Electronic Supplementary Information

Catalytic Asymmetric Synthesis of Pyrrolidine Derivatives Bearing Heteroatom-Substituted Quaternary Stereocenters

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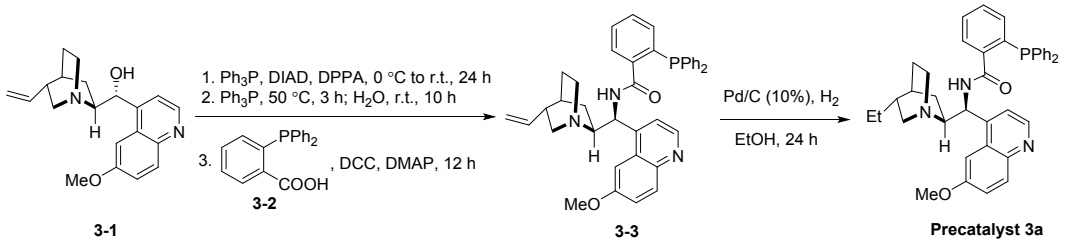
I. General Information

^{1}H and **^{13}C NMR** spectra were recorded on an Agilent 400MR spectrometer at ambient temperature. Chemical shifts were reported in parts per million (ppm), and the residual solvent peak was used as an internal reference: ^{1}H (chloroform δ 7.26), ^{13}C (chloroform δ 77.0). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), coupling constants (Hz) and integration. Melting point (**M.P.**) was obtained on SGW X-4A. For thin layer chromatography (**TLC**), Merck pre-coated TLC plates (Merck 60 F254) were used, and compounds were visualized with a UV light at 254 nm. High resolution mass spectra (**HRMS**) were obtained on a Bruker SolariX 7.0T spectrometer. **Optical rotations** were recorded on a Rudolph Autopol I automatic polarimeter. Enantiomeric excesses (ee) were determined by HPLC analysis on Agilent HPLC units, including the following instruments: pump, G1311C; detector, G1314F; column, Chiralpak AD-H, OD-H, AS-H, OJ-H, IA-H.

Unless otherwise noted, all the reactions were carried out in air. Dichloromethane (DCM), chloroform ($CHCl_3$) and toluene were distilled from calcium hydride. Tetrahydrofuran (THF) and ether were dried and distilled from sodium. N, N-Dimethylformamide (DMF) was dried over calcium hydride and distilled under vacuum. Deuterated solvents were purchased from Cambridge Isotope Laboratories and used as received without further purification. All the chemicals were purchased from commercial suppliers and used as received without further purification.

II. Synthesis of Precatalyst 3a and Bifunctional Squaramide Catalyst 8

II.I Synthesis of Precatalyst 3a



Quinine **3-1** (3.24 g, 10.00 mmol) and triphenylphosphine (2.62 g, 10.00 mmol) were dissolved in anhydrous THF (100 mL), the solution was cooled to 0 °C, diethyl azodicarboxylate (2.00 g, 10.00 mmol) was added slowly. To the resulting solution was added dropwise the solution of diphenyl phosphoryl azide (2.10 mL, 10.00 mmol) in anhydrous THF (10.00 mL) at 0 °C. The mixture was allowed to warm to ambient temperature. After 24 h, it was heated to 50 °C when more triphenylphosphine (2.90 g, 11.00 mmol) was added, and the mixture was allowed to stir at 50 °C for additional 3 h. After that the solution was cooled to ambient temperature and H_2O (1.00 mL) was added. After the reaction mixture was stirred for another 10 h, solvents were removed in vacuo and the residue was dissolved in CH_2Cl_2 and 10% hydrochloric acid (100 mL). The aqueous phase was washed with CH_2Cl_2 (4 × 50 mL). Then the aqueous phase was made alkaline with excess aqueous ammonia and was washed with CH_2Cl_2 (4 × 50 mL). The combined organic phases was dried over Na_2SO_4 and concentrated to get yellow oil, which was used directly without further purification.

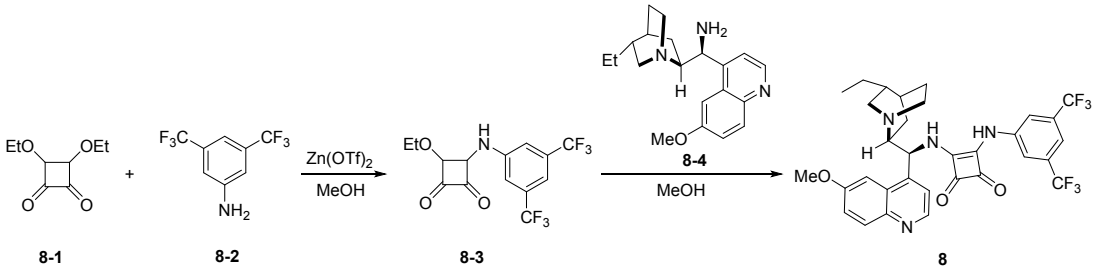
To the solution of the obtained *epi*-quinine derivative (2.20 g, 6.80 mmol) in anhydrous CH_2Cl_2 (100 mL) was added 2-(diphenylphosphino)benzoic acid **3-2** (2.3 g, 7.50 mmol), 4-dimethylaminopyridine (166.00 mg, 1.36 mmol) and *N,N'*-dicyclohexylcarbodiimide (1.55 g, 7.50 mmol). The reaction mixture was stirred at ambient temperature for 12 h, concentrated and purified by flash chromatography (hexanes/ethyl acetate 1:1) to yield **3-3** as white solids (90% yield).

To a solution of **3-3** (3.10 g, 5.00 mmol) in EtOH (100 mL) was added 10% Pd/C

(300 mg). The reaction mixture was stirred under a hydrogen atmosphere for 24 h at ambient temperature, and then filtered through celite washing with EtOH (3 × 20 mL). The filtrate was concentrated and purified by flash chromatography (hexanes/ethyl acetate 1:1) to yield the precatalyst **3a** 2.90 g as white solid (95% yield).

The product spectrum was matched with reported.[1]

II.II Synthesis of Bifunctional Squaramide Catalyst 8



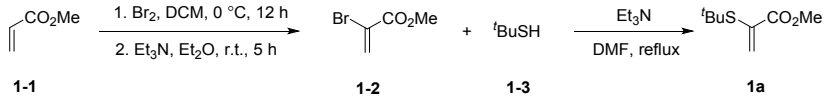
To a stirred solution of 3,4-diethoxycyclobutane-1,2-dione **8-1** (1.00 g, 5.80 mmol) and zinc trifluoromethanesulfonate (40.00 mg, 0.12 mmol) in methanol (10.0 mL) at room temperature was added 3,5-bis(trifluoromethyl)aniline **8-2** (1.10 g, 4.80 mmol). After stirring for 24 h, a white precipitate formed, which was filtered and washed with methanol (3 × 5 mL), yielding **8-3** 1.38 g as a white solid (81% yield).

To a stirred solution of 9-epiaminohydroquinine **8-4** (325.0 mg, 1.0 mmol) in methanol (5.0 mL) was added 3-((3, 5-bis(trifluoromethyl)phenyl)amino)-4-ethoxycyclobutane-1,2-dione **8-3** (355.0 mg, 1.0 mmol). After stirring for 48 h, a white precipitate formed, which was filtered and washed with methanol (3 × 5 mL), yielding the catalyst **8** 400.0 mg as a white solid (63% yield).

The product spectrum was matched with reported.[2]

III. Synthesis of Substrates

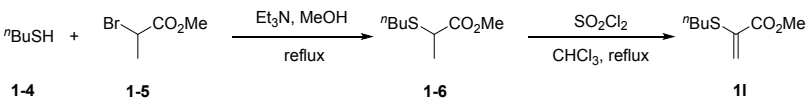
III.I Synthesis of α-thioacrylates



To a solution of methyl acrylate **1-1** (100.0 mmol) in 100mL DCM was added

bromine (110.0 mmol, dissolved in 20 mL DCM) dropwise below 0 °C, stirred at this temperature for 12 h. After completion, quenched with saturated $Na_2S_2O_4$ aqueous solution 10 mL, the aqueous layer was extracted with dichloromethane (3 × 50 mL), the combined organic layers were dried over Na_2SO4, filtered and concentrated to give the crude methyl 2,3-dibromo-propionate as pale yellow oil quantitatively, which was used directly without further purification. The crude methyl 2, 3-dibromopropionate was dissolved in a mixture of 200 mL ether, the resulting mixture was added 16.7 mL (120.0 mmol) of triethylamine. The reaction mixture was stirred for 5 h at room temperature. After completion, the precipitate was filtered with celite, the solvent was removed, and the residue was distilled in vacuo to yield pure methyl 2-bromoacrylate **1-2** 13.2 g (80% for 2 steps, b. p. 65℃, 50 mmHg).[3] This compound is not stable in air.

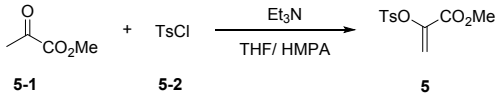
Following the modified conditions developed by Stella and coworkers[4]. To a solution of methyl 2-bromoacrylate **1-2** (8.0 g, 48.5 mmol) in DMF was added mercaptans **1-3** (44.1 mmol), then triethylamine (8.1 mL, 58.1 mmol) was added dropwise, the mixture was heated to 110 °C for 24 h. After completion, the reaction mixture was washed with water, extracted with EA, the combined organic solvent was removed in vacuum to obtain brown oil, which was distilled in vacuum to give the desired product **1a** as colorless oil. 83% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 6.75 (d, *J* = 1.3 Hz, 1H), 6.13 (d, *J* = 1.3 Hz, 1H), 3.79 (s, 3H), 1.31 (s, 9H)；**^{13}C NMR** (101 MHz, Chloroform-d) δ 167.00, 137.14, 134.38, 52.65, 46.32, 30.70. **HRMS** (ESI): m/z calcd. for $[C_8H_{14}NaO_2S, M+Na]^+$: 197.0607; found: 197.0606.



The product was prepared following the modified conditions by Iriuchijima and coworkers.[5] To a solution of mercaptan **1-4** (19.7 mmol) in 50 mL MeOH was added methyl α-bromopropanoate **1-5** (3.3 g, 19.7 mmol), then Et_3N (2.4 g, 24.0 mmol) was added dropwise at 0 °C followed by refluxing for 3 h. After the starting material was

consumed completely by monitoring with TLC, the reaction mixture was extracted with DCM (3 × 50 mL), the combined organic phase was dried over Na_2SO_4 and evaporated at 30 °C in vacuum, the crude product **1-6** was used in the next step without further purification. Sulfuryl chloride (1.62 g, 12.00 mmol) was added to a stirred solution of the residue prepared above (12.00 mmol) in chloroform (50 ml) at 0 °C. The solution was stirred at 0 °C for 10 min, and then refluxed with stirring at 65 °C for 10 h. After the reaction completion, quenched with saturated $NaHCO_3$, extracted with DCM, dried over Na_2SO_4, and concentrated to give pale yellow oil, which was purified by flash chromatography (petroleum ether:EtOAc = 100:1) to give the pure product **1l** as colorless oil, 70% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 6.34 (s, 1H), 5.41 (s, 1H), 3.80 (s, 3H), 2.71 (t, *J* = 7.4 Hz, 2H), 1.68 – 1.61 (m, 2H), 1.45 (h, *J* = 7.4 Hz, 2H), 0.93 (t, *J* = 7.4 Hz, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 165.06, 137.55, 118.98, 52.64, 31.14, 29.71, 22.16, 13.61. **HRMS** (ESI): m/z calcd. for $[C_8H_{14}NaO_2S, M+Na]^+$: 197.0607; found: 197.0605.

III.II Synthesis of α-tosyloxyacrylate[6]

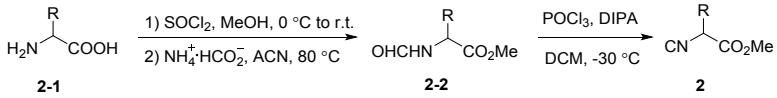


5-1 **5-2** **5**

To a solution of triethylamine (6.0 mL) in dry THF (20.0 mL) and HMPA (1.0 mL) at -10 °C under N_2 atmosphere, a solution of pyruvate **5-1** (5.0 g, 49.0 mmol) in dry THF (10.0 mL) was added dropwise. Then a solution of TsCl (9.8 g, 51.6 mmol) in dry THF (10.0 mL) was slowly added at the same temperature, the resulting mixture was stirred at -10 °C until **5-1** was consumed. The solvent was removed in vacuo, and the residue was redissolved in CH_2Cl_2 (50.0 mL). A saturated aqueous solution of NH_4Cl (100.0 mL) was added and the aqueous layer was extracted with CH_2Cl_2 (3 × 50.0 mL). The combined organic extracts were dried over $MgSO_4$, the solvent was evaporated in vacuo. The residue was successively purified by flash column chromatography on silica gel (hexane/EtOAc, 20:1) to give the acrylate **5** (7.5 g, 60% yield) as colorless oil. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.76 (d, *J* = 8.4 Hz, 2H),

7.30 (d, *J* = 7.9 Hz, 2H), 6.07 (d, *J* = 2.4 Hz, 1H), 5.54 (d, *J* = 2.4 Hz, 1H), 3.63 (s, 3H), 2.39 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 161.33, 145.76, 143.01, 132.36, 129.78, 128.48, 117.07, 52.64, 21.61; **HRMS** (ESI): m/z calcd. for $[C_{11}H_{12}NaO_5S, M+Na]^+$: 279.0298; found: 279.0298.

IV. Synthesis of Isocyanoacetates



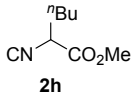
General procedure: Isocyanoacetates **2** were synthesized according to the procedure reported by Zhu.[7]

To a solution of amino acid **2-1** in methanol was added $SOCl_2$ dropwise at 0 °C. The mixture was stirred at RT for 10 hours and evaporated to dryness to give the corresponding methyl ester hydrochloride which was directly used without further purification.

To a solution of the methyl ester hydrochloride prepared above in ACN was added ammonium formate and the mixture was heated to 80 °C for 20 h. ACN was evaporated. The residue was dissolved in AcOEt and washed with water. The aqueous layer was extracted with AcOEt. The combined organic layers were washed with brine, dried over sodium sulfate and concentrated under reduced pressure to give corresponding formamide **2-2** which was used in the next step without purification.

To a solution of formamide **2-2** (1.0 equiv) in CH_2Cl_2 (0.3 M) was added diisopropylamine (2.8 equiv). The mixture was cooled to -30 °C and $POCl_3$ (1.1 equiv) was added slowly. The resulting mixture was stirred at -30 °C for 2 h and quenched with a 10% aqueous solution of K_2CO_3. The aqueous layer was extracted with CH_2Cl_2 (3 × 20 mL), the combined organic layers were washed with brine, dried over sodium sulfate and concentrated under reduced pressure. The crude product was purified by flash column chromatography on silica gel to afford pure product **2**.

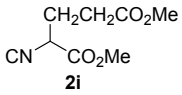
Methyl 2-isocyanohexanoate (2h)



2h

Brown liquid, 70% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 4.27–4.24 (m, 1H), 3.79 (s, 3H), 1.89 (p, *J* = 7.0 Hz, 2H), 1.48 – 1.39 (m, 2H), 1.38 – 1.31 (m, 2H), 0.92 – 0.89 (m, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 167.30, 159.88, 56.48, 53.24, 32.39, 27.21, 21.73, 13.67. **HRMS** (ESI): m/z calcd. for $[C_8H_{13}NNaO_2, M+Na]^+$: 178.0838; found: 178.0837.

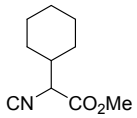
Dimethyl 2-isocyanopentanedioate (2i)



2i

Colorless oil, 41% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 4.44 (dd, *J* = 8.5, 4.9 Hz, 1H), 3.80 (s, 3H), 3.68 (s, 3H), 2.56 – 2.51 (m, 2H), 2.29 (dtd, *J* = 15.0, 7.6, 5.0 Hz, 1H), 2.19 – 2.10 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 172.06, 166.61, 160.90, 55.40, 53.47, 51.95, 29.17, 27.67. **HRMS** (ESI): m/z calcd. for $[C_8H_{11}NNaO_4, M+Na]^+$: 208.0580; found: 208.0581.

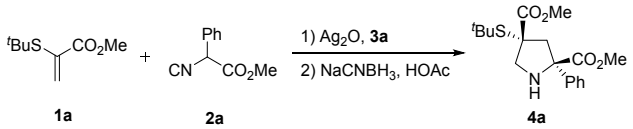
Methyl 2-cyclohexyl-2-isocyanoacetate (2k)



2k

White solid, 80% yield. **M.P.** 50 °C-52 °C. **^{1}H NMR** (400 MHz, Chloroform-d) δ 4.14 (d, J = 4.7 Hz, 1H), 3.81 (s, 3H), 1.96 (br, 1H), 1.80 (dq, J = 9.4, 3.0 Hz, 2H), 1.66 (tdd, J = 18.7, 9.3, 5.5 Hz, 3H), 1.35 – 1.14 (m, 5H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 166.87, 160.21, 62.31, 53.13, 40.27, 29.54, 27.12, 25.68, 25.47, 25.41. **HRMS** (ESI): m/z calcd. for $[C_{10}H_{15}NNaO_2, M+Na]^+$: 204.0995; found: 204.0996.

V. Substrates Scope of Isocyanoacetates



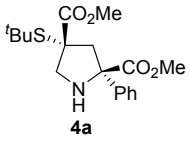
1a **2a** **4a**

General procedure A. To a 10 mL tube charged with **3a** (12.30 mg, 0.02 mmol) and

Ag_2O (2.30 mg, 0.01 mmol) was added $CHCl_3$ (1 mL). The mixture was stirred at -20 ^oC for 5 minutes, then the α-thioacrylate **1a** (17.40 mg, 0.10 mmol) and isocyanoacetate **2a** (21.02 mg, 0.12 mmol) were added. The reaction mixture was stirred at -20 ^oC until **1a** was consumed, and then filtered through a pad of silica gel and washed with ethyl acetate. The solvent was removed under reduced pressure and then the residue was dissolved in MeOH (1.00 mL), $NaCNBH_3$ (12.57 mg, 0.20 mmol) and HOAc (12.01 mg, 0.20 mmol) were added sequentially at room temperature. The reaction mixture was stirred at room temperature for 0.5 h, and then concentrated, purified by flash chromatography on silica gel (hexanes/ethyl acetate, 2:1) to afford the product **4a**.

V.I Characterization of Compounds

Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-phenylpyrrolidine-2,4-dicarboxylate (4a)

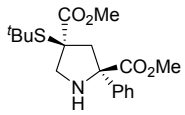


4a

The general procedure A was followed. White solid, **M.P.** 85-87 ^oC, R_f = 0.6 (silica gel, petroleum ether:EtOAc = 2:1), 99% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.51 – 7.53 (m, 2H), 7.32 – 7.24 (m, 3H), 3.75 (d, *J* = 11.3 Hz, 1H), 3.71 (s, 3H), 3.64 (s, 3H), 3.21 (d, *J* = 11.3 Hz, 1H), 2.99 (d, *J* = 14.2 Hz, 1H), 2.97 (d, *J* = 14.1 Hz, 1H), 1.34 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 175.14, 173.96, 141.99, 128.28, 127.56, 126.07, 71.51, 57.45, 56.97, 52.94, 52.54, 48.30, 46.70, 31.57; **HRMS** (ESI): m/z calcd. for $[C_{18}H_{26}NO_4S, M+H]^+$: 352.1577; found: 352.1564.

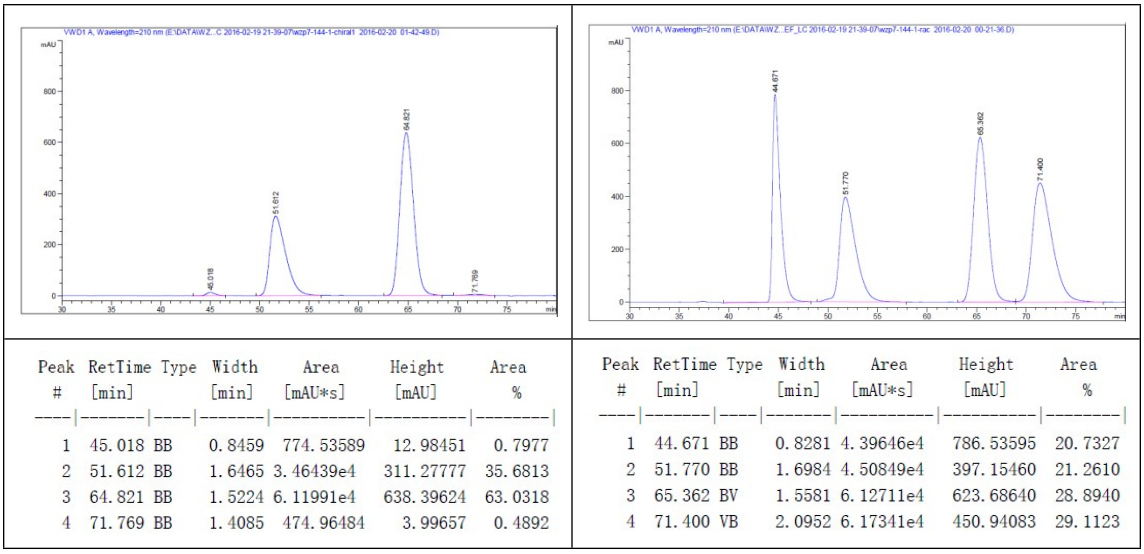
Optical Rotation: $[\alpha]^{25}_D$ = -3.2, (c= 0.41, $CHCl_3$). The absolute configuration of **4a** was assigned by analogy to **4g**. *trans*:*cis* = 75:25, 98% ee, 96% ee [HPLC condition: Chiralpak OJ-H+AD-H+OJ-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 0.8 mL/min, wavelength = 210 nm, t_R = 45.0 min (*cis*-minor), t_R = 51.6 min (*cis*-major), t_R = 64.8 min (*trans*-major), t_R = 71.8 min (*trans*-minor)].

Dimethyl (2*R*,4*S*)-4-(*tert*-butylthio)-2-phenylpyrrolidine-2,4-dicarboxylate (4a′ minor isomer)



4a' (minor isomer)

White solid, **M.P.** 134-136 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 10:1). **^{1}H NMR** (600 MHz, Chloroform-d) δ 7.56 (d, *J* = 7.6 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 2H), 7.26 – 7.24 (m, 1H), 3.94 (d, *J* = 11.7 Hz, 1H), 3.77 (d, *J* = 13.5 Hz, 1H), 3.75 (s, 3H), 3.65 (s, 3H), 3.01 (d, *J* = 11.8 Hz, 1H), 2.39 (d, *J* = 13.5 Hz, 1H), 1.72 (br, 1H), 1.31 (s, 9H); **^{13}C NMR** (151 MHz, Chloroform-d) δ 174.69, 174.31, 142.60, 128.26, 127.55, 126.27, 71.62, 57.78, 57.22, 53.11, 52.76, 50.20, 46.48, 31.70; **HRMS** (ESI), m/z calcd. for [$C_{18}H_{26}NO_4S$, M+H]$^+$: 352.1577; found: 352.1580; **Optical Rotation**: $[\alpha]^{25}_D$ = -46.2, (c= 0.50, $CHCl_3$).



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2	51.612	BB	1.6465	3.46439e4	311.27777	35.6813
3	64.821	BB	1.5224	6.11991e4	638.39624	63.0318
4	71.769	BB	1.4085	474.96484	3.99657	0.4892

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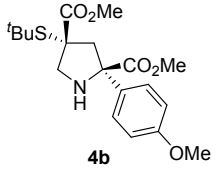
2	51.770	BB	1.6984	4.50849e4	397.15460	21.2610
3	65.362	BV	1.5581	6.12711e4	623.68640	28.8940
4	71.400	VB	2.0952	6.17341e4	450.94083	29.1123

Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-(4-methoxyphenyl)pyrrolidine-2,4-dicarboxylate (4b)

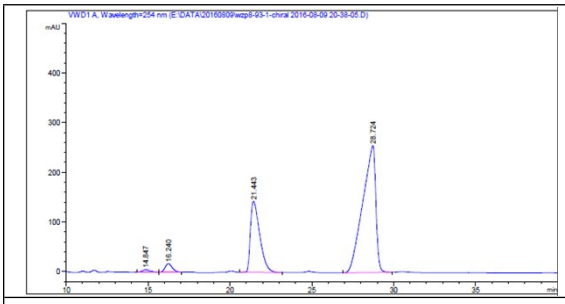


4b

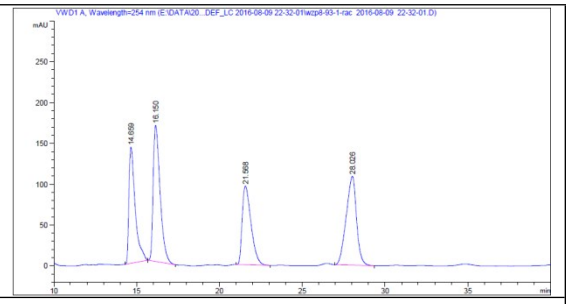
The general procedure A was followed. Colorless oil, R_f = 0.6 (silica gel, petroleum ether:EtOAc = 2:1), 97% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.43 (d, *J* = 8.9 Hz, 2H), 6.83 (d, *J* = 8.9 Hz, 2H), 3.78 (s, 3H), 3.75 (d, *J* = 11.4 Hz, 1H), 3.71 (s, 3H), 3.64 (s, 3H), 3.20 (d, *J* = 11.3 Hz, 1H), 3.11 (d, *J* = 14.1 Hz, 1H), 2.97 (d, *J* = 14.1 Hz, 1H), 1.34 (s, 9H);

^{13}C NMR (101 MHz, Chloroform-d) δ 175.24, 174.01, 158.97, 134.02, 127.29, 113.59, 71.08, 57.47, 57.07, 55.24, 52.82, 52.50, 48.43, 46.66, 31.57; **HRMS** (ESI), m/z calcd. for $[C_{19}H_{27}NNaO_5S, M+Na]^+$: 404.1502; found: 404.1501.

Optical Rotation: $[\alpha]^{25}_D$ = -2.7, (c= 0.37, $CHCl_3$). The absolute configuration of **4b** was assigned by analogy to **4g**. *trans*:*cis* = 67:33, 94% ee, 93% ee [HPLC condition: Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 95:5, flow rate = 1 mL/min, wavelength = 254 nm, t_R = 14.8 min (*trans*-minor), t_R = 16.2 min (*cis*-minor), t_R = 21.4 min (*trans*-major), t_R = 28.7 min (*cis*-major)].

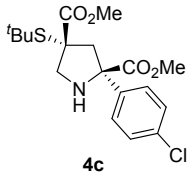


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.847	BB	0.4532	167.27965	5.31546	0.8124
2	16.240	BB	0.4715	528.50537	17.24697	2.5669
3	21.443	BB	0.6143	5665.13574	142.95824	27.5146
4	28.724	BB	0.7895	1.42287e4	255.58376	69.1061



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.659	BB	0.3969	3762.62769	142.12151	22.2799
2	16.150	BB	0.4455	4850.90479	166.71057	28.7240
3	21.568	BB	0.5702	3571.40698	96.39983	21.1477
4	28.026	BB	0.6564	4703.01611	108.78167	27.8483

Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-(4-chlorophenyl)pyrrolidine-2,4-dicarboxylate (4c)

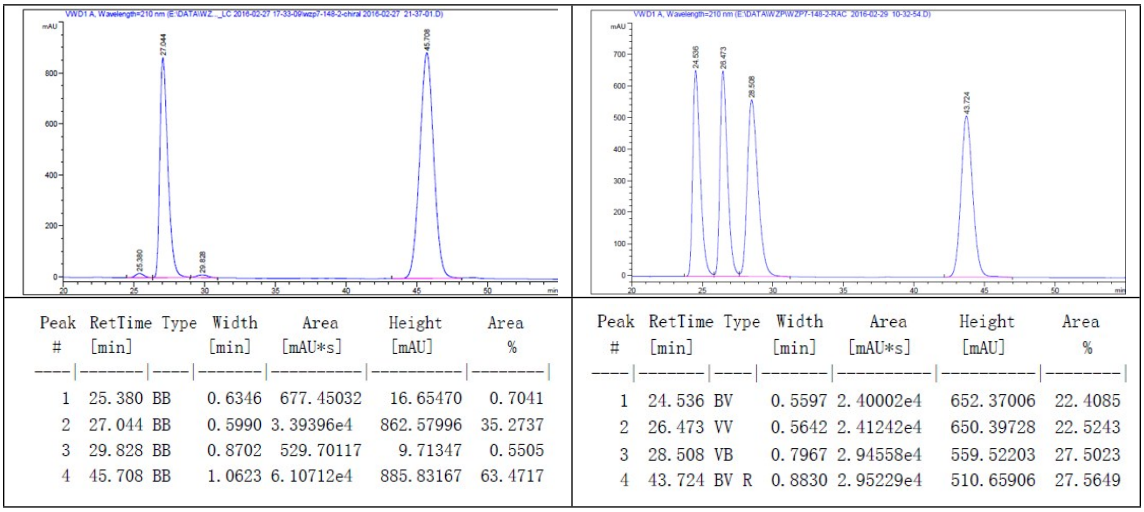


4c

The general procedure A was followed. White solid, **M.P.** 91-93 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 10:1), 98% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.48 (dd, *J* = 8.7, 0.9 Hz, 2H), 7.26 (dd, *J* = 8.8, 0.9 Hz, 1H), 3.71 (s, 3H), 3.3.68 (d, *J* = 0.9 Hz, 1H), 3.63 (s, 3H), 3.21 (d, *J* = 11.2 Hz, 1H), 3.13 (d, *J* = 14.0 Hz, 1H), 2.94 (d, *J* = 14.1 Hz, 1H), 2.73 (br, 1H), 1.33 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 174.74, 173.70, 140.67, 133.46, 128.34, 127.65, 71.03, 57.28, 57.02, 53.03, 52.54, 48.37, 46.76, 31.55; **HRMS** (ESI), m/z calcd. for $[C_{18}H_{24}ClNNaO_4S, M+Na]^+$: 408.1007; found: 408.0989.

Optical Rotation: $[\alpha]^{25}_D$ = -15.9, (c= 0.37, $CHCl_3$). The absolute configuration

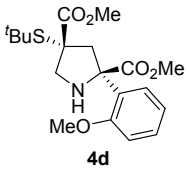
of **4c** was assigned by analogy to **4g**. *trans*:*cis* = 69:31, 98% ee, 96% ee [HPLC condition: Chiralpak AD-H+OJ-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 0.8 mL/min , wavelength = 210 nm, t_R = 25.4 min (*cis*-minor), t_R = 27.0 min (*cis*-major), t_R = 29.8 min (*trans*-minor), t_R = 45.7 min (*trans*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.380	BB	0.6346	677.45032	16.65470	0.7041
2	27.044	BB	0.5990	3.39396e4	862.57996	35.2737
3	29.828	BB	0.8702	529.70117	9.71347	0.5505
4	45.708	BB	1.0623	6.10712e4	885.83167	63.4717

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.536	BV	0.5597	2.40002e4	652.37006	22.4085
2	26.473	VV	0.5642	2.41242e4	650.39728	22.5243
3	28.508	VB	0.7967	2.94558e4	559.52203	27.5023
4	43.724	BV R	0.8830	2.95229e4	510.65906	27.5649

Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-(2-methoxyphenyl)pyrrolidine-2,4-dicarboxylate (4d)

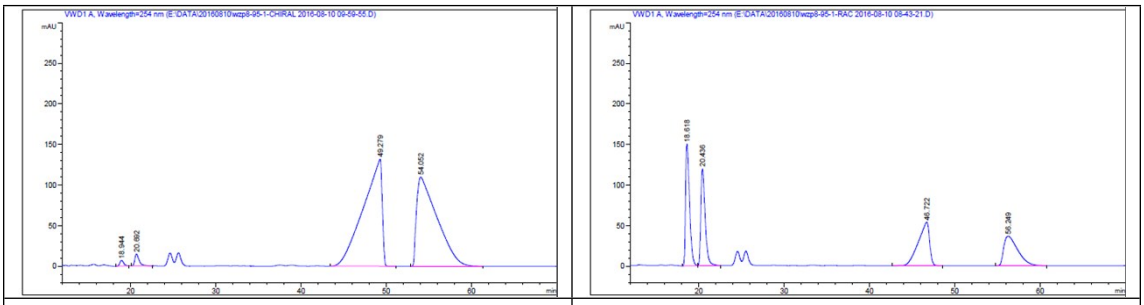


4d

The general procedure A was followed. Colorless oil, R_f = 0.6 (silica gel, petroleum ether:EtOAc = 2:1), 93% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.50 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.23 (dd, *J* = 7.7, 1.6 Hz, 1H), 6.94 (td, *J* = 7.6, 1.2 Hz, 1H), 6.83 (dd, *J* = 8.2, 1.1 Hz, 1H), 4.00 (dd, *J* = 9.9, 1.1 Hz, 1H), 3.76 (s, 3H), 3.64 (s, 3H), 3.59 (s, 3H), 3.24 (d, *J* = 9.9 Hz, 1H), 3.09 – 2.99 (m, 2H), 1.70 (br, 1H), 1.34 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 174.62, 174.37, 156.46, 131.19, 128.65, 125.83, 120.38, 110.71, 68.19, 57.04, 55.76, 55.29, 52.53, 52.45, 46.55, 46.39, 31.61; **HRMS** (ESI), m/z calcd. for $[C_{19}H_{28}NO_5S, M+H]^+$: 382.1683; found: 382.1682.

