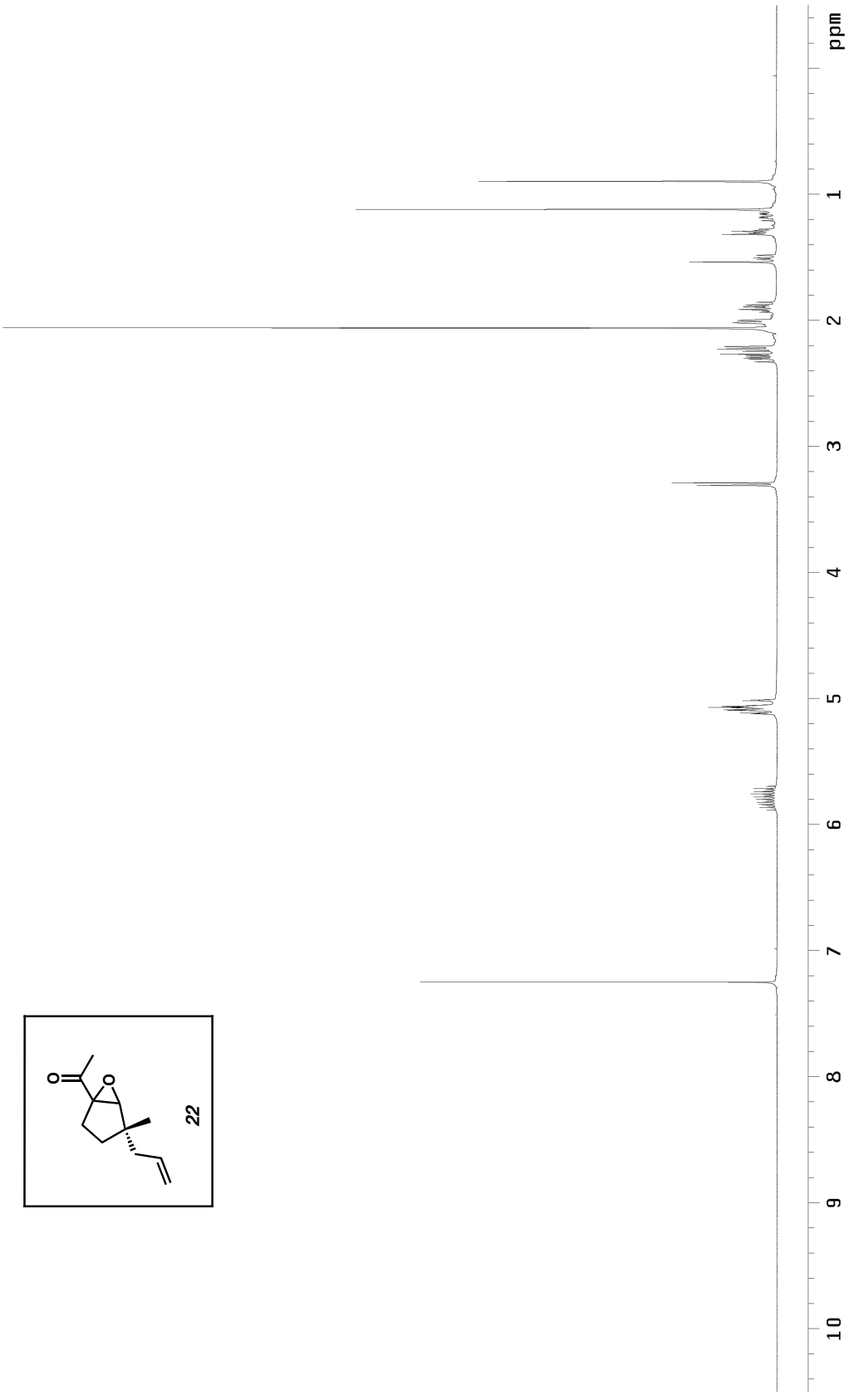


Figure SI-74A. ^{1}H NMR (400 MHz, $CDCl_3$) of compound **22**.

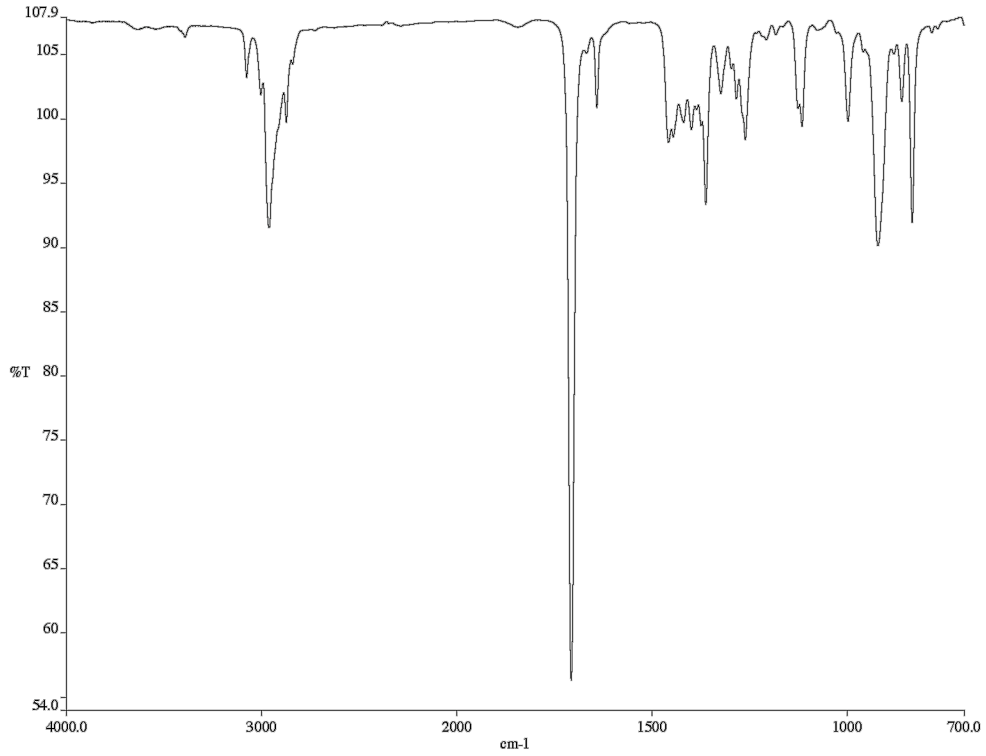


Figure SI-74B. Infrared spectrum (thin film/NaCl) of compound **22**.

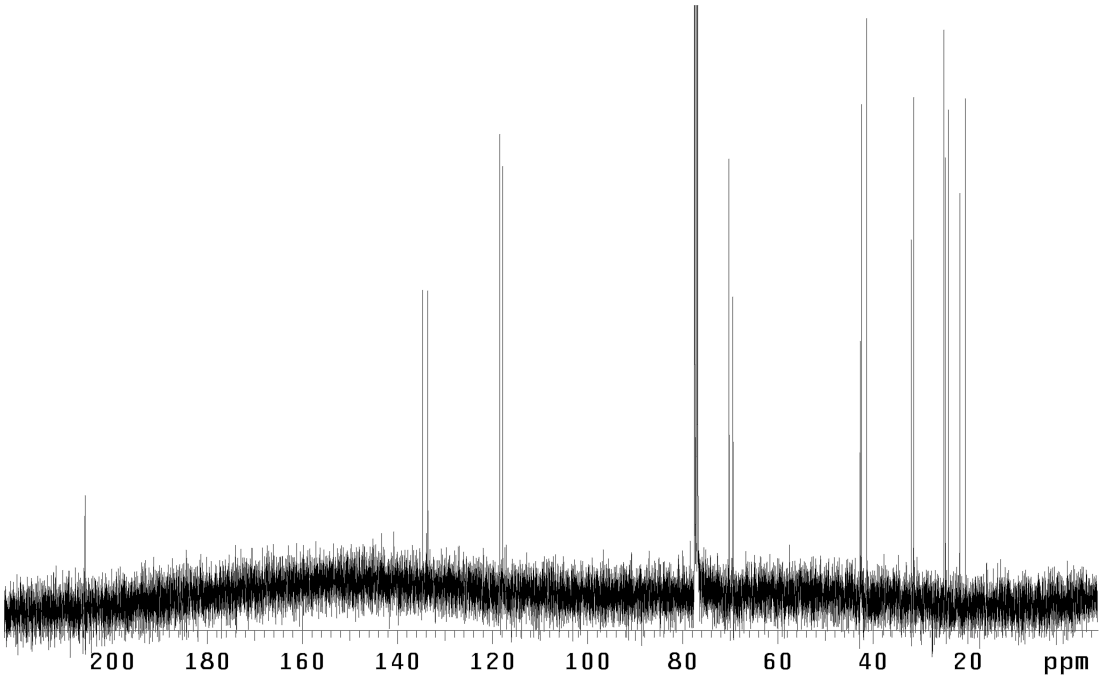


Figure SI-74C. ^{13}C NMR (100 MHz, $CDCl_3$) of compound **22**.

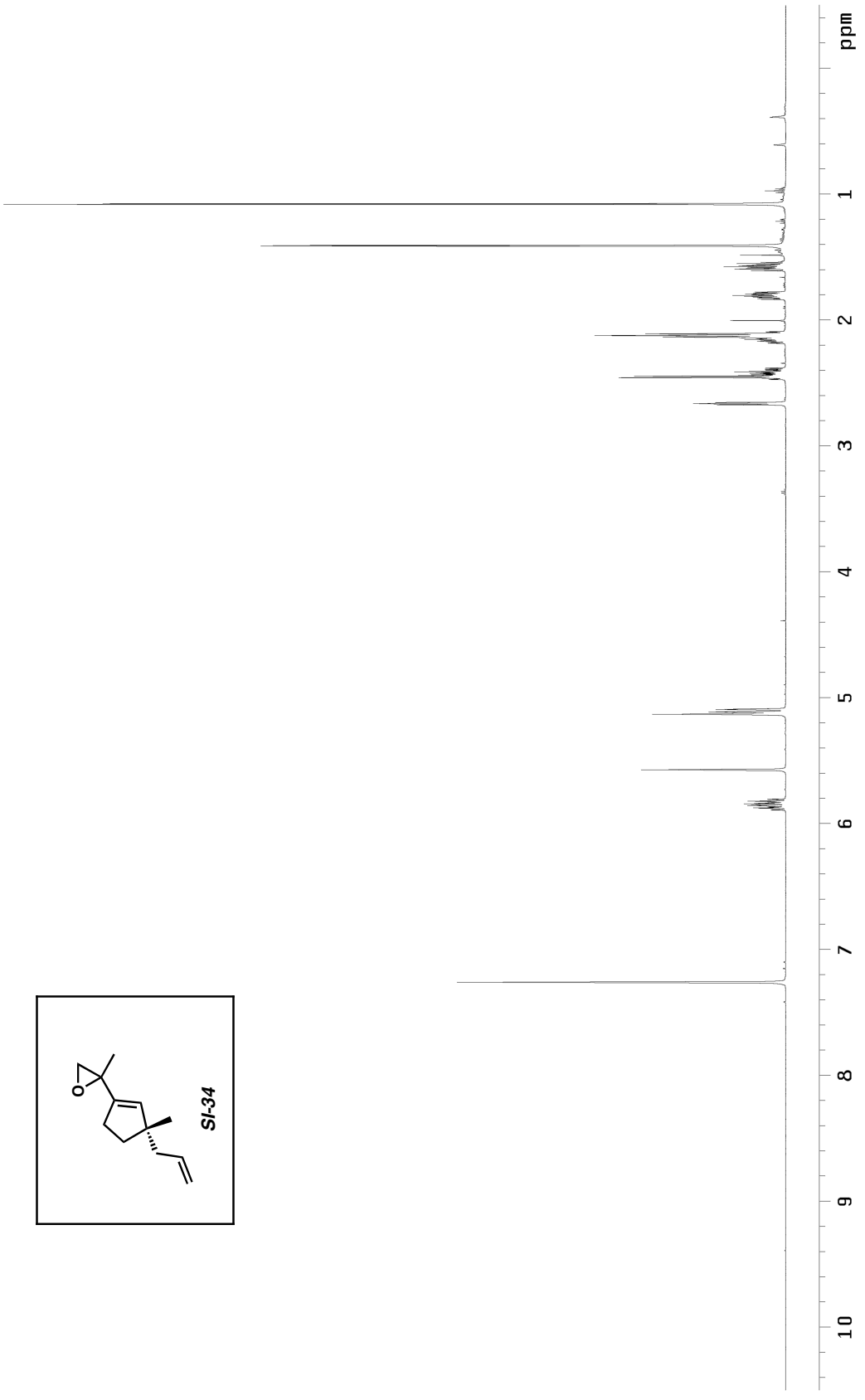


Figure SI-75A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **SI-34**.

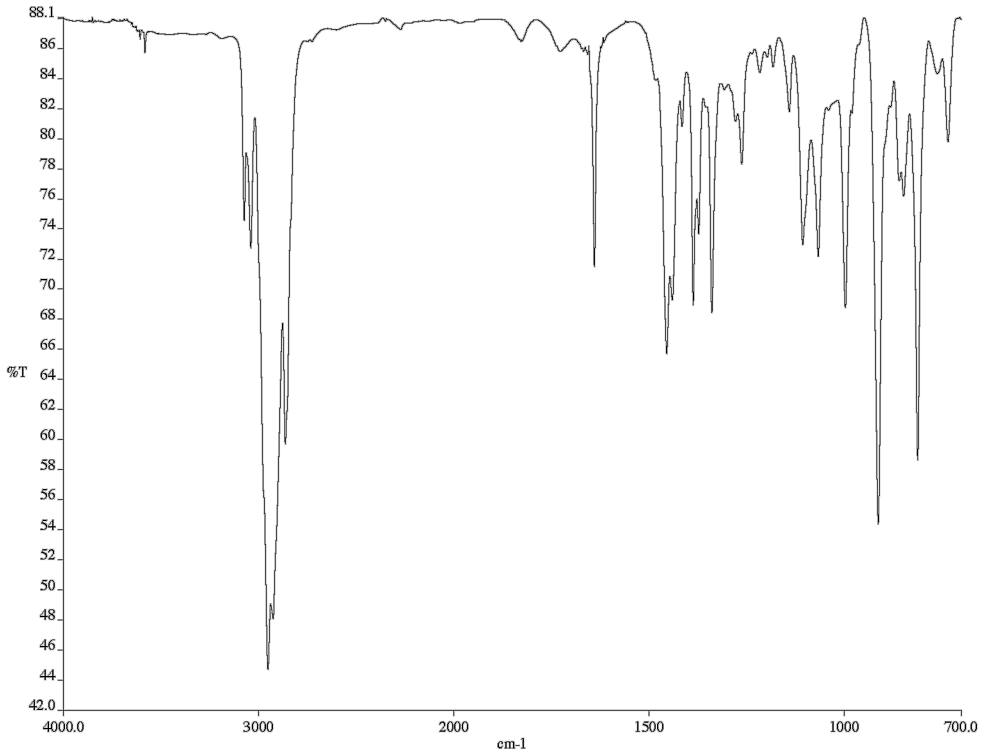


Figure SI-75B. Infrared spectrum (thin film/NaCl) of compound **SI-34**.