Optical Rotation: $[\alpha]^{25}_D$ = -55.9, (c= 0.24, $CHCl_3$). The absolute configuration of **4d** was assigned by analogy to **4g**. *trans*:*cis* = 56:44, 98% ee, 95% ee [HPLC condition: Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 95:5, flow rate = 1.0 mL/min,

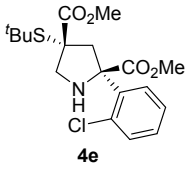
wavelength = 254 nm, t_R = 18.9 min (*trans*-minor), t_R = 20.7 min (*cis*-minor), t_R = 49.3 min (*trans*-major), t_R = 54.1 min (*cis*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.944	BB	0.4534	217.85808	7.11072	0.5541
2	20.692	BB	0.5243	502.20901	14.42028	1.2774
3	49.279	BB	1.9031	2.02593e4	131.81776	51.5295
4	54.052	BB	2.2078	1.83366e4	109.82935	46.6390

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.618	BV	0.5028	4880.42139	150.30789	26.8422
2	20.436	VB	0.5431	4215.49316	119.05304	23.1851
3	46.722	BB	1.2582	4919.77197	53.73335	27.0587
4	56.249	BB	1.6385	4166.19043	36.53156	22.9140

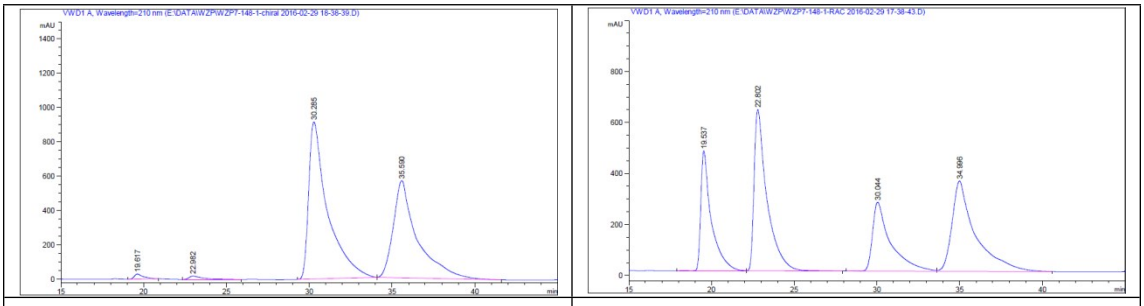
Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-(2-chlorophenyl)pyrrolidine-2,4-dicarboxylate (4e)



4e

The general procedure A was followed. Colorless oil, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 10:1), 97% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.76 (dd, *J* = 7.6, 2.0 Hz, 1H), 7.32 (dd, *J* = 7.4, 1.8 Hz, 1H), 7.25 – 7.18 (m, 2H), 4.00 (d, *J* = 9.3, 1.4 Hz, 1H), 3.68 (s, 3H), 3.54 (s, 3H), 3.33 (d, *J* = 14.0 Hz, 1H), 3.25 (d, *J* = 9.3 Hz, 1H), 2.99 (dd, *J* = 14.0, 1.4 Hz, 1H), 1.60 (br, 1H), 1.34 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 174.02, 173.34, 141.01, 132.34, 129.88, 128.63, 127.11, 126.41, 69.37, 56.64, 55.64, 53.00, 52.43, 46.68, 46.43, 31.62.; **HRMS** (ESI), m/z calcd. for [$C_{18}H_{24}ClNNaO_4S$, M+Na]$^+$: 408.1007; found: 408.0990.

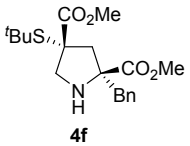
Optical Rotation: $[\alpha]^{25}_D$ = -68.6, (c= 0.22, $CHCl_3$). The absolute configuration of **4e** was assigned by analogy to **4g**. *trans*:*cis* = 57:43, 97% ee, 96% ee [HPLC condition: Chiralpak AS-H+IA-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 0.8 mL/min , wavelength = 210 nm, t_R = 19.6 min (*trans*-minor), t_R = 23.0 min (*cis*-minor), t_R = 30.3 min (*trans*-major), t_R = 35.6 min (*cis*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.617	BB	0.5071	1133.98486	29.59023	0.8640
2	22.982	BB	0.7085	1200.82190	20.30445	0.9149
3	30.285	BB	1.0404	7.23498e4	914.62048	55.1221
4	35.590	BB	1.3117	5.65691e4	565.55511	43.0990

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.537	VV R	0.6119	2.08454e4	470.51990	18.9089
2	22.802	VB	0.7698	3.42896e4	632.69794	31.1042
3	30.044	VV R	1.0267	2.04886e4	270.50018	18.5853
4	34.996	VV R	1.2857	3.46176e4	354.37329	31.4016

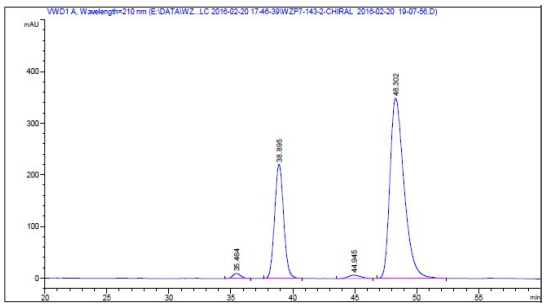
Dimethyl (2*S*,4*R*)-2-benzyl-4-(*tert*-butylthio)pyrrolidine-2,4-dicarboxylate (4f)



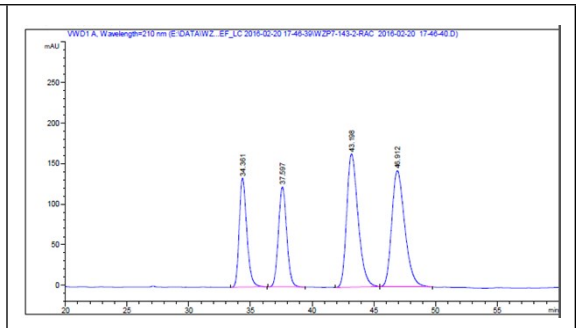
4f

The general procedure A was followed. White solid, **M.P.** 120-122 °C, R_f = 0.4 (silica gel, petroleum ether:EtOAc = 5:1). 95% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.26 – 7.19 (m, 5H), 3.81 (dd, *J* = 11.8, 1.5 Hz, 1H), 3.68 (s, 3H), 3.64 (s, 3H), 3.28 (dd, *J* = 13.7, 1.5 Hz, 1H), 3.10 (d, *J* = 13.2 Hz, 1H), 2.91 (dd, *J* = 15.3, 12.5 Hz, 2H), 2.11 (d, *J* = 13.7 Hz, 1H), 1.32 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 175.46, 174.25, 136.73, 129.93, 128.06, 126.80, 70.27, 57.70, 56.74, 52.70, 52.39, 49.08, 46.49, 45.35, 31.70; **HRMS** (ESI): m/z calcd. for $[C_{19}H_{28}NO_4S, M+H]^+$: 366.1734; found: 366.1718.

Optical Rotation: $[\alpha]^{25}_D$ = -49.2, c= 0.25, $CHCl_3$). The absolute configuration of **4f** was assigned by analogy to **4g**. *trans*:*cis* = 68:32, 97% ee, 92% ee [HPLC condition: Chiralpak AD-H+AD-H+OJ-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 0.8 mL/min, wavelength = 210 nm, t_R = 35.5 min (*cis*-minor), t_R = 38.9 min (*cis*-major), t_R = 45.0 min (*trans*-minor), t_R = 48.3 min (*trans*-major)].

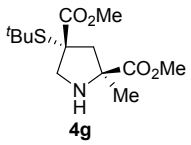


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	35.464	BB	0.5320	438.29099	9.67601	1.1065
2	38.895	BB	0.7584	1.11584e4	221.25592	28.1712
3	44.945	BB	0.8229	450.72763	6.40972	1.1379
4	48.302	BB	1.1594	2.75617e4	348.97766	69.5843



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	34.361	BB	0.6353	5757.07715	134.64734	17.6846
2	37.597	BB	0.7134	5772.78955	123.36200	17.7328
3	43.198	BB	0.9442	1.05252e4	164.21930	32.3312
4	46.912	BB	1.0643	1.04992e4	142.96860	32.2514

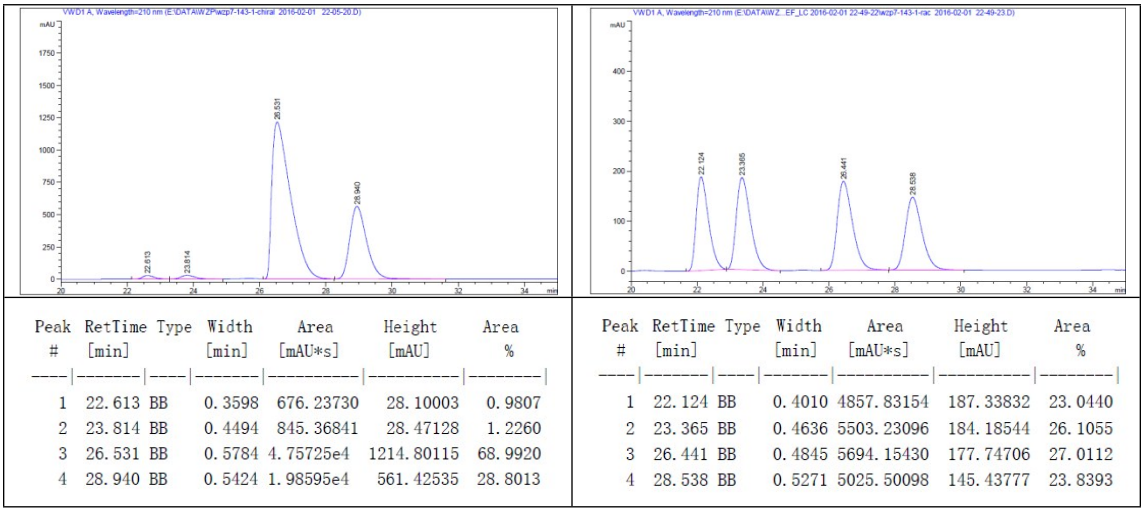
Dimethyl (2*S*,4*R*)-4-(*tert*-butylthio)-2-methylpyrrolidine-2,4-dicarboxylate (4g)



4g

The general procedure A was followed. White solid, **M.P.** 60-62 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 2:1). 86% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 3.81 (dd, *J* = 12.0, 1.4 Hz, 1H), 3.71 (d, *J* = 1.6 Hz, 6H), 3.18 (dd, *J* = 13.8, 1.4 Hz, 1H), 3.02 (d, *J* = 12.0 Hz, 1H), 2.50 (br, 1H), 1.94 (d, *J* = 13.9 Hz, 1H), 1.43 (s, 3H), 1.31 (s, 9H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 176.61, 174.17, 65.52, 57.74, 57.59, 52.75, 52.72, 50.25, 46.57, 31.68, 26.85; **HRMS** (ESI): m/z calcd. for $[C_{13}H_{23}NNaO_4S, M+Na]^+$: 312.1240; found: 312.1231.

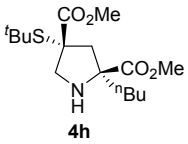
Optical Rotation: $[\alpha]^{25}_D$ = -11.9, (c= 0.37, $CHCl_3$). The absolute configuration of **4g** was assigned by its single crystal. *trans*:*cis* = 67:33, 96% ee, 93% ee [HPLC condition: Chiralpak OJ-H+AD-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 0.8 mL/min, wavelength = 210 nm, t_R = 22.6 min (*cis*-minor), t_R = 23.8 min (*trans*-minor), t_R = 26.5 min (*trans*-major), t_R = 28.9 min (*cis*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.613	BB	0.3598	676.23730	28.10003	0.9807
2	23.814	BB	0.4494	845.36841	28.47128	1.2260
3	26.531	BB	0.5784	4.75725e4	1214.80115	68.9920
4	28.940	BB	0.5424	1.98595e4	561.42535	28.8013

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.124	BB	0.4010	4857.83154	187.33832	23.0440
2	23.365	BB	0.4636	5503.23096	184.18544	26.1055
3	26.441	BB	0.4845	5694.15430	177.74706	27.0112
4	28.538	BB	0.5271	5025.50098	145.43777	23.8393

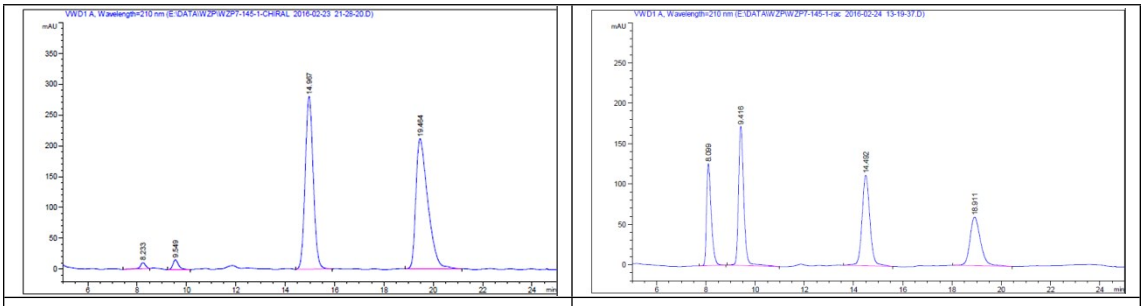
Dimethyl (2*S*,4*R*)-2-butyl-4-(*tert*-butylthio)pyrrolidine-2,4-dicarboxylate (4h)



4h

The general procedure A was followed. White solid, **M.P.** 35-37 °C, R_f = 0.5 (silica gel, petroleum ether:EtOAc = 5:1), 90% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 3.77 (s, 3H), 3.74 (s, 3H), 3.70 (dd, *J* = 10.9, 0.9 Hz, 1H), 3.04 (d, *J* = 11.0 Hz, 1H), 2.68 (dd, *J* = 14.3, 0.9 Hz, 1H), 2.54 (d, *J* = 14.3 Hz, 1H), 1.77 (td, *J* = 12.6, 12.1, 4.5 Hz, 1H), 1.51 (td, *J* = 13.3, 12.9, 3.7 Hz, 1H), 1.31 (s, 9H), 1.27 – 1.24 (m, 4H), 1.03 – 0.98 (m, 1H), 0.87 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, Chloroform-d) δ 176.62, 174.52, 68.94, 57.70, 56.49, 52.71, 52.42, 47.35, 46.50, 40.09, 31.62, 27.03, 22.82, 13.93; **HRMS** (ESI), m/z calcd. for $[C_{16}H_{30}NO_4S, M+H]^+$: 332.1890; found: 332.1879.

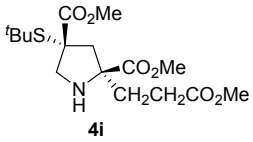
Optical Rotation: $[\alpha]^{25}_D$ = -11.4, (c= 0.18, $CHCl_3$). The absolute configuration of **4h** was assigned by analogy to **4g**. *trans*:*cis* = 61:39, 96% ee, 92% ee [HPLC condition: Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 1.0 mL/min, wavelength = 210 nm, t_R = 8.2 min (*trans*-minor), t_R = 9.5 min (*cis*-minor), t_R = 15.0 min (*cis*-major), t_R = 19.5 min (*trans*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.233	BB	0.2175	144.69868	9.98693	1.0510
2	9.549	BB	0.2361	244.20230	15.58533	1.7737
3	14.967	BB	0.3511	6320.71729	279.76773	45.9092
4	19.464	BB	0.5019	7058.24023	210.51167	51.2661

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.099	BB	0.2008	1658.15088	126.19788	19.5801
2	9.416	BB	0.2257	2543.43433	172.34091	30.0339
3	14.492	BB	0.3390	2475.76611	112.06872	29.2349
4	18.911	BB	0.4346	1791.18103	60.21004	21.1510

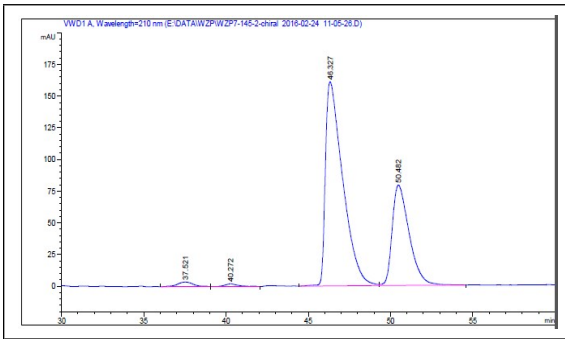
Dimethyl (2*S*,4*R*)-4-(*tert*-butylthio)-2-(3-methoxy-3-oxopropyl) pyrrolidine-2,4-dicarboxylate (4i)



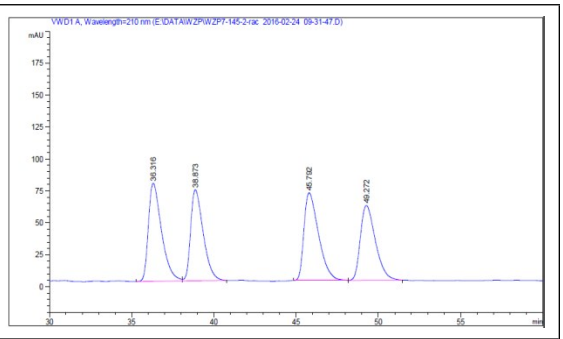
4i

The general procedure A was followed. Colorless oil, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 5:1), 95% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 3.83 (dd, *J* = 12.1, 1.8 Hz, 1H), 3.72 (s, 3H), 3.70 (s, 3H), 3.64 (s, 3H), 3.19 (dd, *J* = 13.8, 1.7 Hz, 1H), 2.88 (dd, *J* = 12.1, 0.8 Hz, 1H), 2.44 (tt, *J* = 13.1, 5.5 Hz, 1H), 2.18 – 2.10 (m, 2H), 1.97 (d, *J* = 13.8 Hz, 1H), 1.94 – 1.88 (m, 1H), 1.31 (s, 9H).; **^{13}C NMR** (101 MHz, Chloroform-d) δ 175.66, 174.17, 173.54, 68.40, 57.90, 57.12, 52.78, 52.69, 51.61, 49.51, 46.43, 34.68, 31.72, 29.98; **HRMS** (ESI), m/z calcd. for $[C_{16}H_{28}NO_6S, M+H]^+$: 362.1632; found: 362.1630.

Optical Rotation: $[\alpha]^{25}_D$ = -28.3, (c= 0.23, $CHCl_3$). The absolute configuration of **4i** was assigned by analogy to **4g**. *trans*:*cis* = 60:40, 96% ee, 96% ee [HPLC condition: Chiralpak AD-H+OJ-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 0.8 mL/min, wavelength = 210 nm, t_R = 37.5 min (*trans*-minor), t_R = 40.3 min (*cis*-minor), t_R = 46.3 min (*trans*-major), t_R = 50.5 min (*cis*-major)].

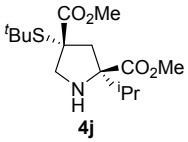


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	37.521	BV R	0.9607	237.06993	3.63611	1.3299
2	40.272	BV R	0.7733	118.59071	2.13080	0.6653
3	46.327	BV	1.0694	1.17793e4	161.02301	66.0783
4	50.482	VV R	1.1113	5691.30664	79.11362	31.9266



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	36.316	VV R	0.7963	4266.49658	76.78261	26.6890
2	38.873	VV R	0.7430	3776.21313	71.23279	23.6220
3	45.792	BV R	0.8699	4225.59619	68.48158	26.4331
4	49.272	VV R	0.8495	3717.67651	58.57498	23.2559

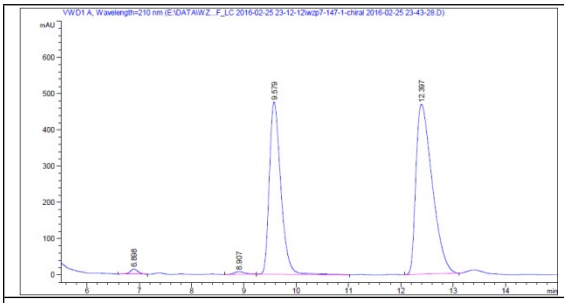
Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-isopropylpyrrolidine-2,4-dicarboxylate (4j)



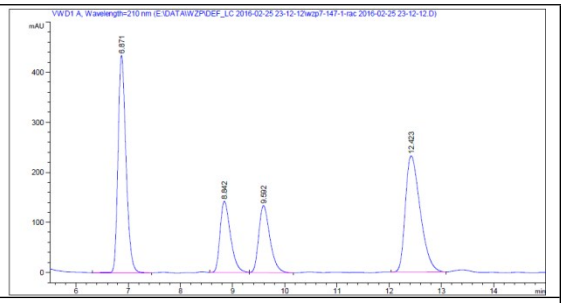
4j

The general procedure A was followed. White solid, **M.P.** 79-81 °C, R_f = 0.5 (silica gel, petroleum ether:EtOAc = 5:1), 99% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 3.83 (dd, *J* = 11.8, 1.8 Hz, 1H), 3.71 (s, 3H), 3.69 (s, 3H), 3.14 (dd, *J* = 13.7, 1.8 Hz, 1H), 2.82 (d, *J* = 11.8 Hz, 1H), 2.09 (d, *J* = 13.7 Hz, 1H), 1.94 (p, *J* = 6.7 Hz, 1H), 1.65 (br, 1H), 1.32 (s, 9H), 0.91 (d, *J* = 6.7 Hz, 3H), 0.84 (d, *J* = 6.7 Hz, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 176.54, 174.31, 72.59, 58.75, 56.93, 52.68, 52.45, 46.36, 46.22, 35.94, 31.72, 18.12, 16.91; **HRMS** (ESI), m/z calcd. for $[C_{15}H_{27}NNaO_4S, M+Na]^+$: 340.1553; found: 340.1541.

Optical Rotation: $[\alpha]^{25}_D$ = -41.7, (c= 0.30, $CHCl_3$). The absolute configuration of **4j** was assigned by analogy to **4g**. *trans*:*cis* = 53:47, 97% ee, 97% ee [HPLC condition: Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 1 mL/min, 4 °C, wavelength = 210 nm, t_R = 6.9 min (*trans*-minor), t_R = 8.9 min (*cis*-minor), t_R = 9.6 min (*cis*-major), t_R = 12.4 min (*trans*-major)].

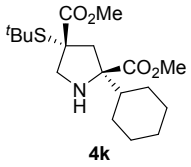


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.898	BB	0.1616	150.01878	14.04918	0.8532
2	8.907	BB	0.2108	99.77483	7.04011	0.5675
3	9.579	BB	0.2327	7217.53418	475.25229	41.0500
4	12.397	BB	0.3337	1.01150e4	468.77124	57.5293



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.871	BB	0.1632	4605.89600	434.23129	34.9788
2	8.842	BV	0.2141	1980.82629	142.10455	15.0431
3	9.592	VB	0.2292	2002.89685	134.12674	15.2107
4	12.423	BB	0.3045	4578.05762	232.19347	34.7674

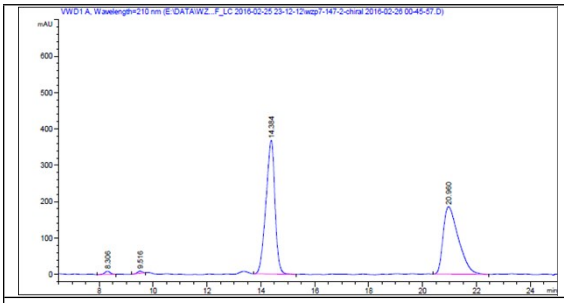
Dimethyl (2*R*,4*R*)-4-(*tert*-butylthio)-2-cyclohexylpyrrolidine-2,4-dicarboxylate (4k)



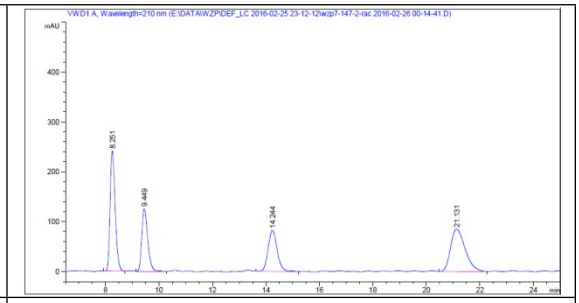
4k

The general procedure A was followed. White solid, **M.P.** 76-78 °C, R_f = 0.5 (silica gel, petroleum ether:EtOAc = 5:1), 87% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 3.81 (dd, *J* = 11.8, 1.8 Hz, 1H), 3.70 (s, 3H), 3.69 (s, 3H), 3.11 (dd, *J* = 13.7, 1.8 Hz, 1H), 2.81 (d, *J* = 11.8 Hz, 1H), 2.13 (d, *J* = 13.7 Hz, 1H), 1.81 – 1.71 (m, 3H), 1.64 – 1.59 (m, 1H), 1.64 – 1.58 (m, 1H), 1.31 (s, 8H), 1.56 – 1.53 (m, 1H), 1.31 (s, 8H), 1.38 – 1.42 (m, 1H), 1.31 (s, 9H), 1.25 – 1.98 (m, 4H), 1.19 – 1.15 (m, 1H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 176.50, 174.33, 72.50, 58.66, 56.83, 52.62, 52.41, 46.33, 46.08, 45.73, 31.73, 28.33, 26.86, 26.44, 26.34, 26.23; **HRMS** (ESI), m/z calcd. for $[C_{18}H_{32}NO_4S, M+H]^+$: 358.2047; found: 358.2031.

Optical Rotation: $[\alpha]^{25}_D$ = -56.6, (c= 0.23, $CHCl_3$). The absolute configuration of **4k** was assigned by analogy to **4g**. *trans*:*cis* = 52:48, 98% ee, 97% ee [HPLC condition: Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 99:1, flow rate = 1.0 mL/min, 4 °C, wavelength = 210 nm, t_R = 8.3 min (*cis*-minor), t_R = 9.5 min (*trans*-minor), t_R = 14.4 min (*trans*-major), t_R = 21.0 min (*cis*-major)].

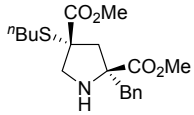


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.306	BB	0.2078	125.56353	8.99546	0.7836
2	9.516	BB	0.1840	71.60851	6.16453	0.4469
3	14.384	BB	0.3475	8530.86621	367.93536	53.2386
4	20.960	BB	0.5910	7295.80078	185.22830	45.5309



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.251	BB	0.2035	3165.73560	240.67480	30.9974
2	9.449	BB	0.2363	1924.50330	125.20577	18.8439
3	14.244	BB	0.3598	1923.24475	82.08813	18.8315
4	21.131	BB	0.5781	3199.41284	84.90332	31.3272

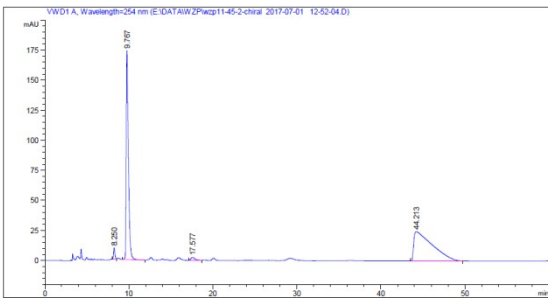
Dimethyl (2*S*,4*R*)-2-benzyl-4-(butylthio)pyrrolidine-2,4-dicarboxylate (4l)



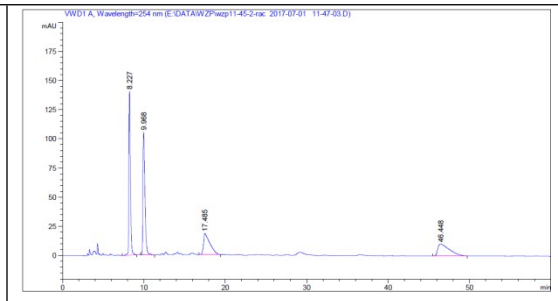
4l

The general procedure A was followed. White solid, M.P. = 75-77 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 8:1), 93% yield. **^{1}H NMR** (600 MHz, Chloroform-d) δ 7.24 – 7.23 (m, 2H), 7.20 (dd, *J* = 10.8, 7.5 Hz, 3H), 3.68 (s, 3H), 3.64 (s, 3H), 3.61 (d, *J* = 11.8 Hz, 1H), 3.12 (dd, *J* = 22.5, 13.6 Hz, 2H), 2.98 (dd, *J* = 12.6, 4.1 Hz, 2H), 2.60 – 2.51 (m, 2H), 2.06 (d, *J* = 14.0 Hz, 1H), 1.09 (br, 1H), 1.49 (dt, *J* = 15.2, 7.5 Hz, 2H), 1.39 – 1.33 (m, 2H), 0.88 (t, *J* = 7.3 Hz, 3H); **^{13}C NMR** (151 MHz, Chloroform-d) δ 175.42, 172.80, 136.49, 129.85, 128.16, 126.88, 70.53, 56.17, 55.59, 52.65, 52.38, 46.27, 45.18, 31.24, 30.59, 22.02, 13.59.; **HRMS** (ESI), m/z calcd. for $[C_{19}H_{28}NO_4S, M+H]^+$: 366.1734; found: 366.1734.

Optical Rotation: $[\alpha]^{25}_D$ = -11.8, (c= 0.4, $CHCl_3$). The absolute configuration of **4l** was assigned by analogy to **4g**. *trans*:*cis* = 57:43, 96% ee, 94% ee [HPLC condition: Chiralpak IF-H column, *n*-hexane/*i*-PrOH = 95:5, flow rate = 1.0 mL/min , wavelength = 254 nm, t_R = 8.3 min (*trans*-minor), t_R = 9.8 min (*trans*-major), t_R = 17.6 min (*cis*-minor), t_R = 44.2 min (*cis*-major)].

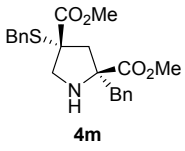


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.250	BB	0.1767	105.37866	9.26566	1.4993
2	9.767	BB	0.2690	3122.08667	173.82698	44.4195
3	17.577	BB	0.3879	82.81821	2.50354	1.1783
4	44.213	BB	1.7786	3718.36035	24.49346	52.9030



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.227	BV R	0.1971	1818.96118	140.40131	32.4112
2	9.968	VV R	0.2594	1803.77783	105.27798	32.1406
3	17.485	VV R	0.6752	984.45703	18.13983	17.5415
4	46.448	VV R	1.1459	1004.94977	10.25397	17.9067

Dimethyl (2*S*,4*R*)-2-benzyl-4-(benzylthio)pyrrolidine-2,4-dicarboxylate (4m)

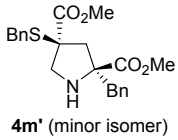


4m

The general procedure A was followed. White solid, M.P. = 72-74 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 8:1), 95% yield. **^{1}H NMR** (600 MHz, Chloroform-d) δ 7.28 (d, *J* = 4.4 Hz, 3H), 7.26 – 7.18 (m, 5H), 7.16 (d, *J* = 7.1 Hz, 2H), 3.79 (s, 1H), 3.64 (s, 3H), 3.60 (s, 3H), 3.57 (d, *J* = 11.9 Hz, 1H), 3.47 (s, 1H), 3.10 (t, *J* = 14.0 Hz, 2H), 2.96 (d, *J* = 12.5 Hz, 2H), 2.05 (d, *J* = 14.1 Hz, 1H), 1.78 (br, 1H); **^{13}C NMR** (151 MHz, Chloroform-d) δ 175.43, 172.52, 137.12, 136.49, 129.85, 128.98, 128.51, 128.16, 127.22, 126.88, 70.44, 56.85, 55.57, 52.61, 52.36, 46.14, 45.22, 35.77; **HRMS** (ESI), m/z calcd. for $[C_{22}H_{26}NO_4S, M+H]^+$: 400.1577; found: 400.1579.

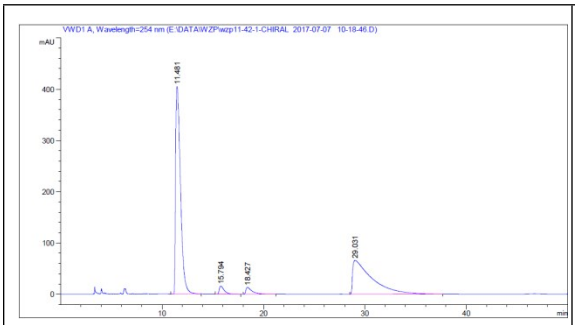
Optical Rotation: $[\alpha]^{25}_D$ = -31.8, (c= 0.50, $CHCl_3$). The absolute configuration of **4m** was assigned by analogy to **4g**. *trans*:*cis* = 57:43, 92% ee, 88% ee [HPLC condition: Chiralpak IC-H column, *n*-hexane/*i*-PrOH = 90:10, flow rate = 1.0 mL/min , wavelength = 254 nm, t_R = 11.5 min (*trans*-major), t_R = 15.8 min (*trans*-minor), t_R = 18.4 min (*cis*-minor), t_R = 29.0 min (*cis*-major)].

Dimethyl (2*S*,4*S*)-2-benzyl-4-(benzylthio)pyrrolidine-2,4-dicarboxylate (4m′ minor isomer)

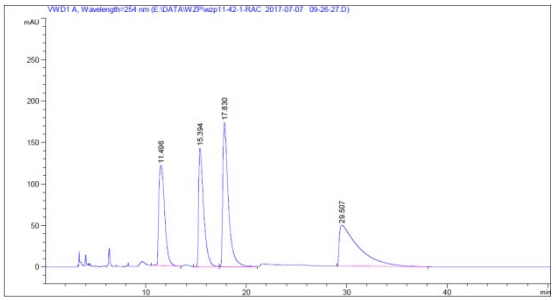


4m' (minor isomer)

White solid, **M.P.** 65-67 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc= 5:1). **^{1}H NMR** (600 MHz, Chloroform-d) δ 7.28 – 7.21 (m, 8H), 7.14 (d, *J* = 7.0 Hz, 2H), 3.75 (s, 1H), 3.64 (s, 6H), 3.47 (d, *J* = 11.5 Hz, 1H), 3.08 (d, *J* = 13.2 Hz, 1H), 3.02 (d, *J* = 11.5 Hz, 1H), 2.84 (d, *J* = 13.2 Hz, 1H), 2.61 (q, *J* = 14.4 Hz, 2H), 1.62 (br, 1H); **^{13}C NMR** (151 MHz, Chloroform-d) δ 175.55, 172.56, 136.79, 136.39, 129.83, 128.99, 128.48, 128.12, 127.19, 126.88, 70.20, 56.87, 55.16, 52.60, 52.25, 45.58, 44.34, 35.53; **HRMS** (ESI), m/z calcd. for $[C_{22}H_{26}NO_4S, M+H]^+$: 400.1577; found: 400.1575; **Optical Rotation**: $[\alpha]^{25}_D$ = -31.2, (c= 0.43, $CHCl_3$).

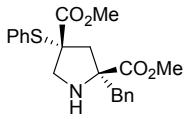


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.481	BB	0.5311	1.35950e4	404.47012	57.7254
2	15.794	BB	0.4761	539.11926	16.03989	2.2891
3	18.427	BB	0.5883	587.04517	13.55372	2.4926
4	29.031	BB	1.6827	8830.00000	66.13196	37.4929



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.496	BB	0.6503	4886.94629	120.59315	21.2174
2	15.394	BB	0.5081	4914.03223	142.92921	21.3350
3	17.830	BB	0.5666	6636.59229	173.75156	28.8138
4	29.507	BB	1.6527	6595.13135	49.23614	28.6338

Dimethyl (2*S*,4*R*)-2-benzyl-4-(phenylthio)pyrrolidine-2,4-dicarboxylate (4n)

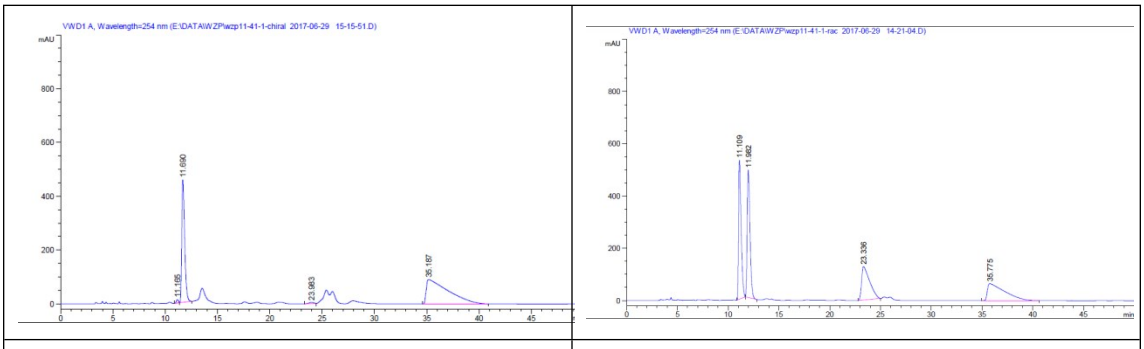


4n

The general procedure A was followed. White solid, M.P. = 81-83 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 7:1), 91% yield. **^{1}H NMR** (600 MHz, Chloroform-d) δ 7.42 (d, *J* = 7.4 Hz, 2H), 7.36 (t, *J* = 7.2 Hz, 1H), 7.31 (t, *J* = 7.3 Hz, 2H), 7.25 (t, *J* = 7.1 Hz, 2H), 7.22 – 7.21 (m, 1H), 7.18 (d, *J* = 7.3 Hz, 2H), 3.62 (s, 3H), 3.58 (s, 3H), 3.49 (d, *J* = 11.9 Hz, 1H), 3.14 (d, *J* = 13.3 Hz, 1H), 3.05 (d, *J* = 12.0 Hz, 1H), 3.02 – 3.00 (m, 1H), 2.17 (d, *J* = 14.2 Hz, 1H), 1.85 (br, 1H); **^{13}C NMR** (151 MHz, Chloroform-d) δ 175.41, 172.47, 136.48, 135.61, 131.41, 129.87, 129.36, 128.91, 128.18, 126.90, 70.58, 59.96, 55.46, 52.48,

52.35, 45.81, 45.31; **HRMS** (ESI), m/z calcd. for $[C_{21}H_{24}NO_4S, M+H]^+$: 386.1421; found: 386.1420.

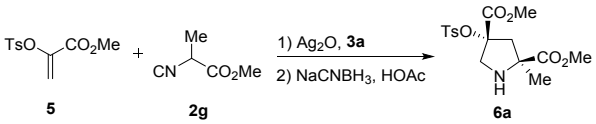
Optical Rotation: $[\alpha]^{25}_D$ = -20.8, (c= 0.50, $CHCl_3$). The absolute configuration of **4n** was assigned by analogy to **4g**. *trans*:*cis* = 60:40, 98% ee, 96% ee [HPLC condition: Chiralpak IF-H column, *n*-hexane/*i*-PrOH = 95:5, flow rate = 1.0 mL/min , wavelength = 254 nm, t_R = 11.2 min (*trans*-minor), t_R = 11.7 min (*trans*-major), t_R = 24.0 min (*cis*-minor), t_R = 35.2 min (*cis*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.165	BV E	0.2205	178.57922	12.66678	0.8046
2	11.690	VV R	0.2928	8752.99414	456.80060	39.4393
3	23.983	BB	0.3644	120.03709	3.86944	0.5409
4	35.187	BB	1.7716	1.31420e4	90.04139	59.2152

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.109	BB	0.2663	9352.30664	532.65283	28.0062
2	11.982	BB	0.2948	9391.93262	489.65564	28.1249
3	23.336	BB	0.7207	7051.87158	128.35049	21.1174
4	35.775	VV R	1.4546	7597.59814	64.29729	22.7516

VI. Substrates Scope with α-Tosyloxyacrylate

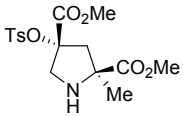


General procedure B. To a 10 mL tube charged with **3a** (12.30 mg, 0.02 mmol) and Ag_2O (2.30 mg, 0.01 mmol) was added $CHCl_3$ (1.0 mL). The mixture was stirred at -20 °C for 5 minutes, then the methyl 2-(tosyloxy)acrylate **5** (25.60 mg, 0.10 mmol) and isocyanoacetate **2g** (13.56 mg, 0.12 mmol) were added. The reaction mixture was stirred at -20 °C until **5** was consumed, and then filtered through a pad of silica gel and washed with ethyl acetate. The solvent was removed under reduced pressure and then the residue was dissolved in MeOH (1.0 mL), $NaCNBH_3$ (12.56 mg, 0.20 mmol) and HOAc (12.00 mg, 0.20 mmol) were added sequentially at room temperature. The

reaction mixture was stirred at room temperature for 0.5 h, and then concentrated, purified by flash chromatography on silica gel (hexanes/ethyl acetate, 2:1) to afford the product **6a**.

VI.I Characterization of Compounds

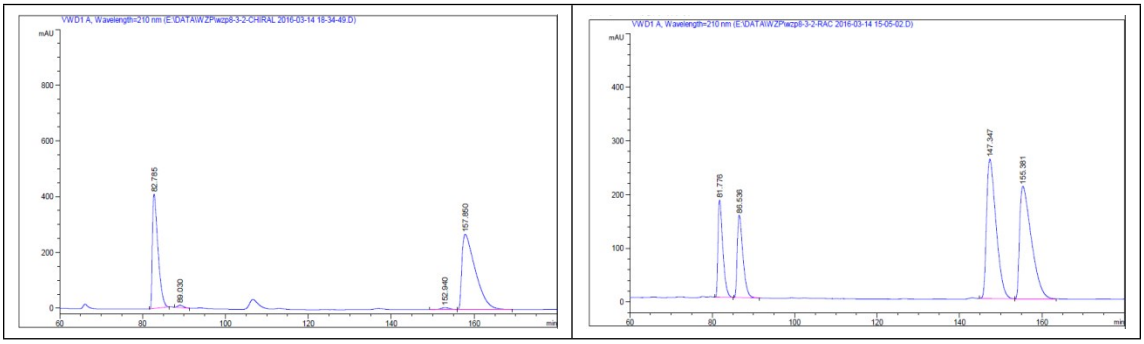
Dimethyl (2*S*,4*R*)-2-methyl-4-(tosyloxy)pyrrolidine-2,4-dicarboxylate (6a)



6a

The general procedure **B** outlined above was followed. Colorless oil, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 2:1), 90% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.84 (d, *J* = 8.2 Hz, 2H), 7.35 (d, *J* = 7.8 Hz, 2H), 3.79 (s, 3H), 3.75 (s, 3H), 3.56 (dd, *J* = 13.4, 1.5 Hz, 1H), 3.43 (d, *J* = 13.4 Hz, 0H), 3.04 (d, *J* = 15.0 Hz, 1H), 2.44 (s, 4H), 2.04 (br, 1H), 1.45 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 175.76, 169.79, 145.00, 134.94, 129.70, 127.70, 93.00, 66.41, 56.87, 53.04, 52.71, 47.27, 25.73, 21.66; **HRMS** (ESI), m/z calcd. for $[C_{16}H_{21}NNaO_7S, M+Na]^+$: 394.0931; found: 394.0912.

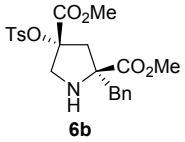
Optical Rotation: $[\alpha]^{25}_D$ = +5.76, (c= 0.50, $CHCl_3$). The absolute configuration of **6a** was assigned by analogy to **4g**. *trans*:*cis* = 60:40, 98% ee, 94% ee [HPLC condition: Chiralpak AS-H+AD-H+AD-H column, *n*-hexane/*i*-PrOH = 60:40, flow rate = 0.7 mL/min, wavelength = 210 nm, t_R = 82.8 min (*cis*-major), t_R = 89.0 min (*cis*-minor), t_R = 152.9 min (*trans*-minor), t_R = 157.9 min (*trans*-major)].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	82.785	BB	1.4113	3.83549e4	410.04474	38.1798
2	89.030	BB	1.3359	757.72058	8.09587	0.7543
3	152.940	BV	1.7565	913.69861	6.16723	0.9095
4	157.850	VB	3.1824	6.04323e4	269.26468	60.1565

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	81.776	BB	1.1220	1.46561e4	180.84023	13.0652
2	86.536	BB	1.2963	1.46010e4	153.21259	13.0160
3	147.347	BB	1.8987	4.14984e4	259.57254	36.9936
4	155.381	BB	2.3112	4.14215e4	209.36278	36.9252

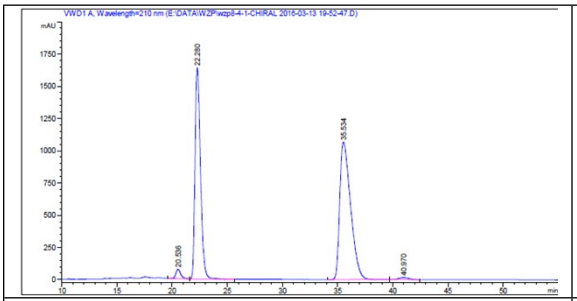
Dimethyl (2*S*,4*R*)-2-benzyl-4-(tosyloxy)pyrrolidine-2,4-dicarboxylate (6b)



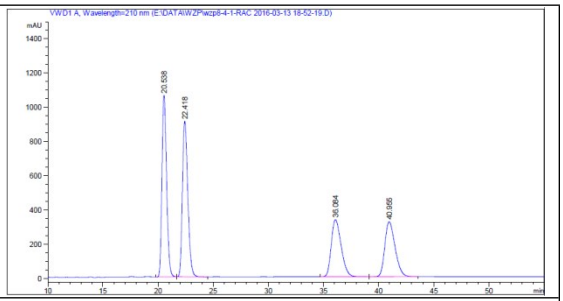
6b

The general procedure **B** outlined above was followed. White solid, **M.P.** 72-74 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 5:1), 96% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.83 (d, *J* = 8.3 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 7.23 – 7.21 (m, 3H), 7.08 (dd, *J* = 7.4, 2.1 Hz, 2H), 3.78 (s, 3H), 3.69 (s, 3H), 3.48 – 3.40 (m, 2H), 3.12 (dd, *J* = 19.9, 14.1 Hz, 2H), 2.92 (d, *J* = 13.3 Hz, 1H), 2.57 (d, *J* = 15.4 Hz, 1H), 2.46 (s, 3H), 2.12 (br, 1H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 174.79, 170.07, 144.93, 135.98, 135.02, 129.71, 129.69, 128.30, 127.70, 127.05, 91.71, 70.80, 56.16, 53.08, 52.46, 45.84, 45.01, 21.70; **HRMS** (ESI), m/z calcd. for $[C_{22}H_{25}NNaO_7S, M+Na]^+$: 470.1244; found: 470.1228.

Optical Rotation: $[\alpha]^{25}_D$ = -18.4, (c= 0.50, $CHCl_3$). The absolute configuration of **6b** was assigned by analogy to **4g**. *trans*:*cis* = 60:40, 97% ee, 92% ee [HPLC condition: Chiralpak AS-H+AD-H column, *n*-hexane/*i*-PrOH = 80:20, flow rate = 1.0 mL/min, wavelength = 210 nm, t_R = 20.5 min (*cis*-minor), t_R = 22.3 min (*cis*-major), t_R = 35.5 min (*trans*-major), t_R = 41.0 min (*trans*-minor)].

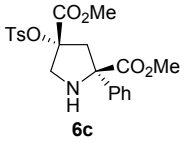


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.536	BB	0.4693	2235.37573	72.18116	1.6867
2	22.280	BB	0.5389	5.65891e4	1638.70410	42.6994
3	35.534	BB	1.0560	7.27596e4	1066.45569	54.9008
4	40.970	BB	0.9512	945.12732	15.16272	0.7131



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.538	BB	0.4536	3.08608e4	1060.11499	29.9591
2	22.418	BB	0.5284	3.08506e4	907.98584	29.9492
3	36.084	BB	0.9701	2.06826e4	333.21588	20.0783
4	40.955	BB	0.9949	2.06158e4	320.30829	20.0135

Dimethyl (2*R*,4*R*)-2-phenyl-4-(tosyloxy)pyrrolidine-2,4-dicarboxylate (6c)

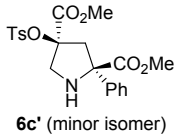


6c

The general procedure **B** outlined above was followed. Colorless oil, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 5:1), 93% yield. **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.70 (d, *J* = 8.3 Hz, 2H), 7.46 (dd, *J* = 7.9, 1.8 Hz, 2H), 7.26 (t, *J* = 8.0 Hz, 5H), 3.82 (s, 3H), 3.69 (s, 3H), 3.60 – 3.56(m, 2H), 3.46 (d, *J* = 12.6 Hz, 1H), 2.84 (d, *J* = 14.7 Hz, 1H), 2.41 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 174.09, 170.42, 144.74, 141.08, 134.98, 129.62, 128.40, 127.77, 127.46, 126.02, 91.51, 72.18, 55.88, 53.13, 53.09, 47.43, 21.63; **HRMS** (ESI), m/z calcd. for $[C_{21}H_{24}NO_7S, M+H]^+$: 434.1268; found: 434.1263.

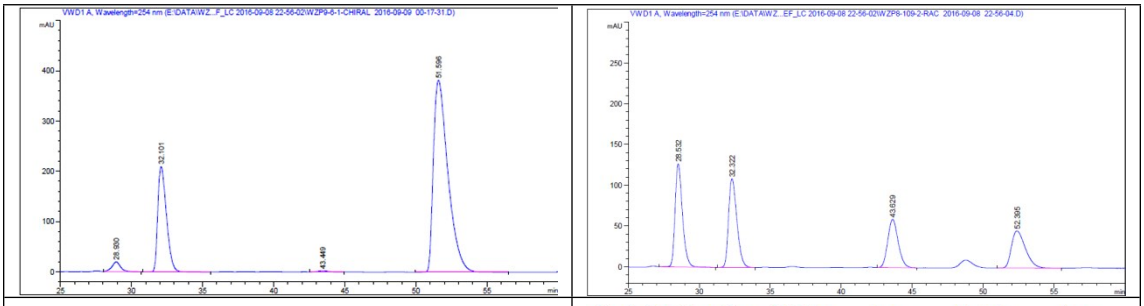
Optical Rotation: $[\alpha]^{25}_D$ = -2.56, (c= 0.39, $CHCl_3$). The absolute configuration of **6c** was assigned by analogy to **4g**. *trans*:*cis* = 69:31, 99% ee, 83% ee [HPLC condition: Chiralpak AD-H+AD-H column, *n*-hexane/*i*-PrOH = 80:20, flow rate = 1.0 mL/min, wavelength = 254 nm, t_R = 28.9 min (*cis*-minor), t_R = 32.1 min (*cis*-major), t_R = 43.4 min (*trans*-minor), t_R = 51.6 min (*trans*-major)].

Dimethyl (2*R*,4*S*)-2-phenyl-4-(tosyloxy)pyrrolidine-2,4-dicarboxylate (6c′ minor isomer)



6c' (minor isomer)

White solid, **M.P.** 97-99 °C, R_f = 0.3 (silica gel, petroleum ether:EtOAc= 5:1). **^{1}H NMR** (600 MHz, Chloroform-d) δ 7.82 (d, *J* = 8.1 Hz, 2H), 7.57 (d, *J* = 7.5 Hz, 2H), 7.35 – 7.27 (m, 4H), 7.27 – 7.25 (m, 1H), 3.76 (s, 3H), 3.69 (t, *J* = 13.4 Hz, 1H), 3.64 (s, 3H), 3.56 (d, *J* = 14.7 Hz, 1H), 3.42 (d, *J* = 13.4 Hz, 1H), 2.79 (d, *J* = 14.7 Hz, 1H), 2.44 (s, 3H); **^{13}C NMR** (151 MHz, Chloroform-d) δ 173.93, 169.17, 144.92, 141.93, 134.94, 129.64, 128.36, 127.77, 127.67, 126.32, 92.89, 71.81, 56.07, 53.09, 52.99, 48.43, 21.67; **HRMS** (ESI), m/z calcd. for $[C_{21}H_{23}NNaO_7S, M+Na]^+$: 456.1087; found: 456.1090; **Optical Rotation**: $[\alpha]^{25}_D$ = +40.5, (c= 0.60, $CHCl_3$).

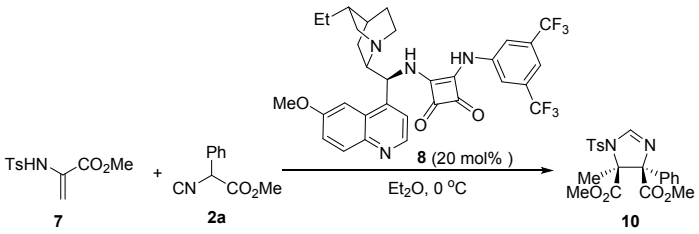


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.930	BB	0.6322	802.00153	19.16460	2.1752
2	32.101	BB	0.6681	8846.41797	209.71991	23.9936
3	43.449	BB	0.7843	117.40453	2.31240	0.3184
4	51.596	BBA	1.0849	2.71040e4	381.46704	73.5127

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.532	BB	0.5664	4579.80908	126.50605	30.2669
2	32.322	BB	0.6391	4438.55225	108.08659	29.3333
3	43.629	BB	0.7883	3017.47559	59.03899	19.9418
4	52.395	BB	1.0661	3095.59302	45.47967	20.4580

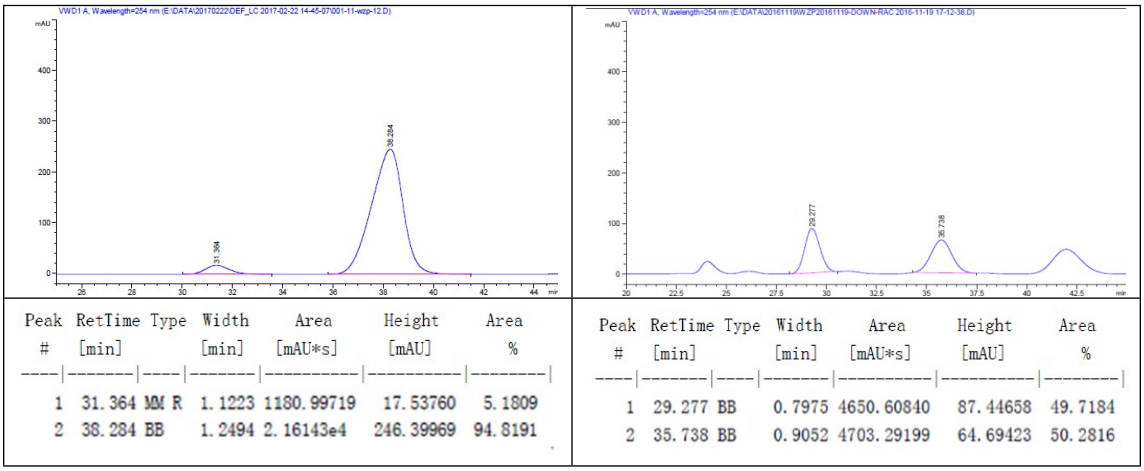
VII. Organocatalytic [3 + 2] Cyclization of 7 and 2a

Dimethyl (4*R*,5*S*)-5-methyl-4-phenyl-1-tosyl-4,5-dihydro-1*H*-imidazole-4,5-dicarboxylate (10)



Procedure: To a 10 mL tube charged with catalyst **8** (12.6 mg, 0.02 mmol) was added Et_2O (2 mL). The mixture was stirred at 0 °C for 5 minutes, then the acrylate **7**[8] (25.5 mg, 0.1 mmol) and isocyanoacetate **2a** (21.0 mg, 0.12 mmol) were added. The reaction mixture was stirred at 0 °C until **7** was consumed. The solvent was removed under reduced pressure and then purified by flash chromatography on silica gel to afford the product **10**. White solid, 98% yield, **M.P.** 40-42 °C, R_f = 0.2 (silica gel, petroleum ether:EtOAc = 2:1). **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.92 (s, 1H), 7.69 (dd, *J* = 6.9, 1.5 Hz, 2H), 7.31 (td, *J* = 7.6, 7.1, 3.0 Hz, 5H), 7.26 – 7.24 (m, 2H), 3.72 (s, 1H), 3.41 (s, 3H), 2.41 (s, 3H), 1.13 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 170.80, 169.99, 149.50, 144.99, 136.07, 133.96, 129.83, 128.93, 128.54, 127.42, 126.86, 89.38, 72.74, 53.17, 52.45, 21.60, 20.14. **HRMS** (ESI), m/z calcd. for $[C_{21}H_{22}N_2NaO_6S, M+Na]^+$: 453.1091; found: 453.1086.

Optical Rotation: $[\alpha]^{25}_D$ = +23.0, (c= 0.35, $CHCl_3$). The absolute configuration of **10** was assigned by single crystal **11**. *cis*:*trans* = 88:12, 90% ee (*cis*) [HPLC condition: Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 80:20, flow rate = 1.0 mL/min, wavelength = 254 nm, t_R = 31.4 min, t_R = 38.3 min].

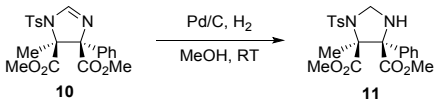


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	31.364	MM R	1.1223	1180.99719	17.53760	5.1809
2	38.284	BB	1.2494	2.16143e4	246.39969	94.8191

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	29.277	BB	0.7975	4650.60840	87.44658	49.7184
2	35.738	BB	0.9052	4703.29199	64.69423	50.2816

VIII. Reduction of Compound 10

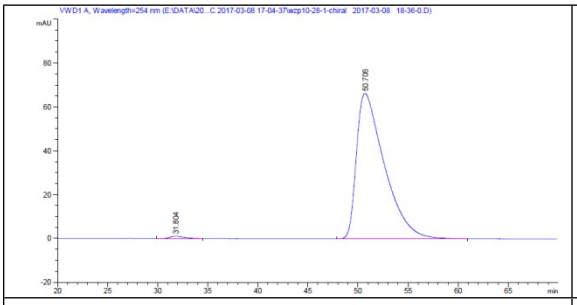
Dimethyl (4*R*,5*S*)-5-methyl-4-phenyl-1-tosylimidazolidine-4,5-dicarboxylate (11)



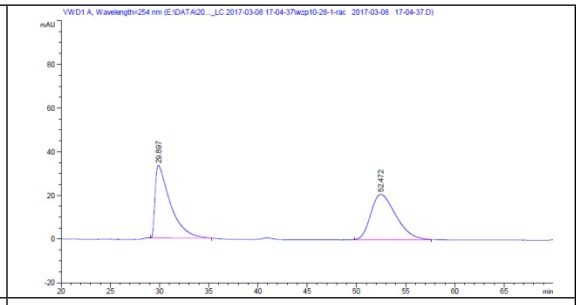
To a solution of amine **10** (43.0 mg, 0.1 mmol) in 2 mL MeOH was added 10% Pd/C (4.3 mg), the reaction mixture was stirred under a hydrogen atmosphere for 12 h at ambient temperature, and then filtered through celite washing with MeOH (3 x 5 mL). The filtrate was concentrated and purified by flash chromatography to yield 43.2 mg of **11** in 99% yield. White solid, **M.P.** 122-123 °C, R_f= 0.4 (silica gel, petroleum ether:EtOAc = 2:1). **^{1}H NMR** (400 MHz, Chloroform-d) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.48 (dd, *J* = 7.0, 2.9 Hz, 2H), 7.31 – 7.30 (m, 3H), 7.21 (d, *J* = 8.0 Hz, 2H), 4.84 (t, *J* = 7.8 Hz, 1H), 4.75 (t, *J* = 7.1 Hz, 1H), 3.70 (m, 4H), 3.60 (s, 3H), 2.38 (s, 3H), 1.46 (s, 3H); **^{13}C NMR** (101 MHz, Chloroform-d) δ 171.96, 170.52, 143.52, 137.56,

135.81, 129.41, 128.43, 128.17, 127.54, 127.03, 79.18, 71.64, 65.78, 53.05, 52.71, 21.47, 20.26. **HRMS** (ESI), m/z calcd. for $[C_{21}H_{24}N_2NaO_6S, M+Na]^+$: 455.1247; found: 455.1246.

Optical Rotation: $[\alpha]^{25}_D$ = -48.5, (c= 0.38, $CHCl_3$), 98% ee (After recrystallization) [HPLC condition: Chiralpak AD-H column, n-hexane/i-PrOH = 80:20, flow rate = 1.0 mL/min, wavelength = 254 nm, t_R = 31.8 min, t_R = 50.7 min].



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	31.804	BB	1.1406	104.21999	1.07357	0.8055
2	50.706	BB	2.7278	1.28351e4	66.38076	99.1945



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	29.897	BB	1.2744	3566.84058	33.30640	49.4222
2	52.472	BB	2.0569	3650.23779	20.73907	50.5778

IX. CD Spectra

Pyrrolidine **6a** (*trans*) showed different behaviors in the specific rotation. Thus the CD spectra of **6a** (*trans*) and **6b** (*trans*) were recorded, which showed **6a** (*trans*) and **6b** (*trans*) have the same absolute configuration (Figure 1).

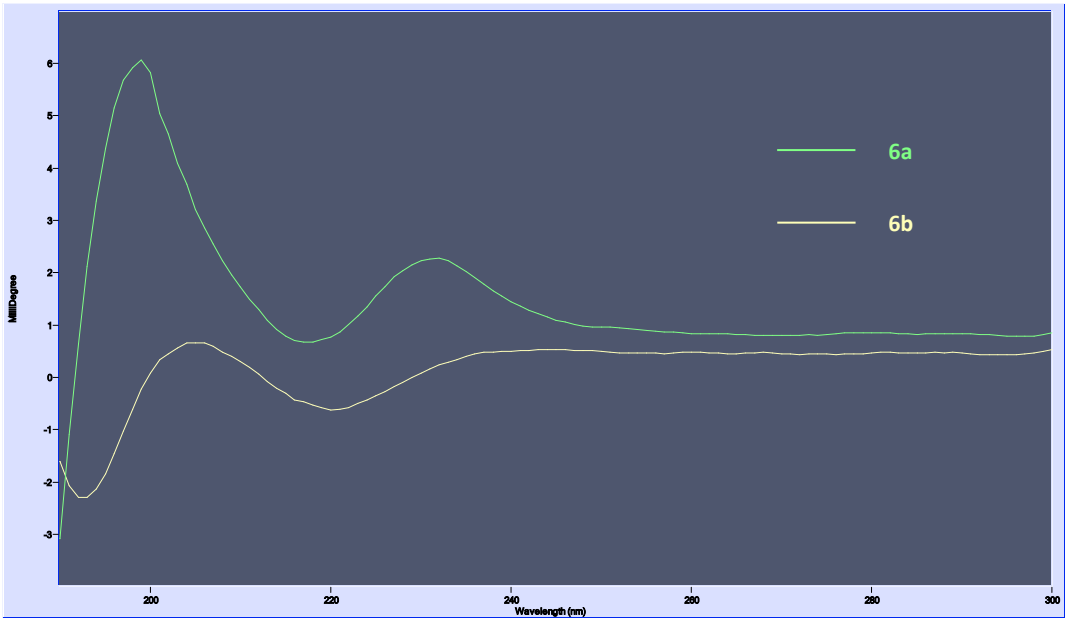


Figure 1. CD spectra of **6a** and **6b**

X. X-ray Crystallographic Analysis and Determination of Configuration of the Products

The absolute configuration of **4g** (**2*S*,4*R***) was assigned by X-ray crystallographic analysis of a single crystal **4g** (Figure 2). The crystal was prepared from the solution of **4g** in 2-propanol/hexane at ambient temperature. The absolute configuration of compound **4g** (**2*S*,4*R***) was deduced. The configurations of **4a-4n** were assigned by analogy.

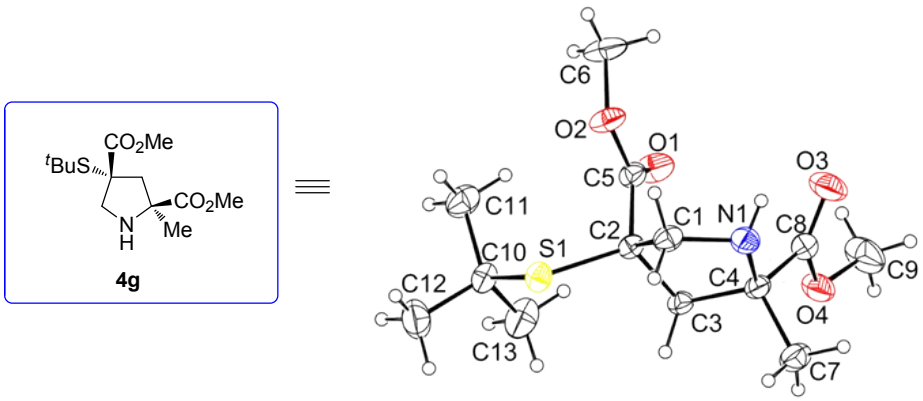


Figure 2. X-ray structure of **4g**

Table 1. Crystal data and structure refinement for CCDC 1538775

Identification code	CCDC 1538775
Empirical formula	$C_{13}H_{23}NO_4S$
Formula weight	289.38
Temperature/K	293.15
Crystal system	orthorhombic
Space group	P212121
a/Å	6.1598(3)
b/Å	8.1330(4)
c/Å	31.1006(15)
α /°	90
β /°	90
γ /°	90
Volume/Å3	1558.07(13)
Z	4
ρ calcg/cm3	1.234
μ /mm‐1	0.217
F(000)	624.0
Crystal size/mm3	0.35 × 0.25 × 0.25
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.368 to 52.744
Index ranges	-7≤h≤7, -10≤k≤10, -38≤l≤38
Reflections collected	7147
Independent reflections	3140 [Rint = 0.0281, Rsigma = 0.0458]
Data/restraints/parameters	3140/0/182
Goodness-of-fit on F2	1.058
Final R indexes [I>=2σ (I)]	R1 = 0.0466, wR2 = 0.0947
Final R indexes [all data]	R1 = 0.0588, wR2 = 0.1025
Largest diff. peak/hole / e Å-3	0.17/-0.18
Flack parameter	0.00(5)

The absolute configuration of **11 (4*R*,5*S*)** was assigned by X-ray crystallographic

analysis of a single crystal **11** (Figure 3). The crystal was prepared from the solution of **11** in ethyl acetate/hexane at ambient temperature. The absolute configuration of **10** (**4*R*,5*S***) was deduced.

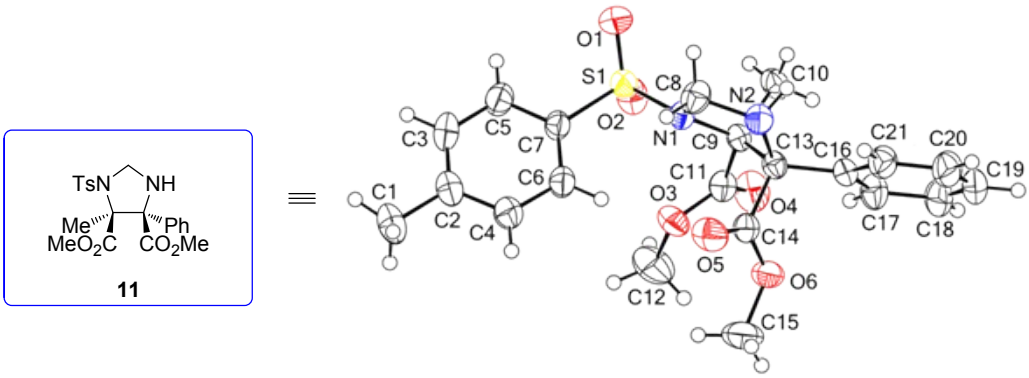


Figure 3. X-ray structure of **11**

Table 2. Crystal data and structure refinement for CCDC 1538777

Identification code	CCDC 1538777
Empirical formula	$C_{21}H_{24}N_2O_6S$
Formula weight	432.48
Temperature/K	293(2)
Crystal system	orthorhombic
Space group	P212121
a/Å	7.9925(3)
b/Å	13.9906(4)
c/Å	19.0487(6)
α /°	90
β /°	90
γ /°	90
Volume/Å3	2130.03(12)
Z	4
ρ calcg/cm3	1.349
μ /mm‐1	0.192
F(000)	912.0
Crystal size/mm3	? × ? × ?

Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.654 to 52.744
Index ranges	-9⩽h⩽9, -17⩽k⩽17, -23⩽l⩽23
Reflections collected	29209
Independent reflections	4342 [Rint = 0.0357, Rsigma = 0.0232]
Data/restraints/parameters	4342/0/279
Goodness-of-fit on F2	1.113
Final R indexes [I>=2σ (I)]	R1 = 0.0389, wR2 = 0.0939
Final R indexes [all data]	R1 = 0.0451, wR2 = 0.0980
Largest diff. peak/hole / e Å-3	0.25/-0.47
Flack parameter	0.00(2)

XI. References

1. a) Y. Huang, L. Yang, P. Shao and Y. Zhao, *Chem. Sci.*, 2013**, 4**, 3275; b) P.-L. Shao, J.-Y. Liao, Y. A. Ho and Y. Zhao, *Angew. Chem. Int. Ed.*, 2014, **53**, 5435.
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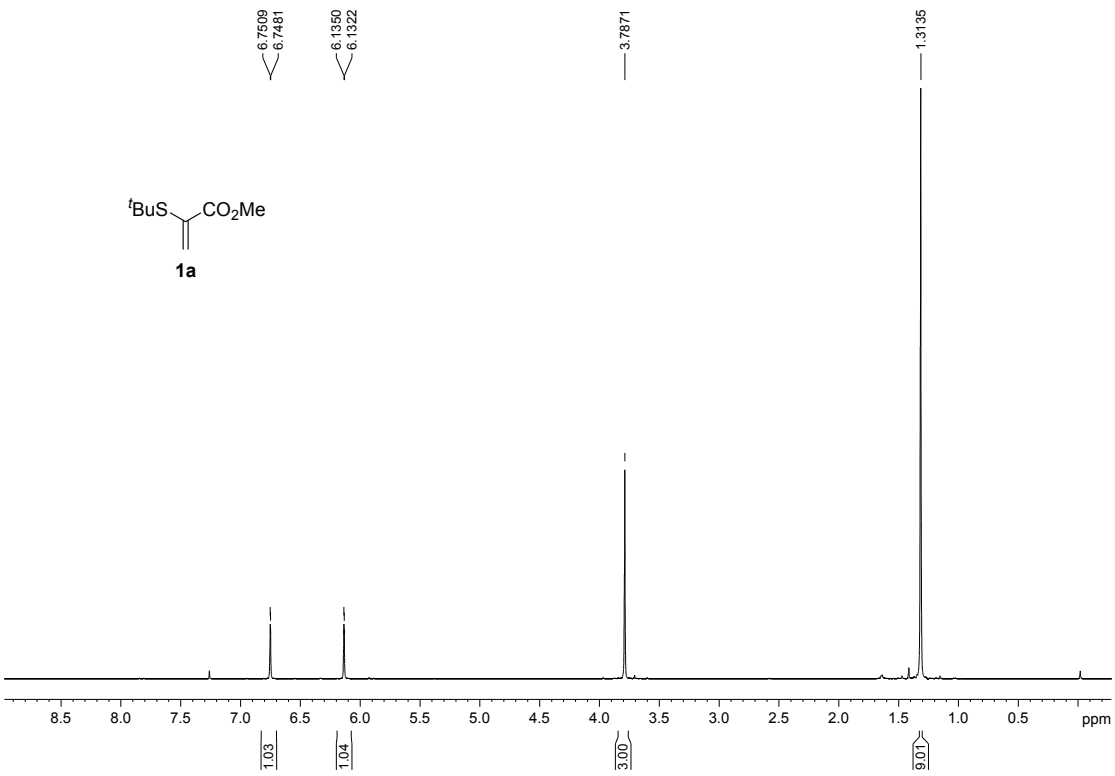
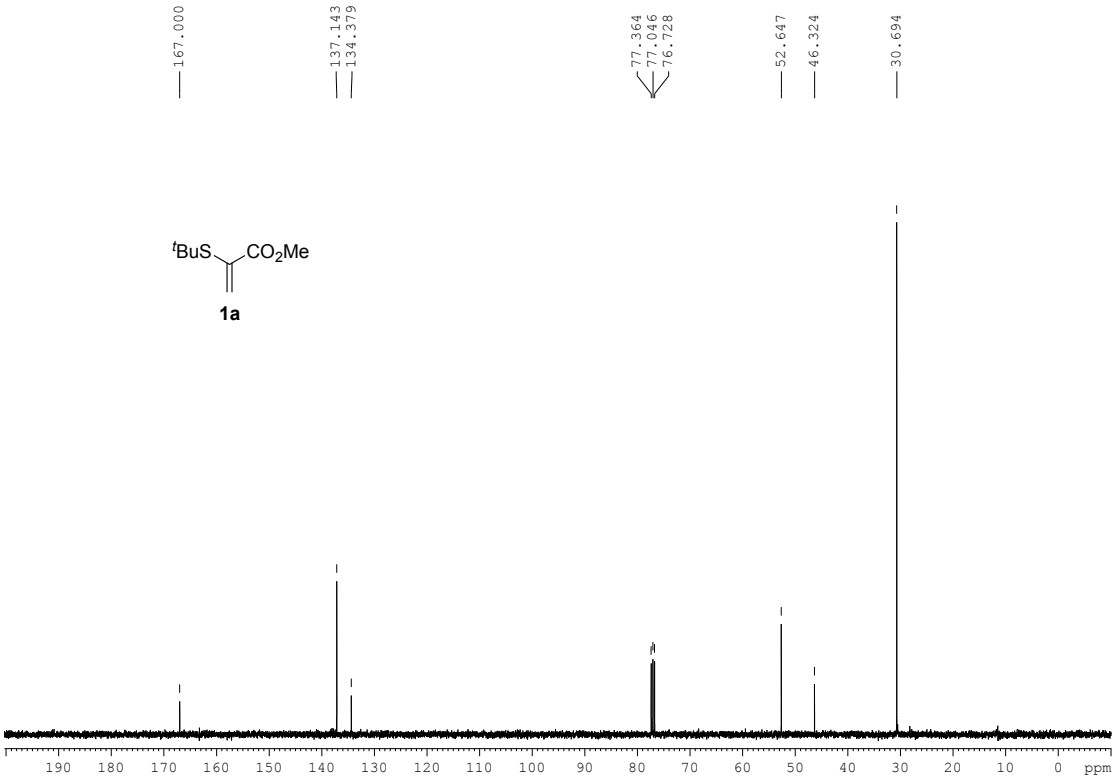
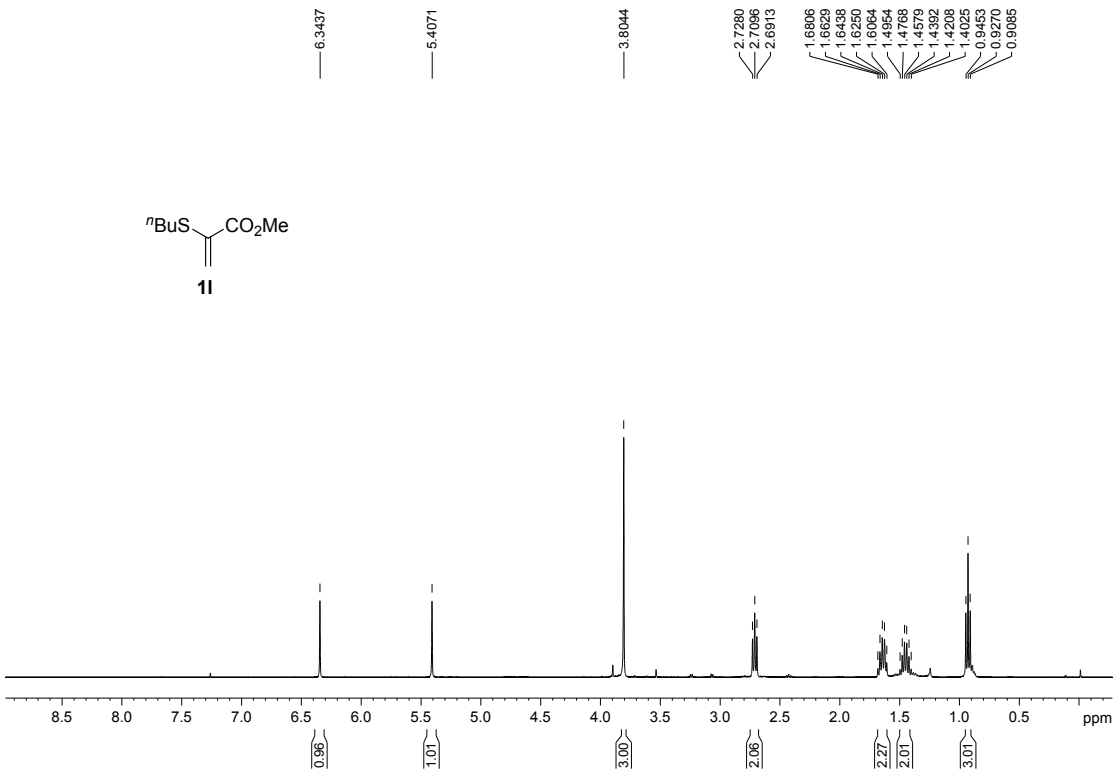
XII. NMR Spectra of the Products



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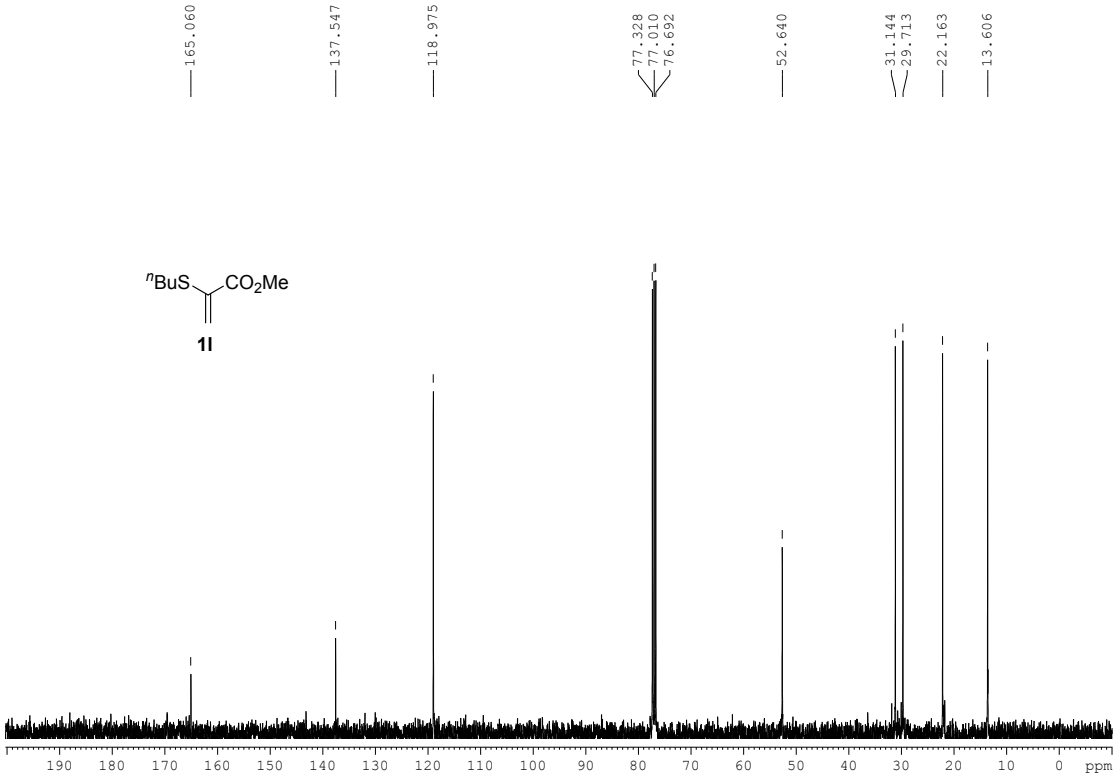
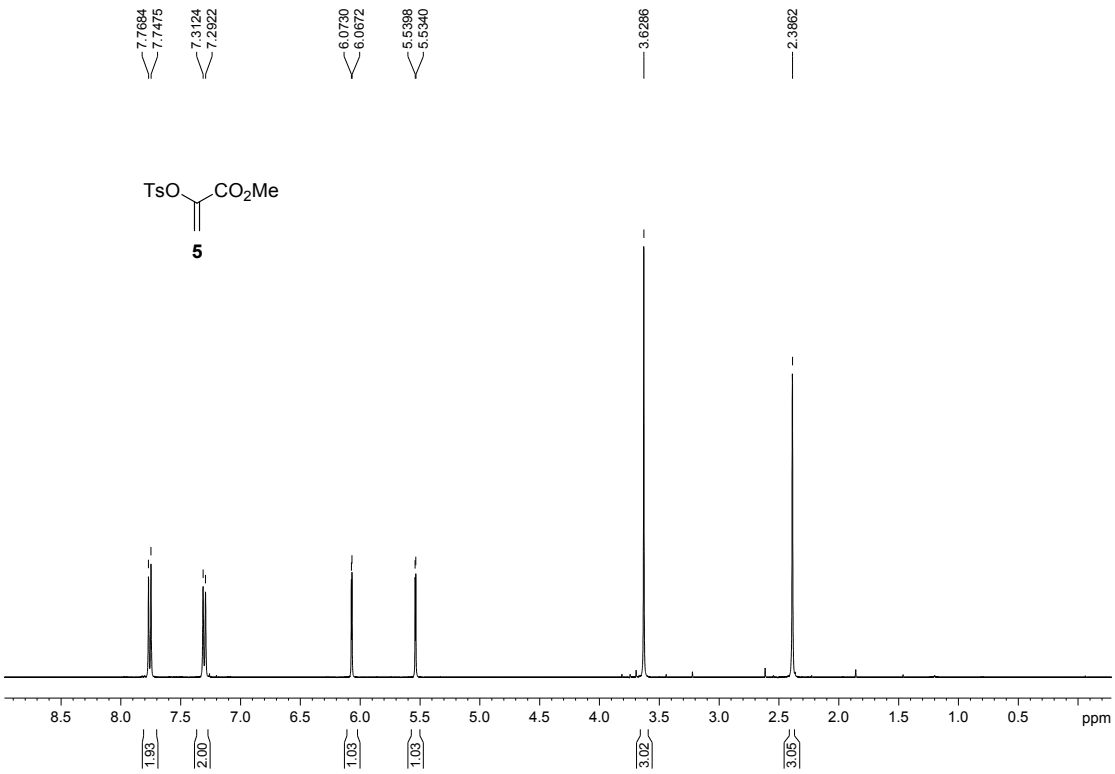
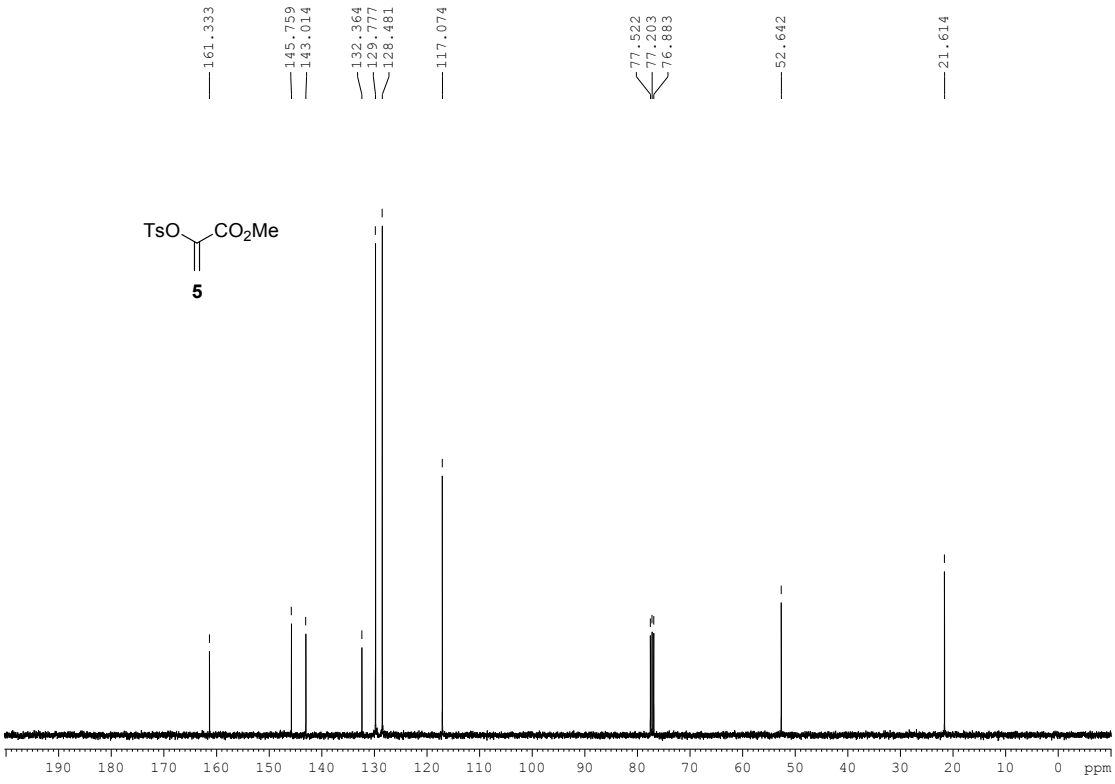
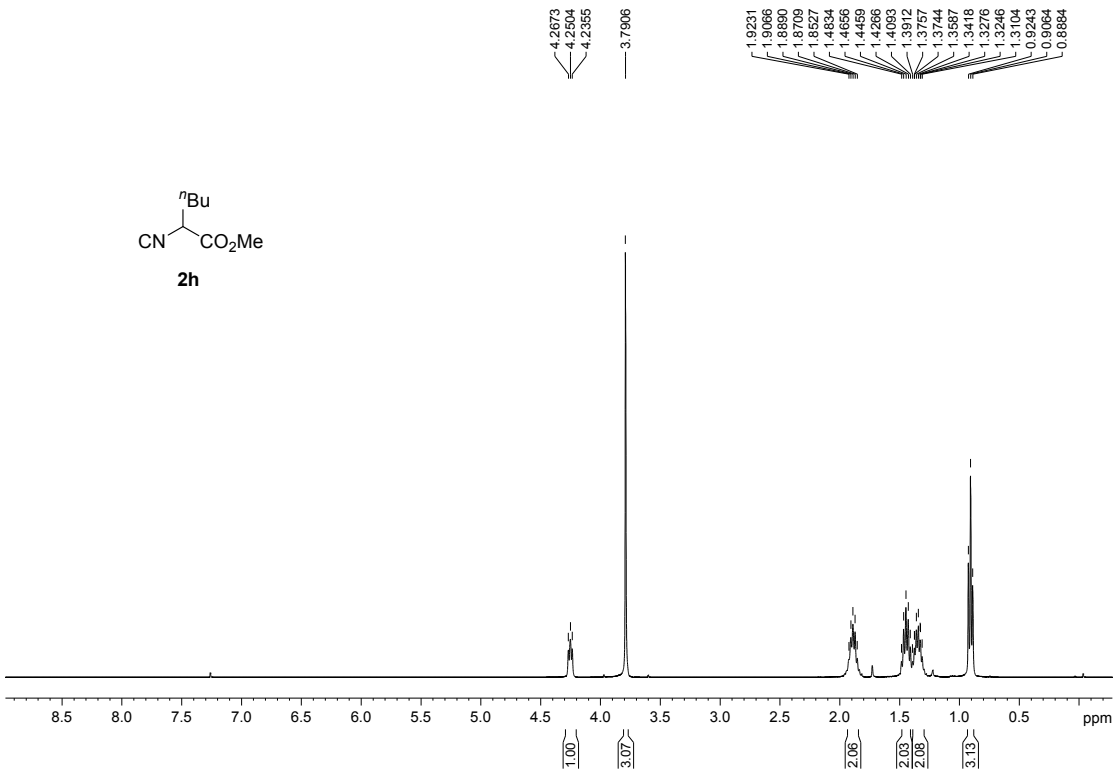
5.4071
3.8044
2.7280
2.7096
2.6913
1.6806
1.6629
1.6438
1.6250
1.6064
1.4954
1.4768
1.4579
1.4392
1.4208
1.4025
0.9453
0.9270
0.9085
nBuS
CO2Me
1l
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
0.96
1.01
3.00
2.06
2.27
2.01
3.01


165.060
137.547
118.975
77.328
77.010
76.692
52.640
31.144
29.713
22.163
13.606
nBuS
CO2Me
1l
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


7.7684
7.7475
7.3124
7.2922
6.0730
6.0672
5.5398
5.5340
3.6286
2.3862
TsO
CO2Me
5
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.93
2.00
1.03
1.03
3.02
3.05


161.333
145.759
143.014
132.364
129.777
128.481
117.074
77.522
77.203
76.883
52.642
21.614
TsO
CO2Me
5
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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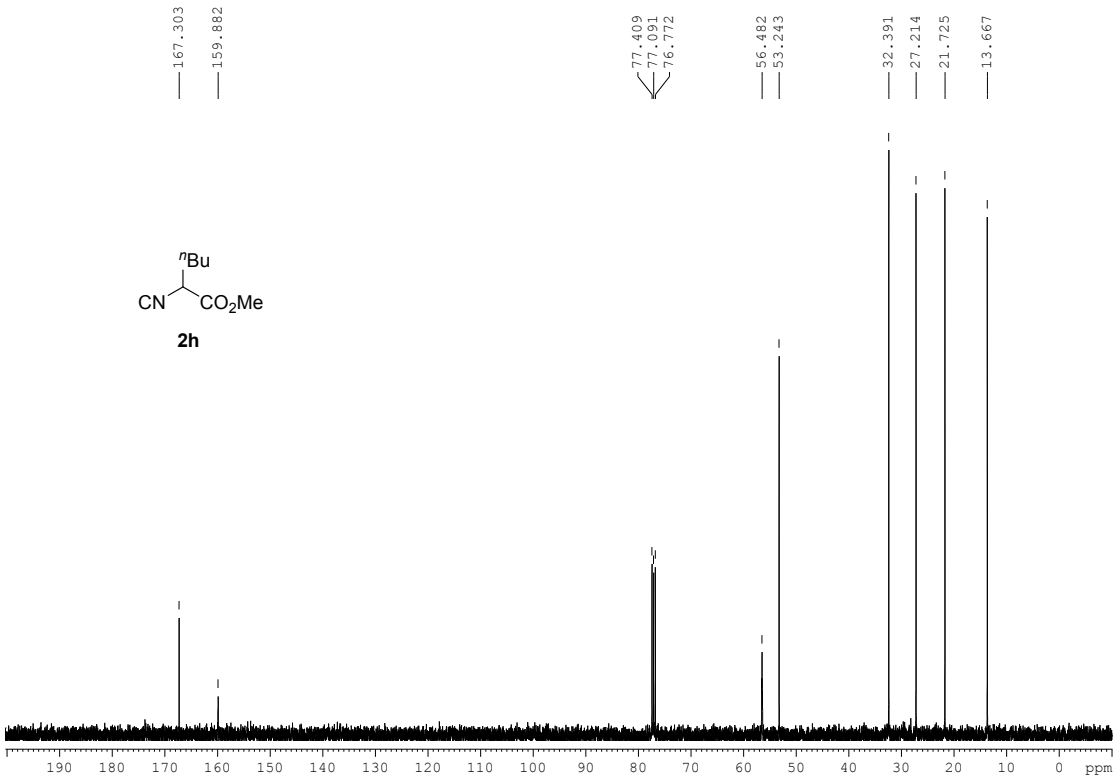
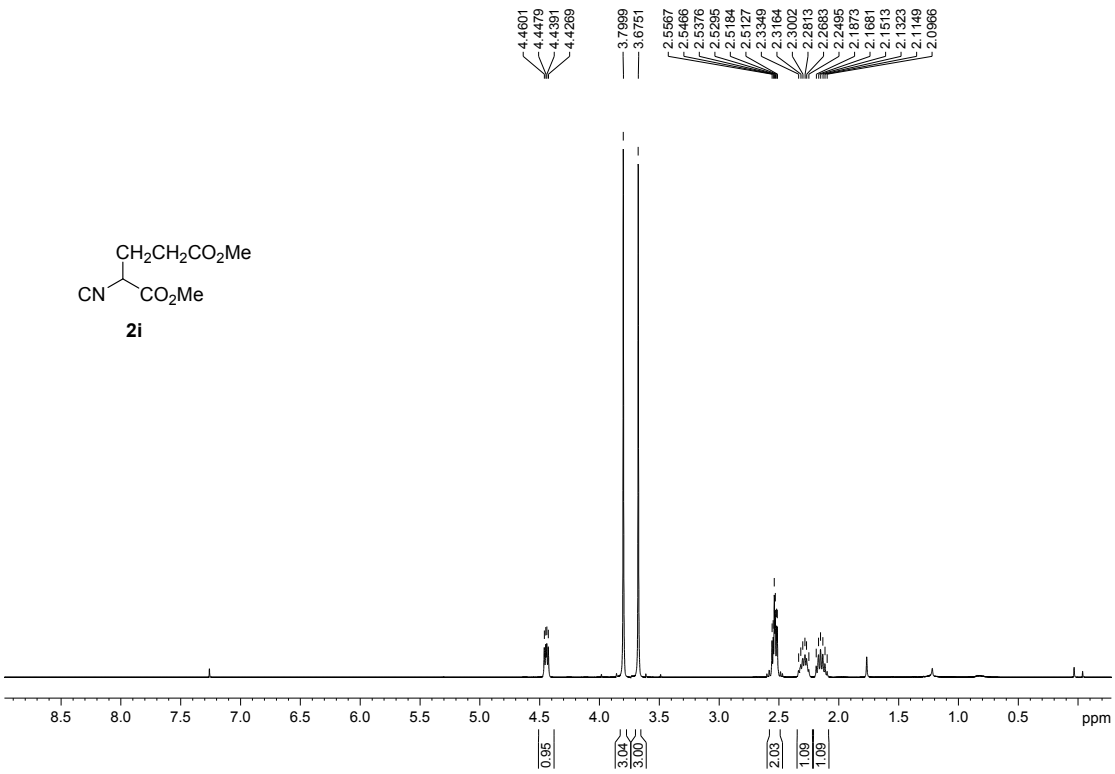
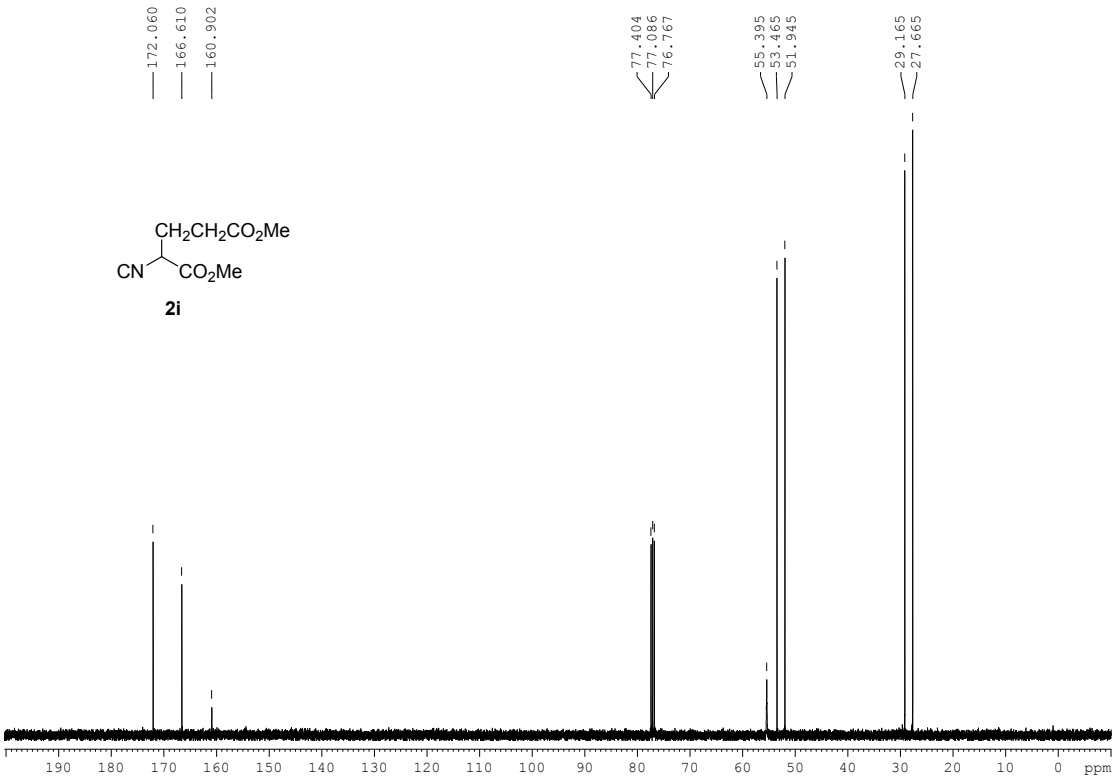
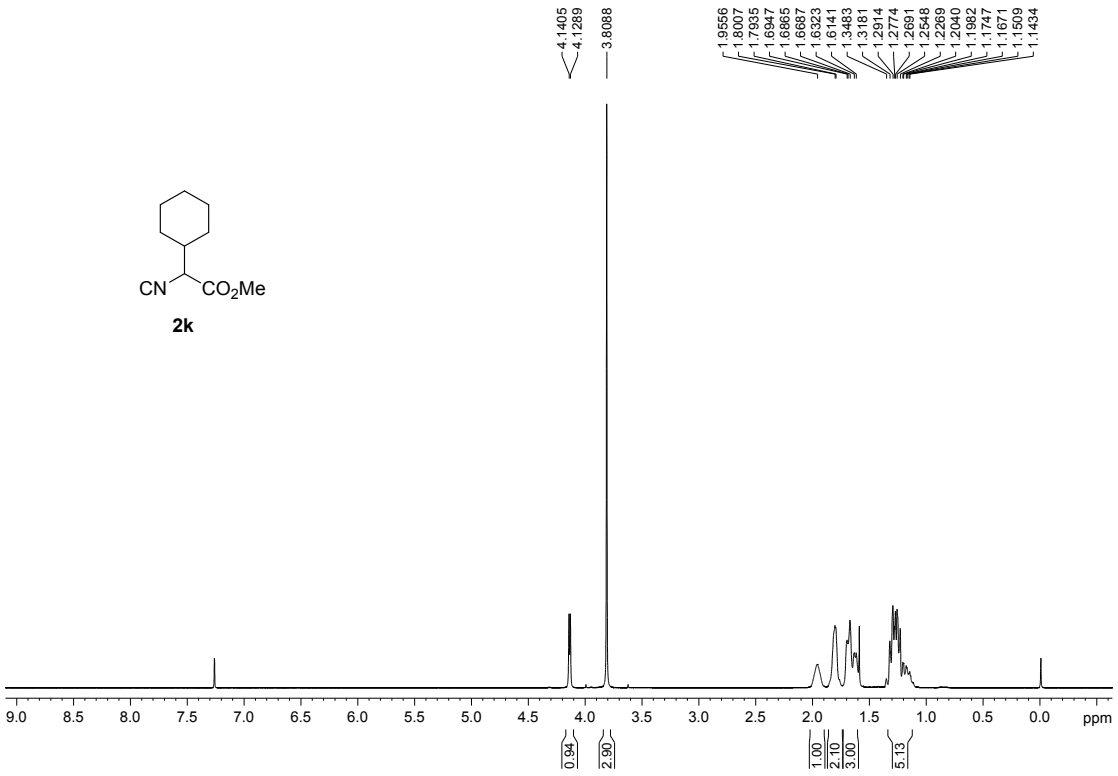
4.2504
4.2355
3.7906
1.9231
1.9066
1.8890
1.8709
1.8527
1.4834
1.4656
1.4459
1.4266
1.4093
1.3912
1.3757
1.3744
1.3587
1.3418
1.3276
1.3246
1.3104
0.9243
0.9064
0.8884
nBu
CN
CO2Me
2h
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.00
3.07
2.06
2.03
2.08
3.13


167.303
159.882
77.409
77.091
76.772
56.482
53.243
32.391
27.214
21.725
13.667
nBu
CN
CO2Me
2h
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


4.4601
4.4479
4.4391
4.4269
3.7999
3.6751
2.5567
2.5466
2.5376
2.5295
2.5184
2.5127
2.3349
2.3164
2.3002
2.2813
2.2683
2.2495
2.1873
2.1681
2.1513
2.1323
2.1149
2.0966
CH2CH2CO2Me
CN
CO2Me
2i
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
0.95
3.04
3.00
2.03
1.09
1.09