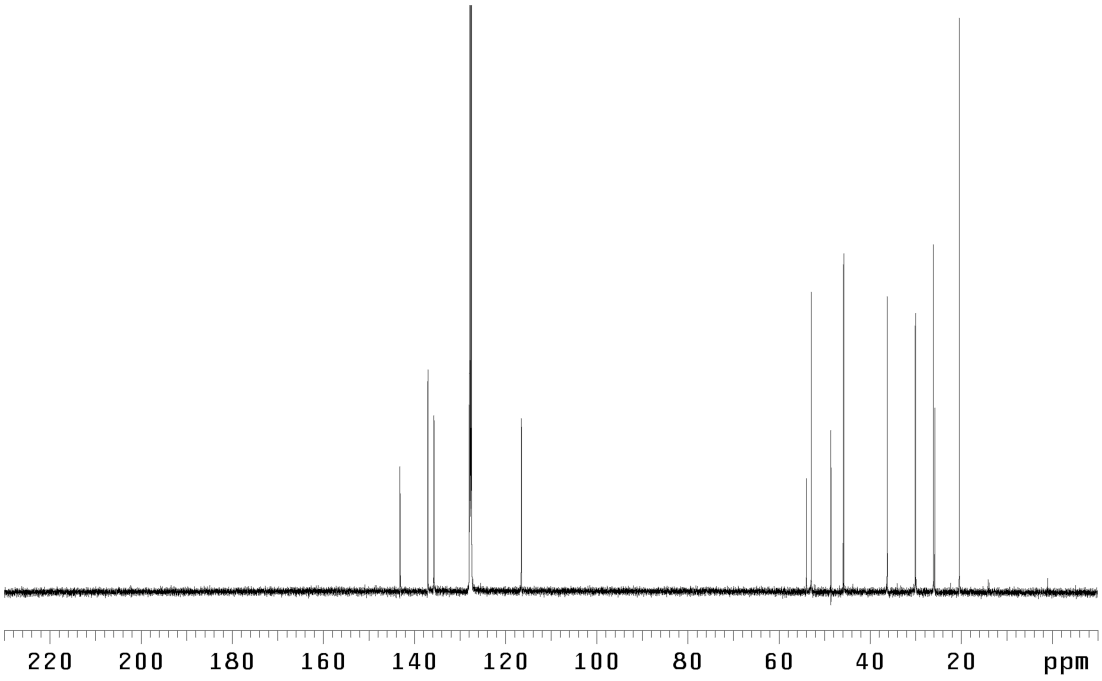


Figure SI-75C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **SI-34**.

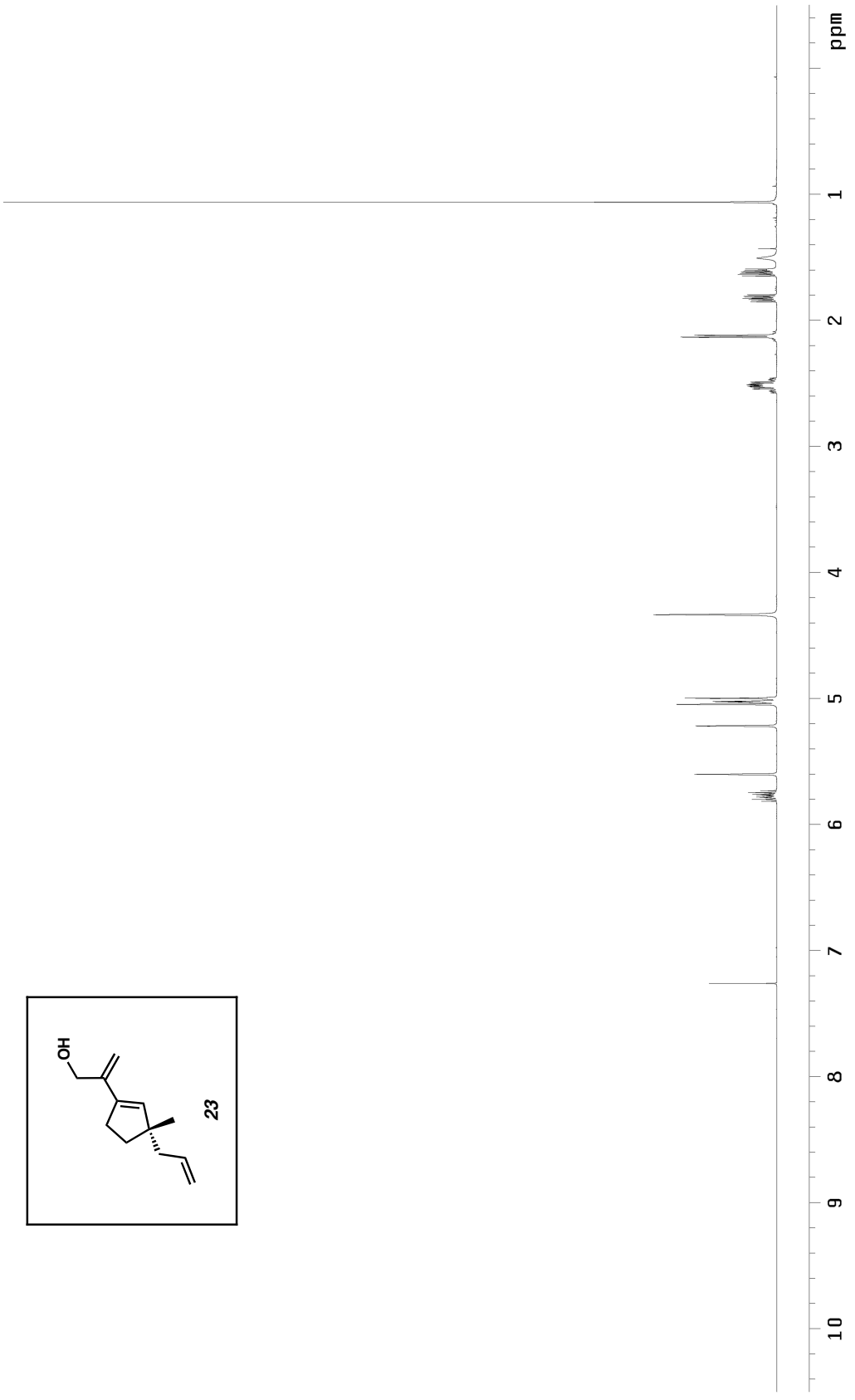


Figure SI-76A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **23**.

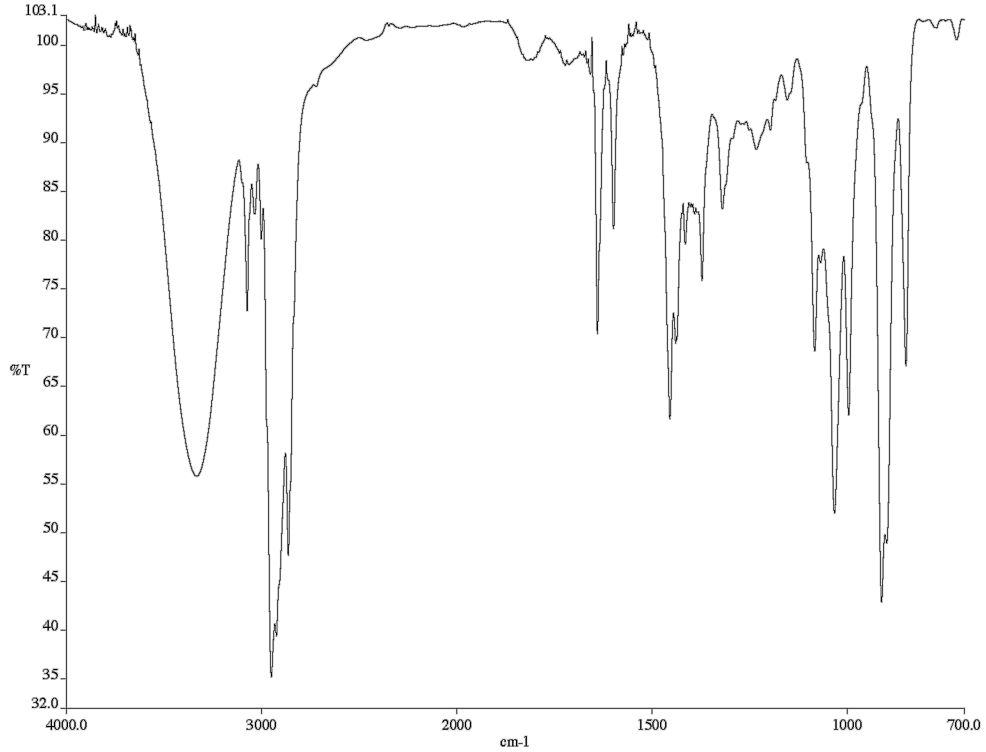


Figure SI-76B. Infrared spectrum (thin film/NaCl) of compound **23**.

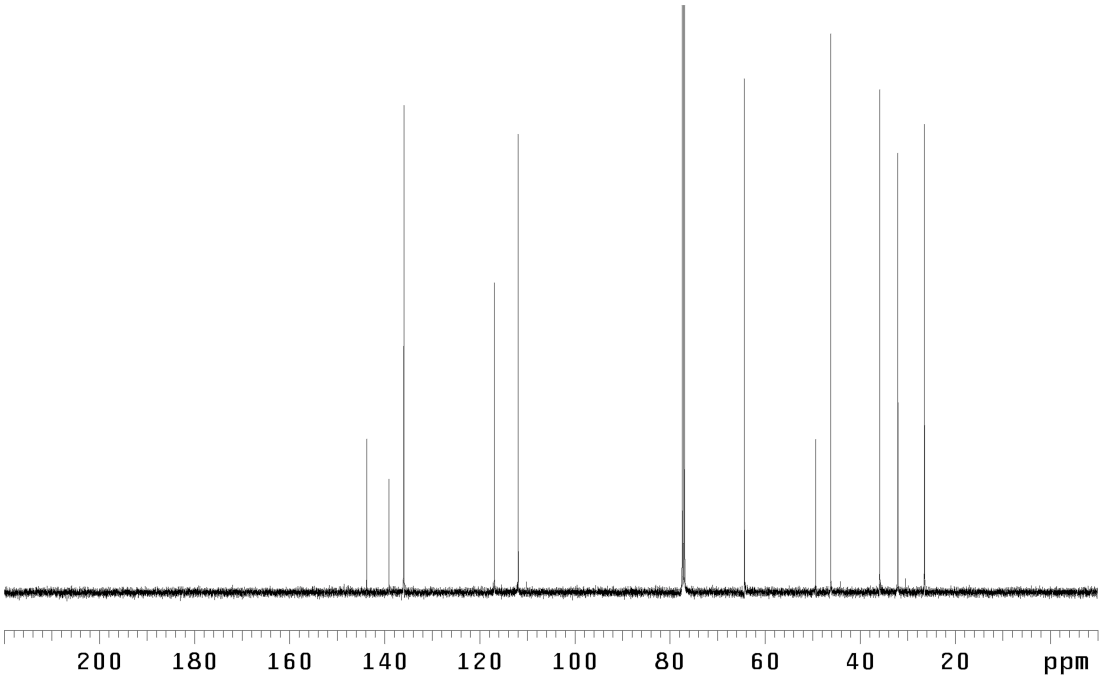


Figure SI-76C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **23**.

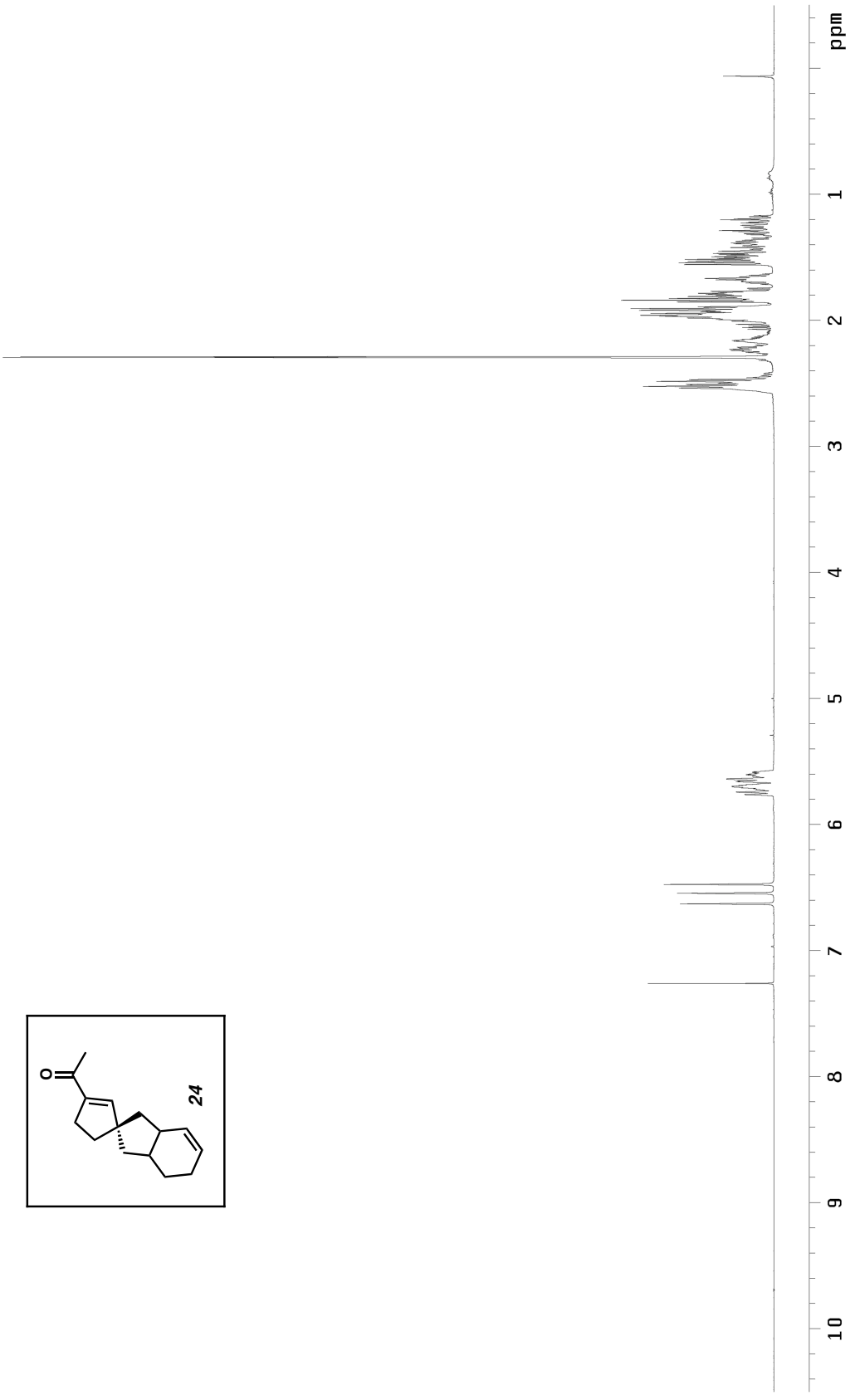


Figure SI-77A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **24**.