172.060
166.610
160.902
77.404
77.086
76.767
55.395
53.465
51.945
29.165
27.665
CH2CH2CO2Me
CN
CO2Me
2i
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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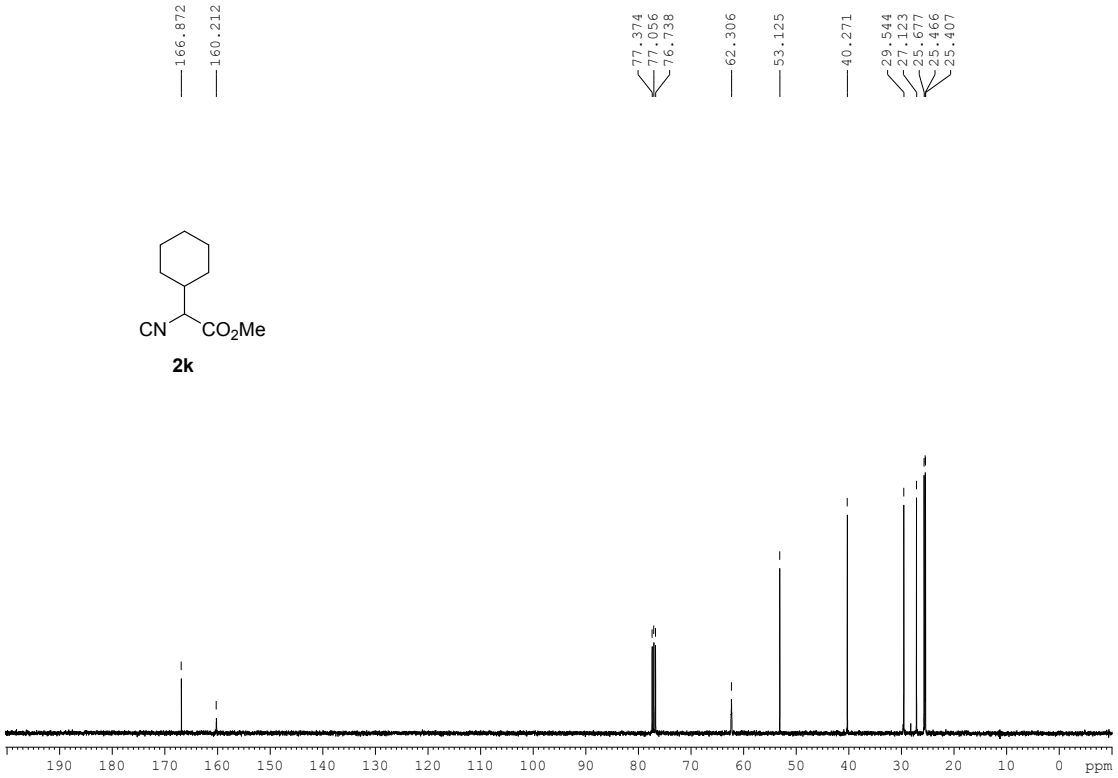
4.1289
3.8088
1.9556
1.8007
1.7935
1.6947
1.6865
1.6687
1.6323
1.6141
1.3483
1.3181
1.2914
1.2774
1.2691
1.2548
1.2269
1.2040
1.1982
1.1747
1.1671
1.1509
1.1434
CN
CO2Me
2k
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
0.94
2.90
1.00
2.10
3.00
5.13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160.212
77.374
77.056
76.738
62.306
53.125
40.271
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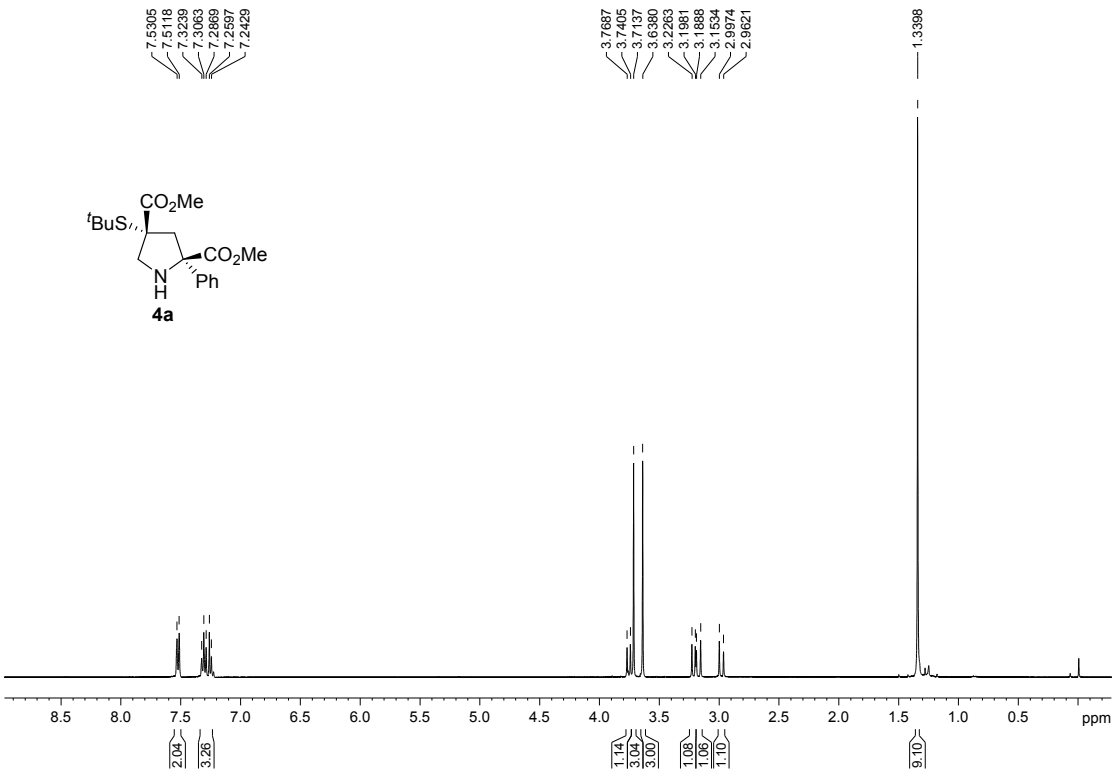
25.677
25.466
25.407
CN
CO2Me
2k
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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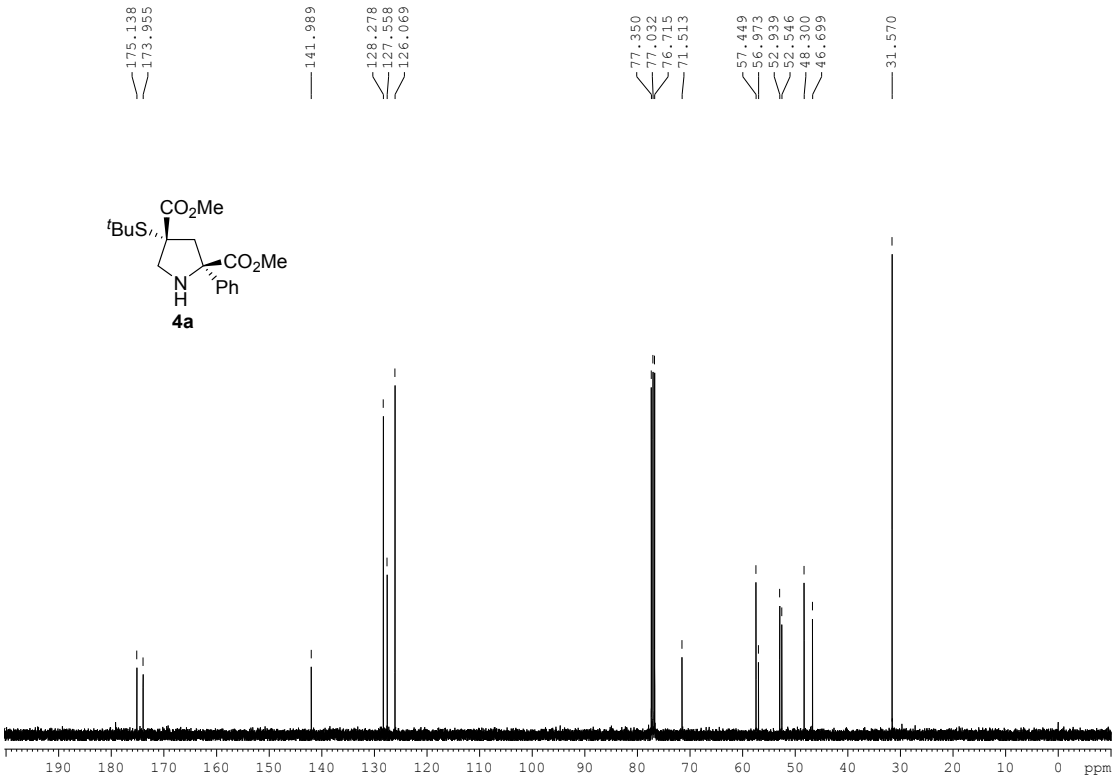
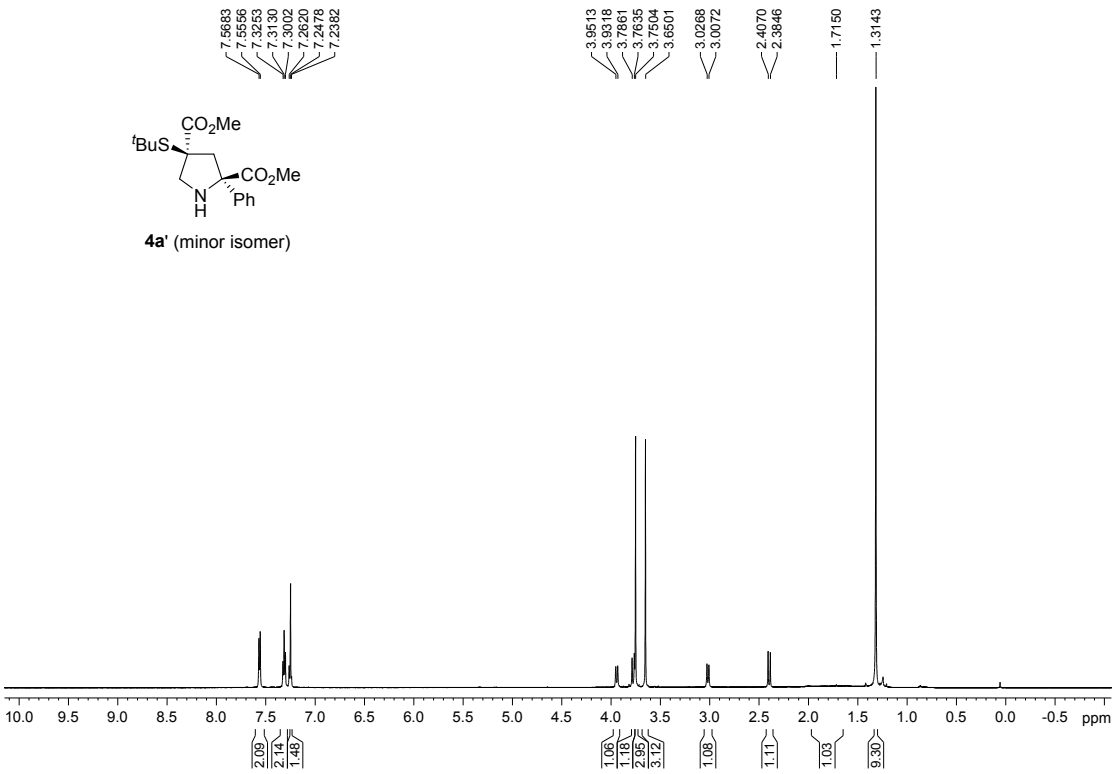
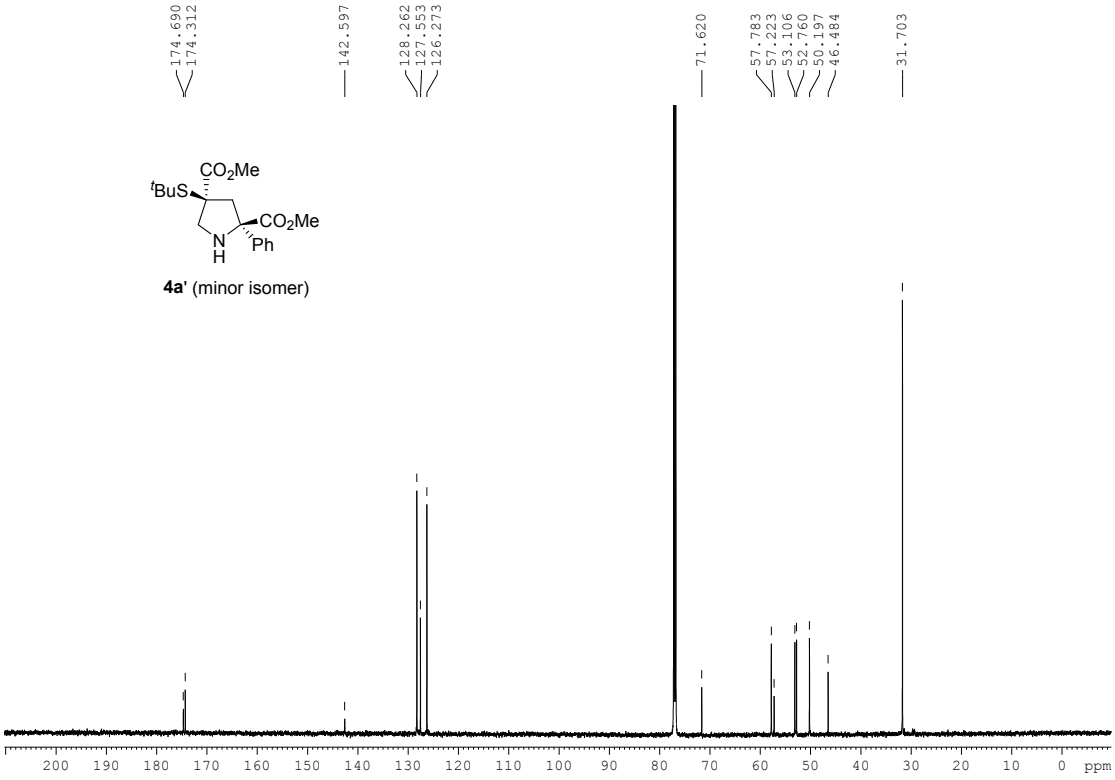
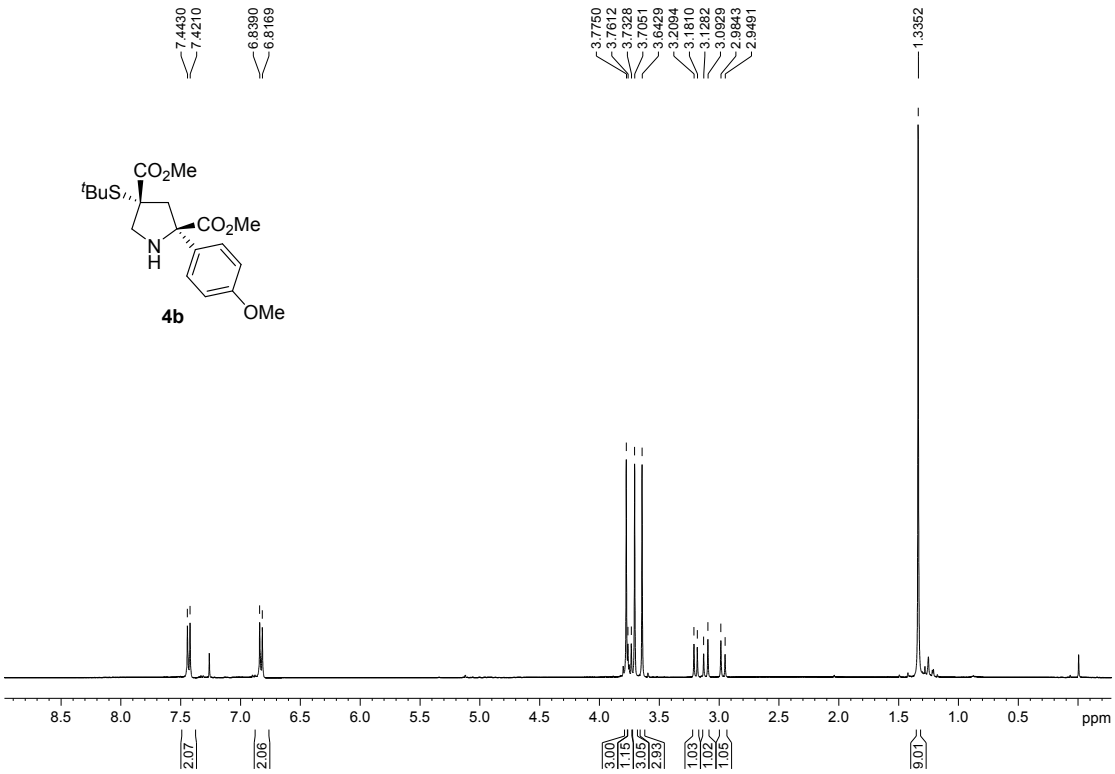
7.5118
7.3239
7.3063
7.2869
7.2597
7.2429
3.7687
3.7405
3.7137
3.6380
3.2263
3.1981
3.1888
3.1534
2.9974
2.9621
1.3398
CO2Me
tBuS
CO2Me
N
H
Ph
4a
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
2.04
3.26
1.14
3.04
3.00
1.08
1.06
1.10
9.10


175.138
173.955
141.989
128.278
127.558
126.069
77.350
77.032
76.715
71.513
57.449
56.973
52.939
52.546
48.300
46.699
31.570
CO2Me
tBuS
CO2Me
N
H
Ph
4a
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


7.5683
7.5556
7.3253
7.3130
7.3002
7.2620
7.2478
7.2382
3.9513
3.9318
3.7861
3.7635
3.7504
3.6501
3.0268
3.0072
2.4070
2.3846
1.7150
1.3143
CO2Me
tBuS
CO2Me
N
H
Ph
4a' (minor isomer)
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 ppm
2.09
2.14
1.48
1.06
1.18
2.95
3.12
1.08
1.11
1.03
9.30


174.690
174.312
142.597
128.262
127.553
126.273
71.620
57.783
57.223
53.106
52.760
50.197
46.484
31.703
CO2Me
tBuS
CO2Me
N
H
Ph
4a' (minor isomer)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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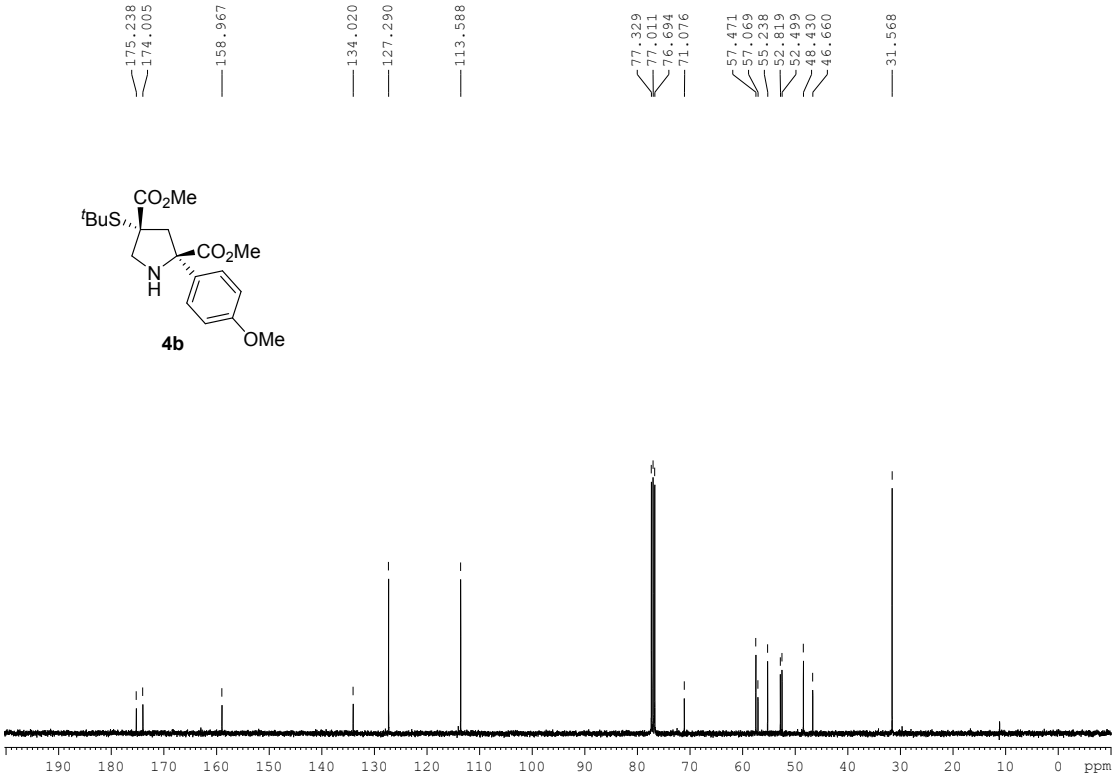
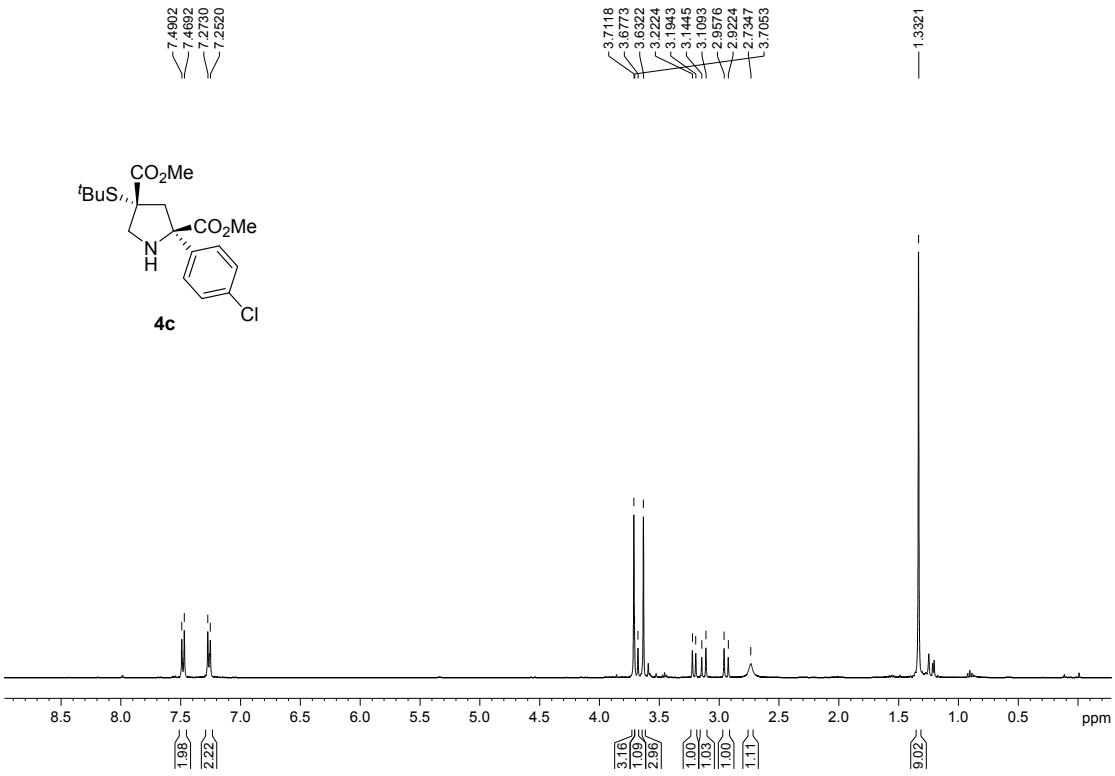
7.4210
6.8390
6.8169
3.7750
3.7612
3.7328
3.7051
3.6429
3.2094
3.1810
3.1282
3.0929
2.9843
2.9491
1.3352
CO2Me
tBuS
CO2Me
N
H
OMe
4b
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
2.07
2.06
3.00
1.15
3.05
2.93
1.03
1.02
1.05
9.01


175.238
174.005
158.967
134.020
127.290
113.588
77.329
77.011
76.694
71.076
57.471
57.069
55.238
52.819
52.499
48.430
46.660
31.568
CO2Me
tBuS
CO2Me
N
H
OMe
4b
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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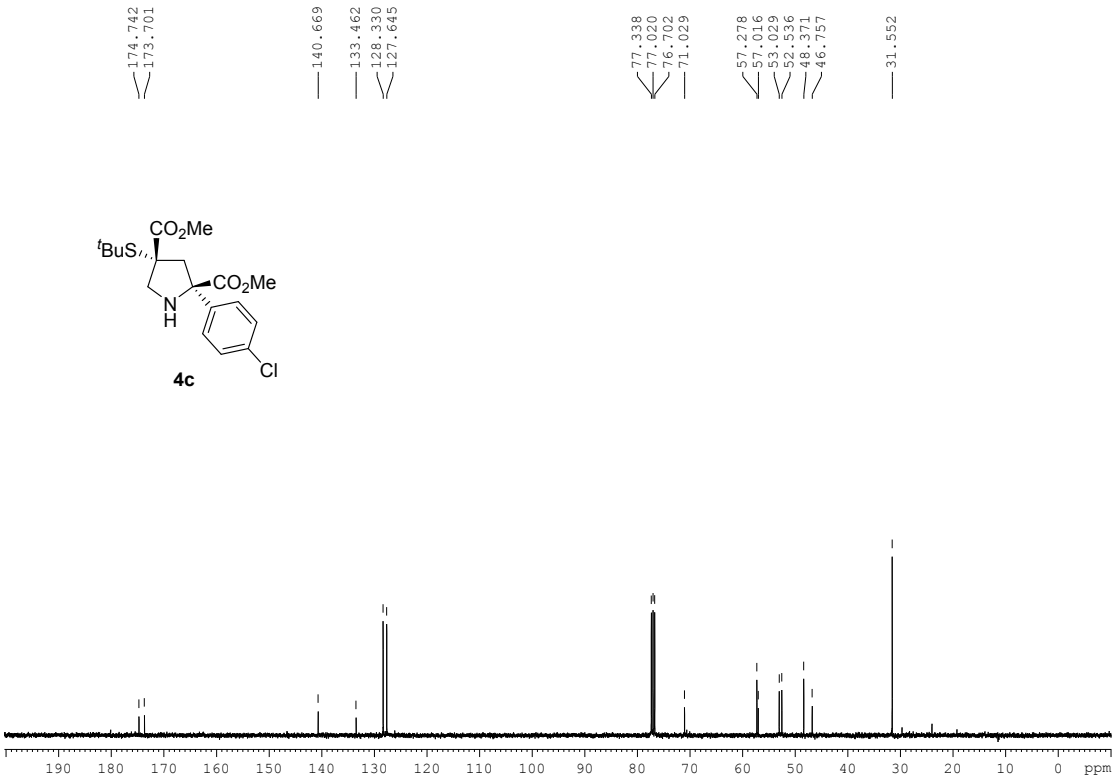
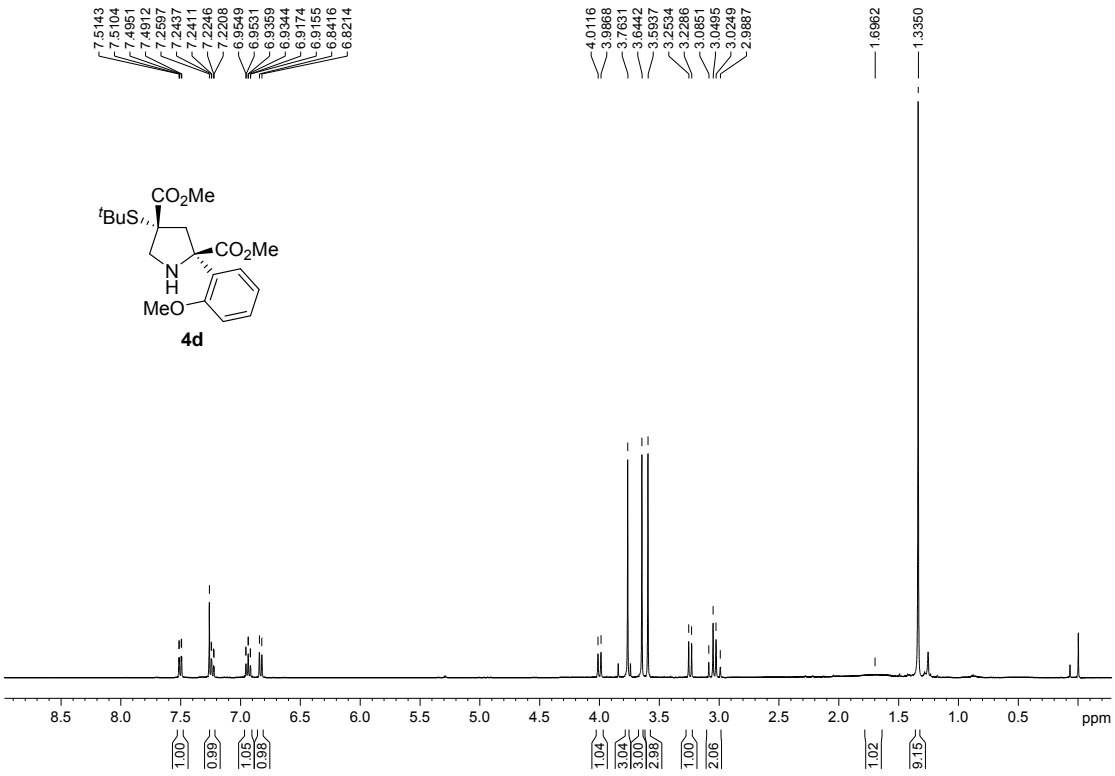
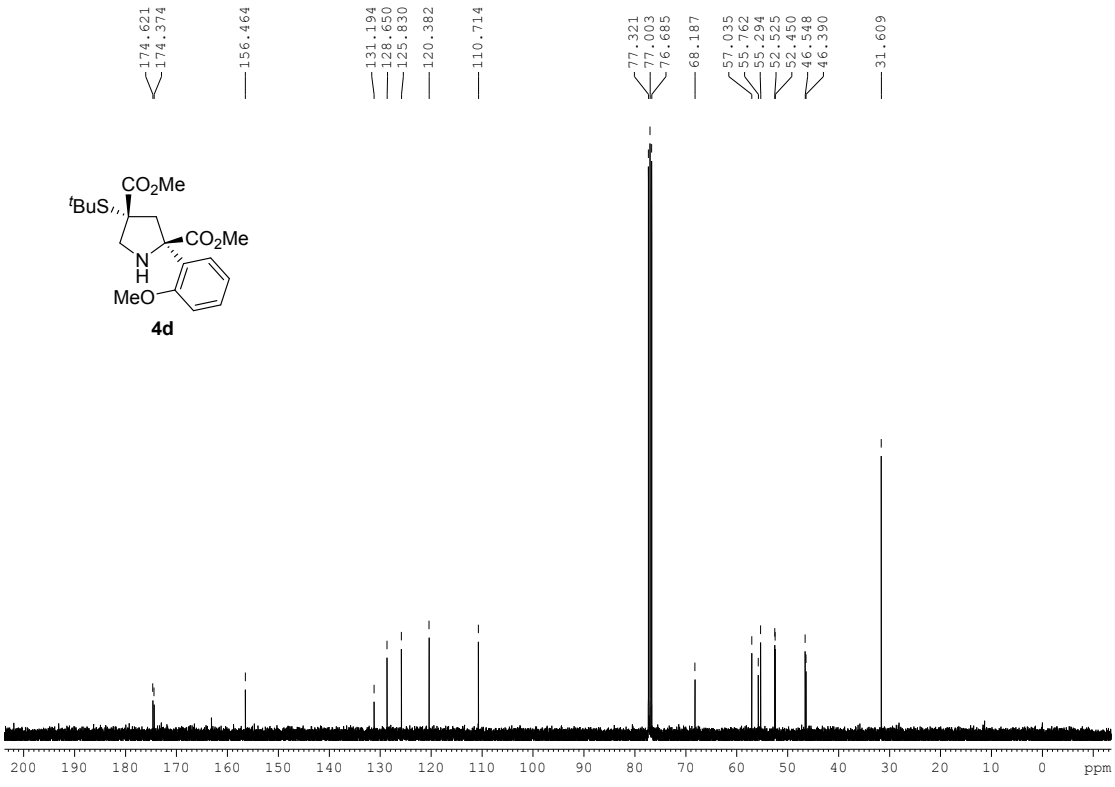
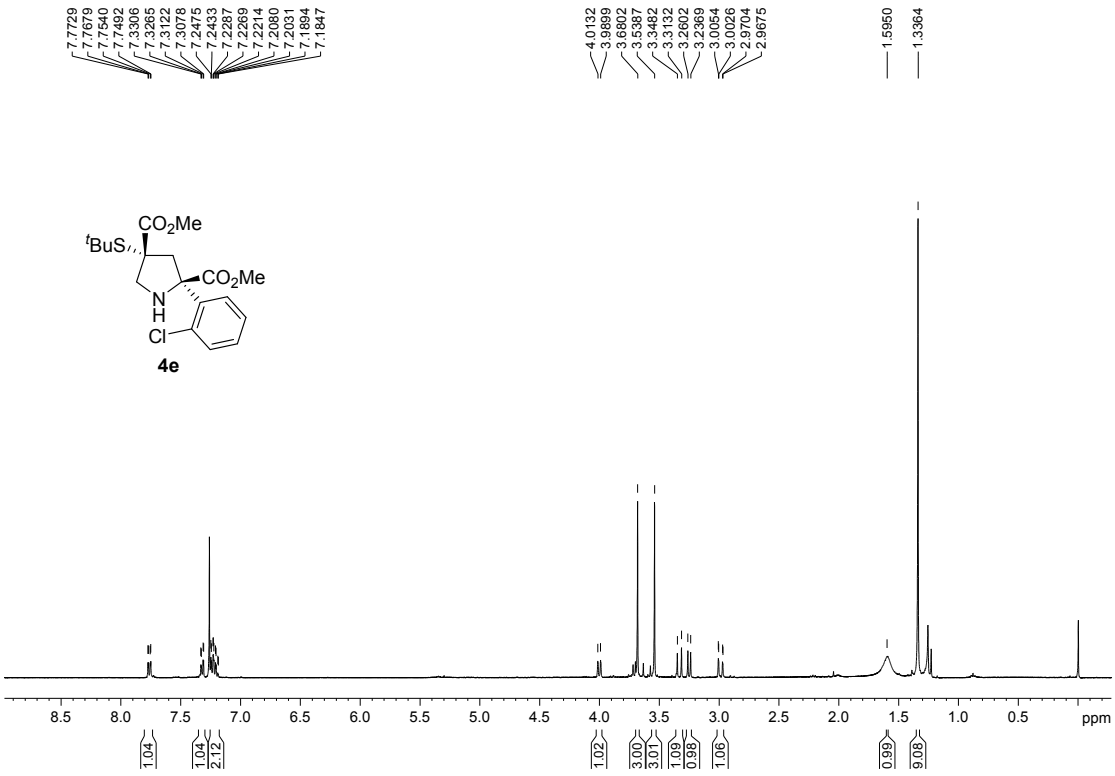
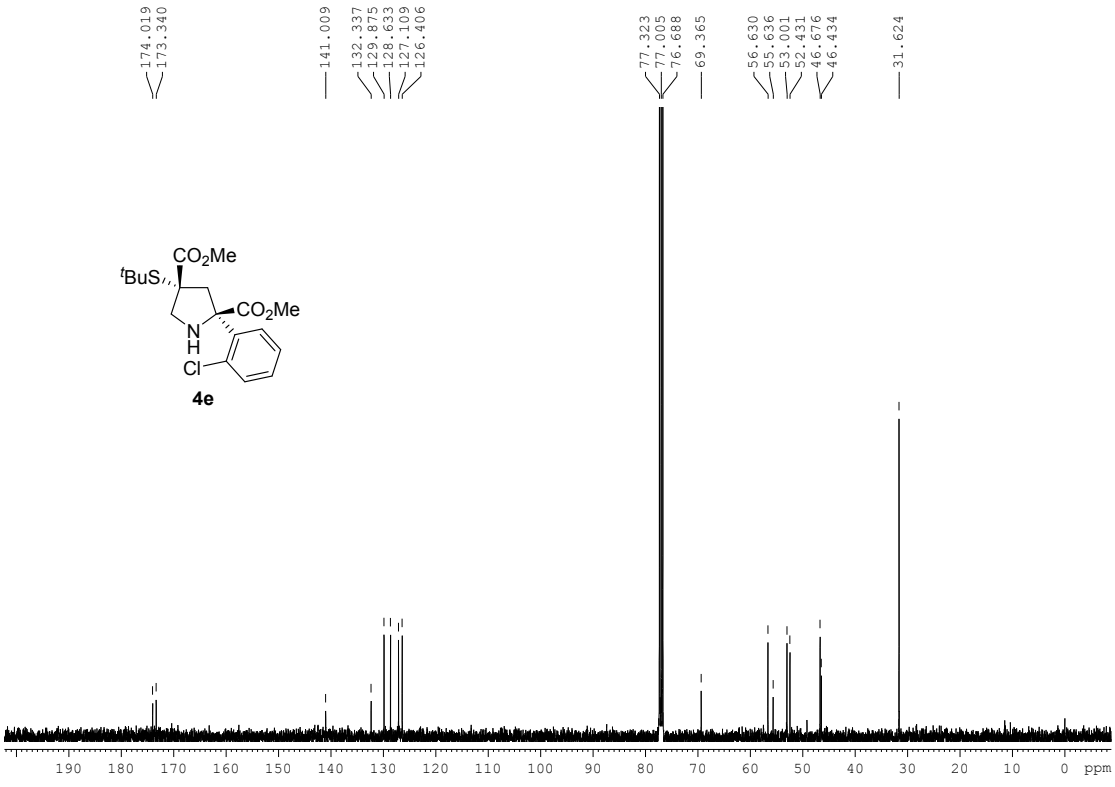
7.2520
3.7118
3.6773
3.6322
3.2224
3.1943
3.1445
3.1093
2.9576
2.9224
2.7347
3.7053
1.3321
CO2Me
tBuS
CO2Me
N
H
Cl
4c
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.98
2.22
3.16
1.09
2.96
1.00
1.03
1.00
1.11
9.02

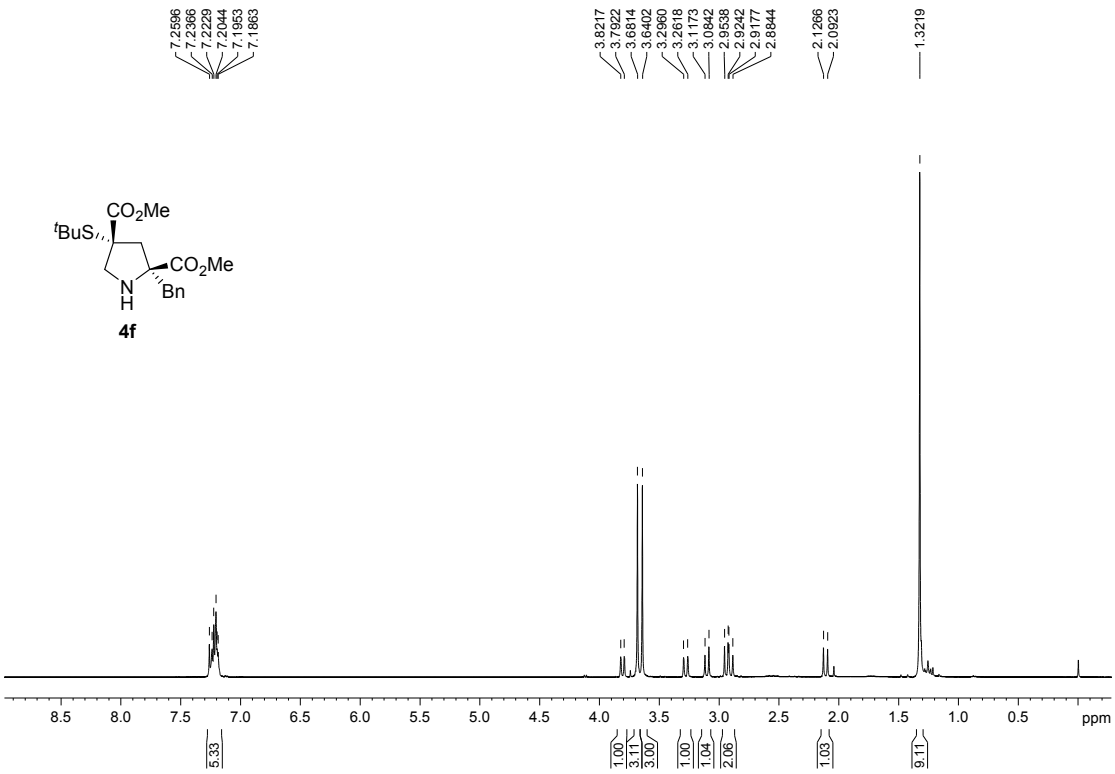

174.742
173.701
140.669
133.462
128.330
127.645
77.338
77.020
76.702
71.029
57.278
57.016
53.029
52.536
48.371
46.757
31.552
CO2Me
tBuS
CO2Me
N
H
Cl
4c
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

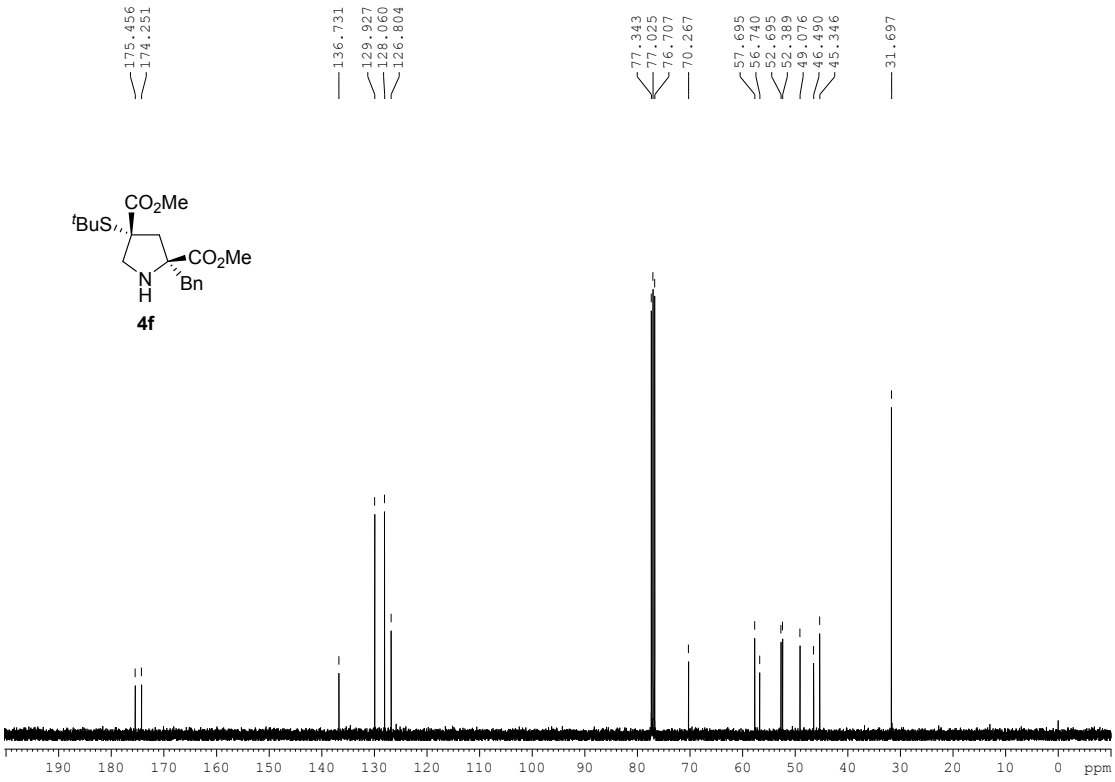

7.5143
7.5104
7.4951
7.4912
7.2597
7.2437
7.2411
7.2246
7.2208
6.9549
6.9531
6.9359
6.9344
6.9174
6.9155
6.8416
6.8214
4.0116
3.9868
3.7631
3.6442
3.5937
3.2534
3.2286
3.0851
3.0495
3.0249
2.9887
1.6962
1.3350
CO2Me
tBuS
CO2Me
N
H
MeO
4d
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.00 0.99 1.05 0.98 1.04 3.04 3.00 2.98 1.00 2.06 1.02 9.15

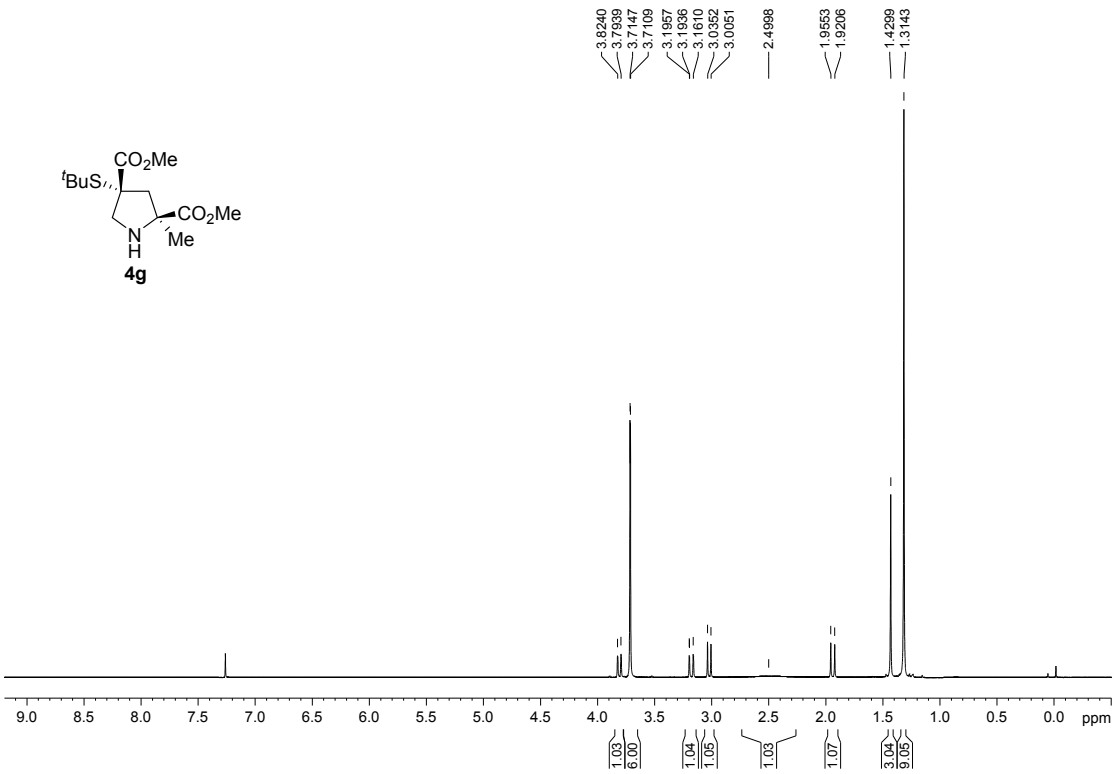

174.621
174.374
156.464
131.194
128.650
125.830
120.382
110.714
77.321
77.003
76.685
68.187
57.035
55.762
55.294
52.525
52.450
46.548
46.390
31.609
CO2Me
tBuS
CO2Me
N
H
MeO
4d
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

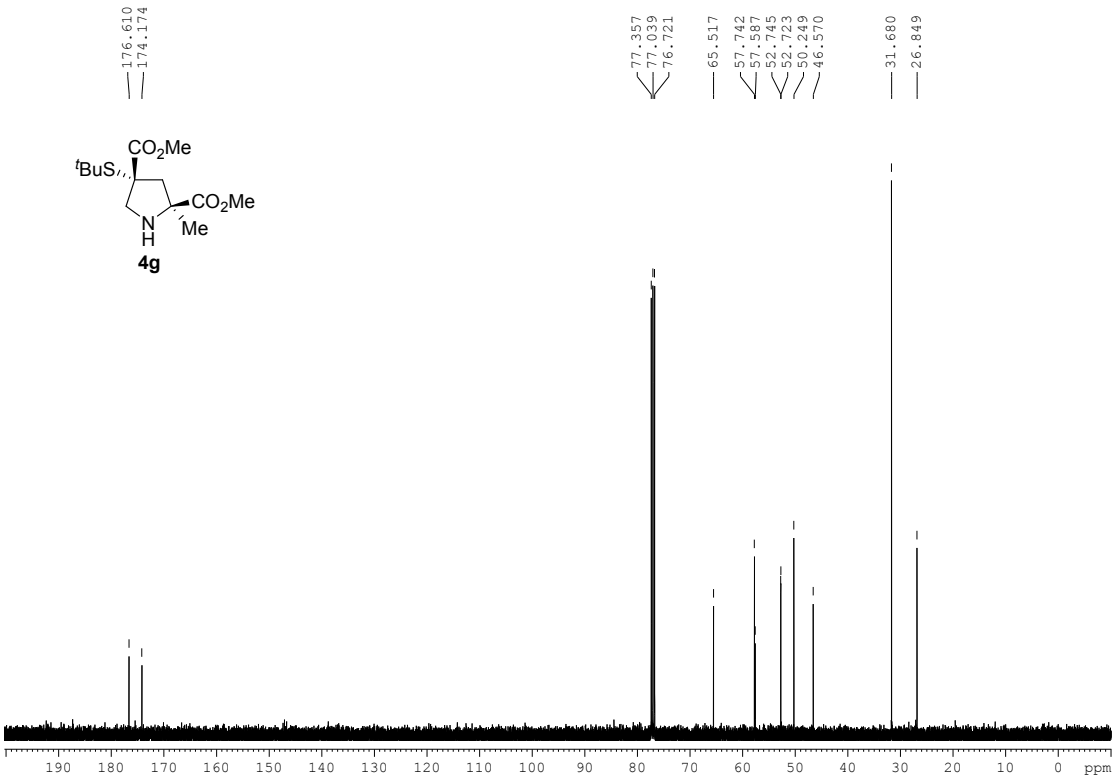

7.7729
7.7679
7.7540
7.7492
7.3306
7.3265
7.3122
7.3078
7.2475
7.2433
7.2287
7.2269
7.2214
7.2080
7.2031
7.1894
7.1847
4.0132
3.9899
3.6802
3.5387
3.3482
3.3132
3.2602
3.2369
3.0054
3.0026
2.9704
2.9675
1.5950
1.3364
CO2Me
tBuS
CO2Me
N
H
Cl
4e
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.04
1.04
2.12
1.02
3.00
3.01
1.09
0.98
1.06
0.99
9.08

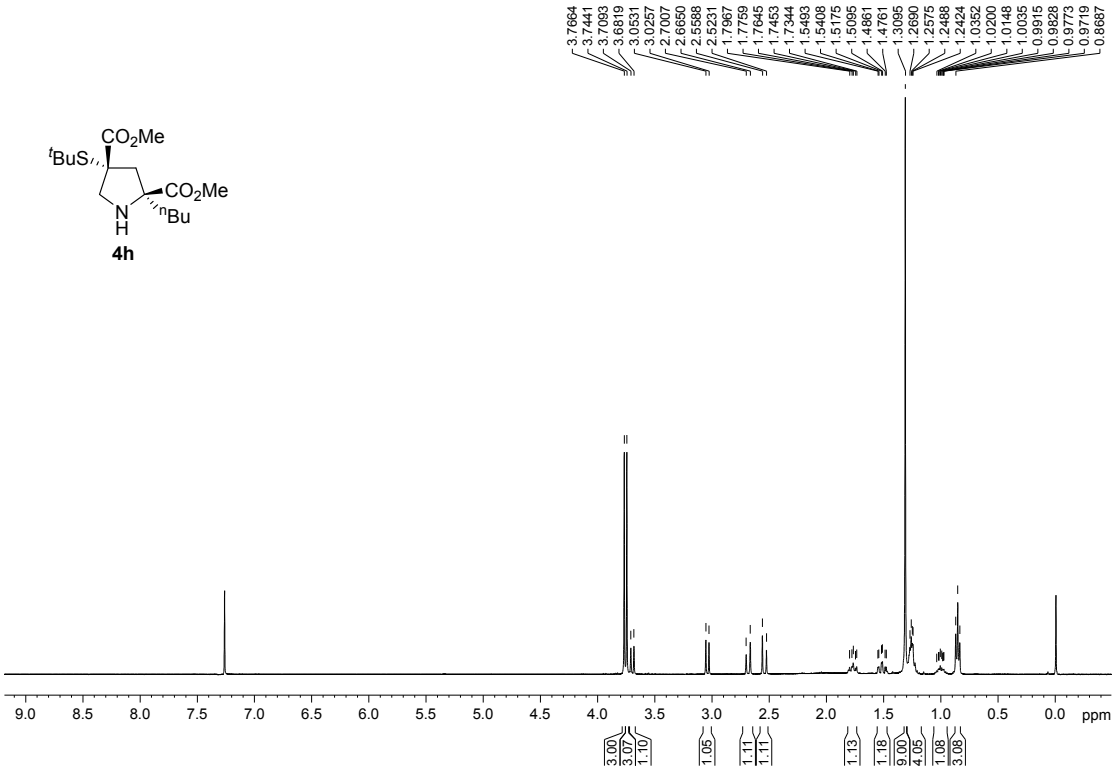

174.019
173.340
141.009
132.337
129.875
128.633
127.109
126.406
77.323
77.005
76.688
69.365
56.630
55.636
53.001
52.431
46.676
46.434
31.624
CO2Me
tBuS
CO2Me
N
H
Cl
4e
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

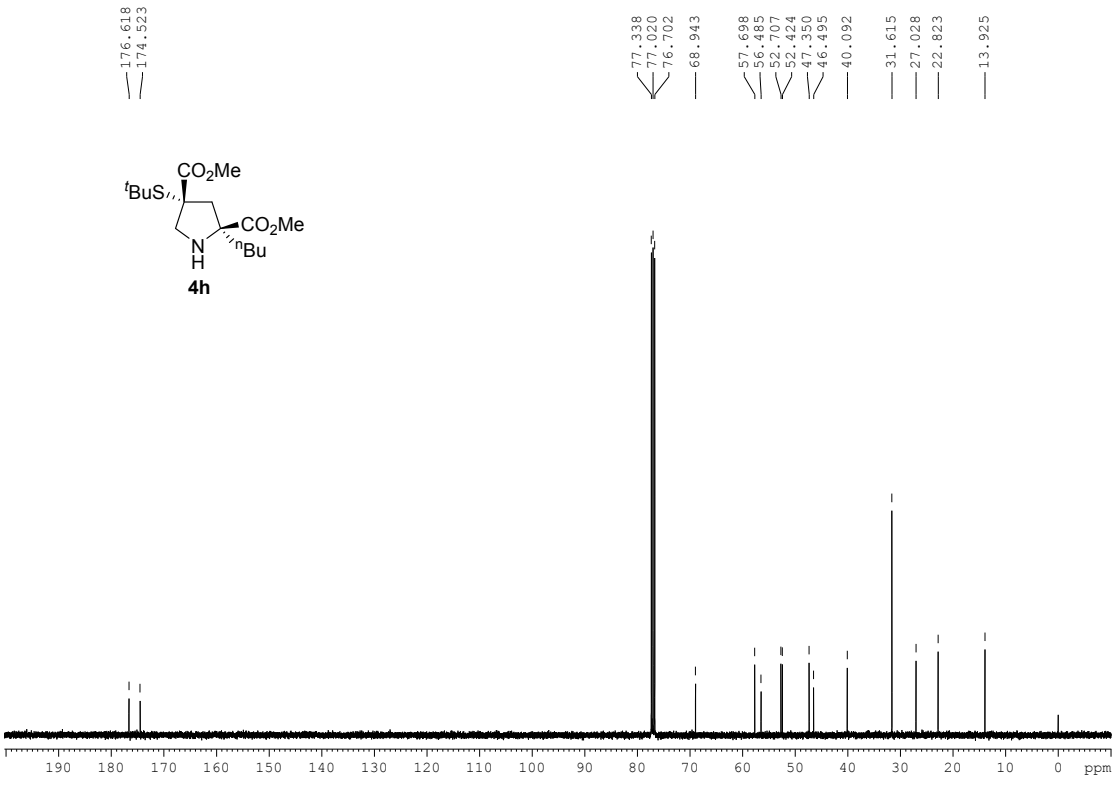

7.2596
7.2366
7.2229
7.2044
7.1953
7.1863
3.8217
3.7922
3.6814
3.6402
3.2960
3.2618
3.1173
3.0842
2.9538
2.9242
2.9177
2.8844
2.1266
2.0923
1.3219
CO2Me
tBuS
CO2Me
N
H
Bn
4f
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
5.33
1.00
3.11
3.00
1.00
1.04
2.06
1.03
9.11

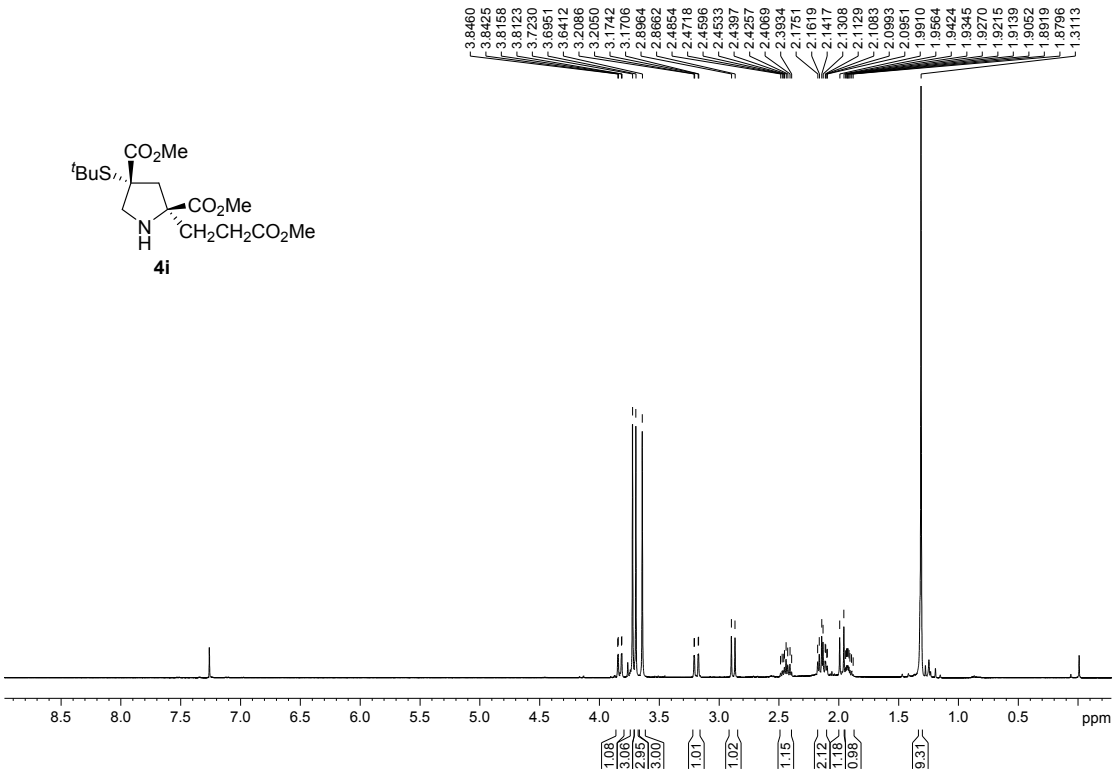

175.456
174.251
136.731
129.927
128.060
126.804
77.343
77.025
76.707
70.267
57.695
56.740
52.695
52.389
49.076
46.490
45.346
31.697
CO2Me
tBuS
CO2Me
N
H
Bn
4f
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

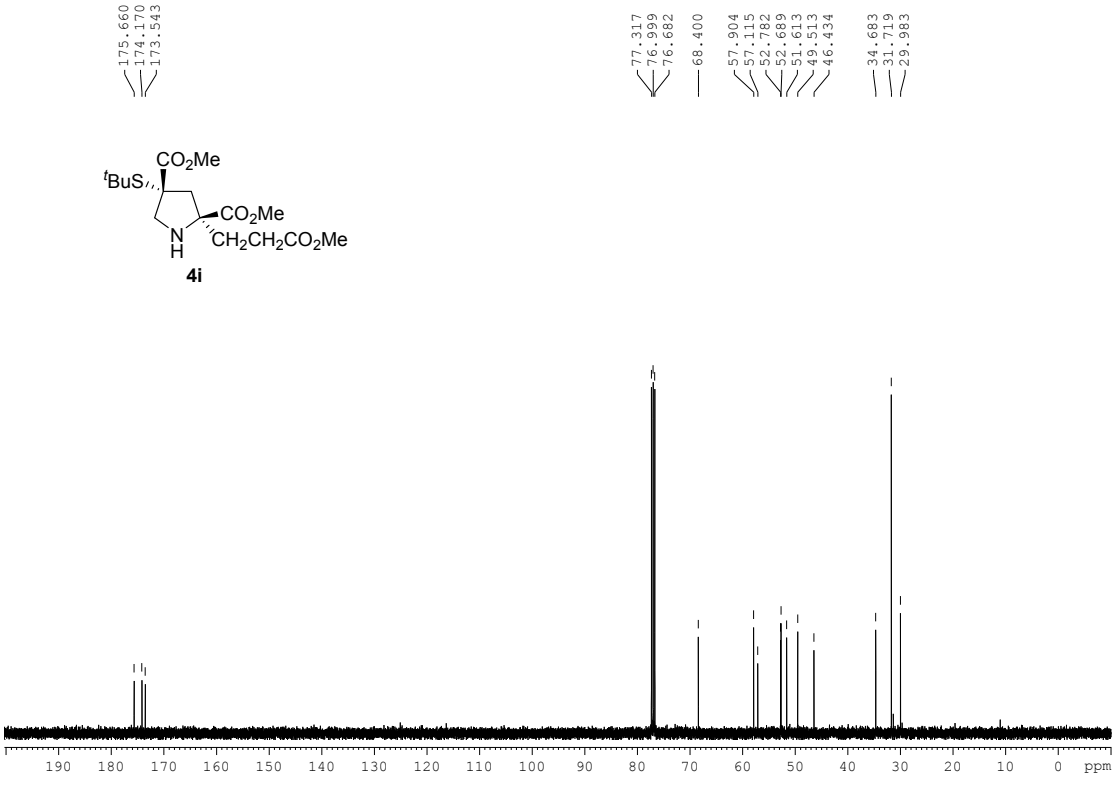

3.8240
3.7939
3.7147
3.7109
3.1957
3.1936
3.1610
3.0352
3.0051
2.4998
1.9553
1.9206
1.4299
1.3143
CO2Me
tBuS
CO2Me
N
H
Me
4g
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
1.03
6.00
1.04
1.05
1.03
1.07
3.04
9.05

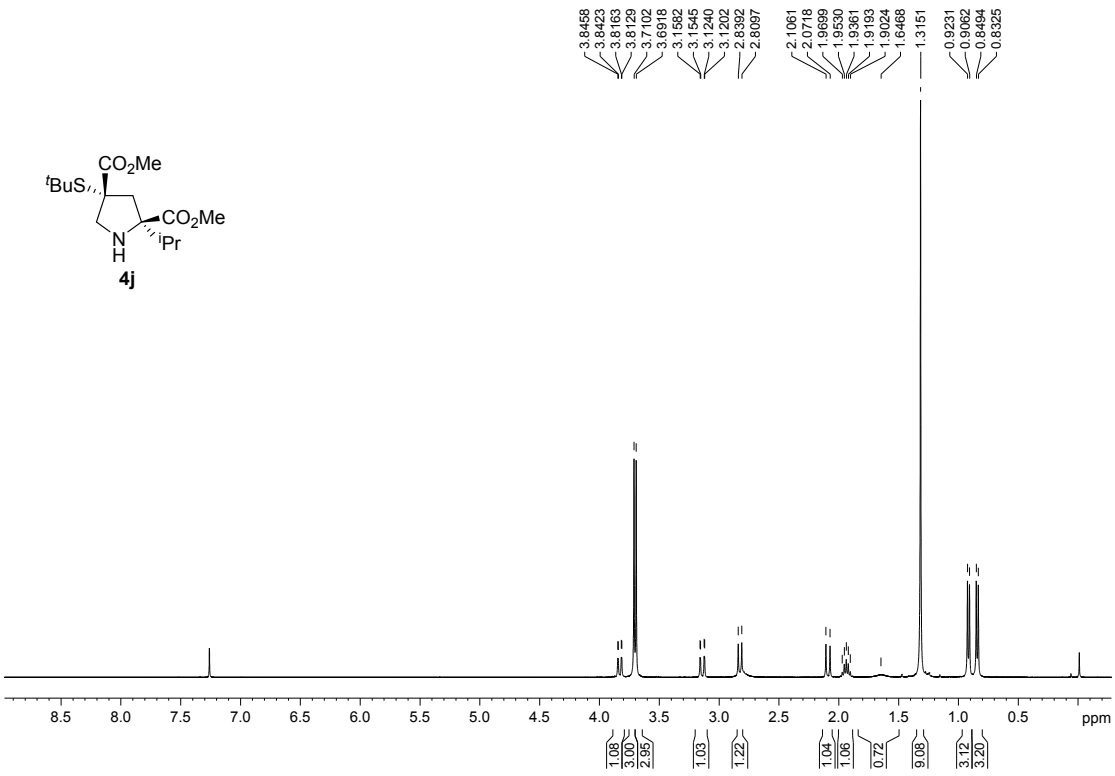

176.610
174.174
77.357
77.039
76.721
65.517
57.742
57.587
52.745
52.723
50.249
46.570
31.680
26.849
CO2Me
tBuS
CO2Me
N
H
Me
4g
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

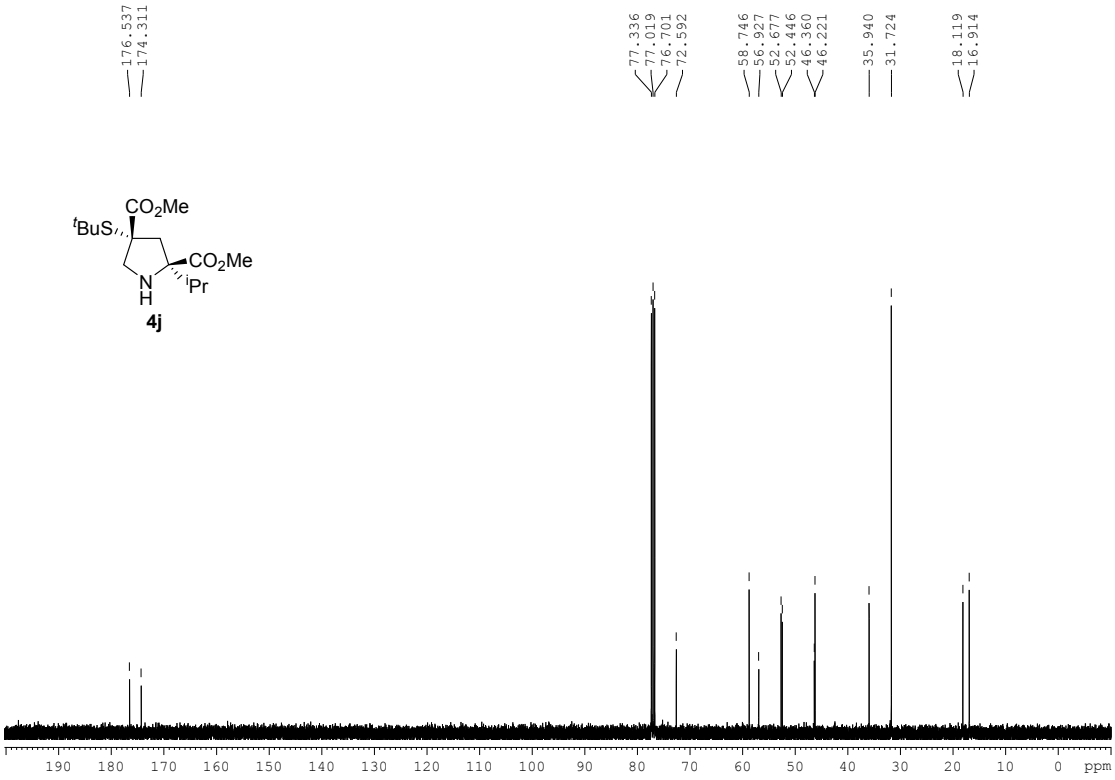

3.7664
3.7441
3.7093
3.6819
3.0531
3.0257
2.7007
2.6650
2.5588
2.5231
1.7967
1.7759
1.7645
1.7453
1.7344
1.5493
1.5408
1.5175
1.5095
1.4861
1.4761
1.3095
1.2690
1.2575
1.2488
1.2424
1.0352
1.0200
1.0148
1.0035
0.9915
0.9828
0.9773
0.9719
0.8687
CO2Me
tBuS
CO2Me
nBu
N
H
4h
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
3.00
3.07
1.10
1.05
1.11
1.11
1.13
1.18
9.00
4.05
1.08
3.08