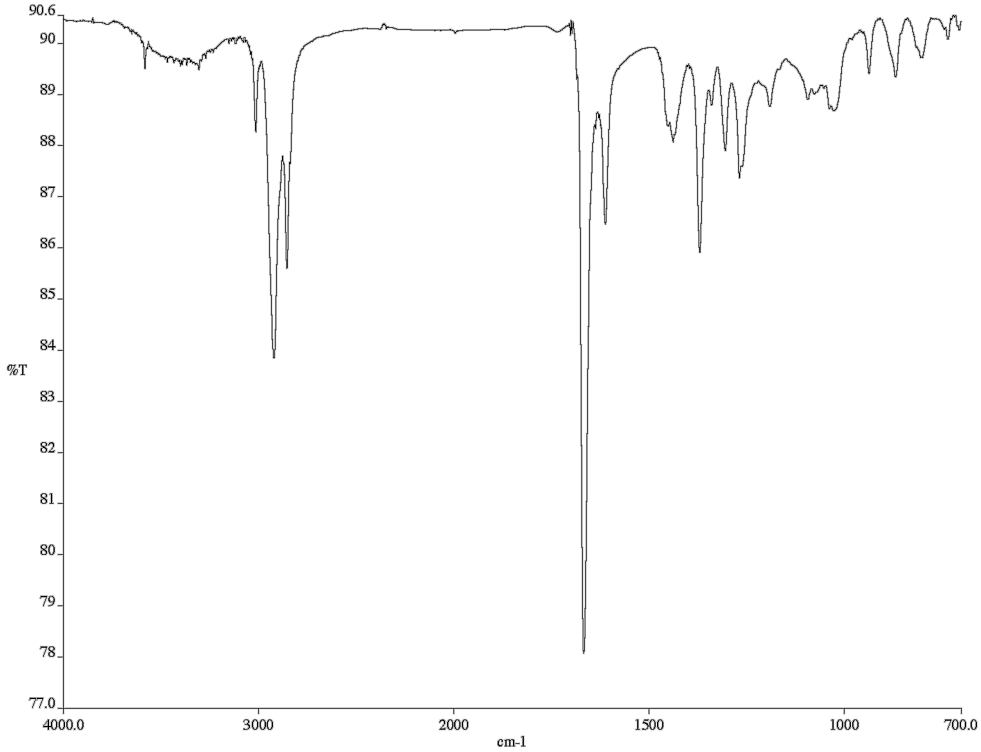


Figure SI-77B. Infrared spectrum (thin film/NaCl) of compound **24**.

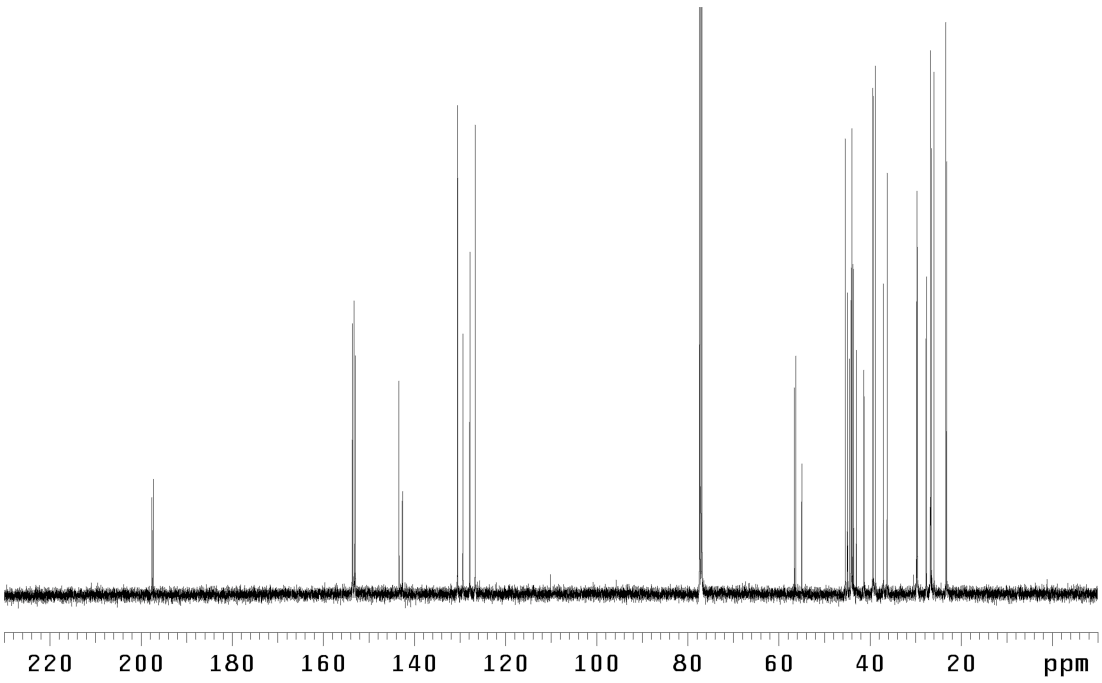


Figure SI-77C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **24**.

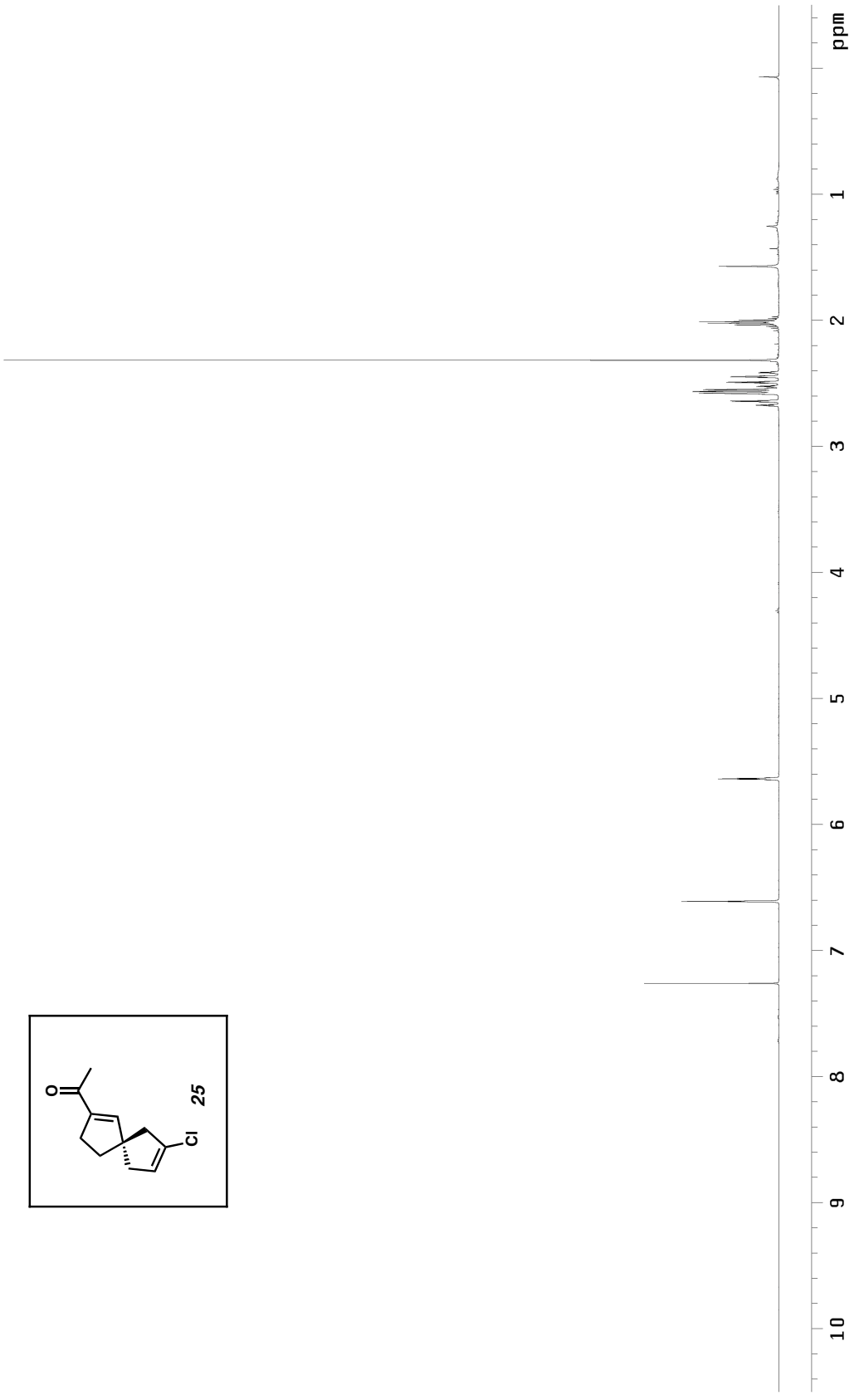


Figure SI-78A. ^{1}H NMR (500 MHz, $CDCl_3$) of compound **25**.

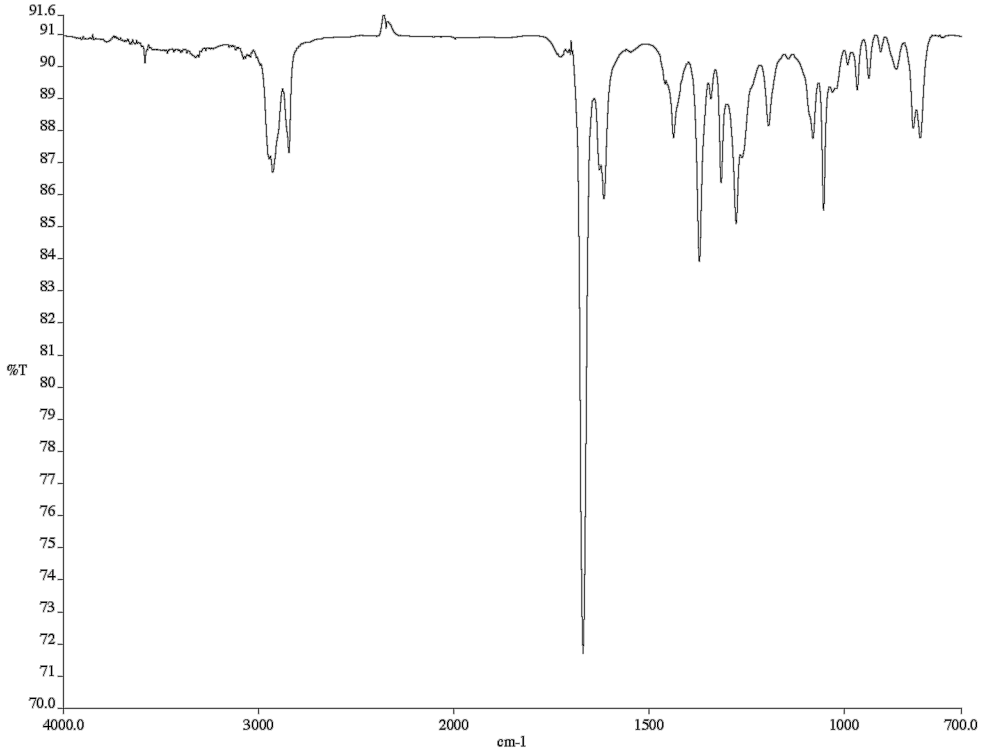


Figure SI-78B. Infrared spectrum (thin film/NaCl) of compound **25**.

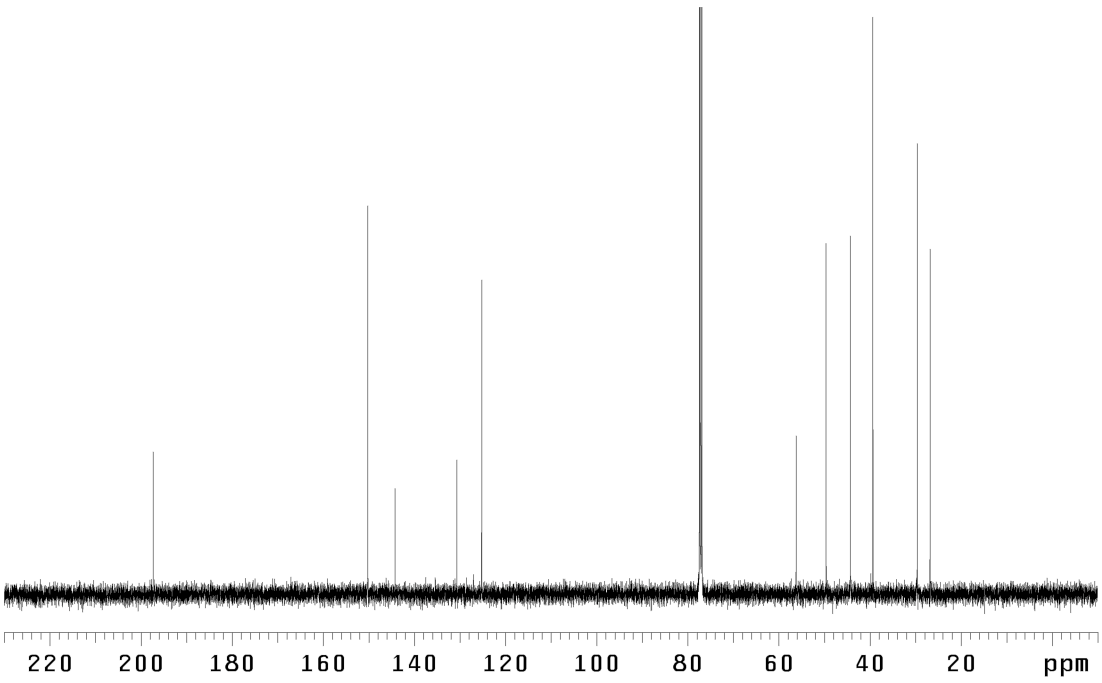


Figure SI-78C. ^{13}C NMR (125 MHz, $CDCl_3$) of compound **25**.

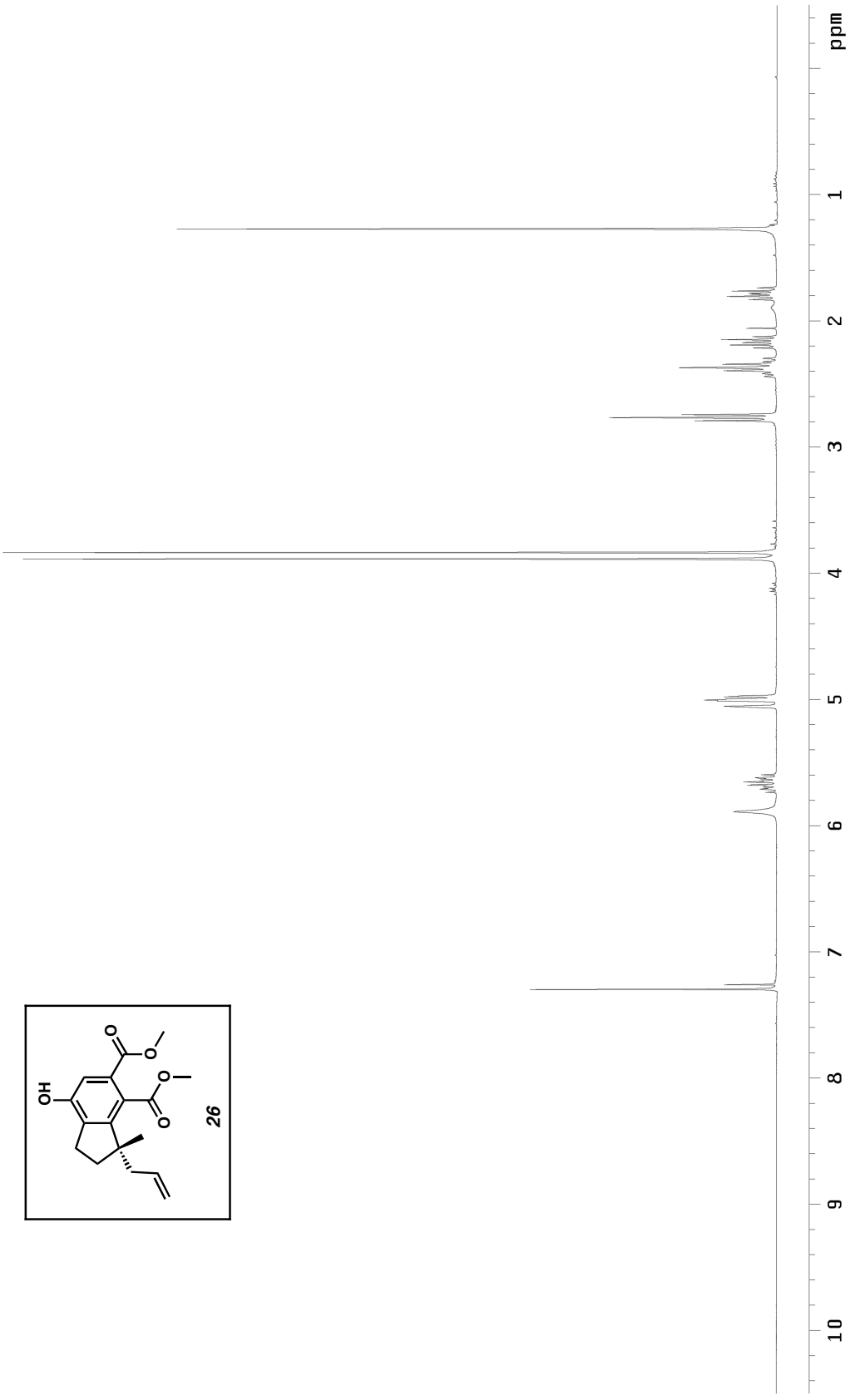


Figure SI-79A. ^{1}H NMR (300 MHz, $CDCl_3$) of compound **26**.

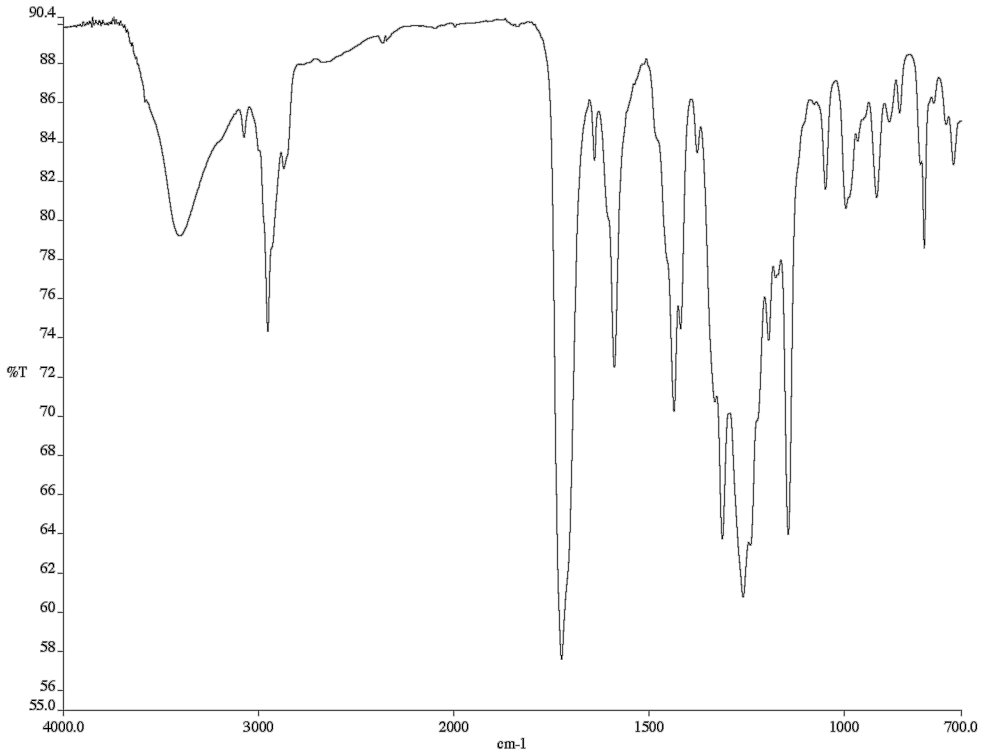


Figure SI-79B. Infrared spectrum (thin film/NaCl) of compound **26**.

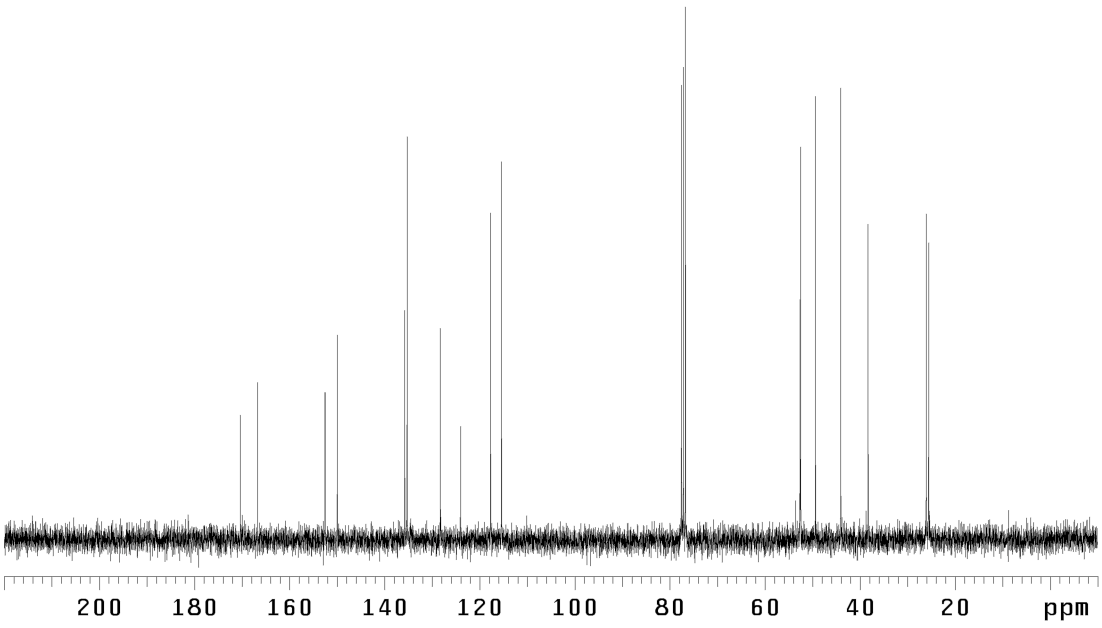
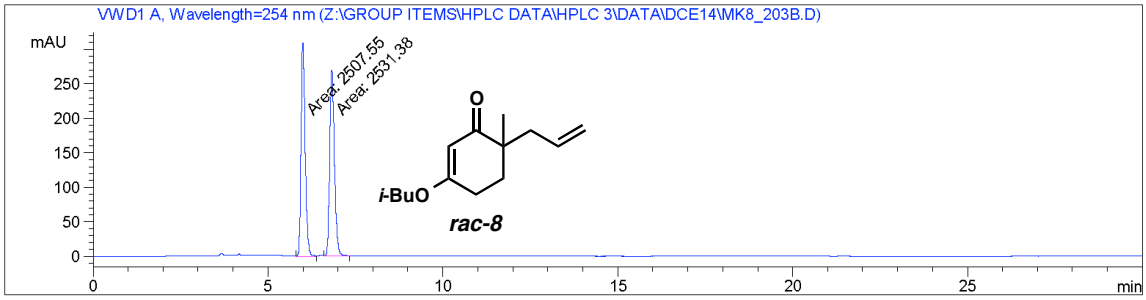


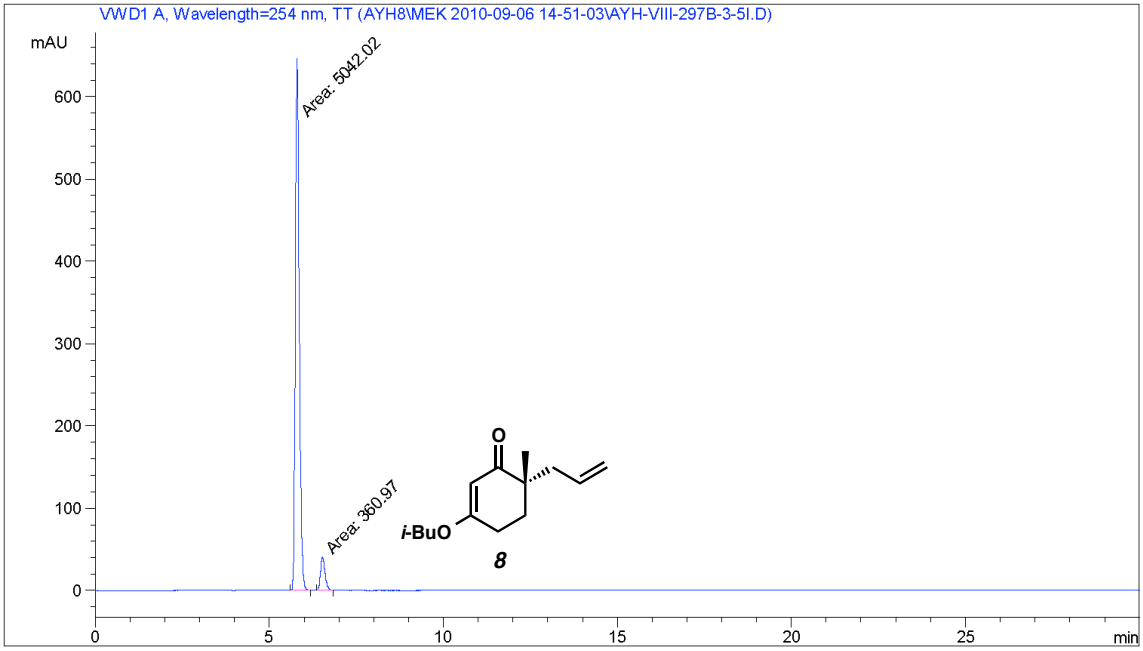
Figure SI-79C. ^{13}C NMR (75 MHz, $CDCl_3$) of compound **26**.

```
Data File Z:\GROUP ITEMS\HPLC DATA\HPLC 3\DATA\DCE14\MK8_203B.D
Sample Name: mrkVIII-203-1

    ==================================================================
    Acq. Operator    : dave e                        Seq. Line :   9
    Acq. Instrument  : Instrument 3                   Location : Vial 61
    Injection Date   : 1/8/2007 4:11:20 PM                 Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\5-IPA30.M
    Last changed     : 9/2/2004 10:08:41 AM by Young
    Analysis Method  : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/9/2011 2:08:05 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 5% IPA
                       OD-H
```



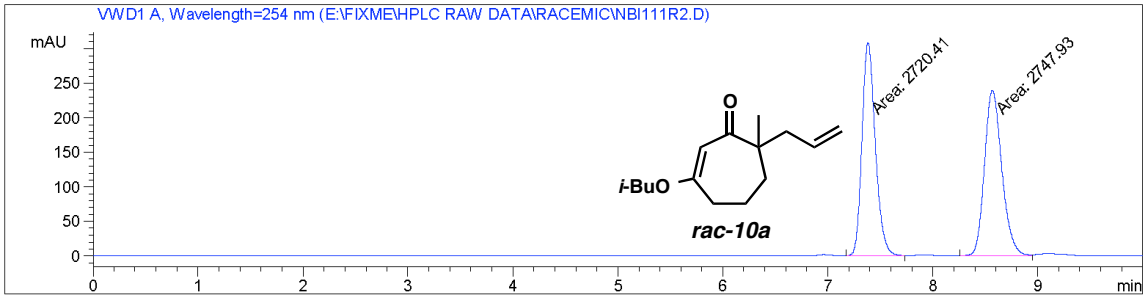

```
    ==================================================================
                            Area Percent Report
    ==================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|-------|
       1   5.998 MM    0.1353 2507.55054  308.81195  49.7635
       2   6.826 MM    0.1567 2531.38281  269.20166  50.2365

    Totals :                  5038.93335  578.01361


    ==================================================================
                            *** End of Report ***
```

```
Data File C:\CHEM32\2\DATA\AYH8\MEK 2010-09-06 14-51-03\AYH-VIII-297B-3-5I.D
Sample Name: AYH-VIII-297B-3-5I

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :   3
    Acq. Instrument : HPLC 2                        Location : Vial 41
    Injection Date  : 9/6/2010 3:03:09 PM               Inj :   1
                                                   Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\2\DATA\AYH8\MEK 2010-09-06 14-51-03\5IPA30_254.M
    Last changed    : 4/26/2010 8:29:46 PM
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```



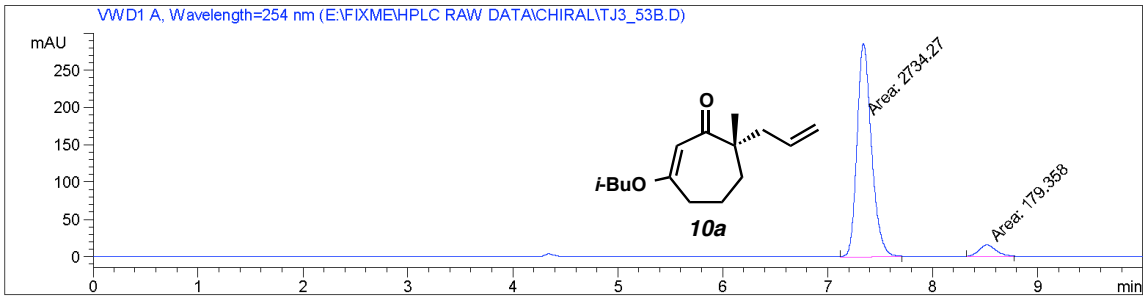

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   5.801 MM    0.1301 5042.01709  645.94580  93.3191
       2   6.533 MM    0.1483  360.97034   40.58105   6.6809

    Totals :                  5402.98743  686.52685
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\NBI111R2.D
Sample Name: NBB-I-111Rac

    ======================================================================
    Acq. Operator    : nbb                          Seq. Line :   4
    Acq. Instrument : Instrument 3                   Location : Vial 41
    Injection Date   : 1/20/2009 10:09:29 AM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\1IPA10.M
    Last changed     : 1/19/2009 2:04:08 PM by jst
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : NBB-I-111, racemic, OD-H, 1% IPA, 1mL/min, 254nm, 10min
```



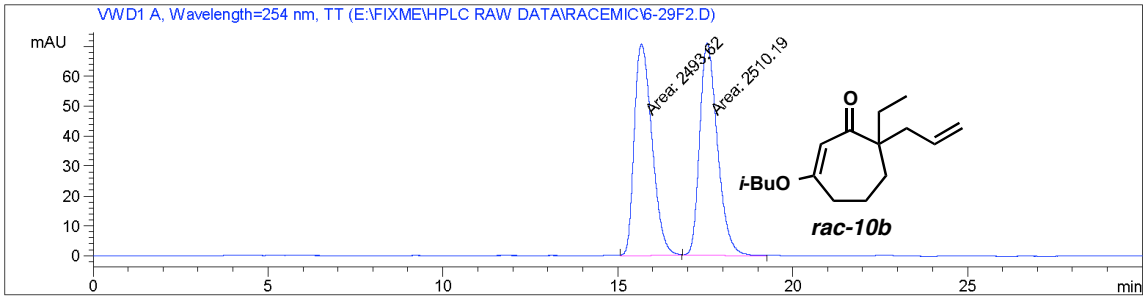

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   7.383 MM    0.1469 2720.40527  308.67719  49.7483
       2   8.568 MM    0.1913 2747.92944  239.44769  50.2517

    Totals :                  5468.33472  548.12488


    ======================================================================
                              *** End of Report ***
```

```
Data File E:\FIXME\HPLC RAW DATA\CHIRAL\TJ3_53B.D
Sample Name: TJ_3_53

    ======================================================================
    Acq. Operator    : JC                              Seq. Line :   3
    Acq. Instrument : Instrument 3                      Location : Vial 91
    Injection Date   : 3/6/2008 11:08:26 PM                Inj :   1
                                                      Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\1-IPA20.M
    Last changed     : 5/24/2007 6:08:07 PM by scm
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:38:58 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```