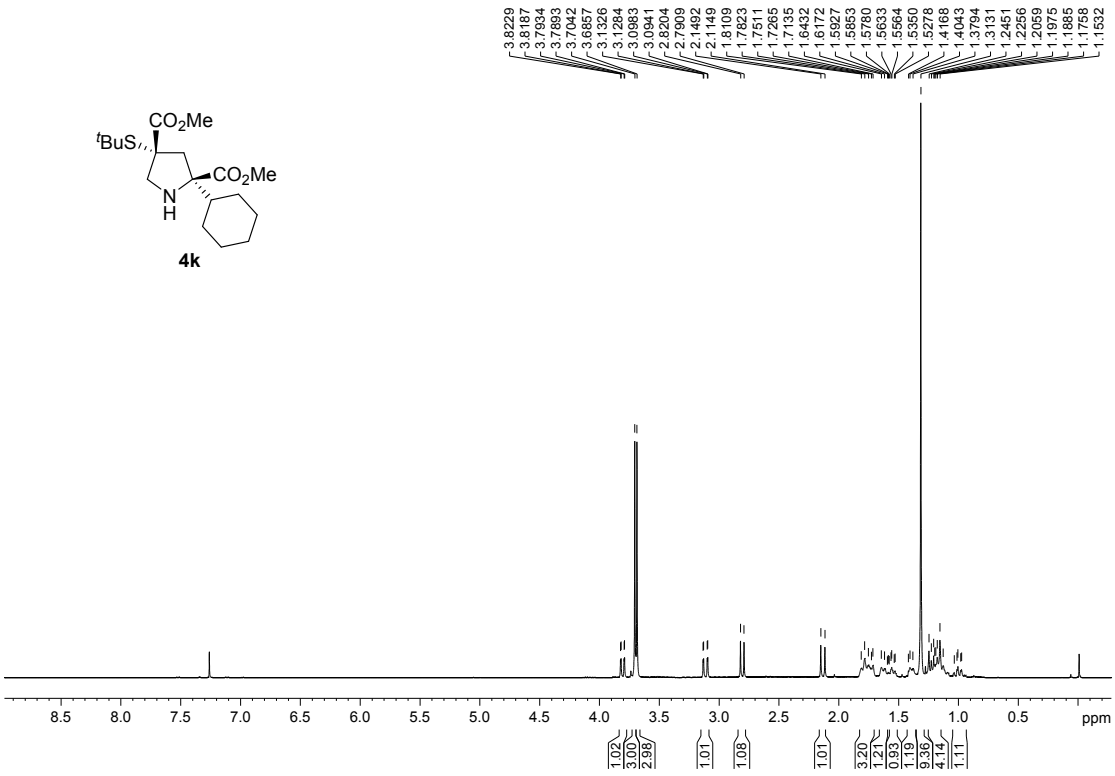

176.618
174.523
77.338
77.020
76.702
68.943
57.698
56.485
52.707
52.424
47.350
46.495
40.092
31.615
27.028
22.823
13.925
CO2Me
tBuS
CO2Me
nBu
N
H
4h
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

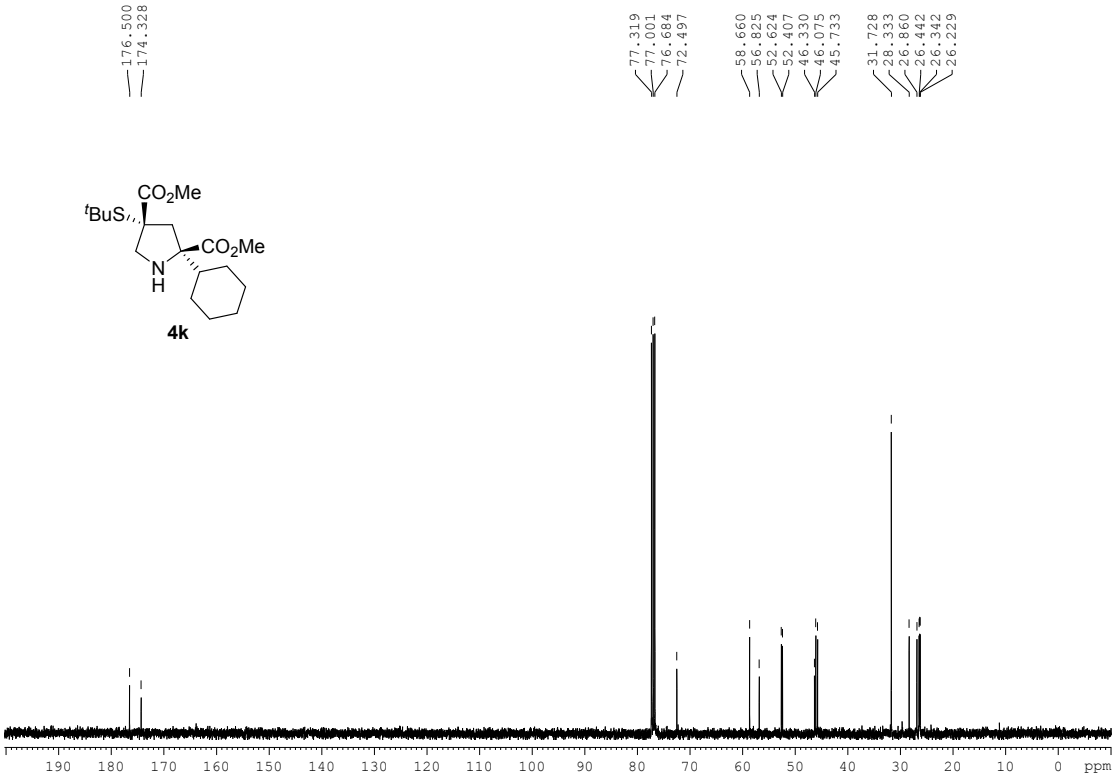

3.8460
3.8425
3.8158
3.8123
3.7230
3.6951
3.6412
3.2086
3.2050
3.1742
3.1706
2.8964
2.8662
2.4854
2.4718
2.4596
2.4533
2.4397
2.4257
2.4069
2.3934
2.1751
2.1619
2.1417
2.1308
2.1129
2.1083
2.0993
2.0951
1.9910
1.9564
1.9424
1.9345
1.9270
1.9215
1.9139
1.9052
1.8919
1.8796
1.3113
CO2Me
tBuS
CO2Me
N
H
CH2CH2CO2Me
4i
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.08
3.06
2.95
3.00
1.01
1.02
1.15
2.12
1.18
0.98
9.31

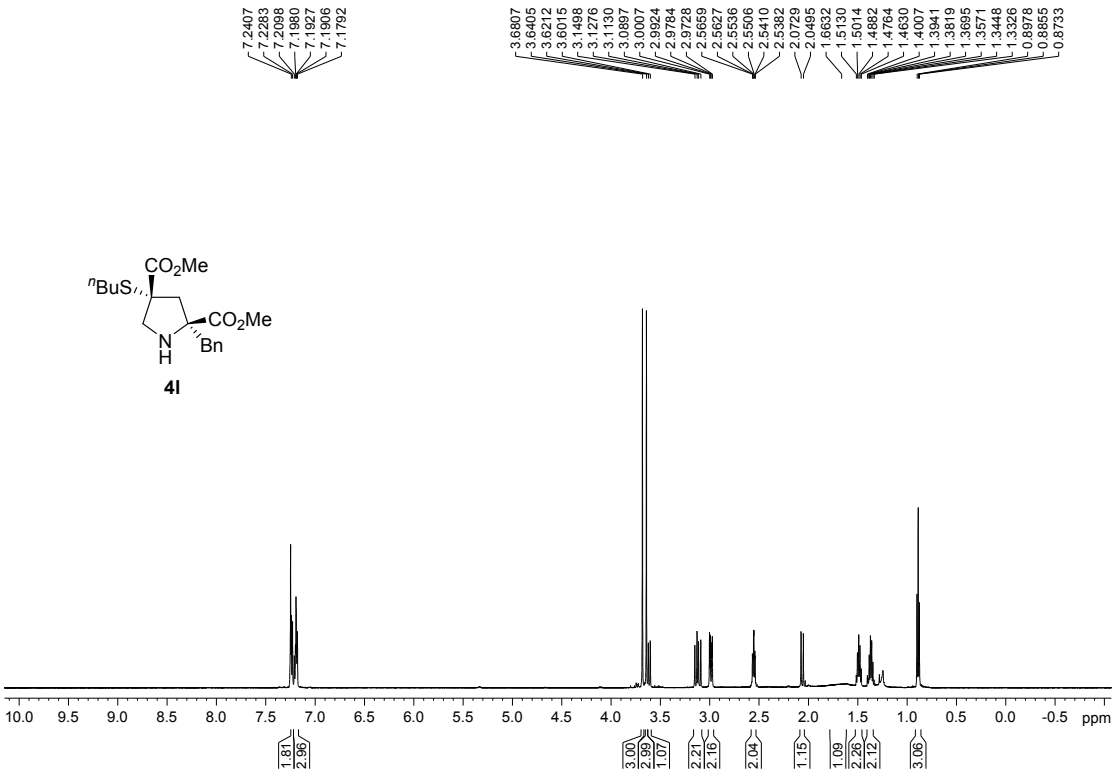

175.660
174.170
173.543
77.317
76.999
76.682
68.400
57.904
57.115
52.782
52.689
51.613
49.513
46.434
34.683
31.719
29.983
CO2Me
tBuS
CO2Me
N
H
CH2CH2CO2Me
4i
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

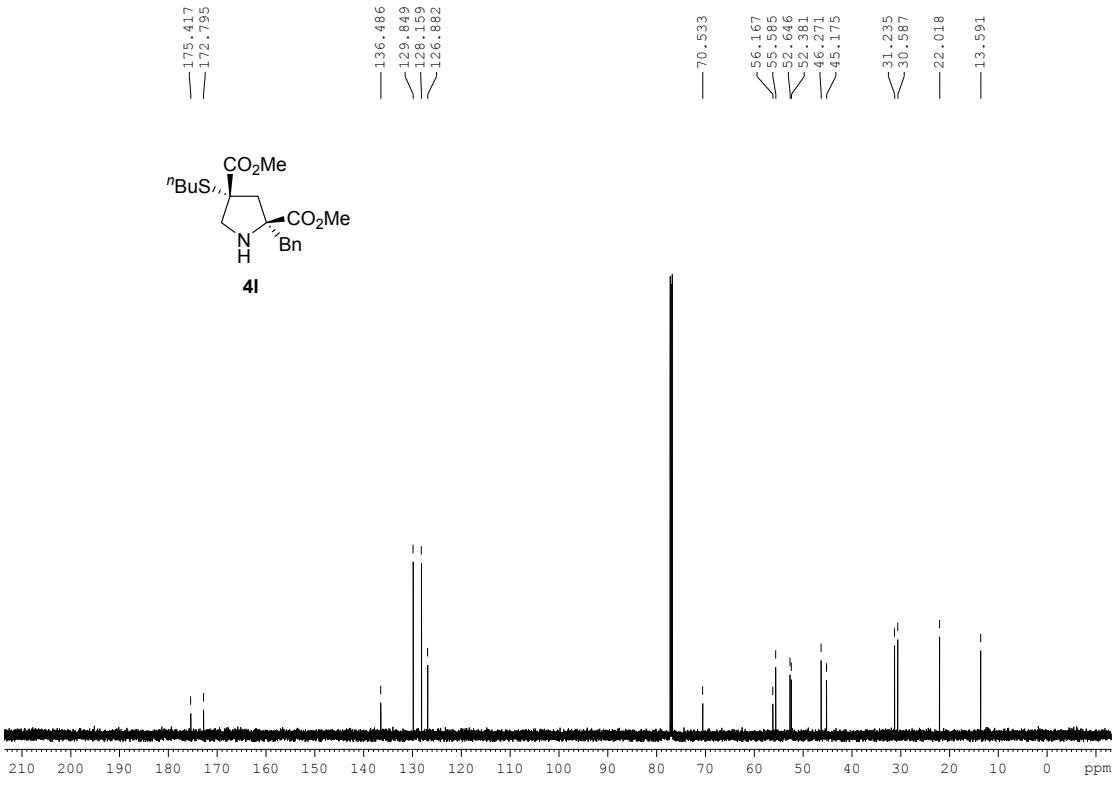

3.8458
3.8423
3.8163
3.8129
3.7102
3.6918
3.1582
3.1545
3.1240
3.1202
2.8392
2.8097
2.1061
2.0718
1.9699
1.9530
1.9361
1.9193
1.9024
1.6468
1.3151
0.9231
0.9062
0.8494
0.8325
CO2Me
tBuS
CO2Me
N
H
iPr
4j
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.08
3.00
2.95
1.03
1.22
1.04
1.06
0.72
9.08
3.12
3.20

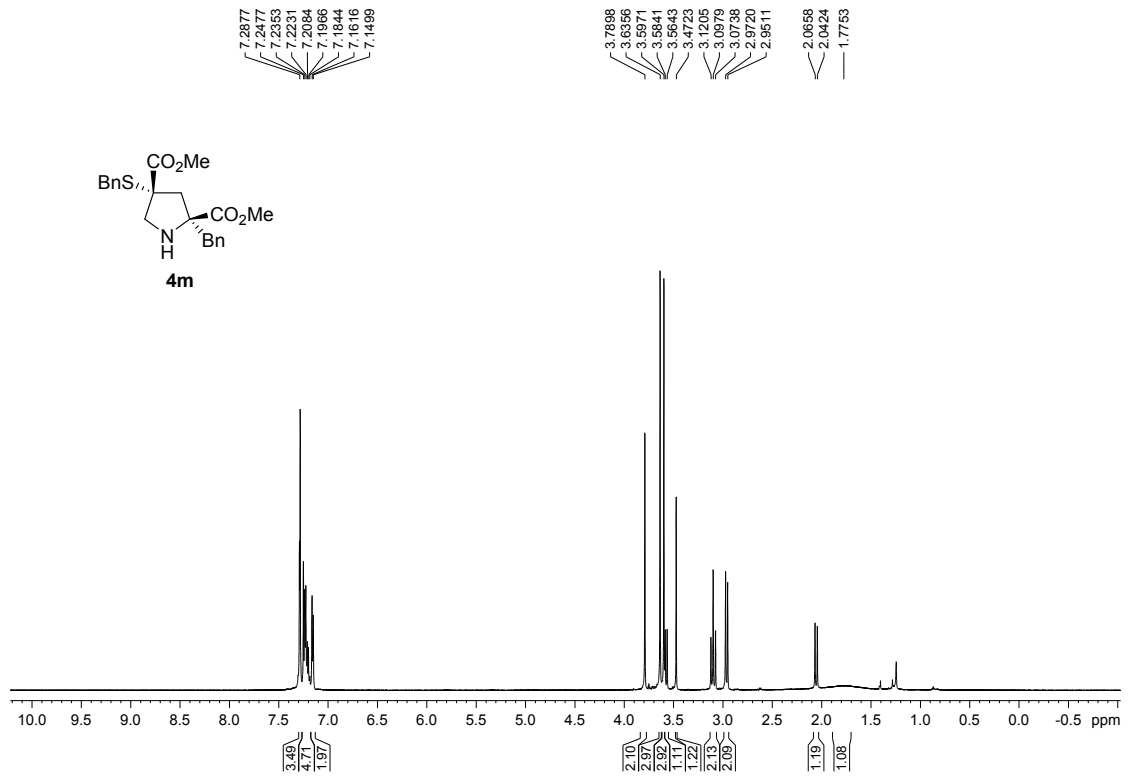

176.537
174.311
77.336
77.019
76.701
72.592
58.746
56.927
52.677
52.446
46.360
46.221
35.940
31.724
18.119
16.914
CO2Me
tBuS
CO2Me
N
H
iPr
4j
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

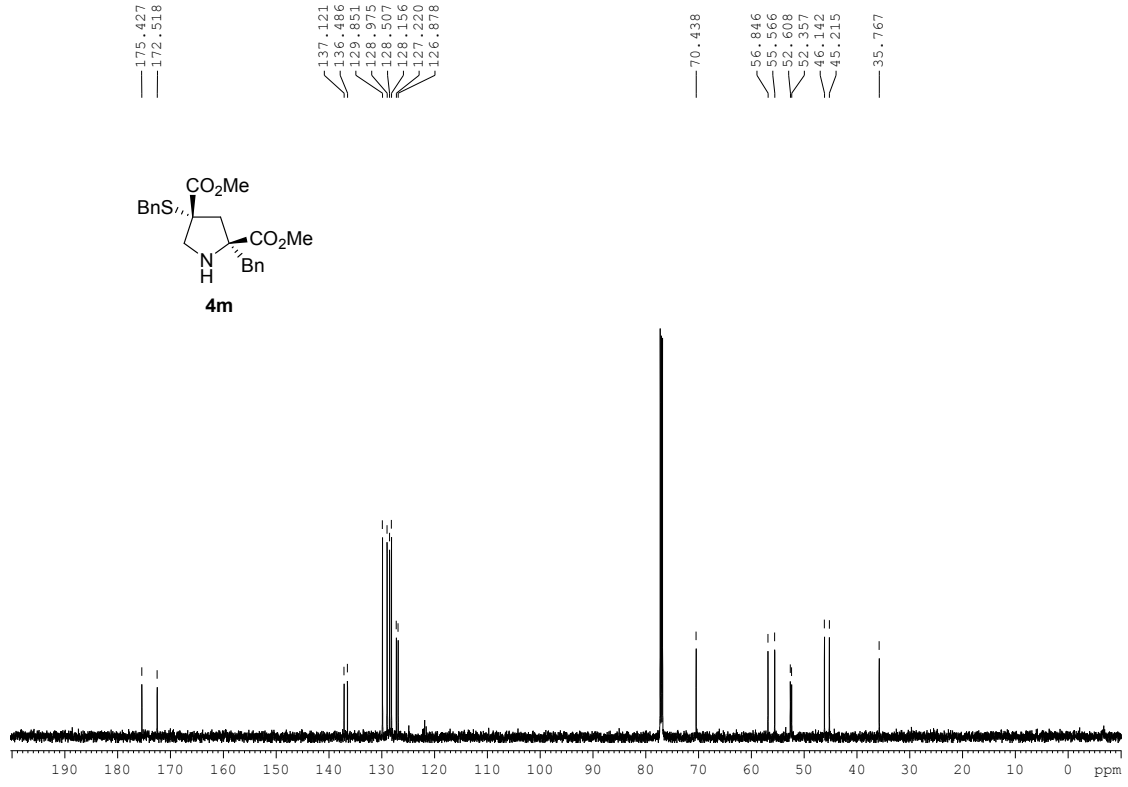

3.8229
3.8187
3.7934
3.7893
3.7042
3.6857
3.1326
3.1284
3.0983
3.0941
2.8204
2.7909
2.1492
2.1149
1.8109
1.7823
1.7511
1.7265
1.7135
1.6432
1.6172
1.5927
1.5853
1.5780
1.5633
1.5564
1.5350
1.5278
1.4168
1.4043
1.3794
1.3131
1.2451
1.2256
1.2059
1.1975
1.1885
1.1758
1.1532
CO2Me
tBuS
CO2Me
N
H
4k
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.02
3.00
2.98
1.01
1.08
1.01
3.20
1.21
0.93
1.19
9.36
4.14
1.11

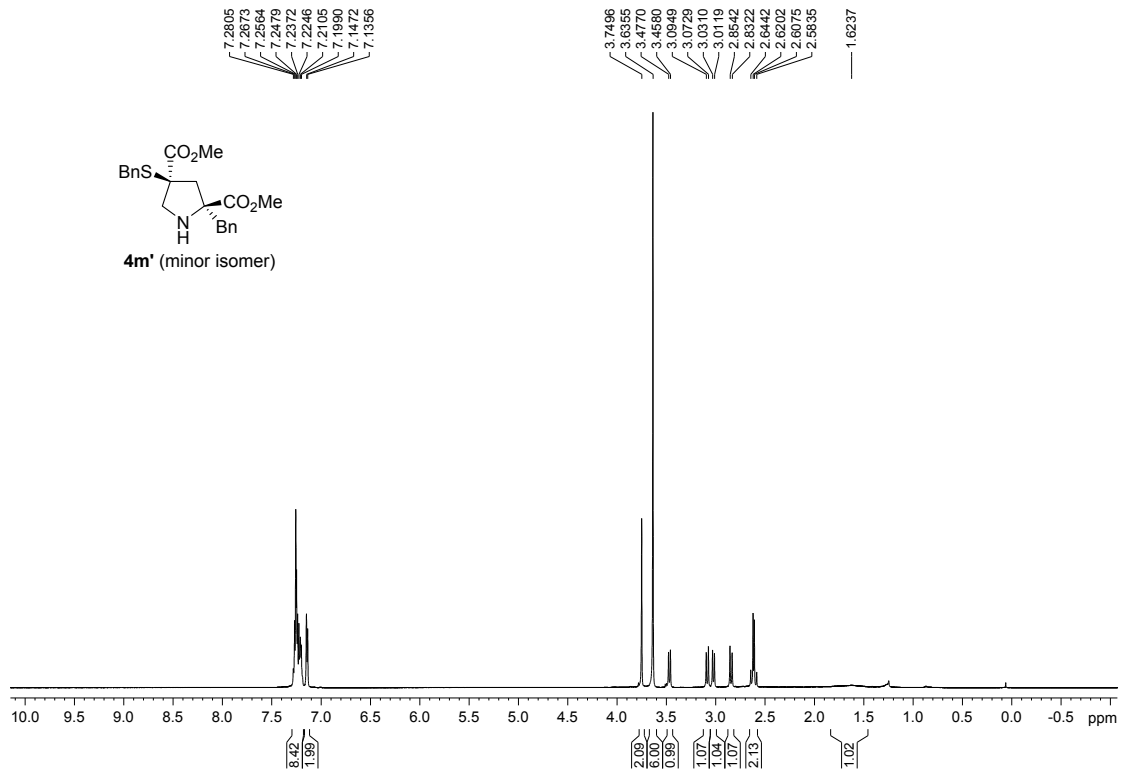

176.500
174.328
77.319
77.001
76.684
72.497
58.660
56.825
52.624
52.407
46.330
46.075
45.733
31.728
28.333
26.860
26.442
26.342
26.229
CO2Me
tBuS
CO2Me
N
H
4k
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

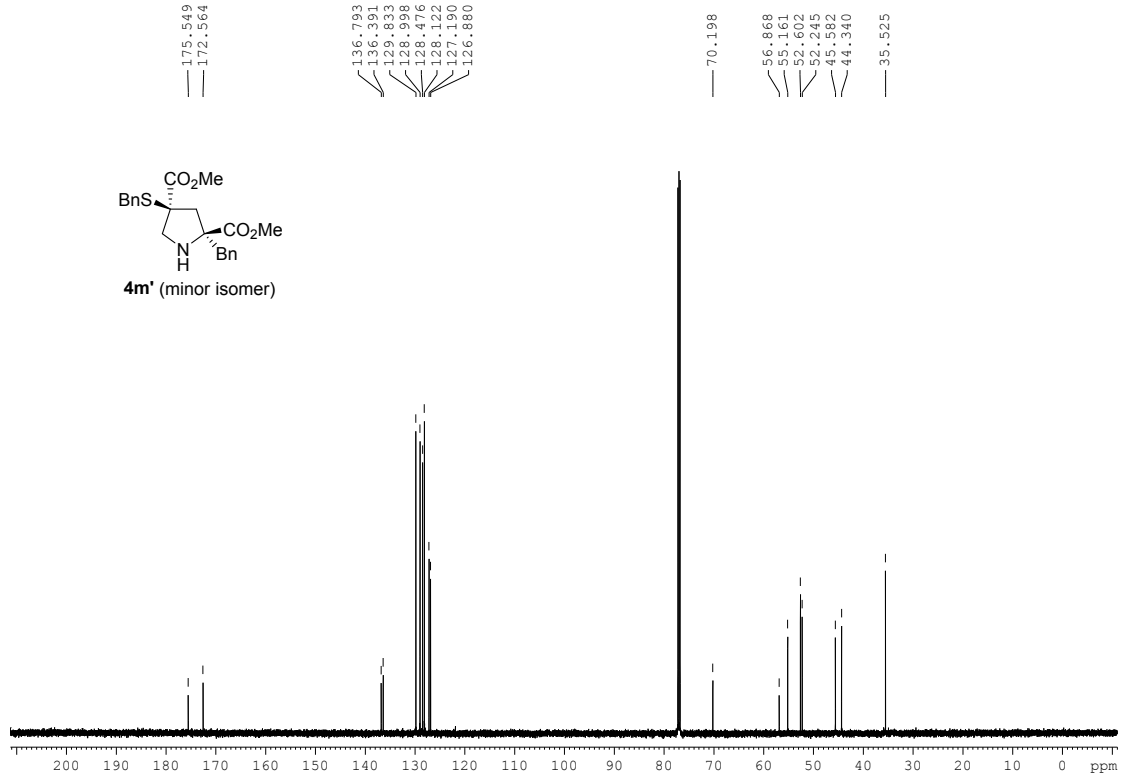

7.2407
7.2283
7.2098
7.1980
7.1927
7.1906
7.1792
3.6807
3.6405
3.6212
3.6015
3.1498
3.1276
3.1130
3.0897
3.0007
2.9924
2.9784
2.9728
2.5659
2.5627
2.5536
2.5506
2.5410
2.5382
2.0729
2.0495
1.6632
1.5130
1.5014
1.4882
1.4764
1.4630
1.4007
1.3941
1.3819
1.3695
1.3571
1.3448
1.3326
0.8978
0.8855
0.8733
CO2Me
nBuS
CO2Me
N
H
Bn
4l
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 ppm
1.81
2.96
3.00
2.89
1.07
2.21
2.16
2.04
1.15
1.09
2.26
2.12
3.06

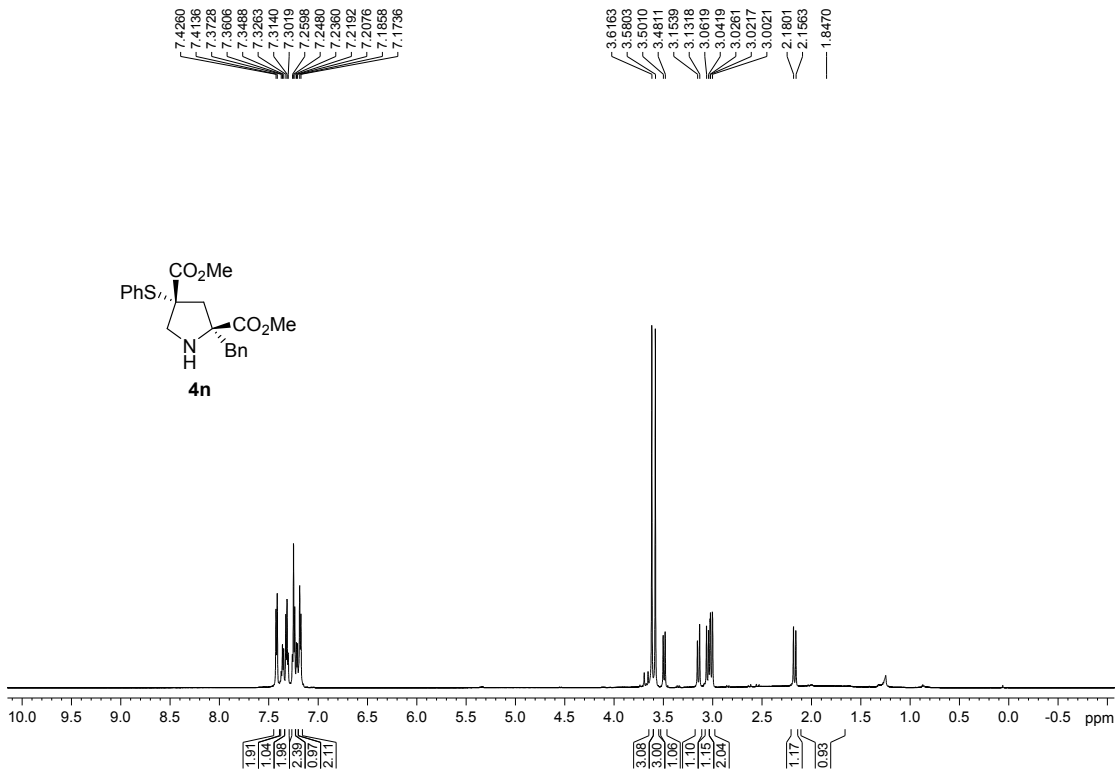

175.417
172.795
136.486
129.849
128.159
126.882
70.533
56.167
55.585
52.646
52.381
46.271
45.175
31.235
30.587
22.018
13.591
CO2Me
nBuS
CO2Me
N
H
Bn
4l
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

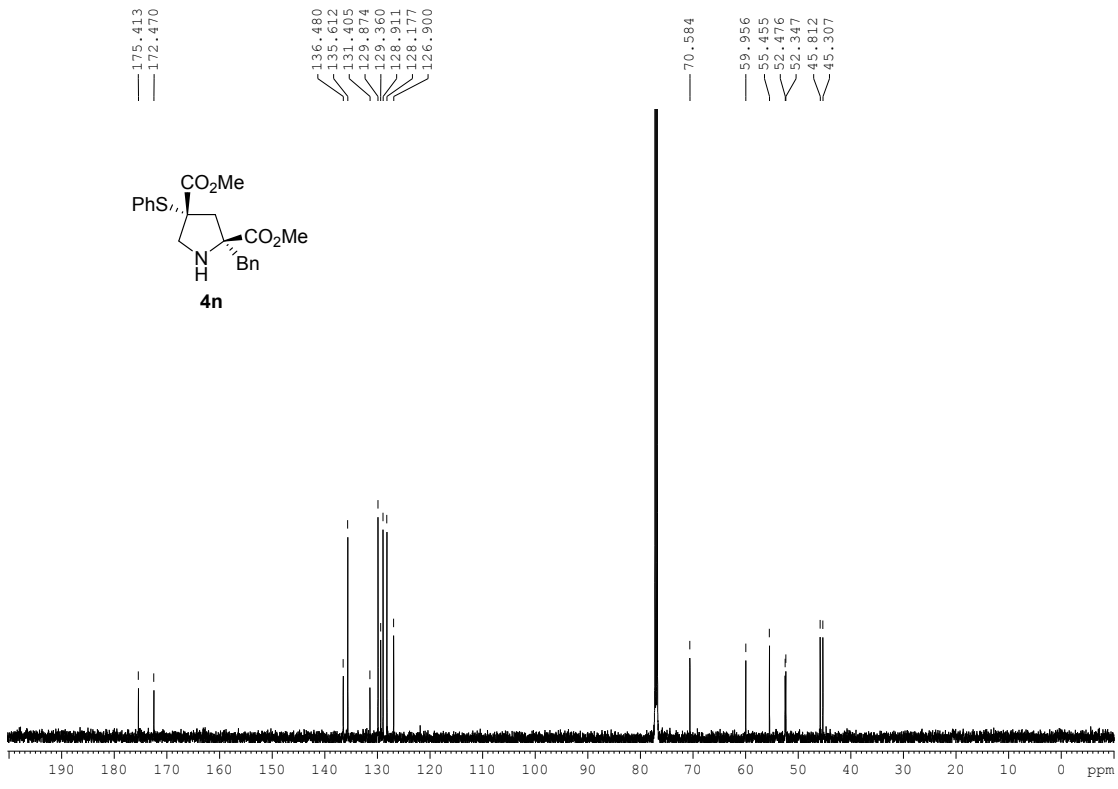

7.2877
7.2477
7.2353
7.2231
7.2084
7.1966
7.1844
7.1616
7.1499
3.7898
3.6356
3.5971
3.5841
3.5643
3.4723
3.1205
3.0979
3.0738
2.9720
2.9511
2.0658
2.0424
1.7753
CO2Me
BnS
CO2Me
N
H
Bn
4m
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 ppm
3.49
4.71
1.97
2.10
2.97
2.92
1.11
1.22
2.13
2.09
1.19
1.08