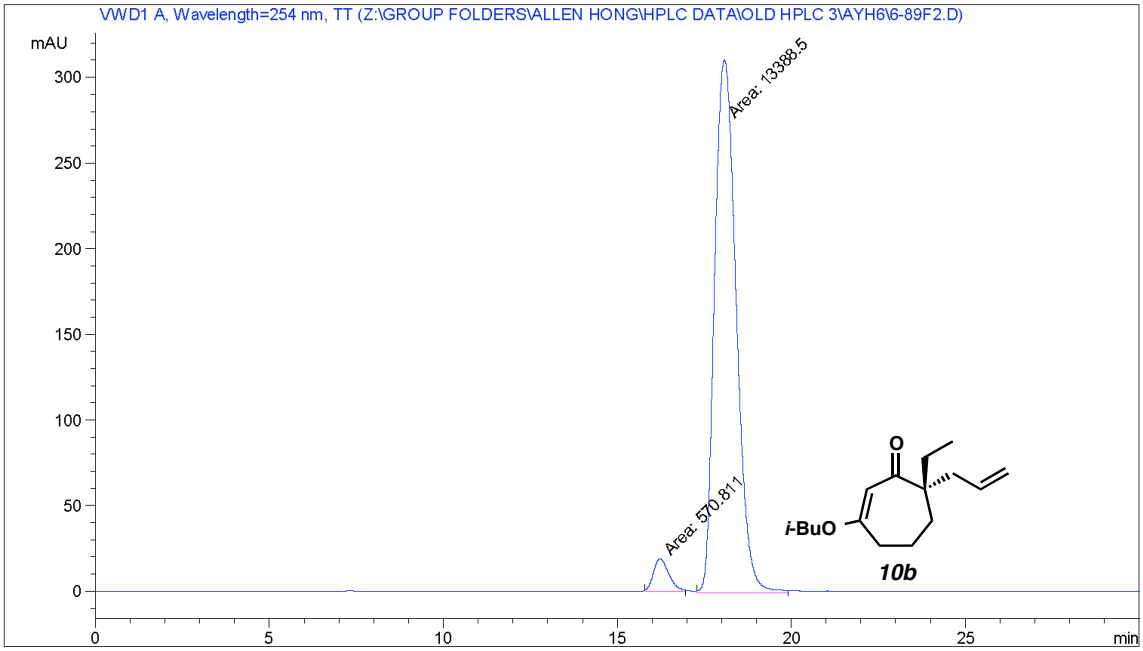

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   7.341 MM    0.1591 2734.27222  286.41141  93.8442
       2   8.517 MM    0.1948  179.35828   15.34834   6.1558

    Totals :                  2913.63049  301.75975


    ======================================================================
                              *** End of Report ***
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\6-29F2.D
Sample Name: AYH-VI-29F2

    ======================================================================
    Acq. Operator    : AYH                          Seq. Line :   5
    Acq. Instrument : Instrument 3                   Location : Vial 92
    Injection Date   : 10/12/2009 11:36:57 AM             Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\D5-30.M
    Last changed     : 10/9/2009 12:15:47 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 5% D bottle, D=5% IPA/Hex, 254 nm, 0.5 mL/min, 30 min,
                       AD
```



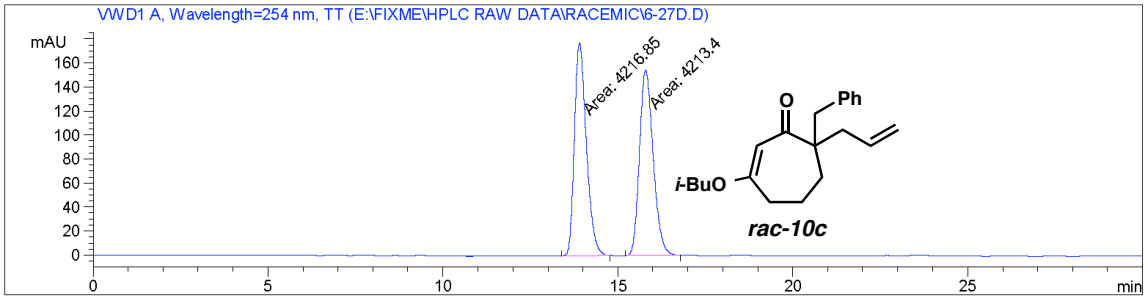

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  15.678 MM    0.5885 2493.61816   70.62130  49.8344
       2  17.558 MM    0.5900 2510.19434   70.91343  50.1656

    Totals :                  5003.81250  141.53473


    ======================================================================
                              *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH6\6-89F2.D
Sample Name: AYH-VI-89F2

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :   4
    Acq. Instrument : Instrument 3                  Location : Vial 82
    Injection Date  : 10/12/2009 11:06:01 AM             Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D5-30.M
    Last changed    : 10/9/2009 12:15:47 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 5% D bottle, D=5% IPA/Hex, 254 nm, 0.5 mL/min, 30 min,
                      AD
```



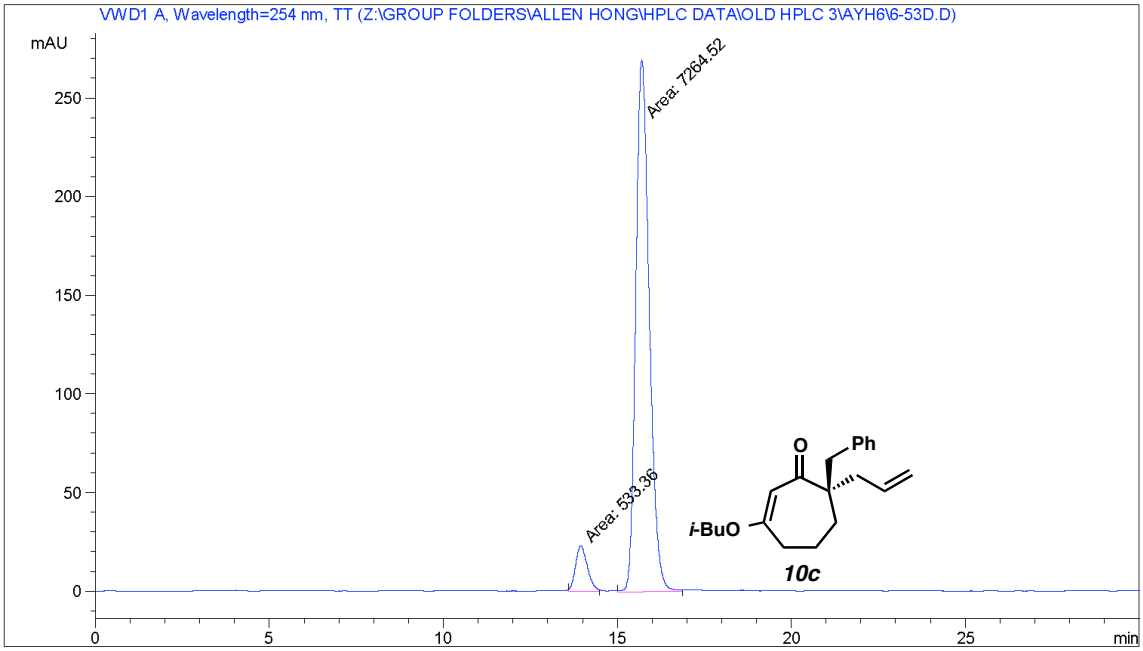

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  16.228 MM    0.5055  570.81091   18.81998   4.0891
       2  18.079 MM    0.7176 1.33885e4   310.94327  95.9109
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\6-27D.D
Sample Name: AYH-VI-27D

    ======================================================================
    Acq. Operator    : AYH                          Seq. Line :   3
    Acq. Instrument : Instrument 3                   Location : Vial 91
    Injection Date   : 10/10/2009 5:26:56 PM             Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\D10-30.M
    Last changed     : 10/9/2009 12:02:39 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 10% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min, O
                       D-H
```



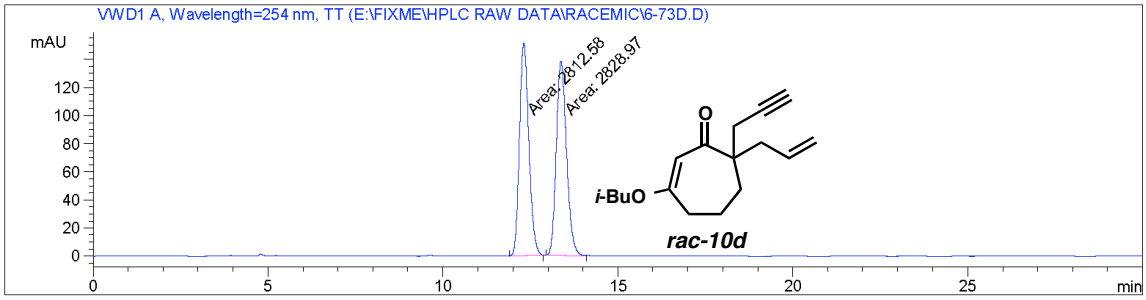

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|-------|
       1  13.904 MM    0.3968 4216.85498  177.13411  50.0205
       2  15.795 MM    0.4553 4213.39600  154.23495  49.9795

    Totals :                  8430.25098  331.36906


    ======================================================================
                              *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH6\6-53D.D
Sample Name: AYH-VI-53D

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  31
    Acq. Instrument : Instrument 3                  Location : Vial 81
    Injection Date  : 10/9/2009 10:38:46 PM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D10-30.M
    Last changed    : 10/9/2009 12:02:39 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 10% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min, O
                      D-H
```



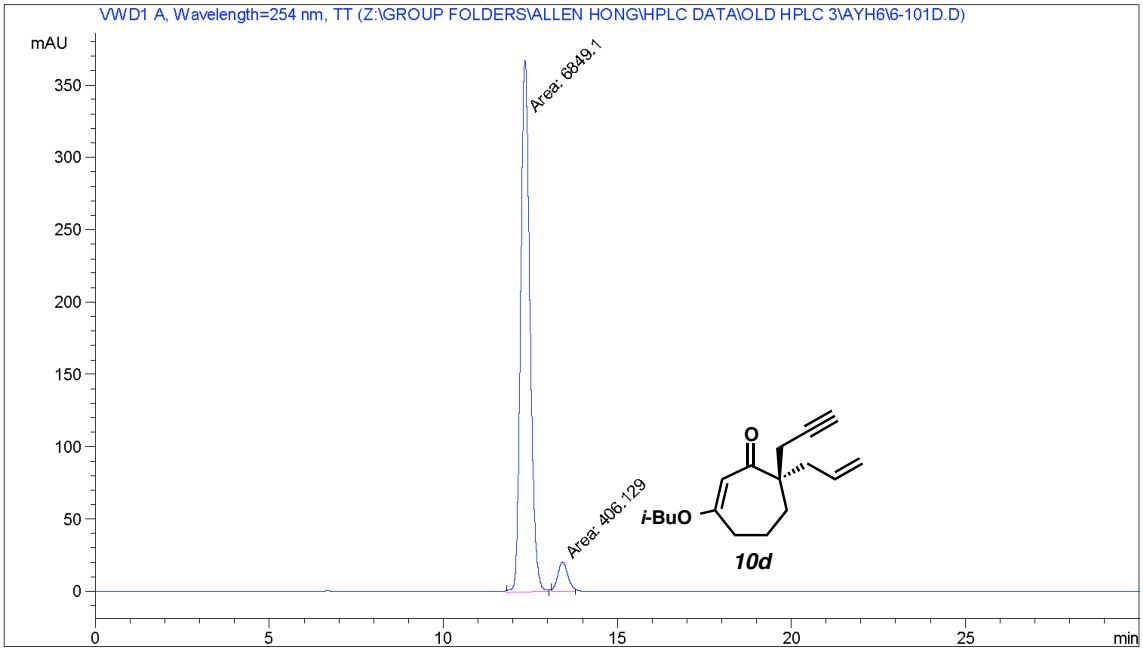

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  13.955 FM    0.3879  533.36029   22.91647   6.8398
       2  15.702 MM    0.4488 7264.51563  269.78458  93.1602
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\6-73D.D
Sample Name: AYH-VI-73D

    ======================================================================
    Acq. Operator    : AYH                          Seq. Line :  26
    Acq. Instrument : Instrument 3                   Location : Vial 94
    Injection Date   : 10/9/2009 8:03:57 PM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\D10-30.M
    Last changed     : 10/9/2009 12:02:39 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 10% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min, O
                       D-H
```



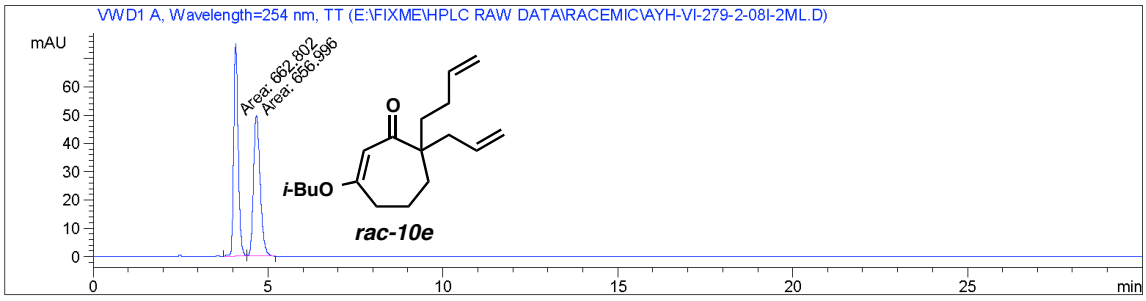

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  12.312 MM    0.3096 2812.58105  151.40250  49.8547
       2  13.377 MM    0.3409 2828.96997  138.29633  50.1453

    Totals :                  5641.55103  289.69882


    ======================================================================
                              *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH6\6-101D.D
Sample Name: AYH-VI-101D

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  27
    Acq. Instrument : Instrument 3                  Location : Vial 84
    Injection Date  : 10/9/2009 8:34:53 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D10-30.M
    Last changed    : 10/9/2009 12:02:39 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 10% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min, O
                      D-H
```




```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  12.352 MM    0.3102 6849.09961  368.04297  94.4023
       2  13.431 FM    0.3359  406.12854   20.15100   5.5977
```

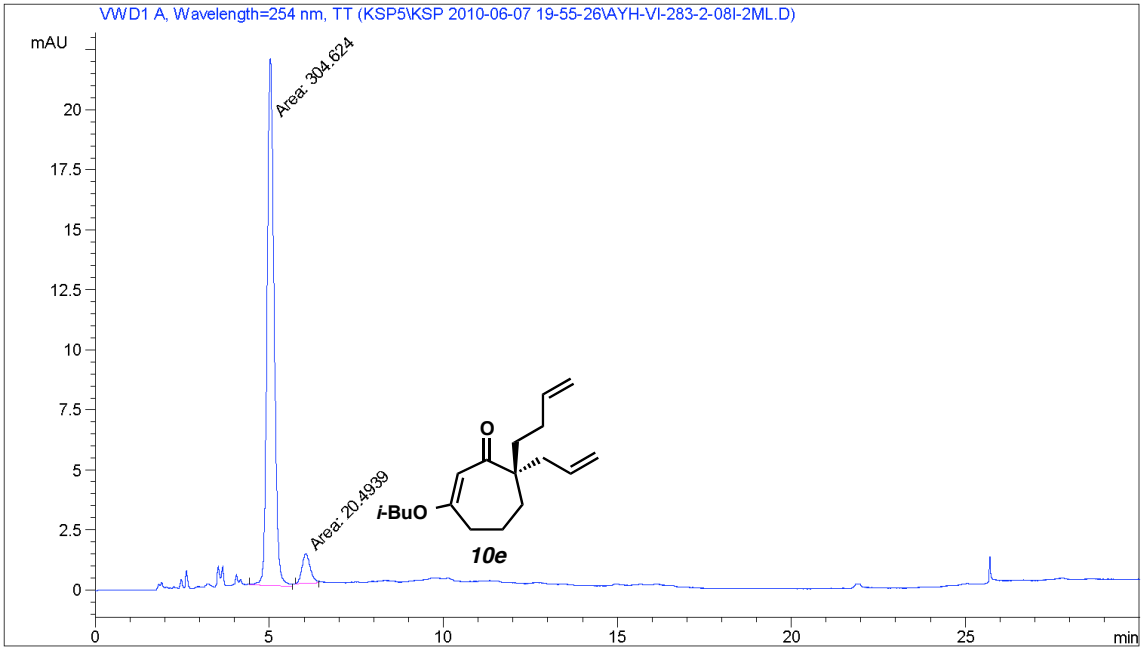
```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\AYH-VI-279-2-08I-2ML.D
Sample Name: AYH-VI-279-2-08I-2ML

    ======================================================================
    Acq. Operator   : ksp                          Seq. Line :  25
    Acq. Instrument : HPLC2                         Location : Vial 72
    Injection Date  : 6/6/2010 9:10:44 PM              Inj :   1
                                                   Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\3\DATA\KSP5\KSP 2010-06-06 11-49-17\08IPA30_254-2ML.M
    Last changed    : 6/4/2010 5:42:40 PM by AYH
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 1/8/2011 10:41:27 PM by JAC
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```




```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   4.078 MM    0.1470  662.80188   75.13438  50.2199
       2   4.671 MM    0.2203  656.99646   49.69901  49.7801

    Totals :                  1319.79834  124.83340


    ======================================================================
                              *** End of Report ***
```

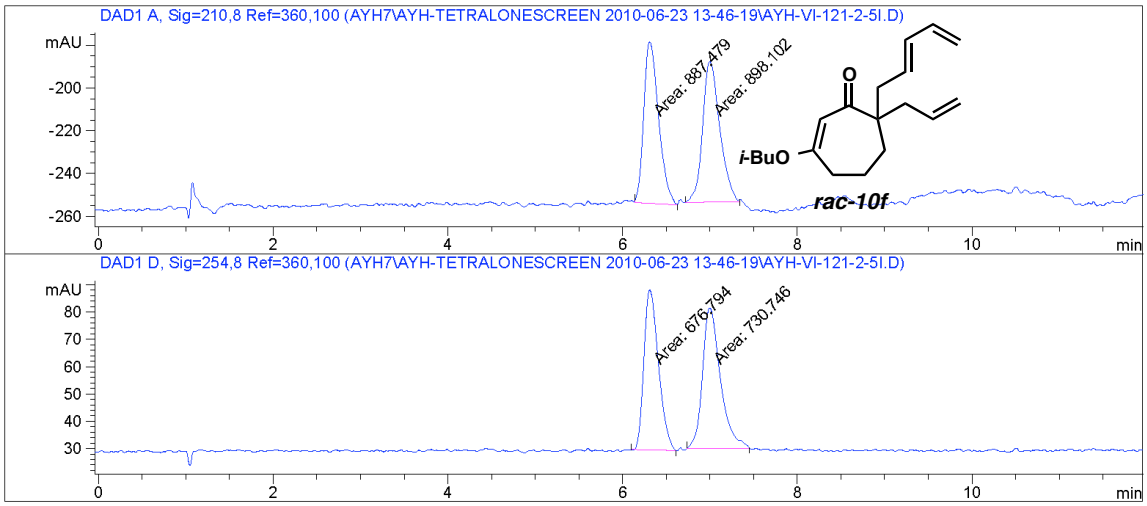
Data File C:\CHEM32\2\DATA\KSP5\KSP 2010-06-07 19-55-26\AYH-VI-283-2-08I-2ML.D
Sample Name: AYH-VI-283-2-08I-2ML

```
======================================================================
Acq. Operator   : ksp                          Seq. Line :   6
Acq. Instrument : HPLC2                         Location : Vial 74
Injection Date  : 6/7/2010 8:59:23 PM               Inj :   1
                                               Inj Volume : 5.0 µl
Acq. Method     : C:\CHEM32\3\DATA\KSP5\KSP 2010-06-07 19-55-26\08IPA30_254-2ML.M
Last changed    : 6/4/2010 5:42:40 PM by AYH
Analysis Method : C:\CHEM32\2\METHODS\POS2.M
Last changed    : 11/3/2010 10:03:07 PM by JJD
                  (modified after loading)
Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```




```
======================================================================
                        Area Percent Report
======================================================================

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: VWD1 A, Wavelength=254 nm, TT

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]  mAU   *s   [mAU   ]      %
----|-------|----|-------|----------|----------|--------|
   1   5.034 MM    0.2314  304.62436   21.93689  93.6965
   2   6.058 MM    0.2755   20.49395    1.23998   6.3035

Totals :                  325.11831   23.17687
```

```
Data File C:\CHEM32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 13-46-19\AYH-VI-121-2-5I.D
Sample Name: AYH-VI-121-2-5I

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  10
    Acq. Instrument : Instrument 1                  Location : P4-F-09
    Injection Date  : 6/23/2010 2:38:57 PM             Inj :   1
                                                   Inj Volume : 5 µl
    Acq. Method     : C:\Chem32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 13-46-19\S3C2 12MIN 5.M
    Last changed    : 4/28/2010 2:30:07 PM by scv
    Analysis Method : C:\CHEM32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 13-46-19\AYH-VI-121-2-5I.
                      D\DA.M (S3C2 12MIN 5.M)
    Last changed    : 1/7/2011 4:48:28 PM by JNI
                      (modified after loading)
    Method Info     : S3C2 12min 5.M: 5% IPA, AD-H 2.5 mL/min, 12 min
```



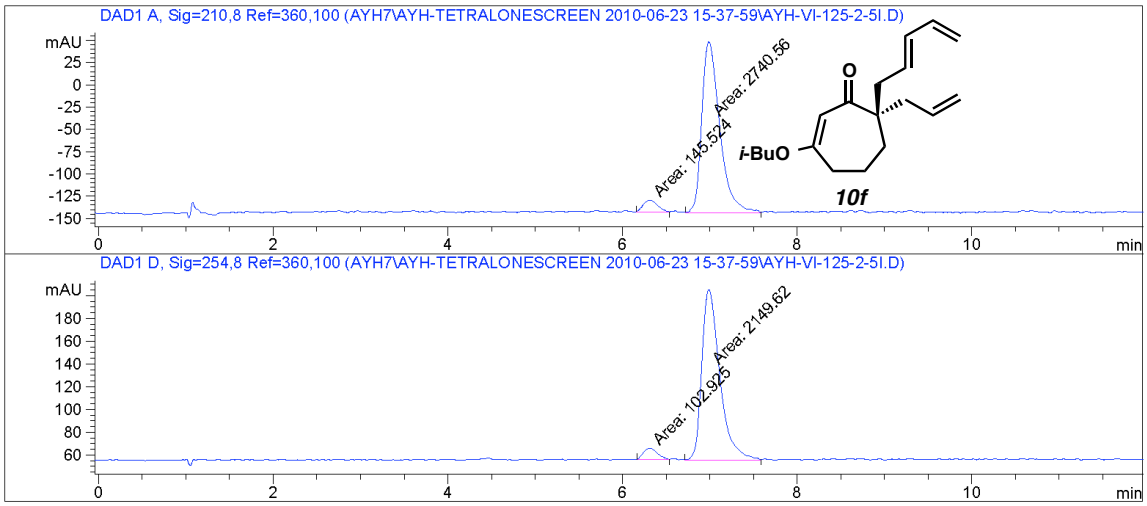

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=210,8 Ref=360,100

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   6.310 MM    0.1956  887.47925   75.62336  49.7025
       2   6.999 MM    0.2275  898.10187   65.79527  50.2975

    Totals :                  1785.58112  141.41862


    Signal 2: DAD1 D, Sig=254,8 Ref=360,100
```

Data File C:\CHEM32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 13-46-19\AYH-VI-121-2-5I.D
Sample Name: AYH-VI-121-2-5I

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.311	MM	0.1922	676.79382	58.69875	48.0834
2	6.998	MM	0.2366	730.74634	51.47878	51.9166
Totals :				1407.54016	110.17752	

*** End of Report ***

```
Data File C:\CHEM32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 15-37-59\AYH-VI-125-2-5I.D
Sample Name: AYH-VI-125-2-5I

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :   3
    Acq. Instrument : Instrument 1                  Location : P4-F-08
    Injection Date  : 6/23/2010 3:44:10 PM             Inj :   1
                                                   Inj Volume : 5 µl
    Acq. Method     : C:\Chem32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 15-37-59\S3C2 12MIN 5.M
    Last changed    : 4/28/2010 2:30:07 PM by scv
    Analysis Method : C:\CHEM32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 15-37-59\AYH-VI-125-2-5I.
                      D\DA.M (S3C2 12MIN 5.M)
    Last changed    : 11/3/2010 11:50:06 PM by hosea
                      (modified after loading)
    Method Info     : S3C2 12min 5.M: 5% IPA, AD-H 2.5 mL/min, 12 min
```



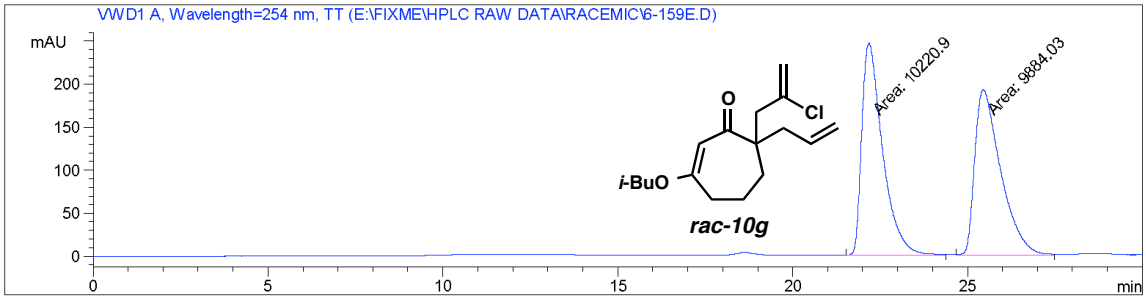

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier            :      1.0000
    Dilution              :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: DAD1 A, Sig=210,8 Ref=360,100

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [mAU*s]     [mAU]       %
    ----|-------|----|-------|----------|----------|--------|
       1   6.313 MM    0.1855  145.52396   13.07477   5.0423
       2   6.990 MM    0.2377 2740.55542  192.18924  94.9577

    Totals :                   2886.07938  205.26400


    Signal 2: DAD1 D, Sig=254,8 Ref=360,100
```

Data File C:\CHEM32\1\DATA\AYH7\AYH-TETRALONESCREEN 2010-06-23 15-37-59\AYH-VI-125-2-5I.D
Sample Name: AYH-VI-125-2-5I

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.307	MM	0.1804	102.92451	9.51000	4.5693
2	6.989	MM	0.2390	2149.61938	149.88602	95.4307
Totals :				2252.54389	159.39601	

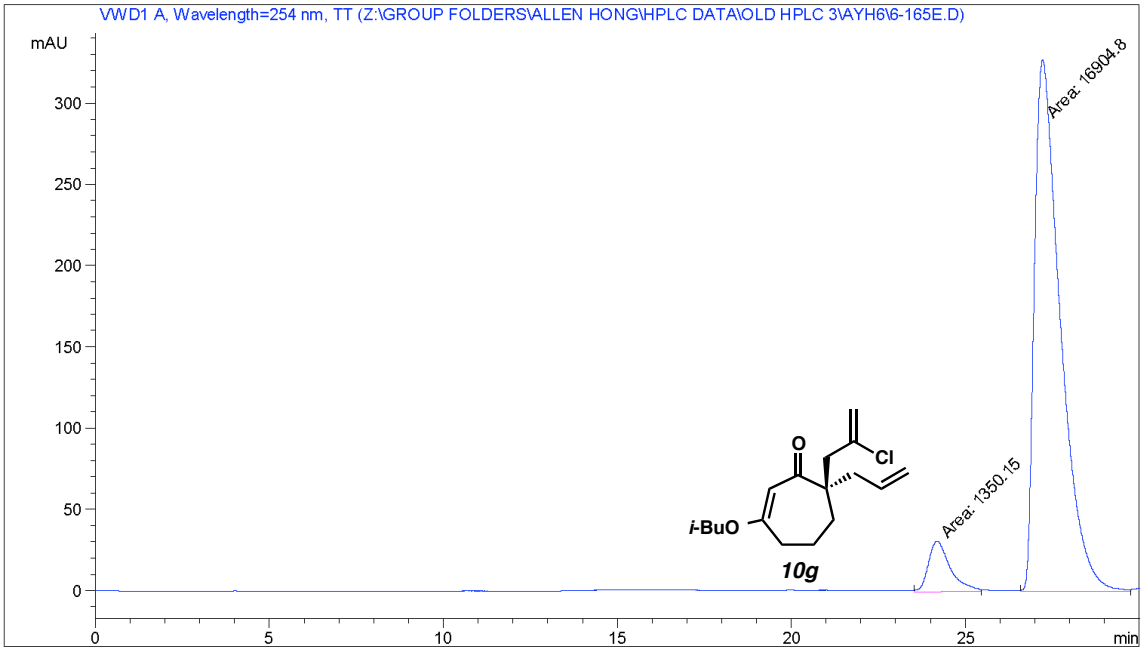
*** End of Report ***

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\6-159E.D
Sample Name: AYH-VI-159E

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  44
    Acq. Instrument : Instrument 3                  Location : Vial 97
    Injection Date  : 10/10/2009 4:18:02 AM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D2-30.M
    Last changed    : 10/9/2009 12:05:51 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 1/8/2011 10:41:27 PM by JAC
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 2% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min, OD
                      -H
```



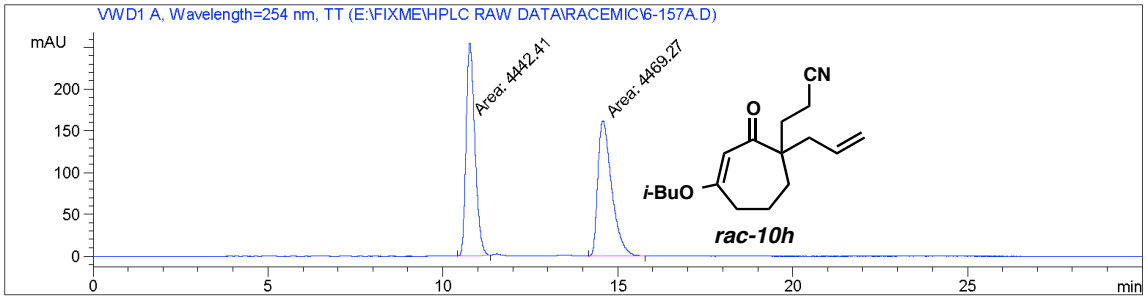

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  22.179 MM    0.6905 1.02209e4   246.71732  50.8379
       2  25.451 MM    0.8575 9884.03418  192.10428  49.1621

    Totals :                  2.01050e4   438.82159


    ======================================================================
                            *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH6\6-165E.D
Sample Name: AYH-VI-165E

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  45
    Acq. Instrument : Instrument 3                  Location : Vial 87
    Injection Date  : 10/10/2009 4:49:01 AM              Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D2-30.M
    Last changed    : 10/9/2009 12:05:51 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 2% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min, OD
                      -H
```



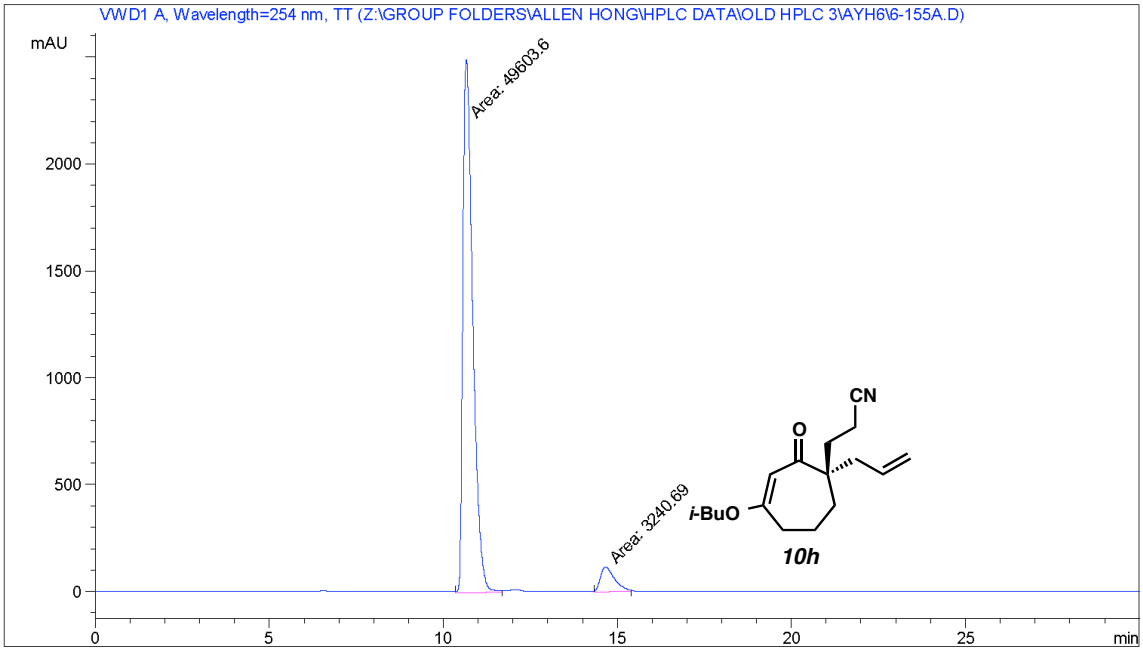

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  24.188 MF    0.7250 1350.15015   31.03589   7.3961
       2  27.224 MM    0.8617 1.69048e4   326.95764  92.6039
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\6-157A.D
Sample Name: AYH-VI-157A

    ======================================================================
    Acq. Operator    : AYH                          Seq. Line :  77
    Acq. Instrument : Instrument 3                   Location : Vial 96
    Injection Date   : 10/9/2009 1:20:20 AM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\D100-30.M
    Last changed     : 10/9/2009 12:04:23 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 100% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min,
                       OD-H
```




```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  10.772 MM    0.2906 4442.41309  254.80130  49.8493
       2  14.576 MM    0.4586 4469.26611  162.43217  50.1507

    Totals :                  8911.67920  417.23347


    ======================================================================
                              *** End of Report ***
```

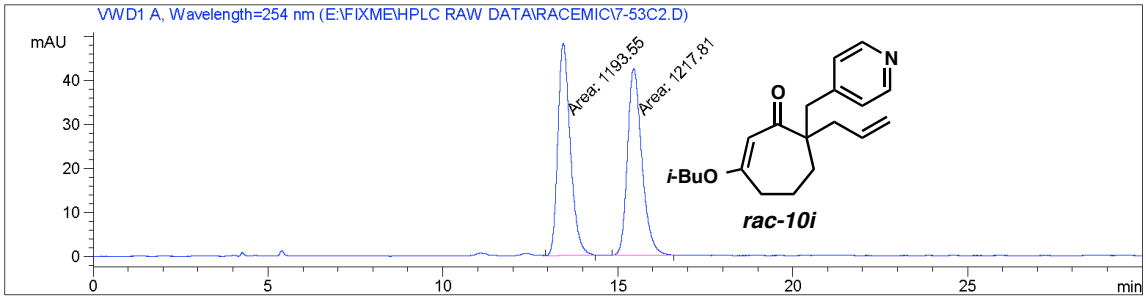
```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH6\6-155A.D
Sample Name: AYH-VI-155A

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  78
    Acq. Instrument : Instrument 3                  Location : Vial 86
    Injection Date  : 10/9/2009 1:51:21 AM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D100-30.M
    Last changed    : 10/9/2009 12:04:23 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 100% D Bottle, D=5% IPA/Hex, 254 nm, 1 mL/min, 30 min,
                      OD-H
```




```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  10.665 MM    0.3313 4.96036e4  2495.76392  93.8675
       2  14.662 MM    0.4653 3240.68872  116.07650   6.1325
```

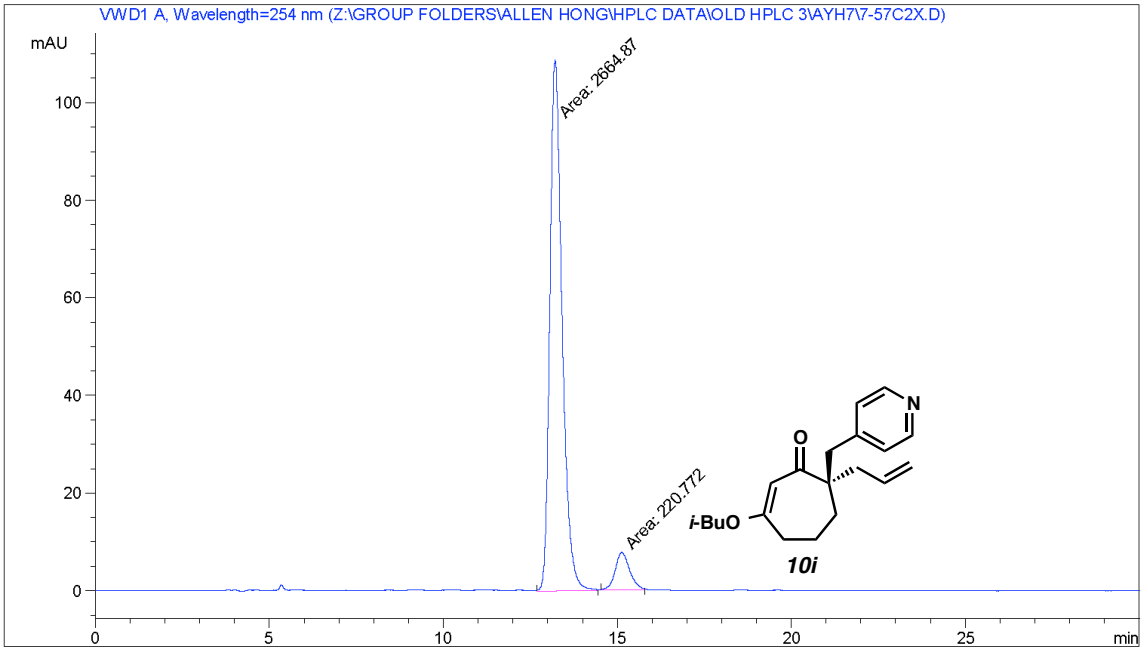
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\7-53C2.D
Sample Name: AYH-VII-53C2

```
    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :  12
    Acq. Instrument : Instrument 3                  Location : Vial 11
    Injection Date  : 12/16/2009 10:51:30 PM             Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\5-EOH30.M
    Last changed    : 5/5/2002 1:38:31 PM by DCB
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 1/8/2011 10:41:27 PM by JAC
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : Chiralpak AD, 5% EtOH, 30 min, Instrument 3, 1 mL/min,
                      254 nm
```



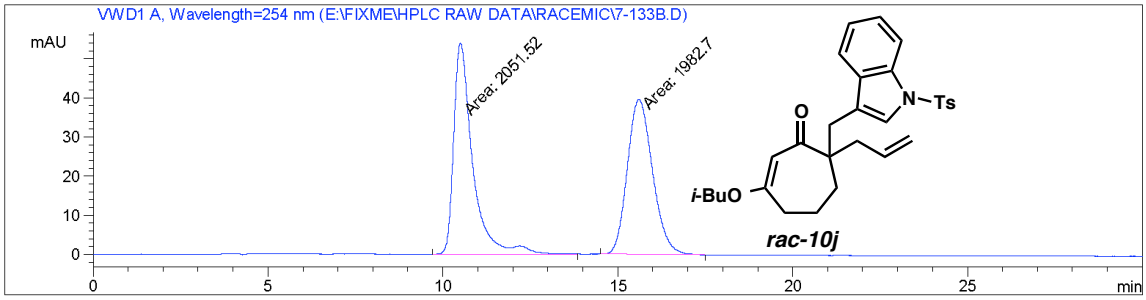

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  13.441 MM    0.4117 1193.54810   48.31984  49.4969
       2  15.456 MM    0.4776 1217.80981   42.49641  50.5031

    Totals :                  2411.35791   90.81625


    ======================================================================
                            *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH7\7-57C2X.D
Sample Name: AYH-VII-57C2x

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :   4
    Acq. Instrument : Instrument 3                  Location : Vial 12
    Injection Date  : 12/17/2009 2:01:02 PM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\5-EOH30.M
    Last changed    : 5/5/2002 1:38:31 PM by DCB
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : Chiralpak AD, 5% EtOH, 30 min, Instrument 3, 1 mL/min,
                      254 nm
```



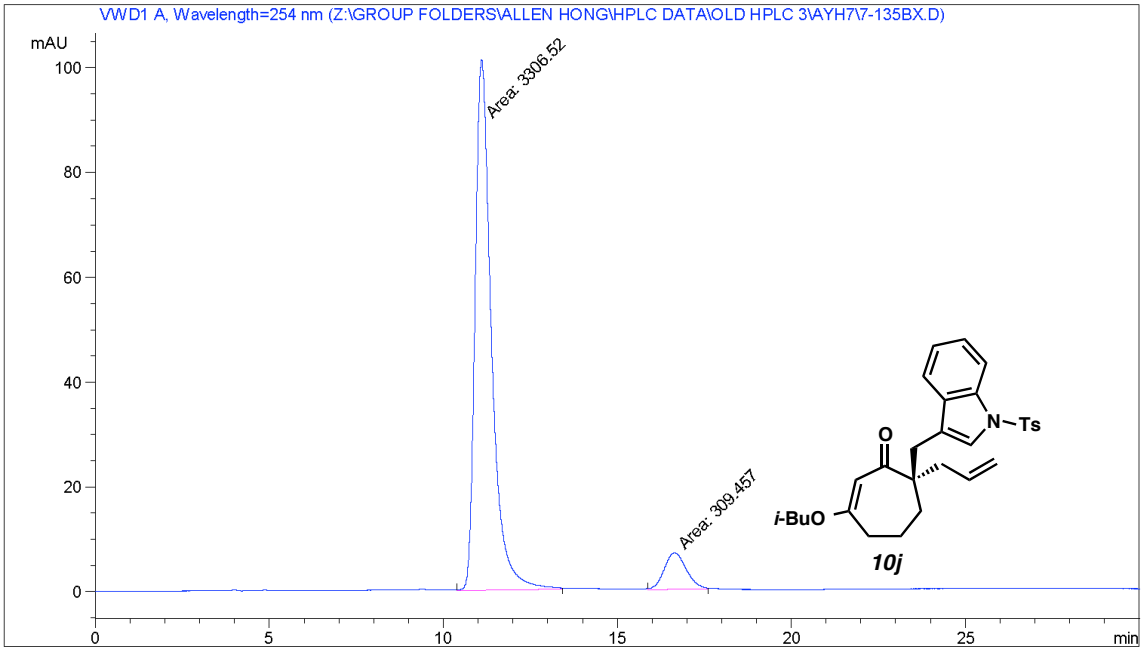

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  13.217 MM    0.4078 2664.87183  108.90872  92.3493
       2  15.127 MM    0.4802  220.77225    7.66259   7.6507
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\7-133B.D
Sample Name: AYH-VII-133B

    ======================================================================
    Acq. Operator    : LMR                          Seq. Line :   8
    Acq. Instrument : Instrument 3                   Location : Vial 11
    Injection Date   : 2/1/2010 12:47:53 AM               Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\5-EOH30.M
    Last changed     : 5/5/2002 1:38:31 PM by DCB
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 5% EtOH/Hex, AD column, 30 min, 1 mL/min, 254 nm, Instr
                       ument 3
```



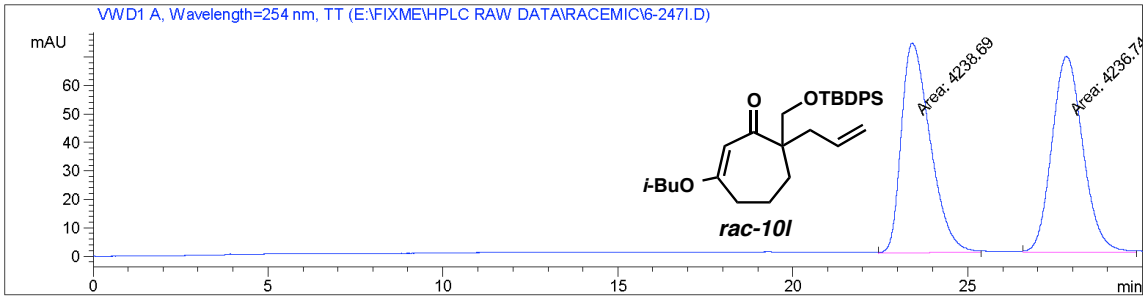

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|-------|
       1  10.505 MM    0.6332 2051.52295   53.99844  50.8530
       2  15.601 MM    0.8354 1982.70142   39.55733  49.1470

    Totals :                  4034.22437   93.55577


    ======================================================================
                              *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH7\7-135BX.D
Sample Name: AYH-VII-135Bx

    ======================================================================
    Acq. Operator   : AYH                          Seq. Line :   3
    Acq. Instrument : Instrument 3                  Location : Vial 11
    Injection Date  : 2/2/2010 11:25:39 AM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\5-EOH30.M
    Last changed    : 5/5/2002 1:38:31 PM by DCB
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info     : 5% EtOH/Hex, AD column, 30 min, 1 mL/min, 254 nm, Instr
                      ument 3
```



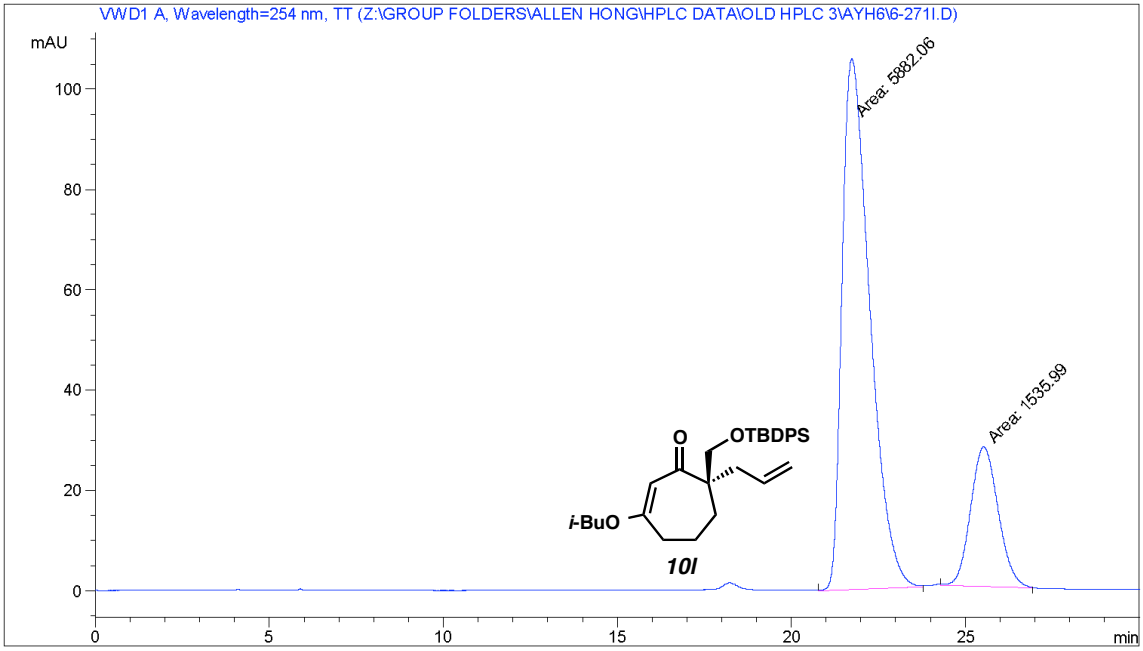

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  11.107 MM    0.5441 3306.51978  101.28896  91.4420
       2  16.651 MM    0.5195  309.45663    7.00771   8.5580
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\6-247I.D
Sample Name: AYH-VI-247I

    ======================================================================
    Acq. Operator    : AYH                          Seq. Line :   7
    Acq. Instrument : Instrument 3                   Location : Vial 82
    Injection Date   : 11/6/2009 12:49:27 AM              Inj :   1
                                                   Inj Volume : 5.000 µl
    Acq. Method      : C:\HPCHEM\3\METHODS\D40-30.M
    Last changed     : 10/9/2009 12:15:07 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/8/2011 10:41:27 PM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      : 40% D Bottle, D=0.5% IPA/Hex, 254 nm, 1 mL/min, 30 min,
                        OD-H
```



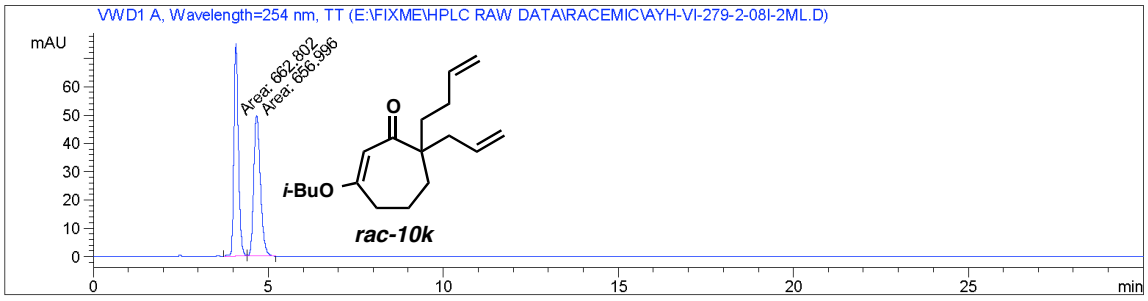

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|-------|
       1  23.422 MM    0.9588 4238.69434   73.68168  50.0115
       2  27.826 MM    1.0277 4236.74414   68.71210  49.9885

    Totals :                  8475.43848  142.39378


    ======================================================================
                              *** End of Report ***
```

```
Data File Z:\GROUP FOLDERS\ALLEN HONG\HPLC DATA\OLD HPLC 3\AYH6\6-271I.D
Sample Name: AYH-VI-271I

    ======================================================================
    Acq. Operator   : Tomoko                        Seq. Line :  18
    Acq. Instrument : Instrument 3                   Location : Vial 12
    Injection Date  : 11/23/2009 8:47:50 PM               Inj :   1
                                                  Inj Volume : 5.000 µl
    Acq. Method     : C:\HPCHEM\3\METHODS\D40-30.M
    Last changed    : 10/9/2009 12:15:07 AM by RN
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```



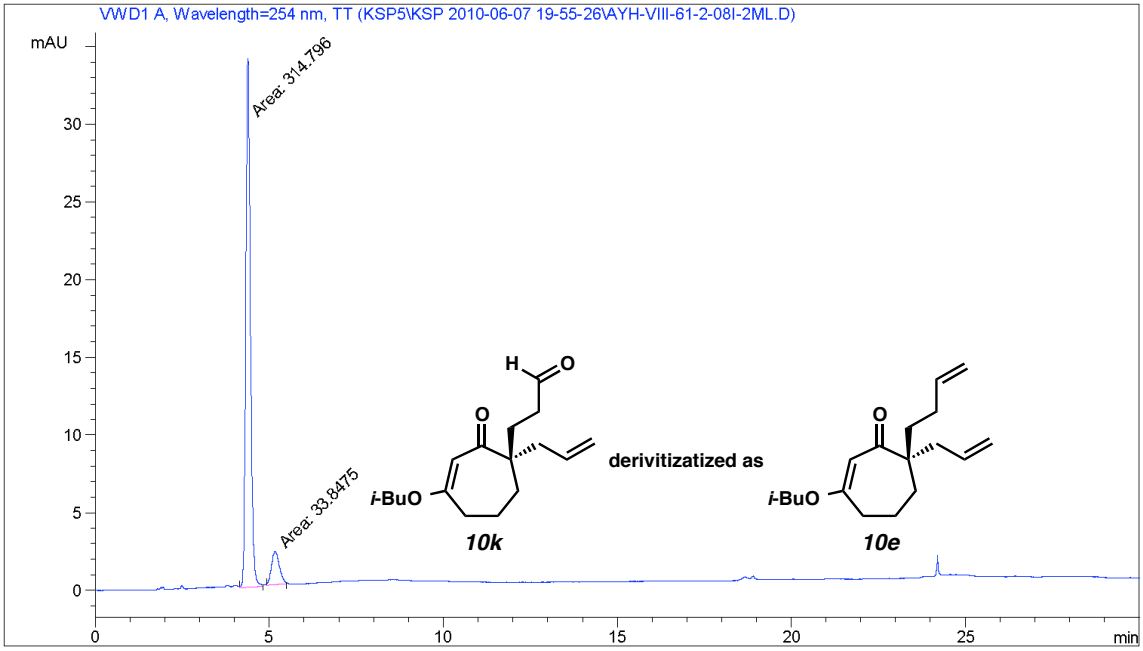

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1  21.741 MM    0.9263 5882.05518  105.83752  79.2939
       2  25.533 MM    0.9195 1535.98706   27.84123  20.7061

    Totals :                  7418.04224  133.67875
```

```
Data File E:\FIXME\HPLC RAW DATA\RACEMIC\AYH-VI-279-2-08I-2ML.D
Sample Name: AYH-VI-279-2-08I-2ML

    ======================================================================
    Acq. Operator   : ksp                          Seq. Line :  25
    Acq. Instrument : HPLC2                         Location : Vial 72
    Injection Date  : 6/6/2010 9:10:44 PM              Inj :   1
                                                   Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\3\DATA\KSP5\KSP 2010-06-06 11-49-17\08IPA30_254-2ML.M
    Last changed    : 6/4/2010 5:42:40 PM by AYH
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 1/8/2011 10:41:27 PM by JAC
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```



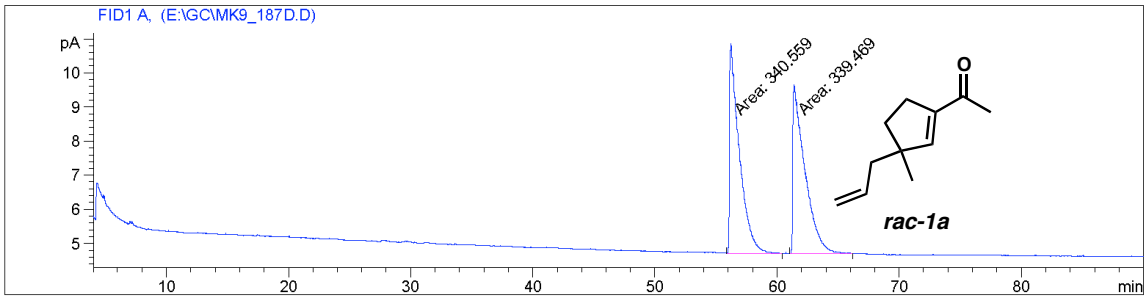

```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   4.078 MM    0.1470  662.80188   75.13438  50.2199
       2   4.671 MM    0.2203  656.99646   49.69901  49.7801

    Totals :                  1319.79834  124.83340


    ======================================================================
                              *** End of Report ***
```

```
Data File C:\CHEM32\2\DATA\KSP5\KSP 2010-06-07 19-55-26\AYH-VIII-61-2-08I-2ML.D
Sample Name: AYH-VIII-61-2-08I-2ML

    ======================================================================
    Acq. Operator   : ksp                          Seq. Line :   5
    Acq. Instrument : HPLC2                         Location : Vial 75
    Injection Date  : 6/7/2010 8:28:09 PM               Inj :   1
                                                   Inj Volume : 5.0 µl
    Acq. Method     : C:\CHEM32\3\DATA\KSP5\KSP 2010-06-07 19-55-26\08IPA30_254-2ML.M
    Last changed    : 6/4/2010 5:42:40 PM by AYH
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 11/3/2010 10:03:07 PM by JJD
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```



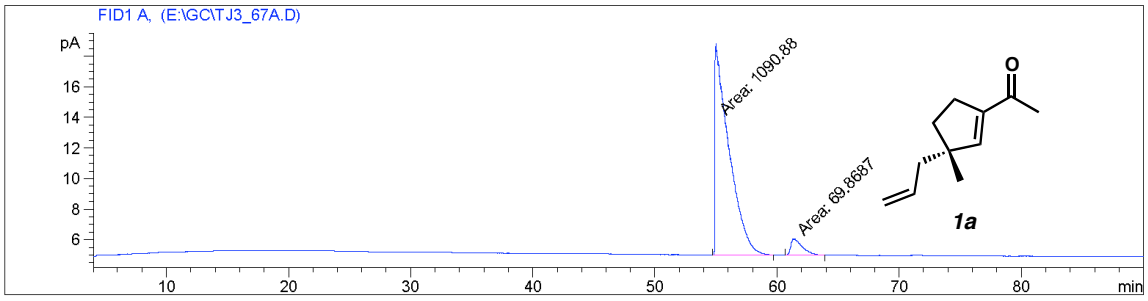

```
    ======================================================================
                            Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: VWD1 A, Wavelength=254 nm, TT

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]  mAU   *s    [mAU   ]      %
    ----|-------|----|-------|----------|----------|--------|
       1   4.390 MM    0.1542  314.79608   34.01938  90.2917
       2   5.176 MM    0.2641   33.84754    2.13569   9.7083

    Totals :                   348.64362   36.15507
```

```
Data File E:\GC\MK9_187D.D
Sample Name: mrkIX-187

======================================================================
Acq. Operator    : mike k                          Seq. Line :  10
Acq. Instrument : Instrument 1                      Location : Vial 4
Injection Date  : 2/5/2008 8:04:50 PM                    Inj :   1
                                                  Inj Volume : 1.000 µl
Acq. Method     : C:\HPCHEM\1\METHODS\80ISO90.M
Last changed    : 8/4/2003 11:12:53 PM by DCB
Analysis Method : C:\CHEM32\2\METHODS\POS2.M
Last changed    : 1/9/2011 10:25:16 AM by JAC
                  (modified after loading)
Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```



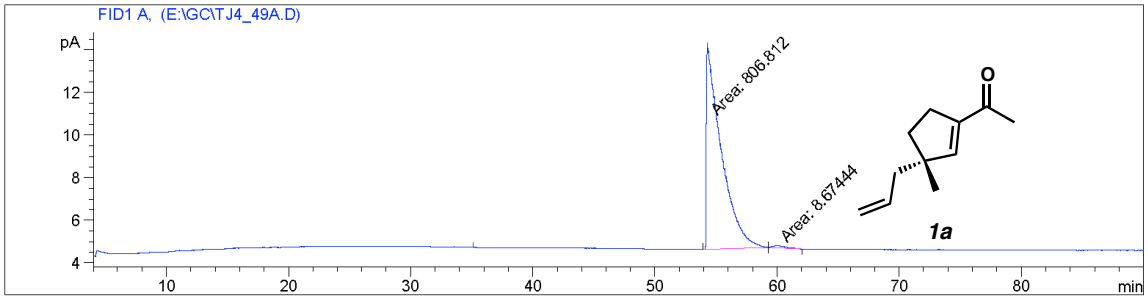

```
======================================================================
                          Area Percent Report
======================================================================

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: FID1 A,

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [pA*s]      [pA]        %
----|-------|----|-------|----------|----------|--------|
   1  56.181 MM    0.9229  340.55878    6.15011  50.0801
   2  61.394 MM    1.1442  339.46878    4.94481  49.9199

Totals :                   680.02756   11.09492


======================================================================
                         *** End of Report ***
```

```
Data File E:\GC\TJ3_67A.D
Sample Name: tj-III-67

    ========================================================================
    Acq. Operator   : thomas j                       Seq. Line :   2
    Acq. Instrument : Instrument 1                    Location : Vial 1
    Injection Date  : 3/10/2008 5:13:19 PM               Inj :   1
                                                    Inj Volume : 1.000 µl
    Acq. Method     : C:\HPCHEM\1\METHODS\80ISO90.M
    Last changed    : 8/4/2003 11:12:53 PM by DCB
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed    : 1/9/2011 10:27:06 AM by JAC
                      (modified after loading)
    Method Info     : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).
```




```
    ========================================================================
                              Area Percent Report
    ========================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: FID1 A,

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [pA*s]      [pA]        %
    ----|-------|----|-------|----------|----------|--------|
       1  54.979 MM    1.3142 1090.88232   13.83439  93.9807
       2  61.349 MM    1.0918   69.86869    1.06654   6.0193

    Totals :                  1160.75101   14.90093


    ========================================================================
                              *** End of Report ***
```

```
Data File E:\GC\TJ4_49A.D
Sample Name: tj4_49

    ======================================================================
    Acq. Operator    : tj                              Seq. Line :   2
    Acq. Instrument : Instrument 1                      Location : Vial 2
    Injection Date   : 5/10/2008 11:00:32 PM                 Inj :   1
                                                     Inj Volume : 1.000 µl
    Acq. Method      : C:\HPCHEM\1\METHODS\80ISO90.M
    Last changed     : 8/4/2003 11:12:53 PM by DCB
    Analysis Method : C:\CHEM32\2\METHODS\POS2.M
    Last changed     : 1/9/2011 10:27:06 AM by JAC
                       (modified after loading)
    Method Info      : POSITION #2 METHOD : Valve to Position # 2 (Column # 1).

    Sample Info      :
```




```
    ======================================================================
                              Area Percent Report
    ======================================================================

    Sorted By             :      Signal
    Multiplier:                   :      1.0000
    Dilution:                     :      1.0000
    Use Multiplier & Dilution Factor with ISTDs


    Signal 1: FID1 A,

    Peak RetTime Type  Width     Area      Height     Area
      #   [min]        [min]   [pA*s]      [pA]        %
    ----|-------|----|-------|----------|----------|--------|
       1  54.257 MM    1.3864  806.81219    9.69890  98.9363
       2  59.951 MM    1.1688    8.67444 1.23698e-1   1.0637

    Totals :                   815.48664    9.82260

    ======================================================================
                             *** End of Report ***
```