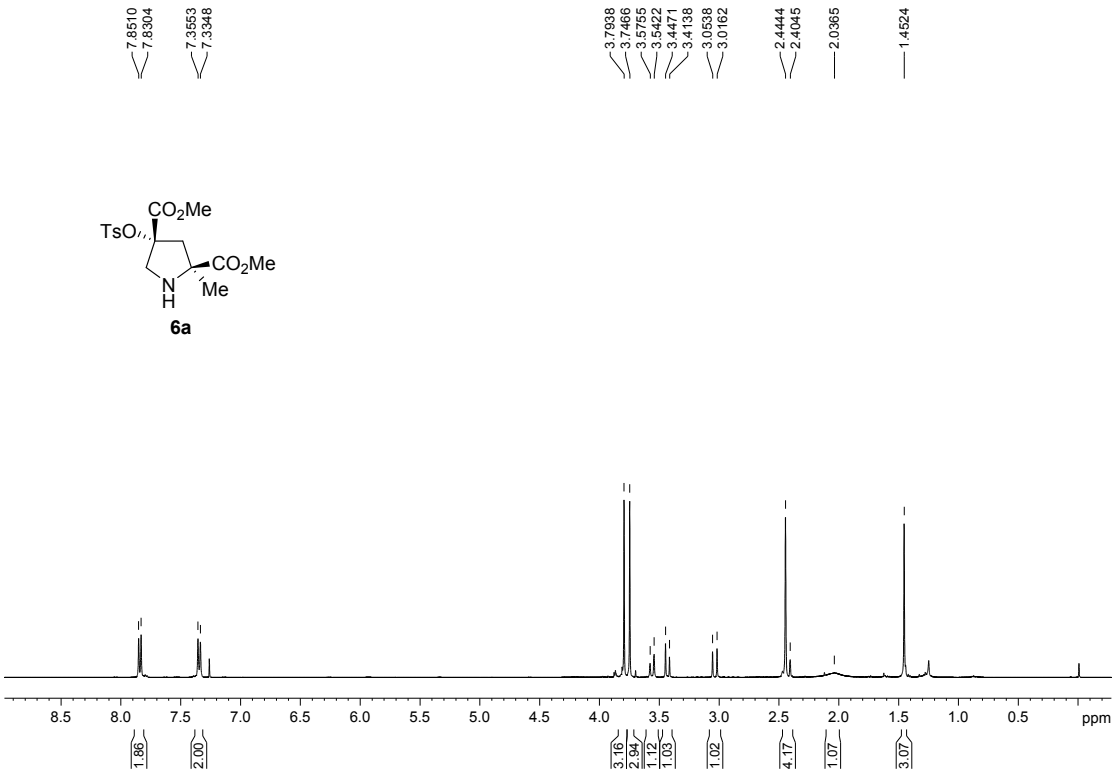

175.427
172.518
137.121
136.486
129.851
128.975
128.507
128.156
127.220
126.878
70.438
56.846
55.566
52.608
52.357
46.142
45.215
35.767
CO2Me
BnS
CO2Me
N
H
Bn
4m
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

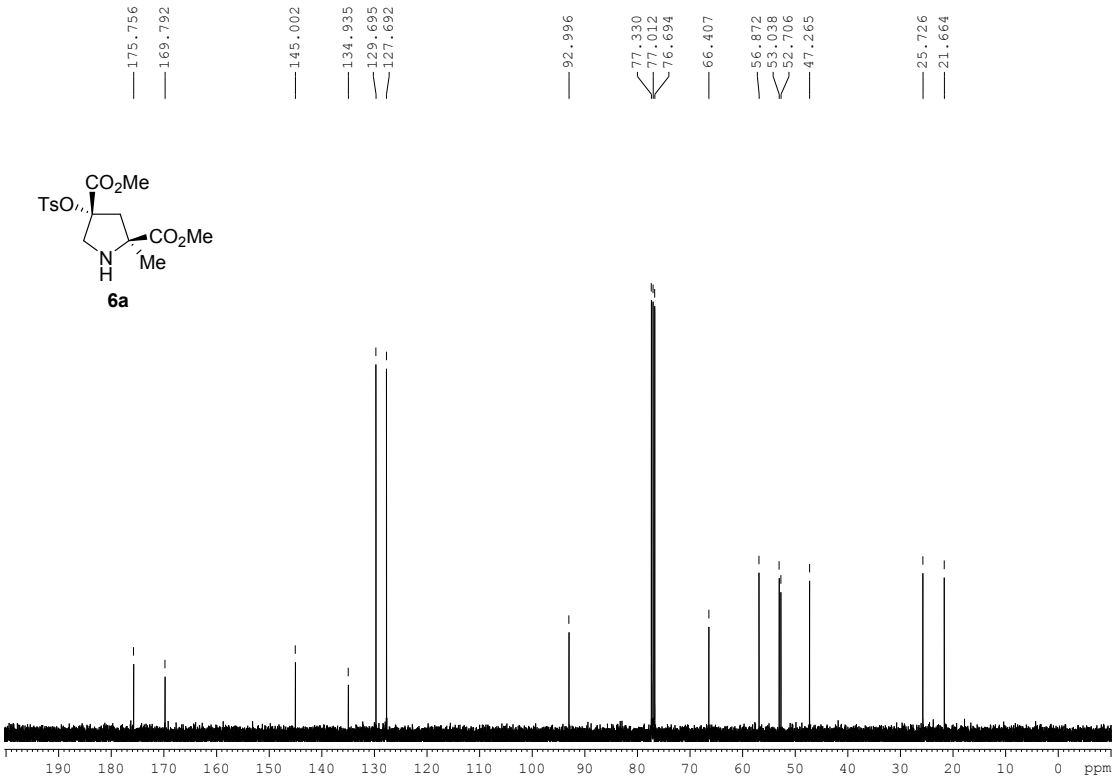

7.2805
7.2673
7.2564
7.2479
7.2372
7.2246
7.2105
7.1990
7.1472
7.1356
3.7496
3.6355
3.4770
3.4580
3.0949
3.0729
3.0310
3.0119
2.8542
2.8322
2.6442
2.6202
2.6075
2.5835
1.6237
CO2Me
BnS
CO2Me
N
H
Bn
4m' (minor isomer)
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 ppm
8.42
1.99
2.09
6.00
0.99
1.07
1.04
1.07
2.13
1.02

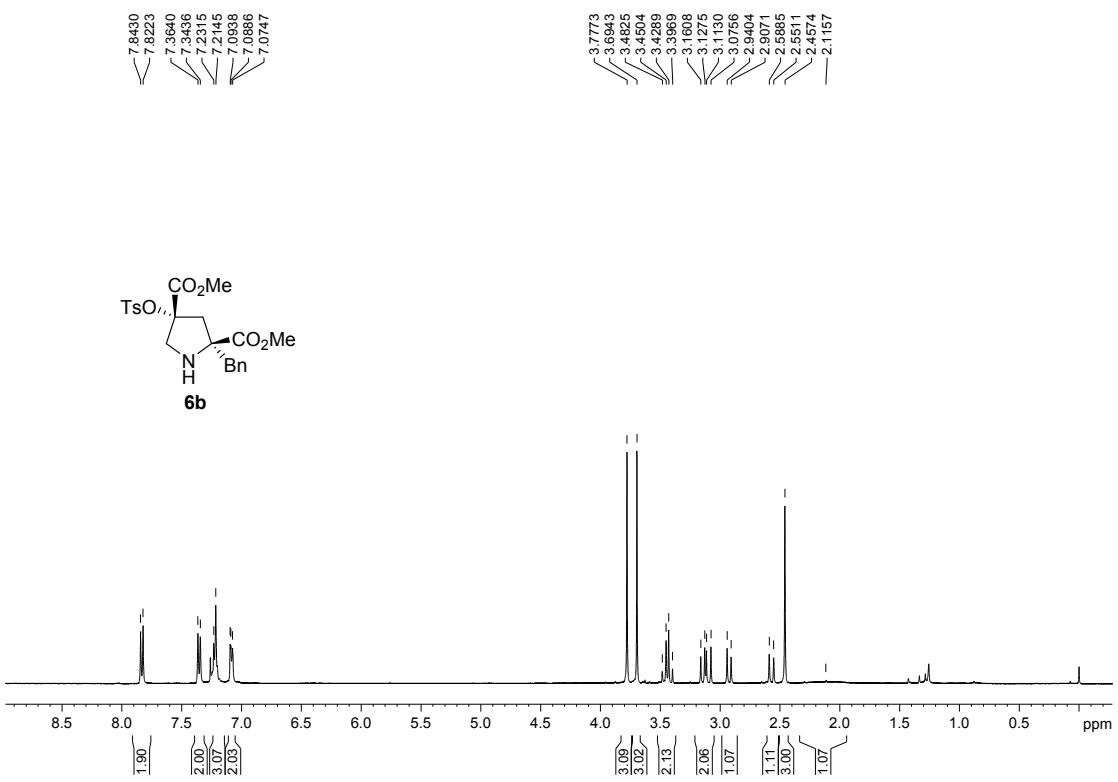

175.549
172.564
136.793
136.391
129.833
128.998
128.476
128.122
127.190
126.880
70.198
56.868
55.161
52.602
52.245
45.582
44.340
35.525
CO2Me
BnS
CO2Me
N
H
Bn
4m' (minor isomer)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

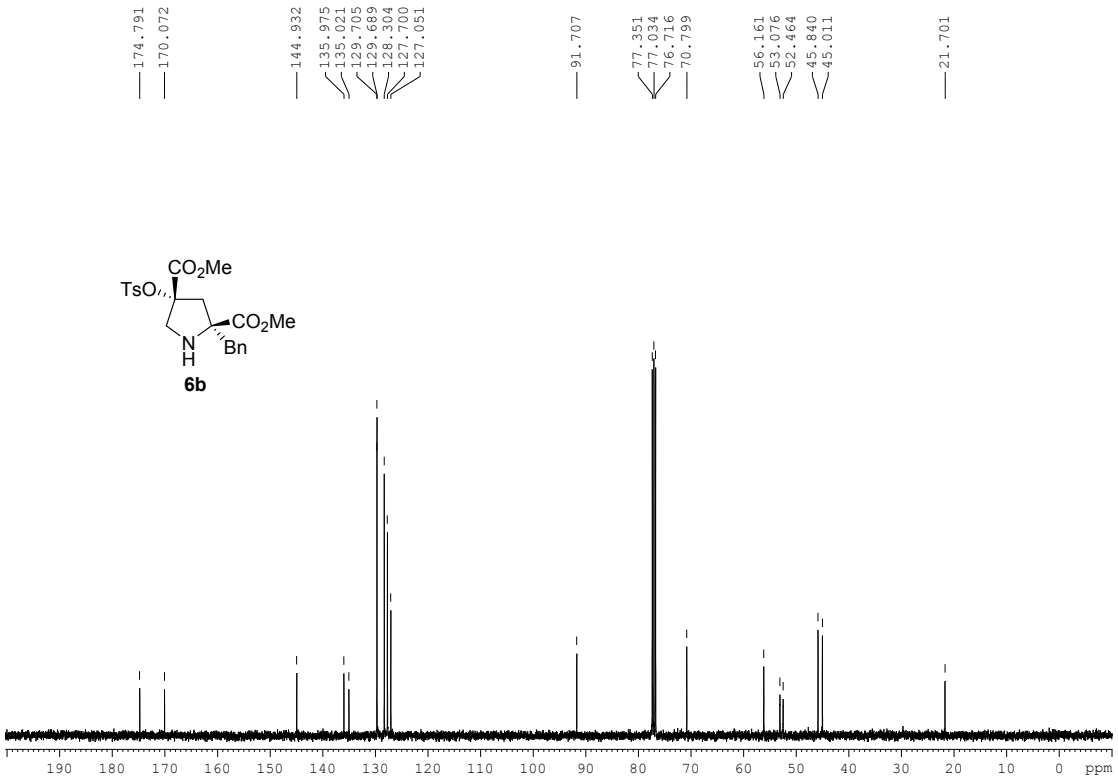

7.4260
7.4136
7.3728
7.3606
7.3488
7.3263
7.3140
7.3019
7.2598
7.2480
7.2360
7.2192
7.2076
7.1858
7.1736
3.6163
3.5803
3.5010
3.4811
3.1539
3.1318
3.0619
3.0419
3.0261
3.0217
3.0021
2.1801
2.1563
1.8470
CO2Me
PhS
CO2Me
N
H
Bn
4n
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 ppm
1.91
1.04
1.98
2.39
0.97
2.11
3.08
3.00
1.06
1.10
1.15
2.04
1.17
0.93

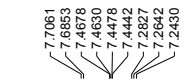

175.413
172.470
136.480
135.612
131.405
129.874
129.360
128.911
128.177
126.900
70.584
59.956
55.455
52.476
52.347
45.812
45.307
CO2Me
PhS
CO2Me
N
H
Bn
4n
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

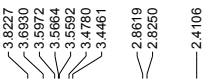

7.8510
7.8304
7.3553
7.3348
3.7938
3.7466
3.5755
3.5422
3.4471
3.4138
3.0538
3.0162
2.4444
2.4045
2.0365
1.4524
CO2Me
TsO
CO2Me
N
H
Me
6a
ppm
1.86
2.00
3.16
2.94
1.12
1.03
1.02
4.17
1.07
3.07

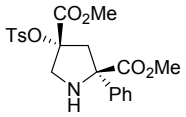

175.756
169.792
145.002
134.935
129.695
127.692
92.996
77.330
77.012
76.694
66.407
56.872
53.038
52.706
47.265
25.726
21.664
CO2Me
TsO
CO2Me
N
H
Me
6a
ppm


7.8430
7.8223
7.3640
7.3436
7.2315
7.2145
7.0938
7.0886
7.0747
3.7773
3.6943
3.4825
3.4504
3.4289
3.3969
3.1608
3.1275
3.1130
3.0756
2.9404
2.9071
2.5885
2.5511
2.4574
2.1157
CO2Me
TsO
CO2Me
N
H
Bn
6b
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.90
2.00
3.07
2.03
3.09
3.02
2.13
2.06
1.07
1.11
3.00
1.07

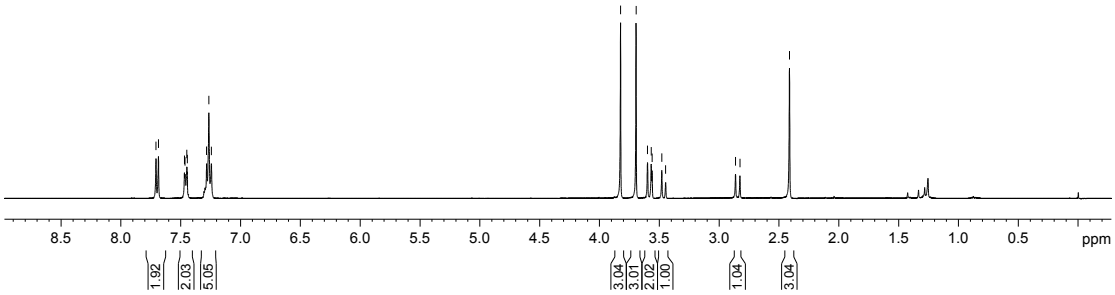

174.791
170.072
144.932
135.975
135.021
129.705
129.689
128.304
127.700
127.051
91.707
77.351
77.034
76.716
70.799
56.161
53.076
52.464
45.840
45.011
21.701
CO2Me
TsO
CO2Me
N
H
Bn
6b
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


7.7061
7.6853
7.4678
7.4630
7.4478
7.4442
7.2827
7.2642
7.2430

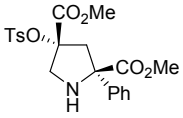

3.8227
3.6830
3.5972
3.5664
3.5592
3.4780
3.4461
2.8619
2.8250
2.4106


CO2Me
TsO
CO2Me
N
H
Ph

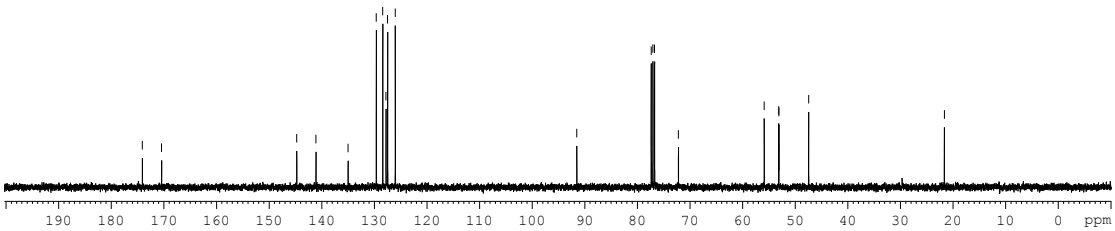
6c

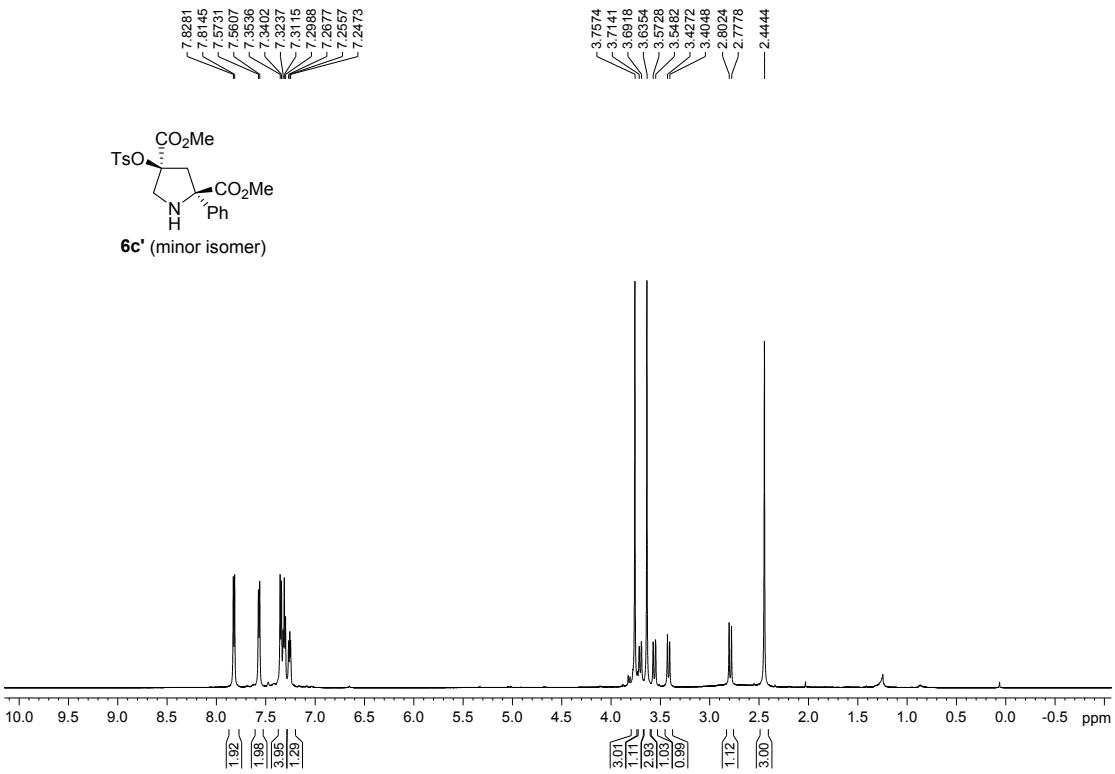

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.92
2.03
5.05
3.04
3.01
2.02
1.00
1.04
3.04

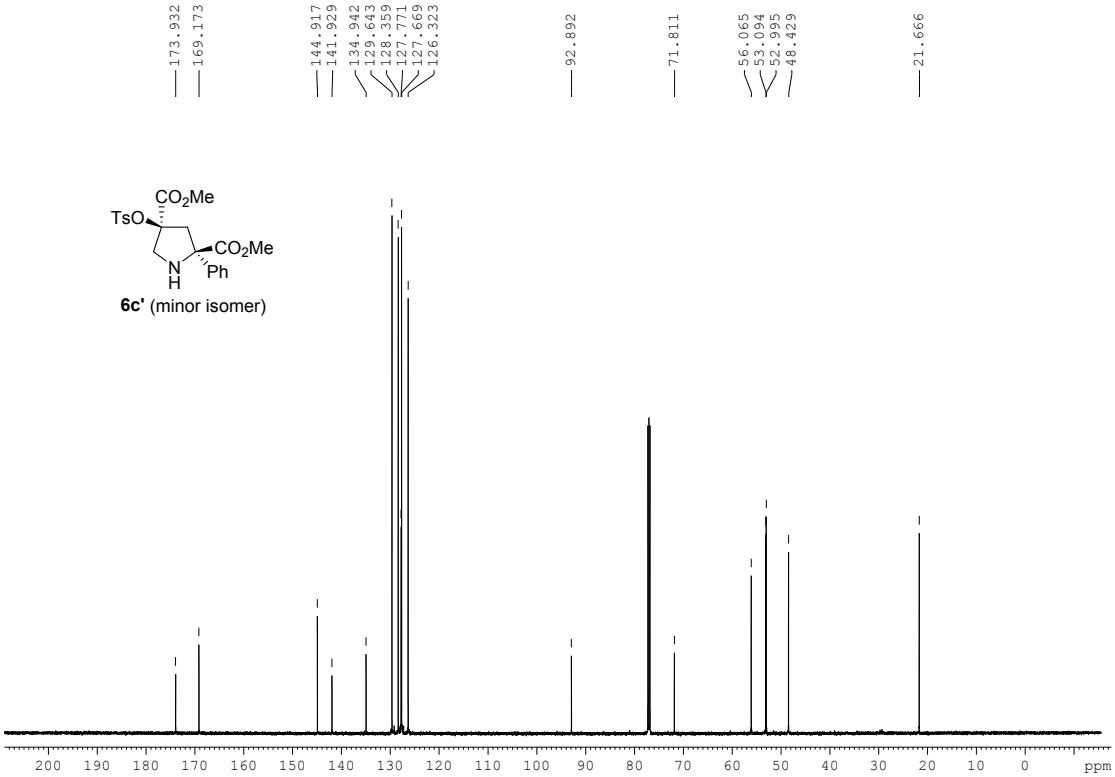

174.093
170.422
144.744
141.078
134.978
129.617
128.394
127.766
127.463
126.015
91.511
77.359
77.041
76.724
72.181
55.880
53.128
53.085
47.428
21.627

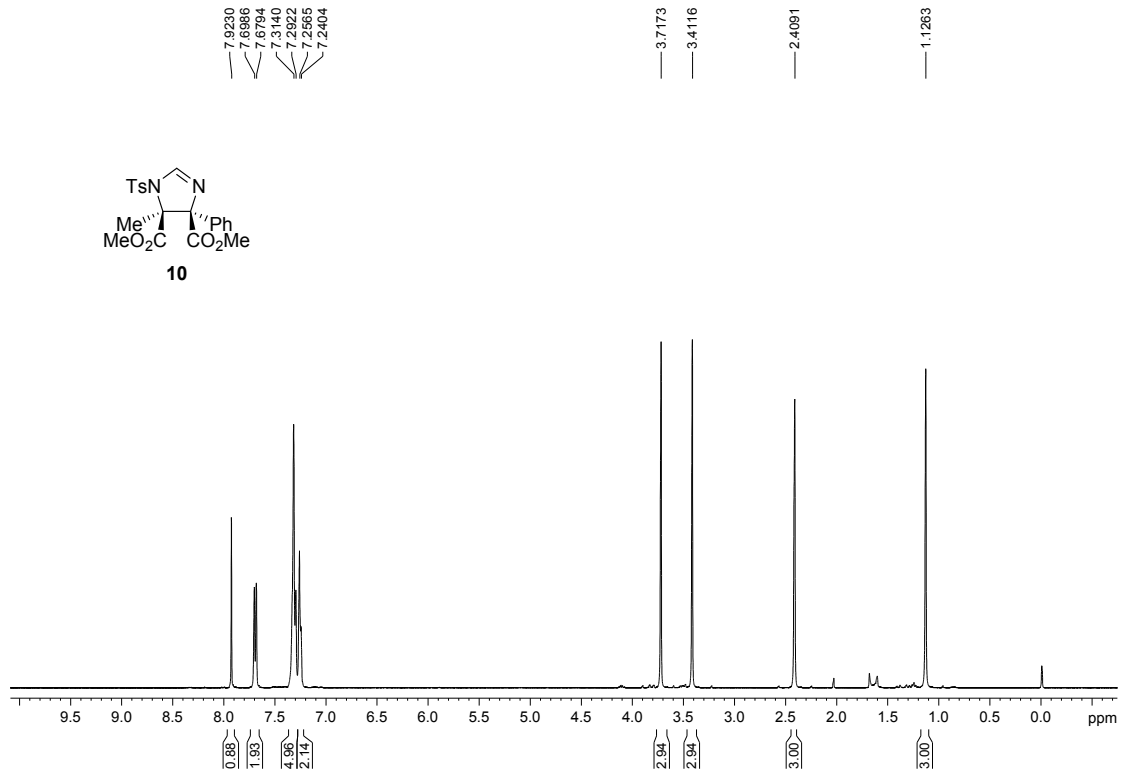

CO2Me
TsO
CO2Me
N
H
Ph

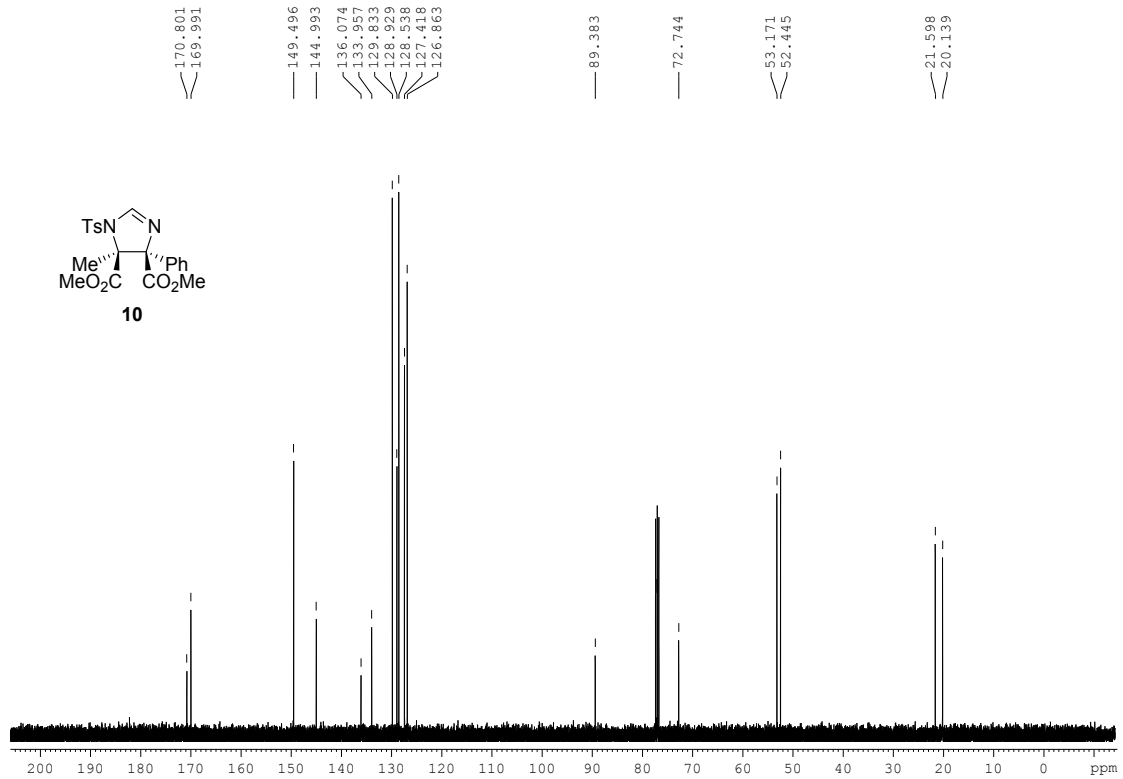
6c

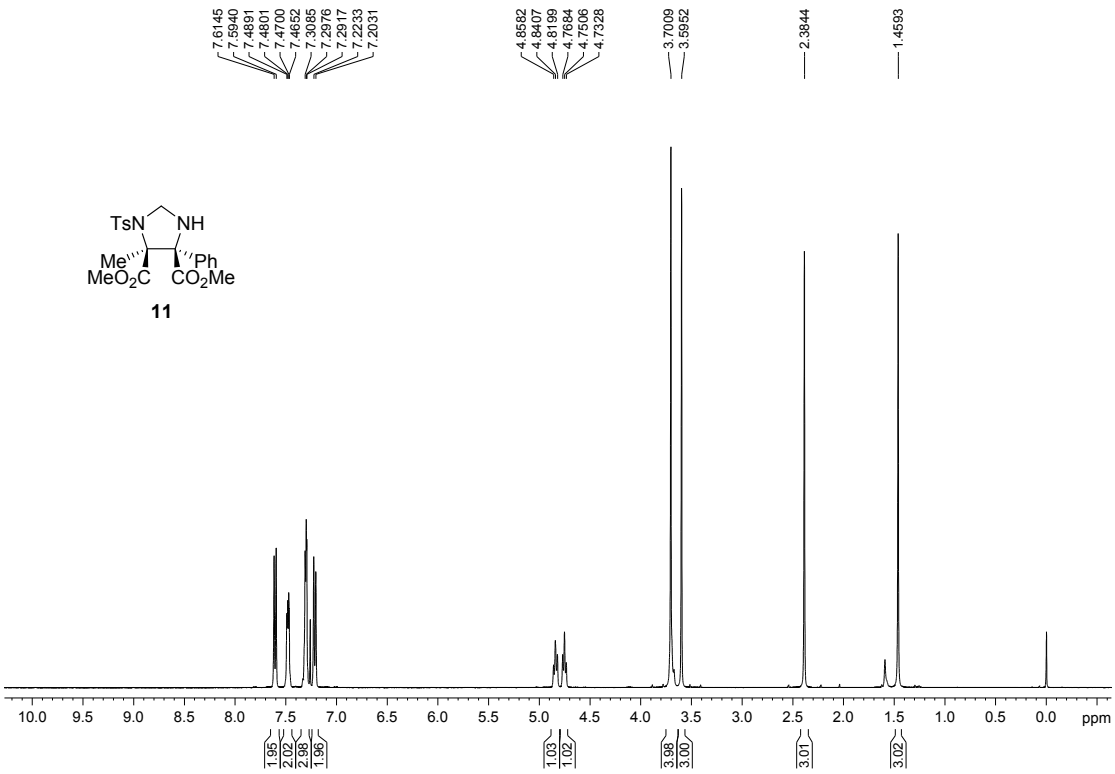

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

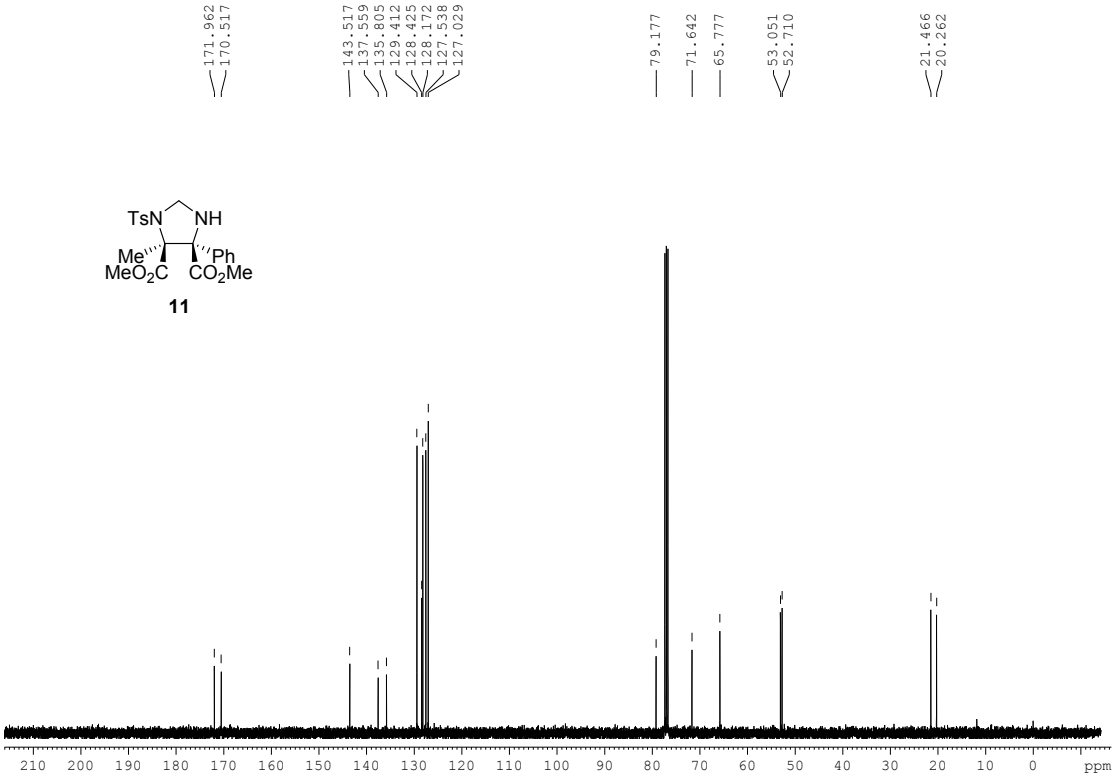

7.8281
7.8145
7.5731
7.5607
7.3536
7.3402
7.3237
7.3115
7.2988
7.2677
7.2557
7.2473
3.7574
3.7141
3.6918
3.6354
3.5728
3.5482
3.4272
3.4048
2.8024
2.7778
2.4444
CO2Me
TsO
CO2Me
N
H
Ph
6c' (minor isomer)
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 ppm
1.92
1.98
3.95
1.29
3.01
1.11
2.93
1.03
0.99
1.12
3.00


173.932
169.173
144.917
141.929
134.942
129.643
128.359
127.771
127.669
126.323
92.892
71.811
56.065
53.094
52.995
48.429
21.666
CO2Me
TsO
CO2Me
N
H
Ph
6c' (minor isomer)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


7.9230
7.6986
7.6794
7.3140
7.2922
7.2565
7.2404
3.7173
3.4116
2.4091
1.1263
TsN
N
Me
Ph
MeO2C
CO2Me
10
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
0.88
1.93
4.96
2.14
2.94
2.94
3.00
3.00


170.801
169.991
149.496
144.993
136.074
133.957
129.833
128.929
128.538
127.418
126.863
89.383
72.744
53.171
52.445
21.598
20.139
TsN
N
Me
Ph
MeO2C
CO2Me
10
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


7.6145
7.5940
7.4891
7.4801
7.4700
7.4652
7.3085
7.2976
7.2917
7.2233
7.2031
4.8582
4.8407
4.8199
4.7684
4.7506
4.7328
3.7009
3.5952
2.3844
1.4593
TsN
NH
Me
Ph
MeO2C
CO2Me
11
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
1.95
2.02
2.98
1.96
1.03
1.02
3.98
3.00
3.01
3.02


171.962
170.517
143.517
137.559
135.805
129.412
128.425
128.172
127.538
127.029
79.177
71.642
65.777
53.051
52.710
21.466
20.262
TsN
NH
Me
Ph
MeO2C
CO2Me
11
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm