Oxidative diversification of amino acids and peptides by small-molecule iron catalysis

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General Methods.

Catalysts Fe(PDP) **1** and Fe(CF_3PDP) **2** were prepared according to literature procedures.[1] The catalysts were stored at 0°C. Prior to use catalysts **1** and **2** were cooled to room temperature and weighed out in air. Acetic acid (glacial) was obtained from JT Baker and used as received. H_2O_2 (50% wt aqueous solution) was purchased from Sigma Aldrich, and used as received. Amino acid materials including L-Proline, D-Proline, L-Valine, L-Leucine, D-Allylglycine, L-Tyrosine, L-Norvaline, L-Glutamic acid dimethyl ester hydrochloride, L-Tryptophan methyl ester hydrochloride, N-Boc amino acids, amino acid methyl ester hydrochloride salts, 3-(3-Dimethylaminopropyl)-1-ethyl-carbodiimide hydrochloride (EDC), 1-hydroxybenzotriazole (HOBt, wetted with 20% water), O-(7-Azabenzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate (HATU) were purchased from Chem-Impex International, Inc. and used as received. 4-nitrophenylsulfonyl chloride (NsCl) was purchased from Sigma Aldrich and used without further purification. Diisopropylethylamine (DIPEA) and triethylamine (NEt_3) were purchased from Sigma Aldrich and distilled over calcium hydride prior to use. Metathesis catalysts Benzylidene-bis(tricyclohexylphosphine)dichlororuthenium (Grubbs I) and (1,3-Bis-(2,4,6-trimethylphenyl)-2-imidazolidinylidene)dichloro(*o*-isopropoxyphenylmethylene)ruthenium (Hoveyda-Grubbs II) were purchased from Sigma Aldrich, and stored and weighed out in an inert atmosphere glove box.

All oxidation reactions were carried out under air with magnetic stirring, with no precautions taken to exclude moisture. All other reactions were conducted in dry glassware with magnetic stirring under an inert atmosphere of dry nitrogen or argon, unless otherwise noted. Thin-layer chromatography was conducted with E. Merck silica gel 60 F254 precoated plates (0.25 mm) and visualized with $KMnO_4$ and UV. Flash column chromatography was performed as described by Still et al. using EM reagent silica gel 60 (230-400 mesh).[2]

^{1}H NMR spectra were recorded on a Varian Unity-500 (500 MHz) or Varian Unity Inova-500 (500 MHz) spectrometer, using solvent as an internal standard ($CDCl_3$ at 7.26 ppm). Data are reported as: s=singlet, d=doublet, t=triplet, q=quartet, p=pentet, oct=octet, m=multiplet,

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[1] For **1**: Chen, M. S. and White, M. C. *Science* **2007**, *318*, 783. For **2**: Gormisky, P. E. and White, M. C. *J. Am. Chem. Soc.* **2013**, *135*, 14052.

[2] Still, W. C.; Kahn, M.; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923.

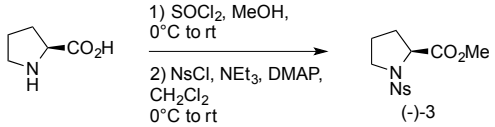
br=broad, app=apparent; coupling constants in Hz; integration. Proton-decoupled ^{13}C NMR spectra were recorded on a Varian Unity 500 (125 MHz) spectrometer and are reported in ppm using solvent as internal standard ($CDCl_3$ at 77.16 ppm, MeOH-d_4 at 49.00 ppm, Acetone-d_6 at 206.26 ppm). High resolution mass spectrometry (HRMS) was performed at the Unversity of Illinois Mass Spectrometry Laboratory (Dr. Furong Sun, Director) using a Waters Q-TOF Ultima ESI spectrometer. Infrared (IR) spectra were recorded as thin films on NaCl plates on a Perkin-Elmer Spectrum BX FT-IR and are reported in wavenumbers (cm^{-1}). Optical rotations were obtained using a JASCO DIP-360 digital polarimeter (cell dimensions: 3.5 x 50 mm) and are reported as follows $[\alpha]_D^{T/°C}$ concentration (c = g / 100 mL, solvent).

Synthesis of Nosyl amino acid methyl ester substrates.

General procedure for the N-(*p*-Nitrosulfonyl) protection of Amino-acid methyl ester hydrochloride salts.

To a glass round-bottom flask containing a Teflon stir bar was added amino-acid methyl ester hydrochloride (1 equiv) and CH_2Cl_2 (0.2 M), and the reaction was cooled to 0 °C in an ice bath. To this was added Triethylamine (NEt_3, 2.2 equiv) dropwise over 2 minutes, followed by Dimethylaminopyridine (DMAP, 0.1 equiv) and 4-Nitrosulfonyl Chroride (1.1 equiv). The reaction was stirred at 0 °C for 30 minutes, and then warmed to room temperature and monitored by TLC for conversion of the hydrochloride salt (typically 2-4 hours).

Upon completion, the reaction was transferred to a separatory funnel and washed with H_2O (1x), 1M $NaHCO_3$ (1x), and Brine (3x). (The H_2O and $NaHCO_3$ washed were each extracted with CH_2Cl_2 (1x), and the organic layers were combined before proceeding to the subsequent wash). The combined organic layers were then dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford a crude residue, which was purified via flash chromatography (Ethyl Acetate/Hexanes mixtures).



Methyl ((4-nitrophenyl)sulfonyl)-*L*-prolinate (-)-3.

(L)-Proline (2 g, 1.0 equiv., 17.3 mmol) was dissolved in MeOH (150 mL) and cooled to 0°C. Thionyl chloride (8.8 mL, 7.0 equiv., 121.6 mmol) was added slowly dropwise to the reaction, and the resulting solution was stirred overnight, allowed to gradually warm to rt. The crude solution was concentrated, with several additions of MeOH (25 mL) and concentrations to

remove thionyl chloride byproducts, to afford crude (L)-Proline methyl ester hydrochloride. The crude material was dissolved in CH_2Cl_2 (100 mL) and cooled to 0°C. To this stirring solution was added NEt_3 (5.5 mL, 2.2 equiv., 38.1 mmol), DMAP (211 mg, 0.1 equiv., 1.73 mmol), and 4-nitrophenylsulfonyl chloride (NsCl, 4.21 g, 1.1 equiv., 19 mmol). The resulting solution was stirred overnight and allowed to warm gradually to rt. The mixture was concentrated to afford a crude solid. To this solid was added 130 mL of 2:1 MeOH / H_2O, and the resulting slurry was heated to boiling until all solids dissolved. The solution was then allowed to cool to rt, resulting in the crystallization of off-white solid (crystals or needles) from a yellow solution. The product was isolated by vacuum filtration, washing with rt H_2O, and air dried for 30 min followed by further drying under high vacuum overnight, to afford (-)-**3** (3.967 g, 73% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.08 (d, *J* = 8.8 Hz, 2H), 4.46 (dd, *J* = 8.7, 3.7 Hz, 1H), 3.71 (s, 3H), 3.46 (dd, *J* = 7.3, 5.9 Hz, 2H), 2.25 – 2.12 (m, 1H), 2.09 – 1.82 (m, 3H);

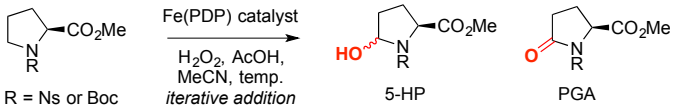
^{13}C NMR (125 MHz, Chloroform-*d*) δ 172.2, 150.2, 144.8, 128.8, 124.3, 60.7, 52.6, 48.4, 31.1, 24.9;

IR (film, cm^{-1}) 3106, 2958, 2885, 1747, 1606, 1531, 1438, 1351, 1311, 1207, 1162, 1101, 1024, 1012, 856;

HRMS (ESI) *m/z* calc'd for $C_{12}H_{15}N_2O_6S$ $[M+H]^+$: 315.0651, found 315.0652;

$[\alpha]_D^{27}$ = -79.8° (c=1.06, CH_2Cl_2).

Table S 1. Optimization of oxidation of (-)-3 to 5-HP.



R = Ns or Boc 5-HP PGA

entry	R	Fe(PDP) loading (mol%)	Equiv. H_2O_2 / AcOH per iteration	temp.	% rsm	% 5-HP	% PGA
1	Ns	1 x 5%	H_2O_2: 1.2 / AcOH: 0.5	rt	44	40	3
2	Ns	2 x 5%	H_2O_2: 1.2 / AcOH: 0.5	rt	26	46	9
3	Ns	3 x 5%	H_2O_2: 1.2 / AcOH: 0.5	rt	9	47	10
4	Ns	3 x 5%	H_2O_2: 1.2 / AcOH: 0.5	0 °C	14	60	13
5	Ns	3 x 5%	H_2O_2: 1.9 / AcOH: 0.5	0 °C	10	65	17
6	Boc	3 x 5%	H_2O_2: 1.9 / AcOH: 0.5	0 °C	5	N/A	39

General Procedure for Reaction Optimization.

The following were prepared prior to the start of the reaction: 1) 1-dram borosilicate vial(s) containing 5 mol % (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ catalyst (23.3 mg, 0.025 mmol, 0.05 equiv) one vial per iteration; 2) 2-dram borosilicate vial(s) containing a solution of H_2O_2 (50 wt% in H_2O, indicated equiv.) in 4.5 mL MeCN, one vial per iteration; 3) a single 40 mL borosilicate vial containing proline substrate (-)-**3** (157 mg, 1.0 equiv., 0.5 mmol), MeCN (1 mL), and a magnetic stir bar. The vials containing peroxide and substrate were then kept at rt or cooled to 0 °C for 5 min prior to beginning the reaction. Glacial acetic acid (14.3 μL, 0.5 equiv., 0.25 mmol) and the contents of one catalyst vial were then added to the substrate-containing vial (0.5 mL MeCN was used to rinse any remaining solid catalyst into the reaction vial). To this solution were then added the contents of a single vial containing H_2O_2 solution dropwise over the course or 2-3 min. The resulting solution was allowed to stir at the indicated temperature for 10 min. The process of addition of catalyst, acetic acid, and H_2O_2 solution were iterated the indicated number of times at ten minute intervals. The crude reaction mixture was concentrated onto silica gel and purified via flash chromatography, eluting with 9:1 $CHCl_3$/EtOAc.

Table S1, entry 1. The General Procedure was followed using a single iteration of catalyst (1 x 5 mol%), AcOH, and H_2O_2 solution (36.7 μL, 1.2 equiv., 0.6 mmol), at rt. Flash chromatography afforded rsm (69.1 mg, 44%), **5-HP** (65.1 mg, 40%), and PGA (5 mg, 3%).

Table S1, entry 2. The General Procedure was followed using two iterations of catalyst (2 x 5 mol%), AcOH, and H_2O_2 solution (36.7 μL, 1.2 equiv., 0.6 mmol), at rt. Flash chromatography afforded rsm (40.8 mg, 26%), **5-HP** (76.3 mg, 46%), and PGA (14.8 mg, 9%).

Table S1, entry 3. The General Procedure was followed using three iterations of catalyst (3 x 5 mol%), AcOH, and H_2O_2 solution (36.7 μL, 1.2 equiv., 0.6 mmol), at rt. Flash chromatography afforded rsm (14.1 mg, 9%), **5-HP** (77.6 mg, 47%), and PGA (16.4 mg, 10%).

Table S1, entry 4. The General Procedure was followed using three iterations of catalyst (3 x 5 mol%), AcOH, and H_2O_2 solution (36.7 μL, 1.2 equiv., 0.6 mmol), at 0 °C. Flash chromatography afforded rsm (22.0 mg, 14%), **5-HP** (99 mg, 60%), PGA (21.6 mg, 13%).

Table S1, entry 5. The General Procedure was followed using three iterations of catalyst (3 x 5 mol%), AcOH, and H_2O_2 solution (56.0 μL, 0.95 mmol, 1.9 equiv.), at 0 °C. Flash chromatography afforded rsm (15.7 mg, 10%), **5-HP** (107 mg, 65%), and PGA (27.3 mg, 17%).

Table S1, entry 6. The General Procedure was followed using Boc-Proline methyl ester as substrate (114.6 mg, 1.0 equiv., 0.5 mmol) and employing three iterations of catalyst (3 x 5 mol%), AcOH, and H_2O_2 solution (56.0 μL, 0.95 mmol, 1.9 equiv.), at 0 °C. Flash chromatography, eluting with 20to40to50% EtOAc / Hexanes afforded rsm (5.6 mg, 5%) and N-Boc-PGA[3] (45.1 mg, 39%) with no **5-HP** product observed.

General C-H Oxidation Procedure A.

Iterative addition of 3 x 5 mol % catalyst at 0 °C. Used for Oxidations of Ns-Pro-OMe and Proline-containing substrates: The following were prepared prior to the start of the reaction: 1) Three 1-dram borosilicate vials each containing 5 mol % (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ catalyst (23.3 mg, 0.025 mmol, 0.05 equiv.); 2) Three 2-dram borosilicate vials each containing a solution of H_2O_2 (50 wt% in H_2O, 56.0 μL, 0.95 mmol, 1.9 equiv.) in 4.5 mL CH_3CN (solutions were then placed in an ice-bath to cool for at least 5 mins); 3) A single 40 mL borosilicate vial containing the proline substrate (0.5 mmol, 1.0 equiv.), CH_3CN (1 mL) and a magnetic stir bar. The 40 mL reaction vial was then placed in an ice-bath and allowed to stir for 30 seconds before adding glacial AcOH (14.3 μL, 0.5 equiv) and the contents of a single catalyst-containing vial in one addition (0.5 mL CH_3CN was used to rinse any remaining solid catalyst into the reaction vial.). To this solution was added the contents of a single peroxide solution vial dropwise over the course of 2-3 mins (small aliquots were pipetted over in order to prevent significant warming). The resulting solution was allowed to stir for 10 mins in the ice-bath before the second round of AcOH/catalyst/oxidant was added and also allowed to stir for 10 mintues again. This process was repeated for a third and final time before the reaction was

[3] Aggarwal, V. K.; Astle, C. J.; Iding, H.; Wirz, B.; Rogers-Evans, M. *Tetrahedron Lett.* **2005**, *46*, 945-947.

analyzed by TLC. Note: For 1.0 mmol and 0.30 sized reactions, the quantities of reagents were scaled accordingly.

Purification 1: Flash chromatography. To purify the reaction by flash chromatography, the reaction was concentrated onto silica gel *in vacuo* for dry loading onto the column, and then eluted using the solvent system or gradient noted for individual products. *Note:* Dry loading directly from crude mixtures for flash chromatography was used primarily to avoid potential issues of insolubility when attempting to re-dissolve concentrated crude materials; additionally, many of the peptide products could only be efficiently dissolved in very polar, strongly eluting solvents (e.g., methanol, acetone), making wet loading unsuitable for the gradients employed in the flash purification. With any especially acid-sensitive compounds, dry loading may lead to decomposition, so care must be taken with these compounds (see compound **5** below for an example).

Purification 2: Plug purification of crude reaction mixture. When taking the product mixture on crude (as in the two-step oxidation / functionalization procedures provided below), the crude reaction mixture was poured onto a pad of packed, dry silica gel (approx. 50 mL dry volume for 0.5 mmol scale reaction) and allowed to sit for 5 min to ensure full adsorption of the crude materials onto the silica gel. Ethyl acetate (500 mL) was then passed through the plug to produce eluent that appeared clear to light yellow while the brown color (Fe catalyst byproducts) remained within the silica-gel plug. Concentration of the eluent affords crude **5-HP** (5-hydroxyproline) products for further functionalization.

General C-H Oxidation Procedure B.

25 mol % slow addition at rt: A 40 mL screwtop vial was charged with the following: substrate (0.5 mmol, 1.0 equiv), CH_3CN (1.0 mL, 0.5 M), AcOH (14.3 μL, 0.25 mmol, 0.5 equiv) and a magnetic stir bar. The vial was placed on a stir plate and stirred vigorously at room temperature while open to atmosphere. A 1.0 mL syringe was loaded with a solution of $Fe(PDP)(MeCN)_2(SbF_6)_2$ catalyst (116.5 mg, 0.125 mmol, 25 mol %) in CH_3CN (0.625 mL, 0.2 M) and placed on a syringe pump set with an addition rate of 0.5 mL/1 h (0.0083 mL/min). Secondly, a 10 mL syringe was loaded with a solution of H_2O_2 (50 wt % in H_2O, 170 μL, 2.5 mmol, 5.0 equiv) in CH_3CN (6.25 mL, 0.4 M) and also placed onto a syringe pump set to the same addition rate of 5 mL/1 h (0.083 mL/min). Both syringes were equipped with 26G needles and directed into the center of the uncapped vial (note: precautions should be taken not to touch

the sides of the vial with the needle tips). The two additions were initiated simultaneously so that both solutions of Fe(PDP) catalyst and H_2O_2 were added to the reaction vial over the course of 75 min. The crude mixture was concentrated onto a small amount of silica gel via rotary evaporation and purified by flash chromatography. Procedure B was used to form products (+)-**27**, (+)-**33**, (-)-**42**, (-)-**49**, (-)-**51**, and (-)-**53**.

General C-H Oxidation Procedure C.

25 mol% Fe catalyst with elevated H_2O_2 and AcOH at rt: The General procedure B was followed, instead using H_2O_2 (9.0 equiv.) in CH_3CN (6.25 mL, 0.72 M) and AcOH (5.0 equiv.). Procedure C was used to form products (-)-**4,** (-)-**35,** and (+)-**38**. Additionally, a modified Procedure C was used to form product (+)-**30**.

Selection of slow addition method. When examining a new substrate for oxidation with Fe(PDP) or Fe(CF_3PDP), it is recommended to begin with **Procedure B.** In cases where low conversion is observed, we then recommend **Procedure C** in order to increase conversion. If further experimentation is required, it is possible to vary the ratios of H_2O_2 and AcOH. The importance of acetic acid in Fe / H_2O_2 oxidations is discussed elsewhere.[4]

Selection of enantiomer for Fe(PDP) oxidations. In general, either (*S,S*)-Fe(PDP) or (*R,R*)-Fe(PDP) can be selected to perform the reactions contained herein without a significant change in product distribution or yield. For most oxidations of proline containing substrates, (*S,S*)-Fe(PDP) was employed. In the case of oxidations of monomeric amino acid substrates, the enantiomer was selected on the basis of availability at the time the reactions were performed. The enantiomer used is noted for each individual substrate.

Selection of nitrogen protecting group. *Ortho*-Nosyl, N-Boc, N-phenylsulfonyl, N-(4-bromo)phenylsulfonyl, and N-Acetyl variants of amino acid esters were also examined for the oxidation reactions. These protecting groups suffered from poor conversion (presumably via nitrogen binding and inactivation at the Fe center) and/or poor stability of the group to the oxidative conditions of the reaction. Thus, the *para*-Nosyl group appears to be uniquely effective nitrogen protecting group for this reaction under the conditions evaluated.

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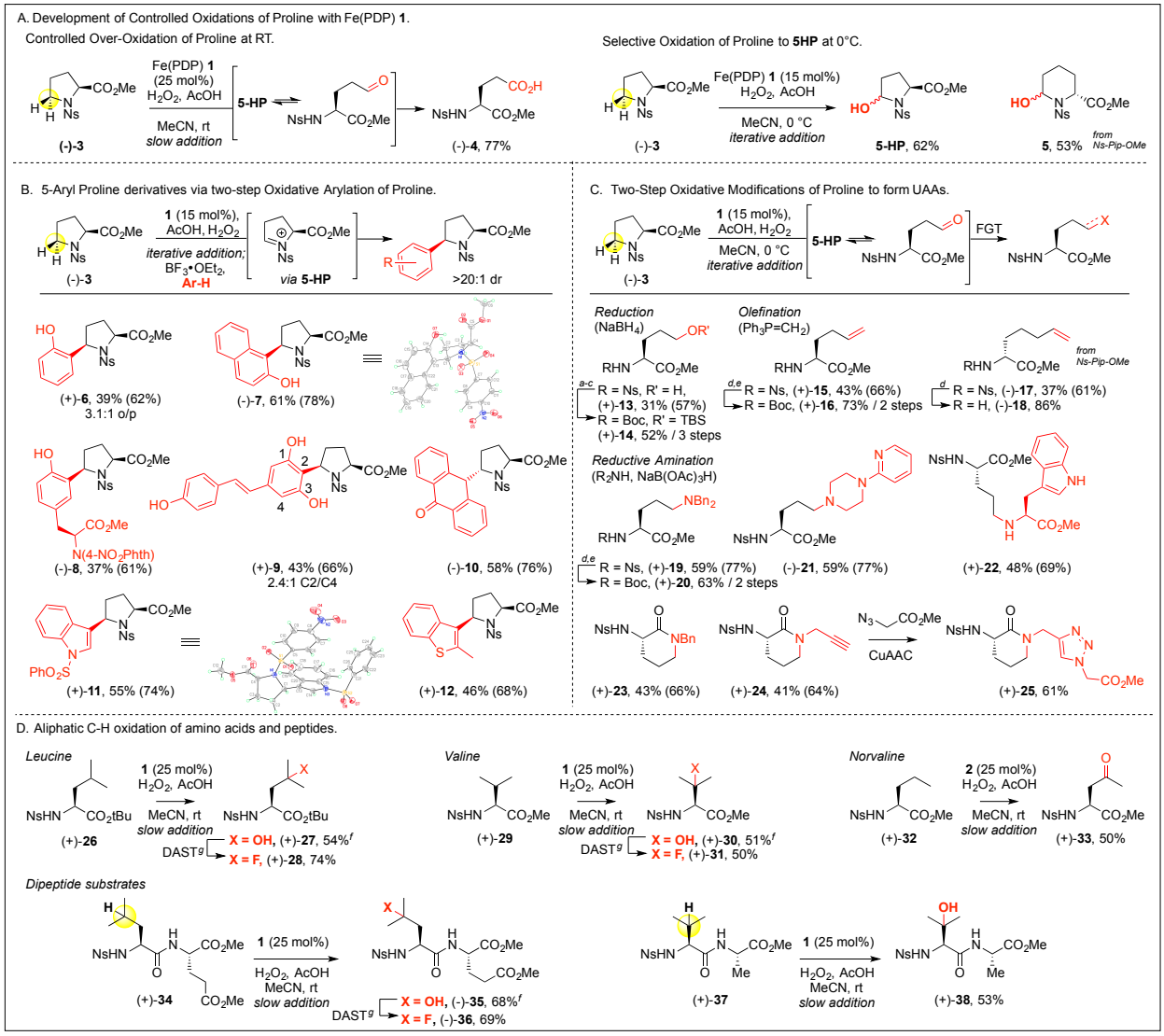
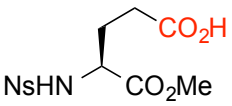
[4] a) White, M. C.; Doyle, A. G.; & Jacobsen, E. N. *J. Am. Chem. Soc.* **2001**, *123*, 7194-5; b) Chen, M. S. & White, M. C. *Science*, **2007**, *318*, 783; c) Mas-Balleste, R. & Que, Jr., L. *J. Am. Chem. Soc*. **2007**, *129*, 15964; d) Bigi, M. A.; Reed, S. A.; & White, M. C. *Nature Chemistry* **2011**, *3*, 216-222; e) Bigi, M. A.; Reed, S. A.; & White, M. C. *J. Am. Chem. Soc*. **2012**, *134*, 9721.

Figure S 1. Unnatural amino acids via Fe catalyzed hydroxylation and derivatization of proline and other amino acids.





(*S*)-5-methoxy-4-((4-nitrophenyl)sulfonamido)-5-oxopentanoic acid (-)-4.

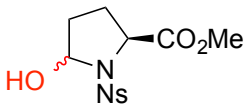
Nosyl Proline methyl ester **(-)-3** was reacted with (*R,R*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (116.5 mg, 0.25 eq, 0.125 mmol), AcOH (143 uL, 5.0 eq, 2.5 mmol), and H_2O_2 (276 uL, 9.0 eq, 4.5 mmol) according to **Procedure C**. The crude mixture was purified by flash chromatography on silica using 5% MeOH/$CHCl_3$ + 0.5% AcOH to yield (-)-**4**. Run 1: 129.8 mg, 0.375 mmol, 75%. Run 2: 134.1 mg, 78%. Average: 77%.

^{1}H NMR (500 MHz, Methanol-d_4) δ 8.38 (d, *J* = 8.8 Hz, 2H), 8.06 (d, *J* = 8.8 Hz, 2H), 4.08 (dd, *J* = 5.1, 9.25 Hz, 1H), 3.47 (s, 3H), 2.38 (t, *J* = 7.3 Hz, 2H), 2.10-2.03 (m, 1H), 1.85-1.77 (m, 1H);

^{13}C NMR (125 MHz, Methanol-d_4) δ 175.9, 172.8, 151.4, 147.9, 129.5, 125.2, 56.4, 54.8, 52.7, 30.4, 28.8;

HRMS (ESI) calc'd for: $C_{12}H_{15}N_2O_8S$ $[M+H]^+$: 347.0549, found: 347.0552;

$[\alpha]_D^{26}$ = -9.7° (c = 0.98, MeOH).



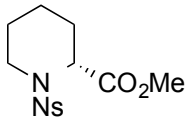
Methyl (2*S*)-5-hydroxy-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (5-HP).

Nosyl-Proline methyl ester **(-)-3** (157 mg, 1.0 eq, 0.5 mmol) was reacted with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH according to **Procedure A**. The crude reaction mixture was purified by flash chromatography using 9:1 $CHCl_3$:EtOAc. Run 1: **5-HP** (102.7 mg, 0.31 mmol, 62%); Run 2: **5-HP** (102.0 mg, 0.31 mmol, 62%). Average 62%. Isolated as an inseparable mixture of C5-epimers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.35 Hz, 4H), 8.10 (d, *J* = 8.8 Hz, 4H), 5.68 (br s, 1H), 5.61 (d, *J* = 3.85, 1H), 4.52 (d, *J* = 9.15 Hz, 1H), 4.43 (m, 1H), 3.65 (s, 3H), 3.63 (s, 3H), 2.85-2.76 (m, 1H), 2.62-2.52 (m, 1H), 2.32-2.25 (m, 1H), 2.20-2.05 (m, 3H), 2.00-1.92 (m, 2H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.8, 171.7, 150.22, 145.6, 128.9, 124.2, 85.6, 84.6, 60.7, 60.2, 53.0, 52.6, 34.3, 32.9, 29.1, 28.3;

HRMS (ESI) calc'd for: $C_{12}H_{13}N_2O_6$ $[M-OH]^+$: 313.0494, found: 313.0479.



Methyl (R)-1-((4-nitrophenyl)sulfonyl)piperidine-2-carboxylate S-1.

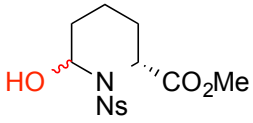
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.3 (d, *J* = 8.9 Hz, 2H), 7.9 (d, *J* = 8.9 Hz, 2H), 4.8 (d, *J* = 4.6 Hz, 1H), 3.9 – 3.8 (m, 1H), 3.6 (s, 3H), 3.2 (td, *J* = 12.7, 2.8 Hz, 1H), 2.2 – 2.1 (m, 1H), 1.8 (tdd, *J* = 13.6, 5.9, 3.5 Hz, 1H), 1.7 – 1.6 (m, 2H), 1.6 – 1.5 (m, 1H), 1.2 (qt, *J* = 14.0, 3.6 Hz, 1H);

^{13}C NMR (125 MHz, Chloroform-*d*) δ 170.8, 149.9, 145.8, 128.5, 124.1, 55.5, 52.3, 43.1, 28.0, 24.9, 20.2;

IR (film, cm-1) 2951, 1739, 1531, 1350, 1244, 1188, 1161, 1111, 1059, 947, 856, 743;

HRMS (ESI) *m/z* calc'd for $C_{27}H_{40}N_{45}O_9S$ $[M+H]^+$: 329.0807, found 329.0804;

$[\alpha]_D^{27}$ = +21.6° (c = 1.1, $CHCl_3$).



Methyl (2*R*)-6-hydroxy-1-((4-nitrophenyl)sulfonyl)piperidine-2-carboxylate (5).

(+)-Nosyl-Pipecolic acid methyl ester **S-1** (Parallel reactions, 2 x 656.6 mg, 1.0 eq, 2.0 mmol total starting material) was reacted with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH in MeCN according to **Procedure A**. The crude reaction mixture was purified by flash chromatography on silica using 3:1→3:2 Hexanes:EtOAc. (Note: the hemiaminal product of this reaction is less stable than 5HP, and care must be taken when concentrating the crude reaction mixture onto silica gel for chromatography. Excessively long times on the rotary evaporator (>30 min) or excessively high temperatures (>30°C) resulted in greatly reduced yields.) Run 1: 343.8 mg, 50%. Run 2: 381.4 mg, 55%. Average: 53%. Isolated as an inseparable mixture of C6-epimers.

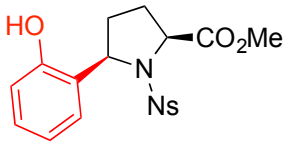
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.32 (d, *J* = 9.0 Hz, 2H), 8.08 (d, *J* = 9.0 Hz, 2H), 5.69 (dt, *J* = 2.55, 8.55 Hz, 1H), 4.85 (dd, *J* = 1.65, 6.6 Hz, 1H), 4.62 (d, *J* = 8.4 Hz, 1H), 3.60 (s, 3H), 2.15-2.12 (m, 1H), 2.12-2.08 (m, 1H), 1.99-1.94 (m, 1H), 1.90-1.80 (m, 1H), 1.68-1.63 (m, 2H), 1.58-1.54 (m, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 174.1, 150.3, 145.7, 129.2, 124.1, 76.6, 54.9, 53.3, 32.5, 27.4, 13.4;

HRMS (ESI) calc'd for: $C_{13}H_{15}N_2O_6S$ [M-OH]+: 327.0651, found: 327.0645.

Standard procedure for 2-step oxidation / arylation sequence. Nosyl proline methyl ester **(-)-3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude residue was dissolved in CH_2Cl_2 (1.5 mL) and transferred to a flame-dried 40mL scintillation vial under inert atmosphere. Nucleophile (1.0 eq, 0.5 mmol) was added as a solution in CH_2Cl_2 (1 mL) and the stirring mixture cooled to -78°C. BF_3OEt_2 (123 μL, 2.0 eq, 1.0 mmol) was added dropwise to the reaction, and the mixture was stirred at -78°C for 1h, then warmed to 0 °C for 2h. The crude reaction was then concentrated onto silica gel and purified by flash chromatography.

Note on the diastereoselectivity of the arylation. A plausible explanation for *syn*-diastereoselectivity is as follows: In the N-Nosyl iminium intermediate, the C2 methyl ester is pointing "up", so it is reasonable that the large nitrophenylsulfonyl group may orient itself away ("down") to avoid steric interactions, thus sterically blocks the bottom face. The result ofthis conformation is a top-face nucleophilic attack, resulting in *syn*-configuration relative to the C2 methyl ester.



Methyl-(2*S*,5*R*)-5-(2-hydroxyphenyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (+)-6.

Nosyl proline methyl ester **(-)-3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with phenol (47.1 mg, 1.0 eq, 0.5 mmol) according to the Standard Procedure was then performed. The crude reaction was concentrated onto silica gel and purified by flash chromatography on silica eluting with 20% EtOAc/Hexanes

to afford (+)-**6** as a 3.1:1 mixture of *ortho*/*para* isomers. Run 1: 79.7 mg, 39%. Run 2: 78.4 mg, 39%. Average: 39% (62% per step). Further purification of the regioisomers by flash chromatography (18% EtOAc/Hexanes → 30%) yielded the major *ortho* isomer (+)-**6** as a single regio- and diastereomer.

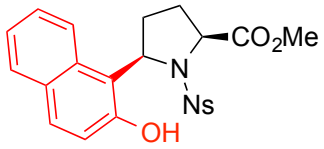
Ortho-substitution for the major isomer was established on the basis of the 1H NMR data, which showed 4 distinct signals attributed to the phenol group, consistent with *ortho* substitution. 2,*5*-*Syn*-stereochemistry was assigned by 1D NOE experiments, which are consistent with a *syn* relationship between the 2- and 5- protons of the proline ring. This is analogous to 1D NOE signals for (-)-**7** (naphthol adduct), (+)-**11** (indole adduct), and (+)-**12** (benzothiophene adduct) which have also been confirmed by X-Ray crystal structure.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.50 (s, 1H), 8.38 (d, *J* = 8.9 Hz, 2H), 8.03 (d, *J* = 8.9 Hz, 2H), 7.69 (dd, *J* = 1.3, 7.6 Hz, 1H), 7.04 (dt, *J* = 1.6, 7.9 Hz, 1H), 6.76 (d, *J* = 8.0 Hz, 1H), 6.73 (dt, *J* = 0.9, 7.6 Hz, 1H), 5.17 (t, *J* = 6.75 Hz, 1H), 4.61 (t, 6.3 Hz, 1H), 3.82 (s, 3H), 2.21-2.12 (m, 2H), 2.06-1.99 (m, 1H), 1.96-1.88 (m, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 175.5, 154.7, 150.0, 143.9, 130.6, 130.3, 129.2, 123.3, 121.2, 120.3, 118.2, 65.8, 60.9, 53.7, 31.6, 29.3;

HRMS (ESI) calc'd for: $C_{18}H_{17}N_2O_7S$ $[M-H]^-$: 405.0756, found: 405.0749;

$[\alpha]_D^{26}$ = +56.2° (c = 1.07, CH_2Cl_2).



Methyl-(2*S*,5*R*)-5-(2-hydroxynaphthalen-1-yl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (-)-7.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with 2-naphthol (144.2 mg, 2.0 eq, 1.0

mmol) according to the Standard Procedure was then performed. The crude reaction was concentrated onto silica gel and purified by flash chromatography on silica eluting with 4:1→2:1 Hexanes/EtOAc afforded (-)-**7** as a single regio- and diastereomer. Run 1: 139.7 mg, 61%. Run 2: 138.0 mg, 60%. Average: 61% (78% per step).

2,5-Syn-stereochemistry was assigned by obtaining an X-Ray crystal structure of (-)-**7**, and 1D NOE experiments are also consistent with a *syn* relationship between the 2- and 5- protons of the proline ring.

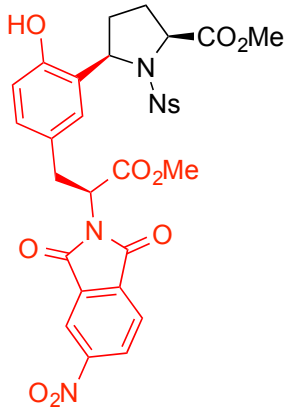
^{1}H NMR (500 MHz, Chloroform-d) δ 8.38 (s, 1H), 8.01 (d, J = 8.7 Hz, 1H), 7.83 (d, J = 8.8 Hz, 2H), 7.74 (d, J = 8.0 Hz, 1H), 7.55 (t, J = 7.6 Hz, 1H), 7.50 (d, J = 8.9 Hz, 1H), 7.43 (d, J = 8.9 Hz, 2H), 7.38 (t, J = 7.4 Hz, 1H), 6.54 (d, J = 8.8 Hz, 1H), 5.76 (dd, J = 11.2, 6.1 Hz, 1H), 5.15 (d, J = 9.1 Hz, 1H), 3.97 (s, 3H), 2.54 (tdd, J = 12.5, 10.5, 6.5 Hz, 1H), 2.44 (qd, J = 12.7, 6.4 Hz, 1H), 2.32 (dq, J = 14.0, 6.5 Hz, 2H);

^{13}C NMR (126 MHz, Chloroform-d) δ 175.6, 153.7, 150.2, 143.1, 132.6, 130.6, 129.3, 129.1, 129.0, 127.5, 123.5, 123.1, 121.0, 120.1, 112.0, 60.5, 59.9, 53.9, 30.7, 29.3;

IR (film, cm^{-1}) 3384, 3104, 2958, 1737, 1621, 1602, 1531, 1471, 1440, 1349, 1313, 1220, 1160, 1089;

HRMS (ESI) *m/z* calc'd for $C_{22}H_{21}N_2O_7S$ $[M+H]^+$: 457.1069, found 457.1069;

$[\alpha]_D^{28}$ = -37.8° (c = 1.12, CH_2Cl_2).



Methyl-(2*S*,5*R*)-5-(2-hydroxy-5-((*S*)-3-methoxy-2-(5-nitro-1,3-dioxoisoindolin-2-yl)-3-oxopropyl)phenyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (-)-8.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with N-(4-nitrophthaloyl)-Tyrosine methyl ester (185.2 mg, 1.0 eq, 0.5 mmol) according to the Standard Procedure was then performed. The crude reaction was concentrated onto silica gel and purified by flash chromatography on silica eluting with 25%→40% EtOAc/Hexanes afforded (-)-**8** as a single regio- and diastereomer. Run 1: 123 mg, 36% yield. Run 2: 129.8 mg, 38% yield. Average: 37% (61% per step).

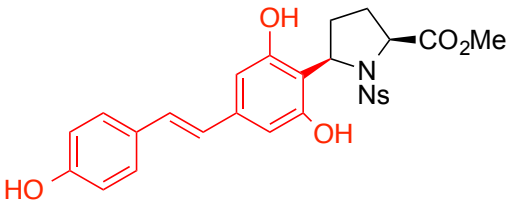
Ortho-substitution was assigned based on the 1H NMR data, which display 3 distinct peaks and chemical shift values consistent with substitution *ortho* to the phenol moiety. *2,5-Syn*-stereochemistry was assigned by 1D NOE experiments, which are consistent with a *syn* relationship between the 2- and 5- protons of the proline ring. This is analogous to 1D NOE signals for (-)-**7** (naphthol adduct), (+)-**11** (indole adduct), and (+)-**12** (benzothiophene adduct) which have also been confirmed by X-Ray crystal structure.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.55-8.51 (m, 2H), 8.07 (d, *J* = 8.95 Hz, 2H), 7.92 (d, *J* = 8.15 Hz, 1H), 7.39 (s, 1H), 7.29 (d, *J* = 8.85 Hz, 2H), 6.96 (dd, *J* = 2.15, 8.25 Hz, 1H), 6.80 (d, *J* = 2.2 Hz, 1H), 6.31 (d, *J* = 8.3 Hz, 1H), 5.12 (dd, *J* = 5.05, 11.45 Hz, 1H), 4.91 (d, *J* = 9.05 Hz, 1H), 4.57 (dd, *J* = 6.15, 10.9 Hz, 1H), 3.85 (s, 3H), 3.83 (s, 3H), 3.55-3.45 (m, 2H), 2.34-2.25 (m, 1H), 2.24-2.09 (m, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ175.3, 168.7, 165.8, 165.6, 153.9, 151.8, 150.1, 143.9, 135.9, 132.9, 131.2, 130.6, 129.5, 128.8, 128.1, 124.9, 123.6, 121.8, 119.1, 118.7, 66.0, 61.1, 54.4, 53.7, 53.3, 33.4, 31.5, 29.2;

HRMS (ESI) calc'd for: $C_{30}H_{25}N_4O_{13}S$ $[M-H]^-$: 681.1139, found: 681.1133;

$[\alpha]_D^{26}$ = -99.0° (c = 1.15, CH_2Cl_2).



Methyl-(2*S*,5*R*)-5-(2,6-dihydroxy-4-((*E*)-4-hydroxystyryl)phenyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (+)-9.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with resveratrol (114.1 mg, 2.0 eq, 1.0 mmol) according to the Standard Procedure was then performed. The crude reaction was concentrated onto silica gel and purified by flash chromatography on silica eluting with 5:1 $CHCl_3$/EtOAc to afford (+)-**9** as a 2.4:1.0 mixture of C2/C4 isomers. Run 1: 116.2 mg, 43%; Run 2: 116.4 mg, 43%. Average: 43% (66% per step).

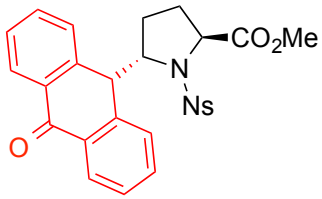
The mixture was dissolved in 10:1 CH_2Cl_2/Acetone in a 1-dram vial and that vial was placed uncapped into a 20 mL scintillation vial containing pentane, which was then capped and allowed to sit for 24h. Upon sitting, small amounts of the pure 2-isomer (+)-**9** crystallized and were sufficient for characterization. The structure was assigned as the 2-isomer on the basis of the ^1H and ^{13}C NMR data, which display the expected number of peaks and splitting patterns consistent with symmetrical substitution (at C2) on the resveratrol fragment.

^1H NMR (500 MHz, Acetone-d_6) δ 8.43 (s, 3H), 8.32 (d, J = 8.9 Hz, 2H), 8.05 (d, J = 8.9 Hz, 2H), 7.41 (d, J = 8.5 Hz, 2H), 6.96 (d, J = 16.3 Hz, 1H), 6.84 (d, J = 8.6 Hz, 2H), 6.81 (d, J = 16.3 Hz, 1H), 6.45 (s, 2H), 5.25 (dd, J = 6.2, 10.1 Hz, 1H), 4.79-4.75 (m, 1H), 3.87 (s, 3H), 2.27-2.10 (m, 4H);

^{13}C NMR (125 MHz, Acetone-d_6) δ 175.5, 158.2, 157.1, 151.3, 143.2, 139.9, 130.5, 129.9, 129.4, 128.8, 126.2, 124.7, 116.4, 110.6, 106.7, 62.2, 58.9, 53.6, 31.1, 30.6;

HRMS (ESI) calc'd for: $C_{26}H_{24}N_2O_9NaS$ $[M+Na]^+$: 563.1100, found: 563.1099;

$[\alpha]_D^{26}$ = +51.4° (c = 0.81, MeOH).



Methyl-(2*S*,5*S*)-1-((4-nitrophenyl)sulfonyl)-5-(10-oxo-9,10-dihydroanthracen-9-yl)pyrrolidine-2-carboxylate (-)-10.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with anthrone (97.1 mg, 1.0 eq, 0.5 mmol) according to the Standard Procedure was then performed. The crude reaction was loaded directly onto a silica gel column and purified by flash chromatography eluting with CH_2Cl_2 to afford (-)-**10** as a single regio- and diastereomer. Run 1: 153 mg, 60%. Run 2: 142 mg, 56%. Average: 58% (76% per step).

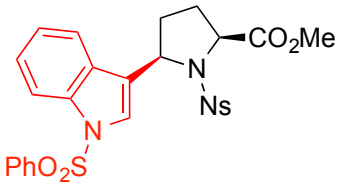
2,5-anti-stereochemistry was assigned on the basis of 2D NMR experiments, as well as the absence of a significant NOE signal between the 2- and 5- protons of the proline ring consistent with the assigned *anti* configuration.

^{1}H NMR (500 MHz, Acetone-d_6) δ 8.56 (d, J = 8.8 Hz, 2H), 8.39 (d, J = 8.8 Hz, 2H), 8.27 (d, J = 6.9 Hz, 1H), 8.21 (d, J = 7.8 Hz, 1H), 7,82-7.70 (m, 4H), 7.62 (t, J = 7.1 Hz, 1H), 7.55 (t, 7.4 Hz, 1H), 5.28 (d, J = 3.3 Hz, 1H), 4.42 (dd, J = 3.4, 8.8 Hz, 1H), 4.30 (d, J = 8.8 Hz, 1H), 3.47 (s, 3H), 1.75-1.61 (m, 1H), 1.33 (dd, J = 7.4, 13.0 Hz, 1H), 1.16 (dd, J = 7.1, 13.5 Hz, 1H), 0.36-0,18 (m, 1H);

^{13}C NMR (126 MHz, Chloroform-d) δ 184.7, 171.9, 150.4, 144.6, 141.6, 139.6, 133.7, 133.3, 132.9, 132.8, 129.8, 129.5, 128.5, 128.3, 128.0, 127.9, 124.2, 68.3, 63.3, 52.5, 45.9, 28.5, 25.5;

HRMS (ESI) *m/z* calc'd for $C_{26}H_{23}N_2O_7S$ $[M+H]^+$: 507.1226, found 507.1234;

$[a]_D^{27}$ = -35.9° (c=0.57, CH_2Cl_2).



Methyl (2*S*,5*R*)-1-((4-nitrophenyl)sulfonyl)-5-(1-(phenylsulfonyl)-1*H*-indol-3-yl)pyrrolidine-2-carboxylate (+)-11.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with N-phenylsulfonyl indole (128.7 mg, 1.0 eq, 0.5 mmol) according to the Standard Procedure was then performed. The crude reaction was concentrated onto silica gel and purified by flash chromatography on silica eluting with 20%→40% EtOAc/Hexanes to afford (+)-**11** as a single regio- and diastereomer. Run 1: 168 mg, 59%. Run 2: 142.8 mg, 50%. Average: 55% (74% per step).

2,5-Syn-stereochemistry was assigned by obtaining an X-Ray crystal structure, and 1D NOE experiments are also consistent with a *syn* relationship between the 2- and 5- protons of the proline ring.

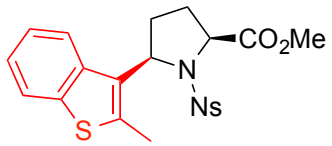
^{1}H NMR (500 MHz, Chloroform-d) δ 7.96 (d, J = 8.2 Hz, 2H), 7.74 (d, J = 8.4 Hz, 1H), 7.65 – 7.59 (m, 2H), 7.58 – 7.49 (m, 7H), 7.16 (t, J = 7.8 Hz, 1H), 7.04 (t, J = 7.6 Hz, 1H), 5.05 (t, J = 7.1 Hz, 1H), 4.88 (dd, J = 9.3, 4.0 Hz, 1H), 3.89 (s, 3H), 2.46 – 2.35 (m, 1H), 2.33 – 2.24 (m, 1H), 2.22 – 2.12 (m, 2H);

^{13}C NMR (126 MHz, Chloroform-d) δ 173.0, 149.3, 144.4, 138.5, 135.1, 134.4, 129.7, 129.1, 127.8, 127.2, 126.1, 125.0, 123.2, 123.1, 120.8, 119.5, 113.4, 61.0, 58.8, 53.0, 32.7, 29.3;

IR (film, cm^{-1}) 3106, 3070, 2954, 1749, 1606, 1531, 1448, 1351, 1313, 1174, 1124, 1095;

HRMS (ESI) *m/z* calc'd for $C_{26}H_{24}N_3O_8S_2$ $[M+H]^+$: 570.1005, found 570.1005;

$[\alpha]_D^{28}$ = +11.8° (c = 1.60, CH_2Cl_2).



Methyl (2*S*,5*R*)-5-(2-methylbenzo[*b*]thiophen-3-yl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (+)-12.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. Arylation with 2-methylbenzothiophene (74.1 mg, 1.0 eq, 0.5 mmol) according to the Standard Procedure was then performed. The crude reaction was concentrated onto silica gel and purified by flash chromatography on silica eluting with 10%→20%→25%→30%→40% EtOAc/Hexanes to afford (+)-**12** as a single regio- and diastereomer. Run 1: 108.2 mg, 47%. Run 2: 103.8 mg, 45%. Average: 46% (68% per step). Crystals suitable for X-ray diffraction were obtained by dissolving (+)-**12** in minimal CH_2Cl_2 in a 1-dram vial, and placing that vial uncapped in a 20 mL scintillation vial containing pentane, which was capped and allowed to sit for 12h.

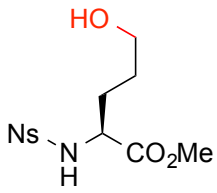
2,5-Syn-stereochemistry was assigned by obtaining an X-Ray crystal structure of (+)-**12**, and 1D NOE experiments are also consistent with a *syn* relationship between the 2- and 5- protons of the proline ring.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.1 Hz, 1H), 7.56 (d, *J* = 8.8 Hz, 2H), 7.46 (d, *J* = 8.8 Hz, 2H), 7.33 (d, *J* = 7.9 Hz, 1H), 7.07 (t, *J* = 7.3 Hz, 1H), 7.01 (t, *J* = 7.4 Hz, 1H), 5.11 (dd, *J* = 5.6, 10.9 Hz, 1H), 5.03 (dd, *J* = 2.3, 10.4 Hz, 1H), 2.63-2.46 (m, 5H, overlap includes a singlet ~2.60, ~3H), 2.40-2.34 (m, 1H), 2.16-2.11 (m, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.27, 148.6, 143.7, 140.4, 137.5, 128.4, 125.7, 123.9, 123.7, 123.1, 122.1, 121.4, 59.9, 59.3, 52.8, 30.7, 28.8, 14.1;

HRMS (ESI) calc'd for: $C_{21}H_{21}N_2O_6S_2$ [M+H]+: 461.0841, found: 461.0834;

$[\alpha]_D^{28}$ = +34.1° (c = 1.03, CH_2Cl_2).



Methyl (*S*)-5-hydroxy-2-((4-nitrophenyl)sulfonamido)pentanoate (+)-13.

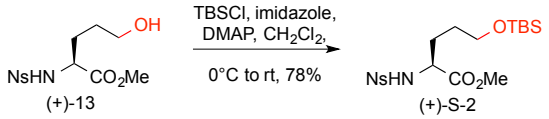
Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude residue was dissolved in 1:1 CH_2Cl_2 / EtOH (8 mL) and cooled to 0°C. $NaBH_4$ (23 mg, 0.6 mmol, 1.2 eq) was added in a few portions and the reaction allowed to warm to RT. After 2h complete conversion of hemiaminal was observed by TLC. The crude reaction mixture was concentrated onto silica gel and purified by flash chromatography eluting with 2.5%→ 4% MeOH/CH_2Cl_2 to afford (+)-**13**. Run 1: 53.6 mg, 32%. Run 2: 49.8 mg, 30%. Average: 31% (57% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.34 (d, *J* = 8.6 Hz, 2H), 8.04 (d, *J* = 8.6 Hz, 2H), 4.06 (dd, *J* = 4.8, 7.8 Hz, 1H), 3.71-3.63 (m, 2H), 3.54 (s, 3H), 1.95-1.88 (m, 1H), 1.85-1.78 (m, 1H), 1.68-1.61 (m, 2H), 1.12 (t, *J* = 7.1 Hz, 1H, R-O<u>H</u>);

^{13}C NMR (125 MHz, $CDCl_3$) δ 171.9, 150.2, 145.9, 128.6, 124.4, 62.0, 55.8, 52.9, 30.2, 27.9;

HRMS (ESI) calc'd for: $C_{12}H_{15}N_2O_7S$ $[M-H]^-$: 331.0600, found: 331.0603;

$[\alpha]_D^{26}$ = +27.2° (c = 1.5, $CHCl_3$).



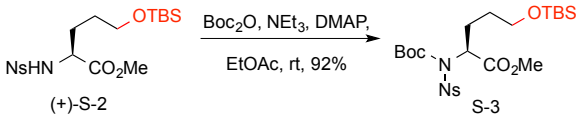
Alcohol (+)-**13** (100 mg, 1.0 equiv., 0.3 mmol) in CH_2Cl_2 (2 mL) was cooled to 0°C, and tert-butyldimethylsilyl chloride (TBSCl, 54.2 mg, 1.2 equiv., 0.36 mmol), imidazole (30.6 mg, 1.5 equiv., 0.45 mmol), and 4-dimethylaminopyridine (DMAP, 7.3 mg, 0.05 equiv., 0.06 mmol) were added sequentially. The reaction was stirred for 2.5 h and concetrated. Flash chromatography of the crude reaction mixture, eluting with 15 to 20% EtOAc/Hexanes, afforded silyl ether product **S-2** (105.1 mg, 78% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.9 Hz, 2H), 8.0 3(d, *J* = 8.9 Hz, 2H), 5.79 (d, *J* = 9.0 Hz, 1H), 4.05 (ddd, *J* = 5.0, 7.6, 8.9 Hz, 1H), 3.63-3.57 (m, 2H), 3.54 (s, 3H), 1.91-1.75 (m, 2H), 1.59-1.49 (m, 2H), 0.87 (s, 9H), 0.04 (s, 6H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 171.9, 150.2, 146.1, 128.6, 124.3, 62.2, 55.8, 52.7, 30.2, 28.1, 26.0, 18.4, -5.3;

HRMS (ESI) calc'd for $C_{18}H_{29}N_2O_7SSi$ $[M-H]^-$: 445.1465, found: 445.1459;

$[\alpha]_D^{27}$ = +21.2° (c = 1.08, $CHCl_3$).

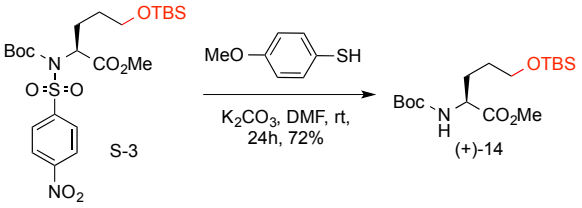


Compound **S-2** (50 mg, 1.0 equiv., 0.11 mmol) was dissolved in EtOAc (1 mL) at RT, and triethylamine (NEt_3, 13.1 mg, 1.2 equiv., 0.13 mmol) in 0.5 mL EtOAc, DMAP (15.9 mg, 1.2 equiv., 0.13 mmol), and Boc_2O (48.0 mg, 2.0 equiv., 0.22 mmol) in 0.5 mL EtOAc were added sequentially. The reaction was stirred for 30 min and concentrated. Flash chromatography of the crude residue, eluting with 9:1 Hexanes/EtOAc, afforded N-Boc(Ns) bis-protected intermediate **S-3** (55.3 mg, 92% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, J = 8.9 Hz, 2H), 8.28 (d, J = 8.9 Hz, 2H), 5.07 (dd, J = 5.1, 10.0 Hz, 1H), 3.74 (s, 3H), 3.71 (t, J = 6.0 Hz, 2H), 2.35-2.27 (m, 1H), 2.15-2.06 (m, 1H), 1.76-1.65 (m, 2H), 1.30 (s, 9H), 0.90 (s, 9H), 0.06 (s, 6H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 170.4, 150.5, 149.7, 145.3, 130.2, 123.8, 86.0, 62.4, 60.0, 52.8, 29.8, 27.9, 27.0, 26.1, 18.5, -5.16;

HRMS (ESI) calc'd for $C_{23}H_{38}N_2O_9SSiNa$ $[M+Na]^+$: 569.1965, found: 569.1967.



(+)-**14.** N-Boc(Ns) bis-protected intermediate **S-3** (55 mg, 1.0 equiv., 0.1 mmol) was dissolved in DMF (0.75 mL) at rt. p-methoxythiophenol (42.1 mg, 3.0 equiv., 0.3 mmol) in DMF (0.5 mL) was added to the reaction, followed by K_2CO_3 (55.3 mg, 4.0 equiv., 0.4 mmol). The resulting bright yellow slurry was stirred rapidly at rt for 24h, diluted with EtOAc and partitioned between EtOAc and sat. brine solution. The organic layer was dried over Na_2SO_4 and concetrated. Flash chromatography of the crude residue, eluting with 5% to 7% to 10% EtOAc/Hexanes afforded N-Boc protected bishomoserine derivative (+)-**14** (26.2 mg, 72% yield).

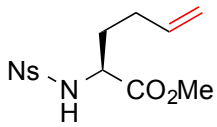
^{1}H NMR (500 MHz, $CDCl_3$) δ 5.18 (br d, J = 7.7 Hz, 1H), 4.29 (app q, J = 7.7 Hz, 1H), 3.73 (s, 3H), 3.61 (t, J = 6.1 Hz, 2H), 1.90-1.83 (m, 1H), 1.75-1.67 (m, 2H), 1.60-1.52 (m, 2H), 1.43 (s, 9H), 0.88 (s, 9H), 0.04 (s, 6H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.5, 155.5, 79.9, 62.5, 53.4, 52.3,29.2, 28.6, 28.5, 26.1, 18.5, -5.2;

HRMS (ESI) calc'd for $C_{17}H_{35}NO_5SiNa$ $[M+Na]^+$: 384.2182, found: 384.2176;

$[\alpha]_D^{27}$ = +7.5° (c = 0.77, $CHCl_3$).

These data are in agreement with the literature report.[5]



Methyl (*S*)-2-((4-nitrophenyl)sulfonamido)hex-5-enoate (+)-15.

Wittig Reagent Preparation: A flame-dried flask under inert atmosphere was charged with methyltriphenylphosphonium bromide (535 mg, 3.0 eq, 1.5 mmol) in THF (6 mL) and cooled to 0°C. Sodium tert-butoxide (151 mg, 2.7 eq, 1.35 mmol) was added in one portion and the reaction allowed to warm to rt, stirring for 12h.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude residue was dissolved in THF (5 mL) and added dropwise to the previously prepared solution of Wittig reagent in THF at 0°C, stirred overnight and allowed to warm to RT. The crude reaction mixture was concentrated onto silica gel and purified by flash chromatography eluting with 8:1 $CHCl_3$/EtOAc to afford (+)-**15**. Run 1: 72.7 mg, 44%. Run 2: Reaction run starting with 3 mmol of Nosyl-proline methyl ester and all other reagents scaled accordingly; 416.5 mg, 42%. Average: 43% (66% per step). Reaction run starting from (D)-(+)-Nosyl-Proline methyl ester; 66.4 mg, 40% (63% per step).

^{1}H NMR (500 MHz, Chloroform-d) δ 8.34 (d, *J* = 8.9 Hz, 2H), 8.05 (d, *J* = 8.8 Hz, 2H), 5.81 – 5.65 (m, 1H), 5.61 (d, *J* = 9.3 Hz, 1H), 5.00 (dd, *J* = 13.7, 2.1 Hz, 2H), 4.09 – 3.91 (m, 1H), 3.54 (s, 3H), 2.12 (app. q, *J* = 7.0 Hz, 2H), 1.93 – 1.82 (m, 1H), 1.75 (dt, *J* = 13.8, 7.2 Hz, 1H);

^{13}C NMR (126 MHz, Chloroform-d) δ 171.9, 150.2, 145.8, 136.3, 128.6, 124.4, 116.6, 55.5, 52.9, 32.5, 29.1;

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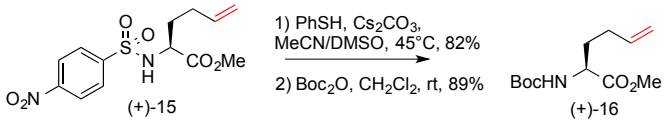
[5] Wu, Y. C., Bernadat, G., Masson, G., Coutourier, C., Schlama, T., Zhu, J. *J. Org. Chem.* **2009**, *74*, 2046-2052.

IR (film, cm^{-1}) 3264, 3108, 3087, 2946, 2902, 1743, 1643, 1606, 1527, 1434, 1348, 1319, 1305, 1228, 1164, 1089, 983;

HRMS (ESI) *m/z* calc'd for $C_{13}H_{16}N_2O_6NaS$ $[M+Na]^+$: 351.0627, found 351.0634;

$[\alpha]_D^{28}$ = +51.3° (c = 1.16, CH_2Cl_2).



Methyl (*S*)-2-((*tert*-butoxycarbonyl)amino)hex-5-enoate (+)-16.

Nosyl homoallylglycine methyl ester **(+)-15** (150 mg, 1.0 eq, 0.46 mmol) was dissolved in 49:1 MeCN/DMSO (3 mL) in a round bottom flask, and thiophenol (163 uL, 3.5 eq, 1.6 mmol) was added, followed by Cs_2CO_3 (596 mg, 4.0 eq, 1.83 mmol). The rapidly stirred slurry was heated to 45°C for 2.5 h, when full conversion of the starting material was observed by TLC. The crude reaction mixture was partitioned between EtOAc and sat. $NaHCO_3$. The aqueous layer was extracted with EtOAc (2 x 20 mL), dried over K_2CO_3, and concentrated onto silica for plug purification. The plug was eluted first with 1:1 Hexanes/EtOAc to remove all nonpolar byproducts, and then 5/95/1 MeOH/CH_2Cl_2/NH_4OH to remove the free amine, affording a crude product (53.8 mg, approx. 82%).

Crude free amine (86.5 mg, 1.0 eq, 0.6 mmol) was dissolved in CH_2Cl_2 (5 mL), and to this solution was added Boc_2O (144 mg, 1.1 eq, 0.66 mmol). The mixture was stirred overnight at rt, then concentrated onto silica gel and purified by flash chromatography (15 % EtOAc/Hexanes), yielding (+)-**16** (129.3 mg, 89%).

Characterization data are in agreement with the literature report.[6] (ref: Chattopadhyay, *Tetrahedron*, **2014**, *70*, 7185.)

^{1}H NMR (500 MHz, $CDCl_3$) δ 5.79 (ddt, *J* = 6.6, 10.3, 16.9 Hz, 1H), 5.07-4.99 (m, 2H), 4.33 (q, *J* = 7.6 Hz, 1H), 3.74 (s, 3H), 2.15-2.04 (m, 2H), 1.94-1.87 (m, 1H), 1.75-1.68 (m, 1H), 1.44 (s, 9H);

$[\alpha]_D^{27}$ = +15.5° (c = 1.07, CH_2Cl_2).

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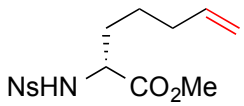
[6] Chattopadhany, *Tetrahedron*, **2014**, *70*, 7185.



Methyl (*R*)-2-((4-nitrophenyl)sulfonamido)hept-6-enoate (-)-17.

Wittig reagent was prepared as above for (+)-**15**. (+)-Ns-Pipecolic acid methyl ester (**S1**) (656.7 mg, 1.0 equiv., 2.0 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude reaction mixture was plugged through silica gel with EtOAc and concentrated. The crude residue was dissolved THF (5 mL) and added dropwise to the previously prepared solution of Wittig reagent in THF at 0 °C, stirred overnight and allowed to warm to rt. The crude reaction mixture was concentrated onto silica gel and purified by flash chromatography eluting with 3:1 Hexanes/EtOAc to afford (-)-**17**. Run 1: 246.7 mg, 36%. Run 2: 266.9 mg, 39%. Average: 37% (61% per step).

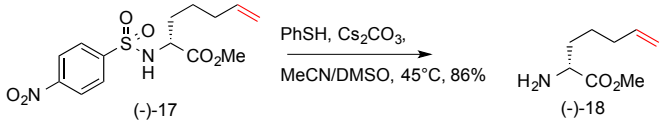
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.04 (d, *J* = 8.8 Hz, 2H), 5.70 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.52 (d, *J* = 9.2 Hz, 1H), 5.07 – 4.86 (m, 2H), 4.00 (ddd, *J* = 9.3, 7.7, 5.1 Hz, 1H), 3.55 (s, 3H), 2.03 (q, *J* = 6.6 Hz, 2H), 1.78 (ddd, *J* = 21.7, 7.5, 5.2 Hz, 1H), 1.65 (dq, *J* = 15.5, 7.8 Hz, 1H), 1.43 (p, *J* = 7.5 Hz, 2H);

^{13}C NMR (126 MHz, Chloroform-*d*) δ 171.9, 150.2, 145.8, 137.6, 128.6, 124.4, 115.5, 55.9, 52.8, 32.9, 32.7, 24.2;

IR (film, cm^{-1}) 3238, 2948, 2917, 2867, 1739, 1639, 1608, 1529, 1456, 1429, 1348, 1307, 1268, 1164, 1143, 1087;

HRMS (ESI) *m/z* calc'd for $C_{14}H_{18}N_2O_6SNa$ $[M+Na]^+$: 365.0783, found 365.0782;

$[\alpha]_D^{26}$ = -43.5° (c = 0.62, CH_2Cl_2).



Methyl (*R*)-2-aminohept-6-enoate (-)-18.

Nosyl bishomoallylglycine methyl ester (-)-**17** (342 mg, 1.0 eq, 1.0 mmol) was dissolved in 49:1 MeCN/DMSO (6.6 mL), and thiophenol (357 µL, 3.5 eq, 3.5 mmol) was added, followed by Cs_2CO_3 (1.303 g, 4.0 eq, 4.0 mmol). The rapidly stirred slurry was heated to 45 °C for 3h, when

full conversion of starting material was observed by TLC. The crude reaction mixture was partitioned between EtOAc and sat. $NaHCO_3$. The aqueous layer was extracted with EtOAc (2x 50 mL), dried over K_2CO_3, and concentrated onto silica purification. Flash chromatography eluting with 2%→5% MeOH/CH_2Cl_2 afforded (-)-**18**. 135.6 mg, 86%.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 5.78 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H), 5.09 – 4.83 (m, 2H), 3.71 (s, 3H), 3.44 (dd, *J* = 7.3, 5.5 Hz, 1H), 2.06 (q, *J* = 6.7 Hz, 2H), 1.79 – 1.66 (m, 1H), 1.64 – 1.38 (m, 3H);

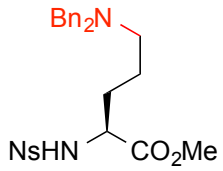
^{13}C NMR (126 MHz, Chloroform-*d*) δ 176.7, 138.4, 115.0, 54.5, 52.1, 34.5, 33.6, 25.1; IR (film, cm^{-1}) 3386, 2860, 1737, 1641, 1438, 1197, 1172;

HRMS (ESI) *m/z* calc'd for $C_8H_{16}NO_2$ $[M+H]^+$: 158.1181, found 158.1185;

$[\alpha]_D^{24}$ = -17.6° (c = 1.41, $CHCl_3$).

General Procedure for Reductive Amination.

A crude reaction mixture containing **5-HP** (0.5 mmol scale proline substrate, generated using **Procedure A**) was dissolved in CH_2Cl_2 (8 mL), and amine (1.0 eq, 0.5 mmol) was added in CH_2Cl_2 (1 mL), followed by sodium triacetoxyborohydride (317.9 mg, 3.0 eq, 1.5 mmol). The reaction was stirred overnight at RT, and concentrated onto silica gel for column chromatography.



Methyl (*S*)-5-(dibenzylamino)-2-((4-nitrophenyl)sulfonamido)pentanoate (+)-19.

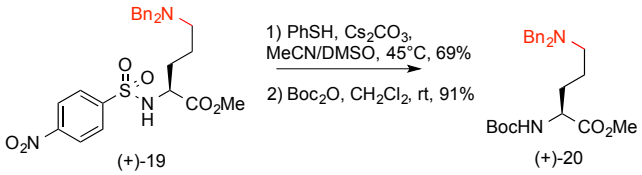
Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude reaction mixture was then subjected to the General Procedure for Reductive Amination, using dibenzyl amine (98.6 mg, 1.0 equiv., 0.5 mmol). Flash chromatography eluting with 2%→3%→4% MeOH/CH_2Cl_2 afforded (+)-**19**. Run 1: 158.8 mg, 62%. Run 2: 139.8 mg, 55%. Average: 59% (77% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.5 Hz, 2H), 7.93 (d, *J* = 9.0 Hz, 2H), 7.35-7.30 (m, 8H), 7.28-7.24 (m, 2H), 6.00 (s, 1H), 3.92 (dd, *J* = 4.8, 7.6 Hz, 1H), 3.56 (d, *J* = 13.7 Hz, 2H), 3.52 (s, 3H), 3.51 (d, *J* = 13.5 Hz, 2H), 2.45-2.35 (m, 2H), 1.82-1.75 (m, 1H), 1.72-1.65 (m, 1H), 1.56-1.51 (m, 2H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.0, 150.1, 146.0, 139.1, 129.1, 128.5, 128.4, 127.2, 124.3, 58.3, 55.6, 52.7, 52.2, 30.9, 22.5;

HRMS (ESI) calc'd for: $C_{26}H_{30}N_3O_6S$ $[M+H]^+$: 512.1855, found: 512.1851;

$[\alpha]_D^{23}$ +17.1° (c = 1.08, $CHCl_3$).



Methyl (*S*)-2-((*tert*-butoxycarbonyl)amino)-5-(dibenzylamino)pentanoate (+)-20.

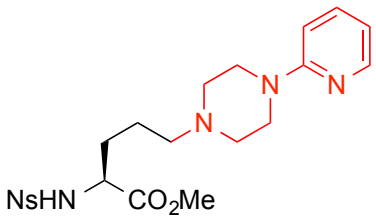
Nosyl amino acid (+)-**19** (80 mg, 1.0 equiv., 0.156 mmol) was dissolved in 98:2 MeCN/DMSO (1.5 mL) in a round bottom flask. To the flask were then added thiophenol (56 uL, 3.5 equiv., 0.547 mmol) and Cs_2CO_3 (204 mg, 4.0 equiv., 0.626 mmol), and the resulting slurry was heated to 45 °C and stirred rapidly for 6h. The reaction was recharged with additional thiophenol (56 uL), Cs_2CO_3 (204 mg), and solvent (1.5 mL) and stirred overnight at 45 °C. The crude reaction mixture was partitioned between EtOAc and sat. $NaHCO_3$. The aqueous layer was extracted with EtOAc (2 x 50 mL), dried over K_2CO_3, and concentrated onto silica for purification. Flash chromatography eluting with 1:1 Hexanes/EtOAc to remove nonpolar byproducts and thiophenol, followed by 10:1:89 MeOH/NH_4OH/CH_2Cl_2 afforded crude free amine (35.0 mg, approximately 69% yield). The crude amine was dissolved in CH_2Cl_2 (1 mL), and Boc_2O (25.7 mg, 1.1 equiv., 0.12 mmol) was added, and the reaction stirred overnight at RT. Flash chromatography eluting with 9:1→4:1 Hexanes / EtOAc afforded (+)-**20** (42.2 mg, 90% yield, 63% yield over two steps).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36-7.23 (m, 10H), 5.18 (d, *J* = 7.2 Hz, 1H), 4.28-4.21 (m, 1H), 3.70 (s, 3H), 3.60-3.51 (m, 4H), 2.47-2.39 (m, 2H), 1.80-1.50 (m, 4H), 1.44 (s, 9H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.5, 155.5, 139.6, 129.0, 128.4, 127.0, 79.9, 58.4, 53.5, 53.0, 52.3, 30.5, 28.5, 23.0;

HRMS (ESI) calc'd for: $C_{25}H_{35}N_2O_4$ [M+H]+: 427.2597, found: 427.2599;

$[\alpha]_D^{26}$ = +9.6° (c = 1.17, $CHCl_3$).



Methyl (*S*)-2-((4-nitrophenyl)sulfonamido)-5-(4-(pyridin-2-yl)piperazin-1-yl)pentanoate (-)-21.

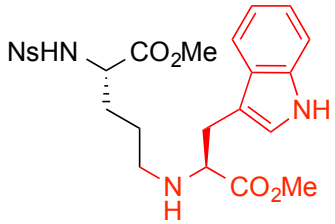
Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude reaction mixture was then subjected to the General Procedure for Reductive Amination, using 1-(2-pyridyl)-piperazine (81.6 mg, 1.0 equiv., 0.5 mmol). Flash chromatography eluting with 2%→4% MeOH/CH_2Cl_2 afforded (-)-**21**. Run 1: 156.8 mg, 60%. Run 2: 138.7 mg, 58%. Average: 59% (77% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.23-8.20 (m, 3H), 7.94 (d, *J* = 8.9 Hz, 2H), 7.50 (ddd, *J* = 2.0, 7.25, 8.6 Hz, 1H), 6.67-6.65 (m, 2H), 4.19 (t, *J* = 4.55 Hz, 1H), 3.72 (ddd, *J* = 3.1, 7.0, 12.4 Hz, 2H), 3.59 (dq, *J* = 3.1, 10.3 Hz, 2H), 3.53 (s, 3H), 2.72 (ddd, *J* = 3.0, 7.0, 10.5 Hz, 2H), 2.52 (ddd, *J* = 2.7, 6.8, 10.3 Hz, 2H), 2.42 (dddt, *J* = 4.3, 9.1, 14.2, 18.2 Hz, 2H), 2.21 (dddd, *J* = 3.4, 5.1, 6.6, 14.8 Hz, 1H), 1.79 (ddt, 3.8, 10.7, 14.7 Hz, 1H), 1.68-1.61 (m, 1H), 1.58-1.49 (m, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.0, 150.1, 146.0, 139.1, 129.1, 128.5, 128.4, 127.2, 124.3, 58.3, 55.6, 52.7, 52.2, 30.9, 22.5;

HRMS (ESI) calc'd for: $C_{21}H_{28}N_5O_6S$ $[M+H]^+$: 478.1760, found: 478.1763;

$[\alpha]_D^{22}$ = -25.1° (c = 1.24, $CHCl_3$).



Methyl (*S*)-5-(((*S*)-3-(1*H*-indol-3-yl)-1-methoxy-1-oxopropan-2-yl)amino)-2-((4-nitrophenyl)sulfonamido)pentanoate (+)-22.

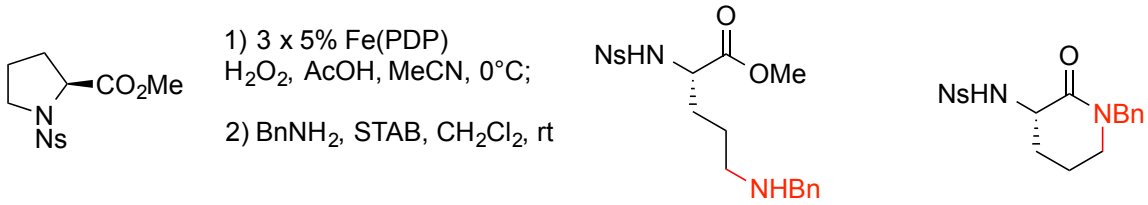
Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude reaction mixture was then subjected to the General Procedure for Reductive Amination, using a solution of L-tryptophan methyl ester, HCl salt (128.9 mg, 1.0 equiv., 0.5 mmol) and triethylamine (70 µL, 1.0 equiv., 0.5 mmol) in CH_2Cl_2. Flash chromatography eluting with 2%→3% MeOH/CH_2Cl_2 afforded (+)-**22**. Run 1: 134.5 mg, 50%. Run 2: 119.0 mg, 45%. Average: 48% (69% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 (d, *J* = 8.9 Hz, 2H), 8.18 (s, 1H), 7.97 (d, *J* = 8.9 Hz, 2H), 7.59 (d, *J* = 8.5 Hz, 1H), 7.36 (d, *J* = 8.1 Hz, 1H), 7.19 (t, *J* = 7.9 Hz, 1H), 7.17 (d, *J* = 2.2 Hz, 1H), 7.12 (t, *J* = 7.05 Hz, 1H), 4.13 (dd, *J* = 4.1, 6.35 Hz, 1H), 3.64 (d, *J* = 7.05 Hz, 1H), 3.61 (s, 3H), 3.52 (s, 3H), 3.31 (d, *J* = 6.1 Hz, 2H), 2.74 (ddd, *J* = 3. 85, 6.3, 11.4 Hz, 1H), 2.35 (ddd, *J* = 3.65, 8.95, 12.25 Hz, 1H), 2.01-1.94 (m, 1H), 1.77 (ddt, *J* = 4.7, 9.3, 14.7 Hz, 1H), 1.64-1.57 (m, 1H), 1.35-1.26 (m, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 174.6, 171.8, 149.9, 147.1, 136.3, 128.3,127.6, 124.2, 123.5, 122.3, 119.7, 118.8, 111.4, 110.5, 61.4, 55.3, 52.5, 52.0, 47.5, 32.3, 29.1, 25.6;

HRMS (ESI) calc'd for: $C_{24}H_{29}N_4O_8S$ $[M+H]^+$: 533.1706, found: 533.1710;

$[\alpha]_D^{25}$ = +26.2° (c = 0.96, $CHCl_3$).



(*S*)-*N*-(1-benzyl-2-oxopiperidin-3-yl)-4-nitrobenzenesulfonamide (+)-23.

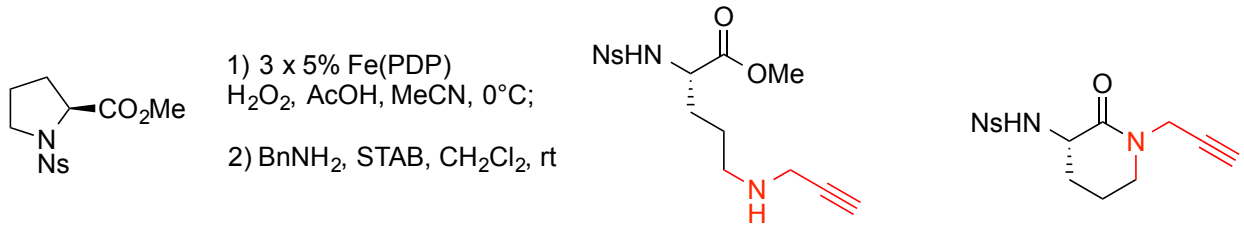
Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude reaction mixture was then subjected to the General Procedure for Reductive Amination, using benzylamine (53.6 mg, 1.0 equiv., 0.5 mmol). Flash chromatography eluting with 5% EtOAc/$CHCl_3$ afforded (+)-**23**. Run 1: 82.8 mg, 43%. Run 2: 80.7 mg, 42%. Average: 43% (66% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, J = 9.0 Hz, 2H), 8.10 (d, J = 9.0 Hz, 2H), 7.29-7.23 (m, 3H), 7.13-7.11 (m, 2H), 6.25 (d, J = 1.0 Hz, 1H), 4.49 (d, J = 14.7 Hz, 1H), 4.45 (d, J = 14.7 Hz, 1H), 3.63-3.59 (m, 1H), 3.18 (dd, J = 4.3, 7.5 Hz, 2H), 2.45-2.40 (m, 1H), 1.89-1.85 (m, 1H), 1.82-1.68 (m, 2H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 167.6, 150.2, 145.4, 136.0, 128.9, 128.7, 128.1, 127.9, 124.5, 54.1, 51.1, 46.8, 28.8, 20.5;

HRMS (ESI) calc'd for: $C_{18}H_{20}N_3O_5S$ $[M+H]^+$: 390.1124; found: 390.1124;

$[\alpha]_D^{27}$ +62.9° (c = 1.06, $CHCl_3$).



(*S*)-4-nitro-*N*-(2-oxo-1-(prop-2-yn-1-yl)piperidin-3-yl)benzenesulfonamide (+)-24.

Nosyl proline methyl ester (-)-**3** (157 mg, 1.0 eq, 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel and concentrated. The crude reaction mixture was then subjected to the General Procedure for Reductive Amination, using propargylamine (27.5 mg, 1.0 equiv., 0.5 mmol). Flash chromatography eluting with 4% EtOAc/$CHCl_3$ afforded (+)-**24**. Run 1: 67.9 mg, 40%. Run 2: 69.4 mg, 41%. Average: 41% (64% per step).

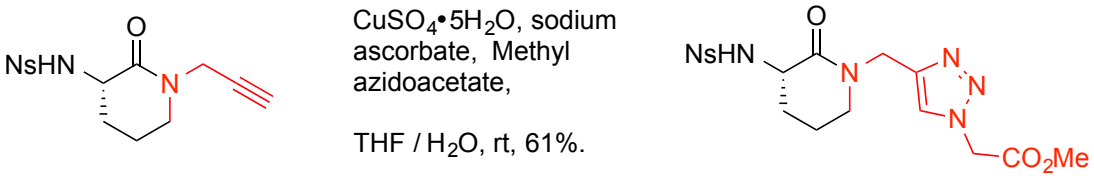
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.34 (d, J = 8.8 Hz, 2H), 8.10 (d, J = 8.8 Hz, 2H), 6.01 (d, J = 3.15 Hz, 1H), 4.12 (dq, J = 2.45, 17.3 Hz, 2H), 3.58 (ddd, J = 11.5, 5.4, 3.5 Hz, 1H), 3.40 (dd, J

= 4.05, 8.25 Hz, 2H), 2.48-2.43 (m, 1H), 2.22 (t, *J* = 2.5 Hz, 1H), 2.00 (ddd, *J* = 17.3, 7.1, 3.0 Hz, 1H), 1.92-1.85 (m, 1H), 1.84-1.74 (m, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 167.4, 150.2, 145.3, 128.7, 124.5, 77.6 72.9, 54.1, 46.9,36.6, 29.1, 20.6;

HRMS (ESI) calc'd for: $C_{14}H_{16}N_3O_5S$ $[M+H]^+$: 338.0811, found: 338.0807;

$[\alpha]_D^{26}$ = +56.9° (c = 1.11, CH_2Cl_2).



Methyl (*S*)-2-(4-((3-((4-nitrophenyl)sulfonamido)-2-oxopiperidin-1-yl)methyl)-1*H*-1,2,3-triazol-1-yl)acetate (+)-25.

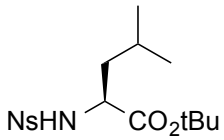
Nosyl-aminopiperidinone (+)-**24** (35.2 mg, 1.0 eq, 0.1 mmol) was dissolved in 5:1 THF:H_2O (2 mL). Methyl azidoacetate (17.3 mg, 1.5 eq, 0.15 mmol) in 1 mL THF:H_2O was added, followed by sodium ascorbate (3.6 mg, 0.2 eq, 0.02 mmol) and $CuSO_4$-$5H_2O$ (2.5 mg, 0.1 eq, 0.01 mmol). The blue copper species turned dark brown over 30 seconds, and the mixture was stirred at rt for 2h. The reaction was recharged with additional methyl azidoacetate, sodium ascorbate, and copper sulfate, and stirred for 2h, when full conversion of starting material was observed. The reaction was diluted with H_2O and CH_2Cl_2. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (5 x 20 mL). Combined organic layers were dried over Na_2SO_4, and concentrated onto silica gel for purification. Flash chromatography eluting with 1%→2%→3% MeOH/CH_2Cl_2 afforded (+)-**25** (27.4 mg, 61%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.10 (d, *J* = 8.8 Hz, 2H), 7.62 (s, 1H), 6.09 (m, 1H), 5.16 (d, *J* = 17.6 Hz, 1H), 5.10 (d, *J* = 17.6 Hz, 1H), 4.57 (d, *J* = 14.7 Hz, 1H), 4.51 (d, *J* = 14.7 Hz, 1H), 3.82 (s, 1H), 3.56 (ddd, *J* = 2.3, 5.4, 11.3, Hz, 2H), 3.48-3.43 (m, 2H), 2.41 (dq, *J* = 3.9, 13.3 Hz, 1H), 1.96-1.91 (m, 1H), 1.88-1.77 (m, 1H), 1.72 (qd, *J* = 3.8, 12.4 Hz, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 167.6, 166.7, 150.3, 145.3, 143.4, 128.8, 124.5, 54.1, 53.3, 50.8, 48.0, 42.9, 28.8, 20.6;

HRMS (ESI) calc'd for: $C_{17}H_{21}N_6O_7S$ $[M+H]^+$: 453.1192, found: 453.1183;

$[\alpha]_D^{27}$ = +42.9° (c = 1.0, CH_2Cl_2).



***Tert*-butyl ((4-nitrophenyl)sulfonyl)-*L*-leucinate (+)-26.**

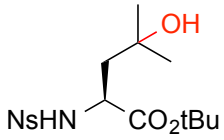
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.23 (d, *J* = 9.0 Hz, 2H), 7.94 (d, *J* = 8.8 Hz, 2H), 5.20 (s, 1H), 4.14 – 3.52 (m, 1H), 1.84 – 1.62 (m, 1H), 1.37 (ddd, *J* = 8.3, 6.0, 1.7 Hz, 2H), 1.13 (s, 9H), 0.82 (dd, *J* = 6.6, 1.6 Hz, 6H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 171.2, 150.2, 145.9, 128.8, 124.3, 82.9, 55.2, 42.5, 27.8, 24.5, 23.0, 21.5;

IR (film, cm^{-1}) 3278, 3106, 2962, 2935, 2874, 1731, 1606, 1531, 1457, 1349, 1309, 1166, 1145, 1091, 1012;

HRMS (ESI) *m/z* calc'd for $C_{16}H_{25}N_2O_6NaS$ $[M+Na]^+$: 395.1253, found 395.1253;

$[\alpha]_D^{24}$ = +38.9° (c=1.16, CH_2Cl_2).



(*S*)-*tert*-butyl 4-hydroxy-4-methyl-2-(4-nitrophenylsulfonamido)pentanoate (+)-27.

N-Nosyl-Leucine tert-butyl ester (+)-**26** (186.2 mg, 1.0 eq, 0.5 mmol) was reacted with (*R,R*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (116.5 mg, 0.125 mmol, 0.25 eq), AcOH (14.3 uL, 0.5 eq, 0.25 mmol), and H_2O_2 (170 uL, 2.5 mmol, 5.0 eq) in MeCN according to **Procedure B**. The crude mixture was purified by flash chromatography on silica using 9:1 $CHCl_3$:EtOAc. Run 1: Recycled 1x for a total of 55% X and 15% RSM; Cycle 1: (+)-**27** (80.1 mg, 0.205 mmol, 41%), RSM (73.1 mg, 0.196 mmol, 39%); Cycle 2: (+)-**27** (26.8 mg, 0.07 mmol, 35%), RSM (27.8 mg, 0.15 mmol, 38%). Run 2: Recycled 1x for a total of 53% yield (+)-**27** and 7% RSM; Cycle 1: (+)-**27** (84.7

mg, 0.22 mmol, 44%), RSM (47.9 mg, 0.13 mmol, 26%); Cycle 2: (+)-**27** (18.3 mg, 0.05mmol, 37%), RSM (25.7 mg, 0.07 mmol, 54%). Average overall yield: 54% with 1 recycle.

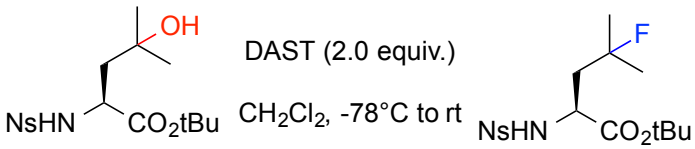
^{1}H NMR (500 MHz, Chloroform-d) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.08 (d, *J* = 8.7 Hz, 2H), 5.92 (d, *J* = 7.2 Hz, 1H), 4.10 (td, *J* = 7.6, 4.9 Hz, 1H), 1.92 – 1.78 (m, 2H), 1.34 (s, 3H), 1.30 (s, 9H), 1.28 (s, 3H);

^{13}C NMR (125 MHz, Chloroform-d) δ 170.9, 150.2, 145.8, 128.9, 124.3, 83.0, 71.2, 54.7, 44.1, 30.7, 29.1, 27.8;

IR (film, cm^{-1}) 3535, 3510, 3271, 3109, 2978, 2931, 1732, 1606, 1531, 1350, 1309, 1255, 1153, 1092, 939, 856, 739, 685615;

HRMS (ESI) *m/z* calc'd for $C_{16}H_{25}N_2O_7S$ $[M+H]^+$: 389.1382, found 389.1383;

$[\alpha]_D^{27}$ = +20.4° (c=0.17, CH_2Cl_2).



Tert-butyl 4-fluoro-4-methyl-2-(4-nitrophenylsulfonamido)pentanoate (+)-28. Tert-butyl 4-hydroxy-4-methyl-2-(4-nitrophenylsulfonamido)pentanoate (+)-**27** (56.3mg, 0.145 mmol, 1 equiv) was dissolved in dry dichloromethane (0.1 M, 1.45 mL) and cooled to -78 °C. Diethylamino sulfur trifluoride (DAST, 1.5 equiv, 0.218 mmol, 35.1 mg, 28.8 µL) was then added dropwise to the reaction mixture using a 50 µL syringe. After one hour the cold bath was removed and the reaction mixture was allowed to warm to ambient temperature, and at two hours the progress of the reaction was checked by TLC. A significant amount of starting material remained unreacted so an additional 0.25 equiv of DAST was added and allowed to stir just as before. After 4 hours some starting material still remained so a final addition of DAST (0.25 equiv.) was added. After 6 hours the crude mixture was concentrated via rotary evaporation to a minimal amount of dichloromethane and loaded directly onto a silica gel column for purification using dichloromethane as the eluent to afford (+)-**28** (41.6mg, 0.107 mmol, 74%).

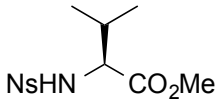
^{1}H NMR (500 MHz, Chloroform-d) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.06 (d, *J* = 8.6 Hz, 2H), 5.38 (d, *J* = 9.0 Hz, 1H), 4.05 (td, *J* = 8.4, 4.8 Hz, 1H), 1.43 (app. t, *J* = 21.3 Hz, 6H), 1.27 (s, 9H);

^{13}C NMR (125 MHz, Chloroform-d) δ 170.3, 150.3, 145.9, 128.9, 124.4, 94.8 (d, *J* = 167 Hz), 83.4, 53.8 (d, *J* = 3.6 Hz), 43.8 (d, *J* = 22.6 Hz), 27.8, 27.4 (d, *J* = 24.4 Hz), 27.0 (d, *J* = 24.3 Hz);

IR (film, cm^{-1}) 3282, 3107, 2981, 2933, 1736, 1606, 1531, 1351, 1151, 1093, 856, 739, 687, 615;

HRMS (ESI) *m/z* calc'd for $C_{16}H_{23}FN_2O_6SNa$ $[M+Na]^+$: 413.1159, found 413.1160;

$[\alpha]_D^{27}$ = +24.9° (c=0.88, CH_2Cl_2).



Methyl ((4-nitrophenyl)sulfonyl)-*L*-valinate (+)-29.

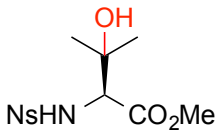
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.04 (d, *J* = 8.8 Hz, 2H), 5.36 (s, 1H), 3.84 (dd, *J* = 10.0, 4.9 Hz, 1H), 3.52 (s, 3H), 2.28 – 1.95 (m, 1H), 0.98 (d, *J* = 6.8 Hz, 3H), 0.88 (d, *J* = 6.9 Hz, 3H);

^{13}C NMR (125 MHz, Chloroform-*d*) δ 171.6, 150.3, 145.8, 128.7, 124.5, 61.4, 52.7, 31.8, 19.2, 17.5;

IR (film, cm^{-1}) 3297, 3272, 3110, 2970, 1733, 1714, 1606, 1529, 1467, 1444, 1349, 1292, 1272, 1174, 1139, 1090;

HRMS (ESI) *m/z* calc'd for $C_{12}H_{17}N_2O_6S$ $[M+H]^+$: 317.0807, found 317.0811;

$[\alpha]_D^{25}$ = +33.2° (c=2.13, CH_2Cl_2).



(*S*)-methyl 3-hydroxy-3-methyl-2-(4-nitrophenylsulfonamido)butanoate (+)-30.

N-Nosyl-valine methyl ester (+)-**29** (158 mg, 1.0 eq, 0.5 mmol) was reacted with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (116.5 mg, 0.25 eq, 0.125 mmol), AcOH (28.6 uL, 1.0 eq, 0.5 mmol), and H_2O_2 (276 uL, 9.0 eq, 4.5 mmol) according to a modified **Procedure C**. The crude mixture was purified on silica using 2:1 $CHCl_3$:EtOAc. Run 1: Recycled 1x for a 51% (+)-**30**. Cycle1: (+)-**30** (58.0 mg, 0.17 mmol, 36%), RSM (89.3 mg, 0.28 mmol, 57%); Cycle 2: (+)-**30** (26.9 mg, 0.081 mmol, 29%), RSM (61.4 mg, 68%). Run 2: Recycled 1x for a 50% yield (+)-**30**. Cycle 1:

(+)-**30** (63.0 mg, 38%), RSM (74.0 mg, 47%). Cycle 2: (+)-**30** (20.0 mg, 26%), RSM (48.0 mg, 65%). Average: 51% with 1x recycle.

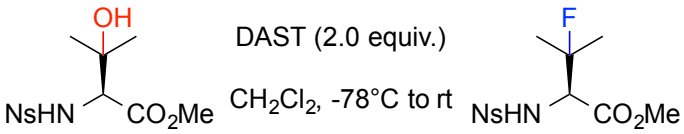
^{1}H NMR (500 MHz, Chloroform-d) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.05 (d, *J* = 8.8 Hz, 2H), 6.19 (d, *J* = 10.2 Hz, 1H), 3.85 (d, *J* = 10.2 Hz, 1H), 3.48 (s, 3H), 1.31 (s, 3H), 2.57 (s, 1H), 1.25 (s, 3H);

^{13}C NMR (125 MHz, Chloroform-d) δ 171.0, 150.3, 145.7, 128.7, 124.4, 72.1, 63.5, 52.6, 26.9, 26.7;

IR (film, cm^{-1}) 3529, 3263, 3107, 2983, 2929, 1736, 1531, 1352, 1314, 1169, 1092, 856, 737, 617;

HRMS (ESI) *m/z* calc'd for $C_{12}H_{17}N_2O_7S$ $[M+H]^+$: 333.0756, found 333.0756;

$[\alpha]_D^{27}$ = +12.2° (c=0.87, CH_2Cl_2).



Methyl (*R*)-3-fluoro-3-methyl-2-((4-nitrophenyl)sulfonamido)butanoate (+)-31.

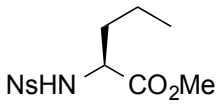
A flame-dried round bottom flask under inert atmosphere was charged with hydroxyvaline (+)-**30** (21.9 mg, 0.066 mmol, 1.0 eq) in CH_2Cl_2 (2 mL) and cooled to -78°C. DAST (17 μL, 0.13 mmol, 2.0 eq.) was added dropwise to the solution over 1 minute. The reaction was allowed to warm to room temperature and was stirred overnight. The crude reaction mixture was concentrated onto silica gel and directly purified via flash chromatography using 10%→15%→25% EtOAc/Hexanes, affording the title compound (11.0 mg, 50%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.35 (d, *J* = 8.9 Hz, 2H), 8.02 (d, *J* = 8.9 Hz, 2H), 5.64 (d, *J* = 10.3 Hz, 1H), 4.01 (dd, *J* = 10.3, 17.7 Hz, 1H), 3.51 (s, 3H), 1.46 (d, *J* = 21.8 Hz, 3H), 1.41 (d, *J* = 21.7 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 168.9, 150.3, 145.5, 128.7, 124.4, 94.9 (d, *J* = 178.3 Hz), 62.7 (d, *J* = 24.4 Hz), 52.9 (d, *J* = 13.1 Hz), 24.5;

HRMS (ESI) calc'd for: $C_{12}H_{14}N_2O_6FS$ $[M-H]^-$: 333.0557, found: 333.0555;

$[\alpha]_D^{27}$ = +21.6° (c = 1.02, CH_2Cl_2).



Methyl (*S*)-2-((4-nitrophenyl)sulfonamido)pentanoate (+)-32.

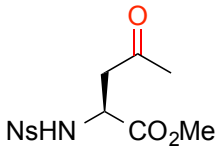
^{1}H NMR (500 MHz, Chloroform-d) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.03 (d, *J* = 8.8 Hz, 2H), 5.21 (d, *J* = 9.35 Hz, 1H), 4.00 (ddd, *J* = 5.1, 7.8, 9.3 Hz, 1H), 3.54 (s, 3H), 1.78-1.71 (m, 1H), 1.67-1.60 (m, 1H), 1.43-1.35 (m, 2H). 0.91, (t, *J* = 7.3 Hz, 3H);

^{13}C NMR (125 MHz, Chloroform-d) δ 172.0, 150.3, 145.8, 128.6, 124.4, 55.8, 52.8, 35.5, 18.4, 13.5;

IR (film, cm^{-1}) 3262, 3108, 2947, 1729, 1606, 1523, 1442, 1432, 1346, 1305, 1226, 1205, 1166, 1091;

HRMS (ESI) *m/z* calc'd for $C_{12}H_{17}N_2O_6S$ $[M+H]^+$: 317.0807, found 317.0806;

$[\alpha]_D^{25}$ = +33.0° (c=1.18, CH_2Cl_2).



Methyl (*S*)-2-((4-nitrophenyl)sulfonamido)-4-oxopentanoate (+)-33.

N-Nosyl-Norvaline, methyl ester (+)-**32** (158 mg, 1.0 eq, 0.5 mmol) was reacted with (*R,R*)-Fe(CF_3PDP)$(MeCN)_2(SbF_6)_2$ (169.5 mg, 0.25 eq, 0.125 mmol), AcOH (14.3 uL, 0.5 eq, 0.25 mmol), and H_2O_2 (170 uL, 5.0 eq, 0.25 mmol) in MeCN according to **Procedure B**. The crude mixture was purified via flash chromatrograpy using 4:1→3:1→2:1 Hexanes:Acetone gradient. Run 1: (+)-**33** (75.5 mg, 0.228 mmol, 48%), RSM (50.6 mg, 0.32 mmol, 32%). Run 2: (+)-**33** (86.3 mg, 0.26 mmol, 52%), RSM (37.4 mg, 0.12 mmol, 24%). Average: 50% (+)-**33**, 28% RSM.

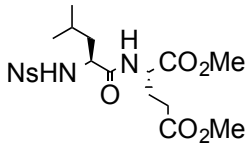
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 8.8 Hz, 2H), 6.09 (d, *J* = 8.7 Hz, 1H), 4.16 (dt, *J* = 8.5, 4.1 Hz, 1H), 3.54 (s, 3H), 3.22 (dd, *J* = 18.4, 4.2 Hz, 1H), 3.06 (dd, *J* = 18.4, 4.2 Hz, 1H), 2.17 (s, 3H);

^{13}C NMR (126 MHz, Chloroform-*d*) δ 206.1, 170.5, 150.1, 145.9, 128.6, 124.3, 53.1, 51.9, 46.5, 29.9;

IR (film, cm^{-1}) 3286, 3108, 2956, 2923, 1743, 1716, 1606, 1531, 1436, 1351, 1311, 1214, 1166, 1122, 1093;

HRMS (ESI) *m/z* calc'd for $C_{12}H_{15}N_2O_7S$ $[M+H]^+$: 331.0600, found 331.0603;

$[\alpha]_D^{23}$ = +41.6° (c=0.85, CH_2Cl_2).



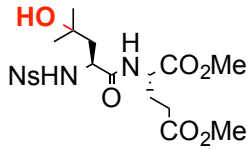
Dimethyl ((4-nitrophenyl)sulfonyl)-*L*-leucyl-*L*-glutamate (+)-34.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.75 Hz, 2H), 8.04 (d, *J* = 8.7 Hz, 2H), 6.52 (d, *J* = 7.35 Hz, 1H), 5.42 (d, *J* = 8.95 Hz, 1H), 4.34 (td, *J* =5.0, 7.7 Hz, 1H), 3.84 (q, 7.45 Hz, 1H), 3.72 (s, 3H), 3.69 (s, 3H), 2.25-2.10 (m, 2H), 2.01 (ddd, *J* = 2.2, 7.3, 14.4 Hz, 1H), 1.87-1.74 (m, 2H), 1.51 (t, *J* = 7.15 Hz, 2H), 0.92 (d, *J* = 6.65 Hz, 3H), 0.89 (d, *J* = 6.55 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.5, 171.8, 171.3, 150.2, 146.0, 128.6, 124.4, 55.6, 52.8, 51.9, 42.7, 29.9, 26.9, 24.4, 22.9, 21.5;

HRMS (ESI) calc'd for: $C_{19}H_{28}N_3O_9S$ $[M+H]^+$: 474.1546, found: 474.1540;

$[\alpha]_D^{27}$ = +19.6° (c = 1.22, CH_2Cl_2).



Dimethyl ((*S*)-4-hydroxy-4-methyl-2-((4-nitrophenyl)sulfonamido)pentanoyl)-*L*-glutamate (-)-35.

Substrate Ns-Leu-Glu(OMe)-OMe (+)-**34** (236.8 mg, 1.0 equiv., 0.5 mmol) was reacted according to **Procedure C** with (*R,R*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (116.5 mg, 0.25 equiv., 0.125 mmol), AcOH (143 uL, 5.0 equiv., 2.5 mmol), and H_2O_2 (256 uL, 9.0 equiv., 4.5 mmol), in MeCN at rt. Flash chromatography eluting with 1:1 EtOAc / Hexanes to 3:1 afforded (-)-**35**. Run 1: Recycled 1x for a total yield of 72%. Cycle 1: (-)-**35** (121.4 mg, 50%) and RSM (105.1 mg, 44%). Cycle 2: (-)-**35** (54.4 mg, 51%) and RSM (47.7 mg, 45%). Total yield: 72%. Run 2: Recycled for a total of yield of 65%. Cycle 1: (-)-**35** (126.0 mg, 51%) and RSM (88.0 mg, 37%).

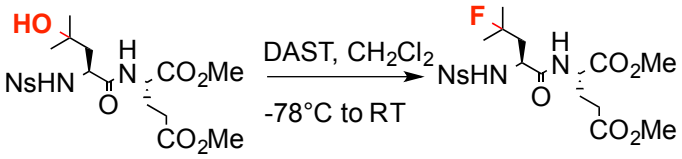
Cycle 2: (-)-**35** (34 mg, 39%) and RSM (53 mg, 61%). Total yield: 65%. Average: 68%, 1x recycle.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.9 Hz, 2H), 8.08 (d, *J* = 8.9 Hz, 2H), 7.43 (d, *J* = 7.7 Hz, 1H), 6.66 (d, *J* = 5.4 Hz, 1H), 4.43 (td, *J* = 5.3, 7.9 Hz, 1H), 3.95 (q, *J* = 5.8 Hz, 1H), 3.73 (s, 3H), 3.67 (s, 3H), 2.30-2.18 (m, 3H), 2.15-2.08 (m, 1H), 1.94-1.86 (m, 3H), 1.31 (s, 3H), 1.10 (s, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.1, 171.9, 171.2, 150.4, 145.0, 129.0, 124.5, 71.8, 54.6, 52.8, 52.1, 52.0, 44.8, 30.0, 27.2;

HRMS (ESI) calc'd for: $C_{19}H_{28}N_3O_{10}S$ $[M+H]^+$: 490.1495, found: 490.1486;

$[\alpha]_D^{26}$ = -40.6 ° (c = 1.0, CH_2Cl_2).



Dimethyl ((*S*)-4-fluoro-4-methyl-2-((4-nitrophenyl)sulfonamido)pentanoyl)-*L*-glutamate (-)-36.

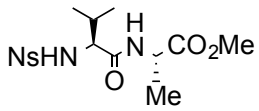
Ns-(Hydroxy)Leu-Glu(OMe)-OMe (-)-**35** (25 mg, 1.0 equiv., 0.051 mmol) was dissolved in CH_2Cl_2 and cooled to -78°C. DAST (34 uL, 5.0 equiv., 0.26 mmol) was added dropwise to the stirring solution, which was allowed to warm to RT over 3.5 h. Additional DAST (17 uL, 2.5 equiv., 0.13 mmol) was added dropwise to the solution and the mixture stirred 1h. The crude material was loaded onto silica gel and purified via flash chromatography eluting with 40% EtOAc/Hexanes to 50%, affording (-)-**36** (17.2 mg, 69%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 8.8 Hz, 2H), 7.01 (d, *J* = 4.8 Hz, 1H), 5.78 (t, *J* = 6.1 Hz, 1H), 4.42 (td, *J* = 5.5, 7.6 Hz, 1H), 3.98-3.94 (m, 1H), 3.74 (s, 3H), 3.69 (s, 3H), 2.32-2.17 (m, 2H), 2.15-1.88 (m, 4H), 1.41 (d, *J* = 22.2 Hz, 3H), 1.19 (d, *J* = 22.0 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.2, 171.5, 170.5, 150.5, 145.0, 129.0, 124.5, 96.5 (d, *J* = 164.2 Hz), 54.1, 52.8, 52.2, 52.1, 43.6, 29.9, 27.2 (d, *J* = 24.4 Hz), 27.0, 26.6 (d, *J* = 24.0 Hz);

HRMS (ESI) calc'd for: $C_{19}H_{26}N_3O_9FSNa$ $[M+Na]^+$: 514.1271, found: 514.1270;

$[\alpha]_D^{26}$ = -18.7° (c = 1.15, CH_2Cl_2).



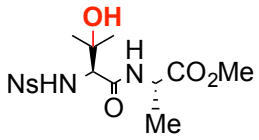
Methyl ((4-nitrophenyl)sulfonyl)-*L*-valyl-*L*-alaninate (+)-37.

^{1}H NMR (500 MHz, Acetone-d_6) δ 8.40 (d, *J* = 8.95 Hz, 2H), 8.10 (d, *J* = 8.95 Hz, 2H), 7.57 (d, *J* = 6.2 Hz, 1H), 6.93 (s, 1H), 4.06 (p, *J* = 7.2 Hz, 1H), 3.79 (d, *J* = 6.45 Hz, 1H), 3.61 (s, 3H), 1.99 (dq, *J* = 6.8, 13.4 Hz, 1H), 1.12 (d, *J* = 7.3 Hz, 3H), 0.95 (d, *J* = 6.75 Hz, 3H), 0.92 (d, *J* = 6.75 Hz, 3H);

^{13}C NMR (125 MHz, Acetone-d_6) δ 173.2, 170.3, 150.9, 147.7, 129.5, 124.9, 62.7, 52.3, 48.6, 32.5, 19.4, 18.2, 17.4;

HRMS (ESI) calc'd for: $C_{15}H_{22}N_3O_7S$ $[M+H]^+$: 388.1178, found: 388.1171;

$[\alpha]_D^{27}$ = +37.7° (c = 1.01, CH_2Cl_2).



Methyl ((*S*)-3-hydroxy-3-methyl-2-((4-nitrophenyl)sulfonamido)butanoyl)-*L*-alaninate (+)-38.

Substrate Ns-Val-Ala-OMe (+)-**37** (193.7 mg, 1.0 equiv., 0.5 mmol) was reacted according to **Procedure C** with (*R,R*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (116.5 mg, 0.25 equiv., 0.125 mmol), AcOH (143 uL, 5.0 equiv., 2.5 mmol), and H_2O_2 (276 uL, 9.0 equiv., 4.5 mmol) in MeCN at RT. The crude mixture was purified via flash chromatography eluting with gradient Hexanes/EtOAc 2:1→3:2→1:1 to afford (+)-**38**. Run 1: 106.7 mg, 53%. Run 2: 107.0 mg, 53%. Average: 53%.

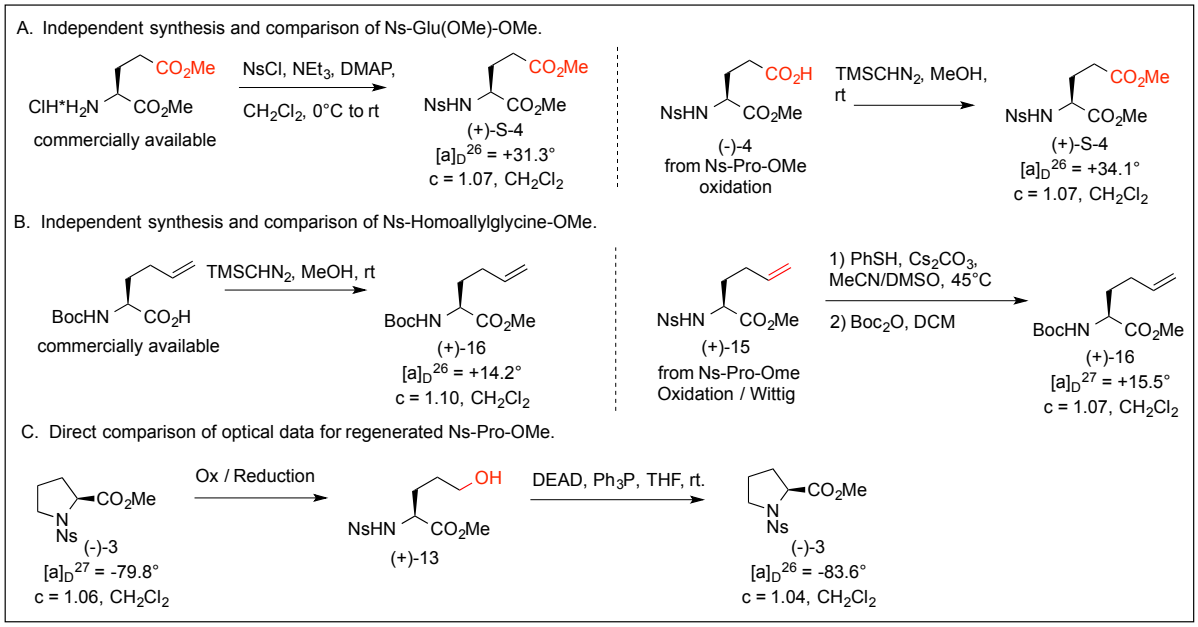
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.32 (d, *J* = 8.95 Hz, 2H), 8.03 (d, *J* = 9.0 Hz, 2H), 6.56 (d, *J* = 6.8 Hz, 1H), 5.78 (d, *J* = 9.15 Hz, 1H), 4.32 (p, *J* = 7.3 Hz, 1H), 3.73 (s, 3H), 3.64 (d, *J* = 9.05 Hz, 1H), 2.94 (s, 1H), 1.39 (s, 3H), 1.23 (d, *J* = 7.3 Hz, 3H), 1.14 (s, 3H);

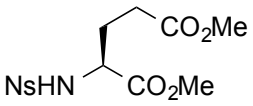
^{13}C NMR (125 MHz,$CDCl_3$) δ 173.5, 168.9, 150.3, 145.5, 128.8, 124.3, 72.9, 63.6, 53.0, 48.5, 28.1, 24.4, 17.6;

HRMS (ESI) calc'd for: $C_{15}H_{22}N_3O_8S$ $[M+H]^+$: 404.1128, found: 404.1122.;

$[\alpha]_D^{25}$ = +13.1° (c = 0.55, MeOH).

Figure S 2. Comparison of optical purity of unnatural amino acids derived from Proline oxidation vs. standard methods.





dimethyl ((4-nitrophenyl)sulfonyl)-*L*-glutamate

Prepared from commercially available materials: (L)-Glutamic acid dimethyl ester hydrochloride (211.6 mg, 1.0 equiv., 1.0 mmol) was reacted with NsCl (243.5 mg, 1.1 equiv., 1.1 mmol), NEt_3 (0.31 mL, 2.2 equiv., 2.2 mmol), and DMAP (12.2 mg, 0.1 equiv., 0.1 mmol) in CH_2Cl_2 (10 mL) according to the General Nosylation Procedure. Flash chromatography, eluting with 3:2 Hexanes/EtOAc, afforded the title compound.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.04 (d, *J* = 8.8 Hz, 2H), 5.72 (d, *J* = 9.1 Hz, 1H), 4.09 (td, *J* = 9.0, 4.8 Hz, 1H), 3.68 (s, 3H), 3.56 (s, 3H), 2.60 – 2.32 (m, 2H), 2.26 – 2.08 (m, 1H), 2.01 – 1.84 (m, 1H);

^{13}C NMR (125 MHz, Chloroform-*d*) δ 173.1, 171.4, 150.2, 145.6, 128.6, 124.4, 55.2, 53.0, 52.1, 29.5, 28.1;

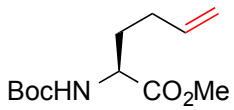
IR (film, cm^{-1}) 3274, 3253, 3108, 2956, 1737, 1531, 1438, 1351, 1311, 1211, 1166, 1111, 1091, 983, 854, 738;

HRMS (ESI) *m/z* calc'd for $C_{13}H_{16}N_2O_8S$ $[M+H]^+$: 361.0706, found 361.0705;

$[\alpha]_D^{26}$ = +31.3˚ (c=1.07, CH_2Cl_2).

Derived from Ns-Pro-OMe: Ns-Glu(OH)-OMe (-)-**4** (50 mg, 1.0 equiv., 0.14 mmol, obtained from oxidation of (-)-**3**, was dissolved in 1:1 MeOH/CH_2Cl_2 at rt. Then, a solution of trimethylsilyldiazomethane (2M in Et_2O, 0.14 mL, 2.0 equiv., 0.28 mmol), was added dropwise to the solution, which bubbled immediately and remained yellow after the bubbling had ceased. The reaction was quenched by addition of drops of AcOH until the color of the solution changed from yellow to clear. The solution was concentrated onto silica gel and purified via flash chromatography, eluting with 3:2 Hexanes / EtOAc to afford the title compound (48.2 mg, 96%). The sample was spectroscopically identical to that prepared using the above procedure.

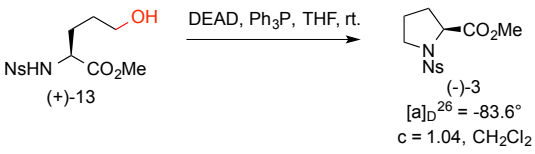
$[\alpha]_D^{26}$ = +34.1˚ (c=1.07, CH_2Cl_2).



methyl (*S*)-2-((*tert*-butoxycarbonyl)amino)hex-5-enoate

Derived from commercially available sources: (S)-2-((*tert*-butoxycarbonyl)-amino)-hex-5-enoic acid (50 mg, 1.0 equiv., 0.22 mmol) was dissolved in 1:1 MeOH/CH_2Cl_2 at rt. Then, a solution of trimethylsilyldiazomethane (2M in Et_2O, 0.22 mL, 2.0 equiv., 0.44 mmol), was added dropwise to the solution, which bubbled immediately and remained yellow after the bubbling had ceased. The reaction was quenched by addition of drops of AcOH until the color of the solution changed from yellow to clear. The solution was concentrated onto silica gel and purified via flash chromatography, affording the title compound. The sample obtained with this route was spectroscopically identical to the same molecule prepared from (-)-**3**.

$[\alpha]_D^{26}$ = +14.2˚ (c=1.10, CH_2Cl_2).



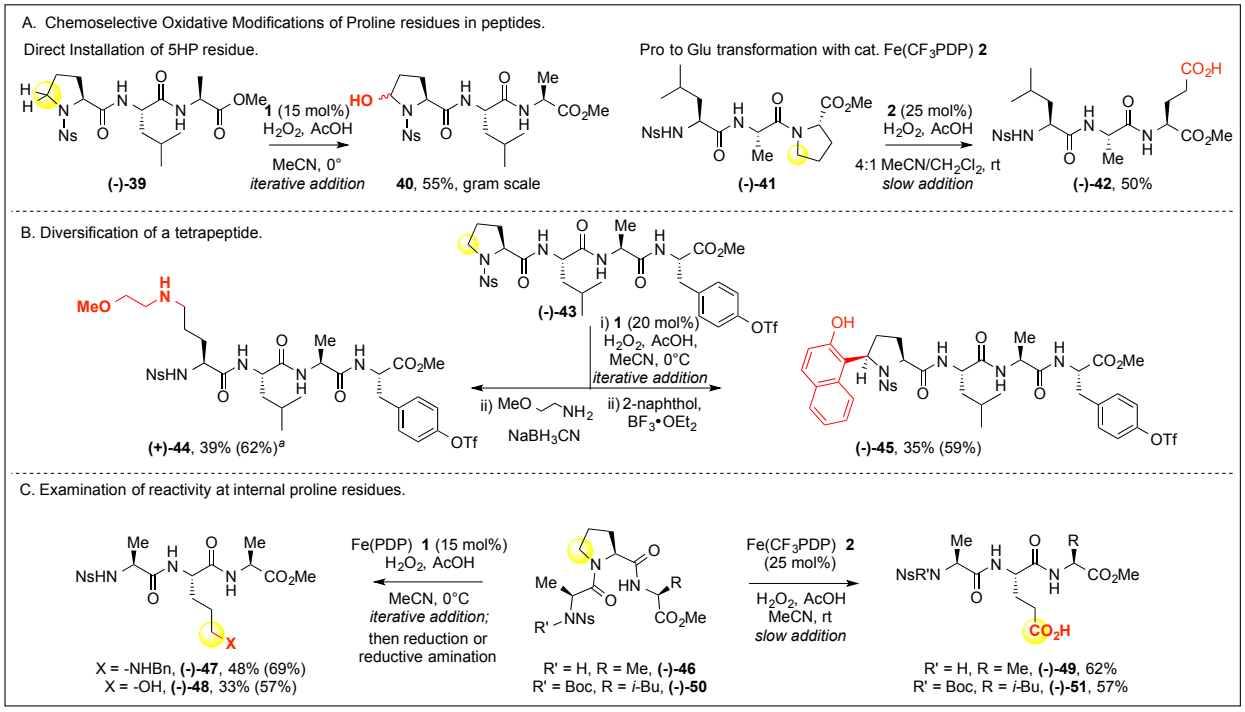
Mitsunobu reaction of Proline-derived bishomoserine compound to re-form Ns-Pro-OMe.

Triphenylphosphine (31.5 mg, 1.3 equiv., 0.12 mmol) was dissolved in CH_2Cl_2 (5 mL) at rt, and diethylazodicarboxylate (DEAD, 40% wt in PhMe, 41 mg, 1.5 equiv., 1.4 mmol) was added

dropwise to the stirring solution. Finally, Ns-Bishomoserine-OMe (+)-**13** (30 mg, 1.0 equiv., 0.09 mmol) was added as a solution in CH_2Cl_2 (1 mL). The solution was stirred at RT overnight, concentrated, and purified via flash chromatography, eluting with 18% EtOAc / Hexanes to 25%, to afford Ns-Pro-OMe (14.6 mg, 52%). The sample obtained using this synthetic route was spectroscopically identical to the starting material.

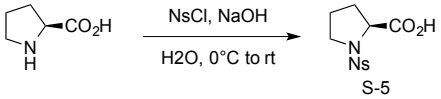
$[\alpha]_D^{26}$ = -83.6° (c=1.04, CH_2Cl_2).

Figure S 3. Direct oxidative modification of amino acids in peptides by Fe(PDP) catalyzed hydroxylation.



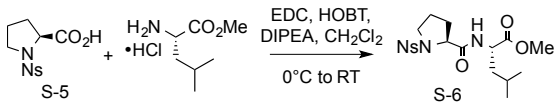
Synthesis of Peptide Substrates.

Substrates were generally synthesized N-to-C-terminus using standard solution phase peptide coupling procedures. Representative General Procedures are provided below for the synthesis of tripeptide Ns-P-L-A-OMe (-)-**39**.



General procedure for the *p*-Nitrosulfonyl protection of α-amino acids.

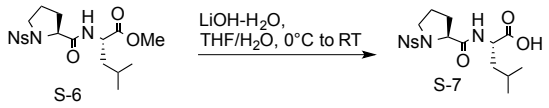
Example: Preparation of Ns-Pro-OH **S-5**. To a glass round-bottom flask with Teflon stir bar was added (*L*)-Proline (6.93 g, 1.0 equiv., 60.2 mmol) 1M Aq. NaOH (60 mL, 1M reaction concentration based on amino-acid). The reaction was cooled to 0 °C and stirred vigorously. To this was added 4-Nitrosulfonyl Chloride (20 g, 1.5 equiv., 90.2 mmol) in small portions over 1-2 minutes. The reaction was stirred at 0°C for 10 minutes, and was then warmed to room temperature. As the reaction proceeded, the pH of the solution became more acidic. Every 30 minutes, the pH was taken and if pH was <7, additional 1M NaOH (approx. 1 equiv.) was added slowly until a pH ~ 10-12 was achieved. This process was repeated until a basic pH is sustained for 45 minutes without requiring additional base. The reaction was transferred to a separatory funnel. The basic solution was extracted with EtOAc (3x) and the organic layers were combined and set aside. The Aqueous solution (containing product) was then cooled to 0 °C and acidified to pH 2 with HCl (10% Aq.) via dropwise addition and vigorous stirring. The acidic aqueous solution was then transferred to a separatory funnel and extracted with EtOAc (3x), making sure the aqueous solution retained an acidic pH (~2) prior to each extraction. The combined organic layers were then dried over $MgSO_4$, filtered, and concentrated *in vacuo* to afford crude Ns-Pro-OH **S-5** in approx. 90% purity (17.9 g, 98%). This crude material was carried forward to peptide coupling reactions without further purification.



General Procedure for peptide coupling.

Example: Coupling of Ns-Pro-OH **S-5** to H-Leu-OMe•HCl. (*L*)-Leucine methyl ester hydrochloride (8.41 g, 1.0 equiv., 46.3 mmol) was weighed into a round-bottom flask with a stir bar, diluted with CH_2Cl_2 (500 mL, 0.1-0.2M), and cooled to 0°C in an ice bath. To this solution was added Diisopropyl Ethylamine (8.06 mL, 1.0 equiv., 46.3 mmol) dropwise. Next were added, in the following order: 1) Ns-Pro-OH **S-5** (13.9 g, 1.0 equiv., 46.3 mmol), 2) Hydroxybenzotriazole (HOBt, 20% by weight H_2O, 8.60 g, 1.1 equiv), and 3) 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (EDC, 8.88 g, 1.0 equiv, 46.3 mmol) and the reaction was warmed to room temperature. The reaction was then stirred overnight or until complete consumption of the carboxylic acid coupling partner was observed by TLC (typically: 1% Acetic Acid in Ethyl Acetate eluent).

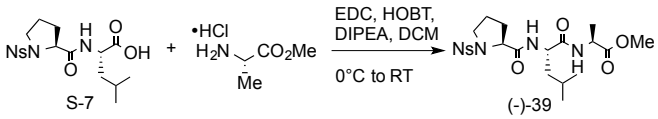
The reaction contents were added to an appropriately sized separatory funnel and washed with a 1:1 volume each of $NaHCO_3$ (Sat. Aq.), Citric Acid (10 wt% Aq.), and Brine. Following each of the first two washes, the aqueous layer was extracted with CH_2Cl_2 (2 x), and the combined organic layers were taken on to the next wash. The combined organic layers were then dried over Na_2SO_4, filtered, and concentrated *in vacuo* to provide crude Ns-Pro-Leu-OMe **S-6** (assumed quantitative yield) which was taken on without further purification to the next step. The crude material can alternatively be purified via flash chromatography on silica gel to afford the desired product. (**Note 1**: in order to achieve a dry solid after purification, it may be necessary to rotovap down the pure oil from Hexanes several times to completely remove residual CH_2Cl_2, followed by placement on a high vacuum line for 24h. **Note 2**: in the case of using a free amine methyl ester in place of a hydrochloride salt, DIPEA (0.1 equiv) was used).



General Procedure for methyl ester hydrolysis.

Example: Hydrolysis of Ns-Pro-Leu-OMe **S-6**. To a glass round-bottom flask with Teflon stir bar was added crude Ns-Pro-Leu-OMe **S-6** (46.3 mmol, 1.0 equiv) in 3:1 THF:H_2O (130 mL, 0.5 M). The solution was cooled to 0°C in an ice bath, and LiOH (9.71 g, 5.0 equiv., 231.5 mmol) was added in 1 portion. The reaction was held at 0°C for 10 minutes, and then warmed to room temperature and stirred for 24 hours, or until complete conversion of the methyl ester was observed by TLC.

Upon complete conversion, the reaction was cooled back down to 0°C, and acidified to a pH of <2 via dropwise addition of $KHSO_4$ (10 wt% Aq.). The solution was then diluted with Ethyl Acetate (~1:1 v/v) and the two layers were separated via separatory funnel. The pH of the Aqueous layer was then taken, and if found to be >4/5, was re-acidified with $KHSO_4$ (10 wt% Aq.) to a pH <2. It was then extracted with Ethyl Acetate (2x), making sure to retain an acidic pH before extraction each time. The organic layers were combined and washed with Water (1x) and Brine (1x), dried over $MgSO_4$, filtered, and concentrated *in vacuo* to afford crude Ns-Pro-Leu-OH **S-7** (16.6 g, 87% over two steps). The acid materials were typically obtained in >90% purity and carried on crude to further peptide coupling steps, but can also be purified via flash chromatography on silica gel.



Peptide coupling reaction – Synthesis of Ns-P-L-A-OMe (-)-39.

Crude Ns-Pro-Leu-OH **S-7** (16.6 g, 1.0 equiv., 40.1 mmol) was coupled with (*L*)-alanine methyl ester hydrochloride (5.6 g, 1.0 equiv., 40.1 mmol) using DIPEA (6.98 mL, 1.0 equiv., 40.1 mmol), HOBt (7.45 g, 1.1 equiv., 44.1 mmol) and EDC (7.69 g, 1.0 equiv., 40.1 mmol) according to the General Procedure for peptide coupling. After workup, the crude material was purified via flash chromatography eluting with 2:1 Hexanes/Acetone to afford (-)-Ns-P-L-A-OMe (-)-**39** (15.90 g, 80% yield).

methyl ((4-nitrophenyl)sulfonyl)-*L*-prolyl-*L*-leucyl-*L*-alaninate

(Ns)Pro-Leu-Ala-OMe (Ns-P-L-A-OMe) (-)-39.

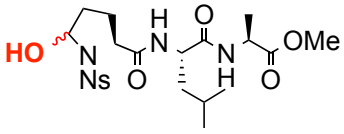
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.42 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.8 Hz, 2H), 6.96 (dd, *J* = 13.4, 8.2 Hz, 2H), 4.81 – 4.40 (m, 2H), 4.08 (dd, *J* = 8.3, 3.7 Hz, 1H), 3.73 (s, 3H), 3.67 (ddd, *J* = 10.1, 6.7, 3.9 Hz, 1H), 3.27 – 3.19 (m, 1H), 2.20 – 2.09 (m, 1H), 1.90 – 1.82 (m, 3H), 1.78 – 1.69 (m, 1H), 1.66 – 1.57 (m, 2H), 1.39 (d, *J* = 7.2 Hz, 3H), 0.95 (d, *J* = 6.3 Hz, 3H), 0.92 (d, *J* = 6.3 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.2, 171.2, 170.6, 150.8, 141.1, 129.4, 124.8, 62.6, 52.5, 52.0, 50.4, 48.2, 40.7, 31.1, 25.2, 24.7, 23.2, 21.7, 18.1;

IR (film, cm^{-1}) 3394, 3302, 3105, 2958, 2873, 1743, 1658, 1531, 1454, 1352, 1165, 912, 735;

HRMS (ESI) *m/z* calc'd for $C_{21}H_{30}N_4O_8S$ $[M+H]^+$: 499.1863, found 499.1864;

$[a]_D^{26}$ = -133.7° (c=1.06, CH_2Cl_2).



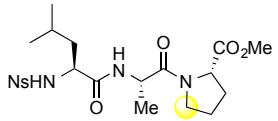
Methyl ((2*S*)-5-hydroxy-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonyl)-*L*-leucyl-*L*-alaninate 40.

Substrate Ns-Pro-Leu-Ala-OMe (-)-**39** (1.496 g, 1.0 equiv., 3.0 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. Flash chromatography eluting with 2:1→3:2→1:1 EtOAc/$CHCl_3$ afforded **40** as a mixture of hemiaminal epimers. Run 1: 859.4 mg, 56%. Run 2: On 2 mmol scale yielded 558.4 mg, 54%. Average: 55%.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (d, *J* = 8.9 Hz, 2H), 8.10 (d, *J* = 8.8 Hz, 2H), 7.22 (d, *J* = 8.2 Hz, 1H), 6.94 (d, *J* = 7.5 Hz, 1H), 5.68-5.63 (m, 1H), 4.56-4.42 (m, 3H), 4.22-4.10 (m, 1H), 3.73 (s, 3H), 1.95-1.71 (m, 3H), 1.71-1.56 (m, 3H), 1.40 (d, *J* = 7.2 Hz, 3H), 0.94 (d, *J* = 6.4 Hz, 3H), 0.90 (d, *J* = 6.4 Hz, 3H);

^{13}C NMR (125 MHz,$CDCl_3$) δ 173.4, 171.8, 171.7, 150.7, 143.3, 128.9, 124.9, 86.3, 62.8, 52.7, 52.4, 48.4, 40.8, 33.5, 31.1, 29.4, 25.0, 23.2, 21.7, 17.8;

HRMS (ESI) calc'd for: $C_{21}H_{31}N_4O_9S$ $[M+H]^+$: 515.1812, found: 515.1806.



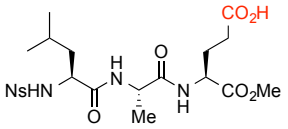
Methyl ((4-nitrophenyl)sulfonyl)-*L*-leucyl-*L*-alanyl-*L*-prolinate (-)-41.

^{1}H NMR (500 MHz, Acetone-d_6) δ 8.40 (d, *J* = 9.0 Hz, 2H), 8.12 (d, *J* = 9.0 Hz, 2H), 7.37 (d, *J* = 6.8 Hz, 2H), 4.34 (dd, *J* = 5.0, 8.6 Hz, 1H), 4.31-4.26 (m, 1H), 4.06 (dd, *J* = 4.9, 10.0 Hz, 1H), 3.63 (s, 3H), 3.61-3.57 (m, 1H), 3.52 (dt, *J* = 9.8, 6.8 Hz, 1H), 2.56-2.55 (m, 1H), 2.25-2.17 (m, 1H), 2.14-2.08 (m, 2H), 2.01-1.73 (m, 2H, overlaps somewhat with residual acetone solvent), 1.51 (ddd, *J* = 14.8, 10.2, 4.9 Hz, 1H), 1.44 (ddd, *J* = 13.9, 9.0, 5.0 Hz, 1H), 1.04 (d, *J* = 6.9 Hz, 3H), 0.89 (d, *J* = 6.7 Hz, 3H), 0.85 (d, *J* = 6.6 Hz, 3H);

^{13}C NMR (125 MHz, Acetone-d_6) δ 173.01, 171.1, 151.0, 147.8, 129.7, 125.1, 59.6, 56.3, 55.1, 52.2, 47.4, 43.3, 25.7, 25.1, 23.4, 21.6, 17.7;

HRMS (ESI) calc'd for: $C_{21}H_{31}N_4O_8S$ $[M+H]^+$: 499.1863, found: 499.1858;

$[\alpha]_D^{26}$ = -40.0°, (c = 0.97, Acetone).



(*S*)-5-methoxy-4-((*S*)-2-((*S*)-4-methyl-2-((4-nitrophenyl)sulfonamido)pentanamido)propanamido)-5-oxopentanoic acid (-)-42.

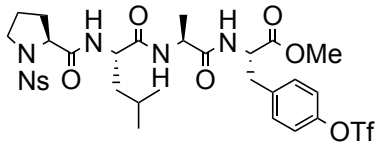
Substrate Ns-Leu-Ala-Pro-OMe (-)-**41** (149.6 mg, 1.0 equiv., 0.3 mmol) was reacted according to General Oxidation **Procedure B** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (101.7 mg, 0.25 equiv., 0.075 mmol), AcOH (8.6 uL, 0.5 equiv., 0.15 mmol), and H_2O_2 (86.5 uL, 5.0 equiv., 1.5 mmol) in 4:1 $MeCN/CH_2Cl_2$ (to increase solubility of the substrate). Flash chromatography of the crude mixture eluting with gradient 0:99.5:0.5→5:94.5:0.5 $MeOH/Et_2O$/AcOH afforded (-)-**42**. Run 1: 74.1 mg, 47%. Run 2: 83.6 mg, 53%. Average: 50%.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (d, *J* = 8.7 Hz, 2H), 8.07 (d, *J* =8.7 Hz, 2H), 4.38 (dd, *J* = 5.2, 9.0 Hz, 1H), 3.95 (q, *J* =7.1 Hz, 1H), 3.91 (dd, *J* = 9.7, 5.2 Hz, 1H), 3.69 (s, 3H), 2.35 (t, *J* = 7.4 Hz, 2H), 2.11 (dq, *J* =13.4, 7.6 Hz, 1H), 1.88 (dq, *J* = 14.7, 8.3, 7.8 Hz, 1H), 1.70 (dq, *J* =13.0, 7.8, 6.9 Hz, 1H), 1.46 (dtd, *J* =17.4, 8.8, 4.1 Hz, 2H), 1.18 (d, *J* =7.1 Hz, 3H), 0.91 (d, *J* =6.7 Hz, 3H), 0.83 (d, *J* =6.5 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 176.2, 174.6, 173.4, 173.3, 151.4, 147.8, 129.8, 125.1, 56.3, 53.0, 52.7, 49.9, 42.9, 31.0, 30.9, 27.7, 25.4, 23.3, 21.6, 17.6;

HRMS (ESI) calc'd for: $C_{21}H_{31}N_4O_{10}S$ $[M+H]^+$: 531.1761, found: 531.1765;

$[\alpha]_D^{26}$ = -43.2° (c = 1.01, MeOH).



Methyl-(2*S*)-2-((2*S*)-2-((2*S*)-4-methyl-2-((2*S*)-1-((4-nitrophenyl)sulfonyl)-1λ^4-pyrrolidine-2-carboxamido)pentanamido)propanamido)-3-(4-(((trifluoromethyl)sulfonyl)oxy)phenyl)propanoate (-)-43.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 8.8 Hz, 2H), 7.24 (d, *J* = 8.7 Hz, 2H), 7.18 (d, *J* = 8.7 Hz, 2H), 7.14 (t, *J* = 6.8 Hz, 2H), 7.04 (d, *J* = 8.4 Hz, 1H), 4.77 (dt, *J* = 7.5, 6.1 Hz, 1H), 4.56 – 4.47 (m, 1H), 4.45 (t, *J* = 7.2 Hz, 1H), 4.01 (dd, *J* = 8.8, 4.0 Hz, 1H),

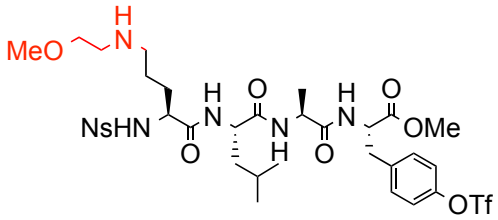
3.68 (s, 4H), 3.31 – 3.13 (m, 2H), 3.08 (dd, *J* = 14.0, 6.6 Hz, 1H), 2.13 – 2.04 (m, 1H), 1.98 – 1.89 (m, 1H), 1.86 – 1.78 (m, 2H), 1.76 – 1.66 (m, 1H), 1.65 – 1.56 (m, 2H), 1.31 (d, *J* = 7.1 Hz, 3H), 0.94 (d, *J* = 6.2 Hz, 3H), 0.91 (d, *J* = 6.2 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.2, 172.1, 171.5, 171.4, 150.9, 148.7, 140.7, 137.2, 131.5, 129.5, 124.9, 121.5, 118.9 (d, *J* = 320.8 Hz), 62.8, 53.6, 52.7, 52.4, 50.5, 49.3, 40.4, 37.3, 31.4, 25.4, 24.8, 23.3, 21.5, 17.2;

IR (film, cm^{-1}) 3386, 2958, 1741, 1658, 1531, 1502, 1421, 1352, 1250, 1217, 1167, 1142, 1109, 1018, 910, 893, 735;

HRMS (ESI) *m/z* calc'd for $C_{31}H_{39}F_3N_5O_{12}S_2$ $[M+H]^+$: 794.1989, found 794.1984;

$[a]_D^{26}$ = -70.3° (c=1.25, CH_2Cl_2).



Methyl (9*S*,12*S*,15*S*,18*S*)-12-isobutyl-15-methyl-9-((4-nitrophenyl)sulfonamido)-10,13,16-trioxo-18-(4-(((trifluoromethyl)sulfonyl)oxy)benzyl)-2-oxa-5,11,14,17-tetraazanonadecan-19-oate (+)-44.

Substrate Ns-Pro-Leu-Ala-Tyr(OTf)-OMe (-)-**43** (119.0 mg, 1.0 equiv., 0.15 mmol) was reacted with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, AcOH, and H_2O_2 according to General Oxidation **Procedure A** with the following modification: an additional round of catalyst, AcOH, and H_2O_2 were added to the reaction, for a total of 4 x 5% Fe(PDP). The crude material was purified via plug and subjected to a modified Reductive Amination Procedure: The crude material was dissolved in MeOH (2 mL), and methoxyethylamine (27.0 mg, 6.0 equiv., 0.36 mmol) was added in 0.5 mL MeOH, followed by $NaBH_3CN$ (2.3 mg, 0.6 equiv., 0.036 mmol) in 0.5 mL MeOH. The resulting solution was stirred at 45°C for 48h, and the crude mixture was purified via flash chromatography eluting with MeOH/CH_2Cl_2 2% →4%→7%→10% MeOH/CH_2Cl_2 +1% NH_4OH, affording (+)-**44**. Run 1: Recycled 1x for a total yield of 40%. Cycle 1: Product (+)-**44** (42.6 mg, 33%) and RSM (47.1 mg, 40%). Cycle 2: Product (+)-**44** (9.3 mg, 18%), RSM (40%). Total yield: 40%. Run 2: Recycled 1x for a total yield of 37%. Cycle 1: Product (+)-**44** (40.4

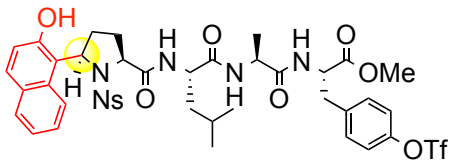
mg, 31%) and RSM (45.0 mg, 38%). Cycle 2: Product (+)-**44** (7.4 mg, 15%), RSM (35%). Total yield: 37%. Average: 39% with 1x recycle.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 8.8 Hz, 2H), 7.62 (d, *J* = 6.0 Hz, 1H), 7.20 (q, *J* = 8.8 Hz, 1H), 4.68 (q, *J* = 6.5 Hz, 1H), 4.51 (p, *J* = 6.9 Hz, 1H), 4.27 (q, *J* = 8.2 Hz, 1H), 3.96 (br s, 1H), 3.79-3.72 (m, 2H), 3.70-3.65 (m, 4H including s at 3.66, 3H), 3.36 (s, 3H), 3.18-2.96 (m, 6H), 2.04-1.96 (m, 3H), 1.73-1.62 (m, 1H), 1.61-1.52 (m, 2H), 1.37-1.33 (m, 1H), 1.30 (d, *J* = 7.05 Hz, 3H), 0.84 (d, *J* = 6.55 Hz, 3H), 0.72 (d, *J* = 6.5 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.9, 172.6, 171.4, 170.7, 150.2, 148.7, 145.2, 136.8, 131.3, 128.8, 124.5, 121.6, 118.8 (q, *J* = 320.8 Hz), 67.6, 59.1, 55.4, 53.7, 53.1, 52.6, 49.0, 48.2, 47.7, 40.6, 37.2, 30.7, 25.0, 22.9, 22.3, 21.4, 17.9;

HRMS (ESI) calc'd for: $C_{34}H_{48}N_6O_{13}F_3S_2$ $[M\text{-}H_2O]^+$: 869.2673, found: 869.2657;

$[\alpha]_D^{25}$ = +13.1° (c = 0.55, MeOH).



Methyl (*S*)-2-((*S*)-2-((*S*)-2-((2*S*,5*R*)-5-(2-hydroxynaphthalen-1-yl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxamido)-4-methylpentanamido)propanamido)-3-(4-(((trifluoromethyl)sulfonyl)oxy)phenyl)propanoate (-)-45.

Substrate Ns-Pro-Leu-Ala-Tyr(OTf)-OMe (-)-**43** (396.6 mg, 1.0 equiv., 0.5 mmol) was reacted with Fe(PDP), AcOH, and H_2O_2 according to **Procedure A** with the following modification: an additional round of catalyst, AcOH, and H_2O_2 were added to the reaction, for a total of 4 x 5% Fe(PDP). The crude material was purified via silica plug and subjected to the Standard Arylation Procedure (see above) using 2-naphthol (72 mg, 1.0 equiv., 0.5 mmol) and BF_3-OEt_2 (126 µL, 2.0 equiv., 1.0 mmol) in CH_2Cl_2 (3 mL). Flash chromatography of the crude reaction mixture eluting with gradient Et_2O/EtOAc 6:1→4:1→3:1 afforded (-)-**45**. Run 1: 150.2 mg, 32%. Run 2: 180.0 mg, 38%. Average: 35%. The diastereoselectivity of the addition was assigned based on analogy to (-)-**7**.

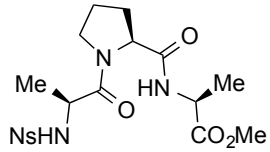
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16-8.12 (m, 2H), 8.09 (d, *J* = 8.0 Hz, 1H), 7.78 (d, *J* = 8.0 Hz, 1H), 7.62-7.56 (m, 5H), 7.50 (t, *J* = 8.7 Hz, 1H), 7.45 (d, *J* = 8.7 Hz, 2H), 7.36-7.30 (m, 3H),

6.74 (d, *J* = 8.8 Hz, 1H), 5.74 (dd, *J* = 6.1, 10. Hz, 1H), 5.01 (d, *J* = 8.9 Hz, 1H), 4.73 (td, *J* =7.6, 5.9 Hz, 1H), 4.68-4.64 (m, 1H), 4.45 (p, *J* =7.1 Hz, 1H), 3.66 (s, 3H), 3.22 (dd, *J* = 5.8, 14.0 Hz, 1H), 3.12 (dd, *J* = 7.6, 13.9 Hz, 1H), 2.52-2.43 (m, 2H), 2.32-2.25 (m, 1H), 2.22-2.15 (m, 1H), 1.87-1.79 (m, 1H), 1.73-1.63 (m, 2H), 1,30 (d, *J* = 7.1 Hz, 3H), 0.99 (d, *J* = 6.6 Hz, 3H), 0.98 (d, *J* = 6.6 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 174.5, 172.7, 172.1, 171.7, 154.5, 150.6, 149.1, 143.8, 138.5, 133.6, 132.0, 130.4, 129.6, 129.2, 127.2, 123.8, 123.3, 121.8, 120.5, 118.0, 133.5, 110.4, 62.5, 60.1, 53.9, 52.3, 49.4, 41.7, 37.2, 30.8, 25.2, 23.4, 21.8, 18.2;

HRMS (ESI) calc'd for: $C_{41}H_{45}N_5O_{13}F_3S_2$ $[M+H]^+$: 936.2407, found: 936.2404;

$[\alpha]_D^{24}$ = -33.5° (c = 0.93, $CHCl_3$).



Methyl ((4-nitrophenyl)sulfonyl)-*L*-alanyl-*L*-prolyl-*L*-alaninate (-)-46.

Isolated as a 13:1 mixture of apparent rotamers.

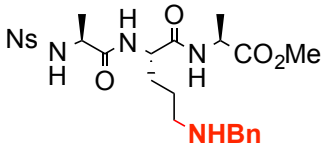
^{1}H NMR (500 MHz, $CDCl_3$) Major: δ 8.33 (d, *J* = 8.6 Hz, 2H), 8.05 (d, *J* = 8.6 Hz, 2H), 6.82 (d, *J* = 7.3 Hz, 1H), 6.46 (d, *J* = 8.8 Hz, 1H), 4.45 (p, *J* = 7.2 Hz, 1H), 4.27-4.18 (m, 2H), 3.71 (s, 3H), 1.03 (dq, *J* = 4.4, 8.4 Hz, 1H), 3.48-3.38 (m, 1H), 2.20-2.08 (m, 2H), 1.32 (d, *J* = 3.2 Hz, 3H), 1.31 (d, *J* = 2.9 Hz, 3H);

Minor (only non-overlapping peaks listed): δ 3.75 (s, 3H), 1.46 (d, δ 7.2 Hz, 3H), 1.27 (d, δ 6.9 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.3, 170.8, 170.3, 150.2, 146.6, 128.4, 124.4, 60.0, 52.6, 50.6, 48.3, 47.3, 28.1, 25.1, 19.4, 18.2;

HRMS (ESI) calc'd for: $C_{18}H_{24}N_4O_8NaS$ $[M+Na]^+$: 479.1213, found: 479.1209;

$[\alpha]_D^{25}$ = -52.9° (c = 2.88, CH_2Cl_2).



Methyl ((*S*)-5-(benzylamino)-2-((*S*)-2-((4-nitrophenyl)sulfonamido)propanamido)pentanoyl)-*L*-alaninate (-)-47.

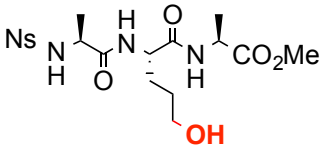
Ns-A-P-A-OMe (-)-**46** (136.9 mg, 1.0 equiv., 0.3 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)(MeCN)$_2$(SbF$_6$)$_2$, H_2O_2, and AcOH. Immediately after completion of the oxidation, without any purification, the solution was diluted with CH_2Cl_2 (2 mL), and benzylamine (48.2 mg, 1.5 equiv., 0.45 mmol) was added in CH_2Cl_2 (1 mL), followed by sodium triacetoxyborohydride (STAB, 190.7 mg, 3.0 equiv., 0.9 mmol). The mixture was allowed to warm to RT and was stirred overnight, concentrated onto silica gel, and purified via flash chromatography eluting with MeOH/CH_2Cl_2 5%→7%→10%→12%, to afford (-)-**47**. Run 1: 82.6 mg, 49% yield; Run 2: 77.5 mg, 46% yield. Average: 48% (69% per step).

^{1}H NMR (500 MHz, Methanol-d4) δ 8.40 (d, *J* = 8.95 Hz, 2H), 8.11 (d, *J* = 8.95 Hz, 2H), 7.51-7.41 (m, 5H), 4.37 (q, *J* = 7.3 Hz, 1H), 4.26 (dd, *J* = 5.75, 7.45 Hz, 1H), 4.19 (s, 2H), 3.94 (q, *J* = 7.0 Hz, 1H), 3.70 (s, 3H), 3.05 (t, *J* = 7.85 Hz, 2H), 1.89-1.75 (m, 3H), 1.70-1.63 (m, 1H), 1.38 (d, *J* = 7.35 Hz, 3H), 1.24 (d, *J* = 7.05 Hz, 3H);

^{13}C NMR (125 MHz, Methanol-d4) δ 174.6, 174.2, 172.9, 151.5, 147.6, 133.2, 130.9, 130.5, 130.2, 129.6, 125.4, 53.7, 53.4, 52.9, 52.4, 49.9, 48.1, 30.3, 23.4, 19.1, 17.2;

HRMS (ESI) calc'd for: $C_{25}H_{34}N_5O_8S$ $[M+H]^+$: 564.2128, found: 564.2128;

$[\alpha]_D^{24}$ = -49.3° (c = 1.3, MeOH).



Methyl ((*S*)-5-hydroxy-2-((*S*)-2-((4-nitrophenyl)sulfonamido)propanamido)pentanoyl)-*L*-alaninate (-)-48.

Ns-A-P-A-OMe (-)-**46** (136.9 mg, 1.0 equiv., 0.3 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)(MeCN)$_2$(SbF$_6$)$_2$, H_2O_2, and AcOH. Immediately after completion of the oxidation, without any purification, the solution was diluted with EtOH (2 mL) and, still at 0°C,

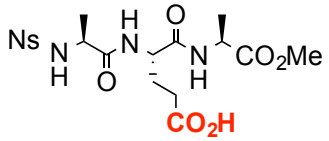
sodium borohydride (56.7 mg, 5.0 equiv., 1.5 mmol) was added. The solution was allowed to warm to RT and stirred for 3h. The solution was concentrated onto silica gel and purified via flash chromatography, eluting with MeOH/EtOAc 0% to 1% to 3% to afford (-)-**48**. Run 1: 47.2 mg, 33%; Run 2: 46.1 mg, 32%. Average: 33% (57% per step).

^{1}H NMR (500 MHz, Methanol-d_4) δ 8.39 (d, *J* = 8.9 Hz, 2H), 8.08 (d, *J* = 8.9 Hz, 2H), 4.34 (q, *J* = 7.3 Hz, 1H), 4.10 (dd, *J* = 5.7, 8.2 Hz, 1H), 3.96 (q, *J* = 7.1 Hz, 1H), 3.69 (s, 3H), 3.53 (t, *J* = 6.3 Hz, 2H), 1.83-1.76 (m, 1H), 1.62-1.44 (m, 3H), 1.36 (d, *J* = 7.3 Hz, 3H), 1.27 (d, *J* = 7.1 Hz, 3H);

^{13}C NMR (125 MHz, Methanol-d_4) δ 174.4, 173.8, 173.6, 151.5, 147.7, 129.6, 125.3, 62.3, 54.0, 53.6, 52.7, 49.4, 29.8, 29.6, 19.6, 17.2;

HRMS (ESI) calc'd for: $C_{18}H_{27}N_4O_9S$ $[M+H]^+$: 475.1499, found: 475.1483;

$[\alpha]_D^{26}$ = -54.0° (c = 1.0, MeOH).



(*S*)-5-(((*S*)-1-methoxy-1-oxopropan-2-yl)amino)-4-((*S*)-2-((4-nitrophenyl)sulfonamido)propanamido)-5-oxopentanoic acid (-)-49.

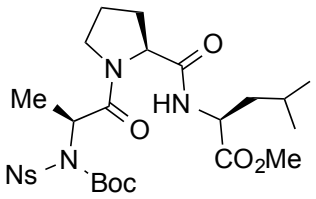
Ns-A-P-A-OMe (-)-**46** (228.2 mg, 1.0 equiv., 0.5 mmol) was subjected to General Oxidation **Procedure B** with (S,S)Fe(CF_3PDP) (169.5 mg, 0.25 equiv., 0.125 mmol), AcOH (14.3 µL, 0.5 equiv., 0.25 mmol) and H_2O_2 (170 µL, 5.0 equiv., 2.5 mmol) in MeCN at RT. The crude reaction mixture was concentrated onto silica gel and purified via flash chromatography, eluting with Et_2O/EtOAc/MeOH/AcOH 97.5/0/2/0.5→92/5/2/0.5, to afford (-)-**49**. Run 1: 151.5 mg, 62%; Run 2: 149.8 mg, 61%. Average: 62%.

^{1}H NMR (500 MHz, Methanol-d_4) δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.08 (d, *J* = 8.8 Hz, 2H), 4.34 (q, *J* = 7.3 Hz, 1H), 4.15 (dd, *J* = 5.8, 8.05 Hz, 1H), 3.97 (q, *J* = 7.1 Hz, 1H), 3.67 (s, 3H), 2.32-2.24 (m, 2H), 2.03-1.96 (m, 1H), 1.83-1.76 (m, 1H), 1.36 (d, *J* = 7.35 Hz, 3H), 1.27 (d, *J* = 7.15 Hz, 3H);

^{13}C NMR (125 MHz, Methanol-d_4) δ 176.4, 174.4, 173.8, 173.0, 151.5, 147.7, 129.6, 125.3, 53.6, 53.4, 52.7, 30.8, 28.5, 19.6, 17.1;

HRMS (ESI) calc'd for: $C_{18}H_{25}N_4O_{10}S$ $[M+H]^+$: 489.1291, found: 489.1274;

$[\alpha]_D^{26}$ = -48.0° (c = 1.1, MeOH).



Methyl *N*-(*tert*-butoxycarbonyl)-*N*-((4-nitrophenyl)sulfonyl)-*L*-alanyl-*L*-prolyl-*L*-leucinate (-)-50.

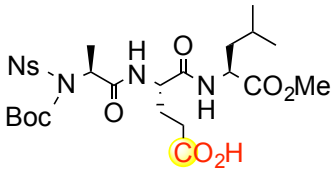
Note: The N-terminal Boc group was installed on this substrate to obviate N-terminal-to-proline cyclization events during the Fe(PDP) oxidation when Ns-Ala-Pro-Leu-OMe was employed.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.21 (d, *J* = 8.8 Hz, 2H), 6.92 (d, *J* = 7.6 Hz, 1H), 5.23 (q, *J* = 6.9 Hz, 1H), 4.55-4.48 (m, 2H), 3.71 (s, 3H), 3.69-3.67 (m, 1H), 3.64-3.54 (m, 1H), 2.33-2.28 (m, 1H), 2.24-2.14 (m, 1H), 2.03-1.98 (m, 1H), 1.69-1.61-1.51 (m, 7H), 1.34 (s, 9H), 0.92 (d, *J* = 6.2 Hz, 3H), 0.90 (d, *J* = 6.1 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.4, 171.0, 168.5, 150.5, 150.0, 145.3, 130.0, 124.0, 86.1, 61.0, 55.7, 52.4, 51.1, 47.7, 41.4, 28.0, 27.6, 25.6, 24.9, 22.9, 22.1, 17.3;

HRMS (ESI) calc'd for: $C_{26}H_{39}N_4O_{10}S$ $[M+H]^+$: 599.2387, found: 599.2404;

$[\alpha]_D^{24}$ = -56.8° (c = 1.11, MeOH).

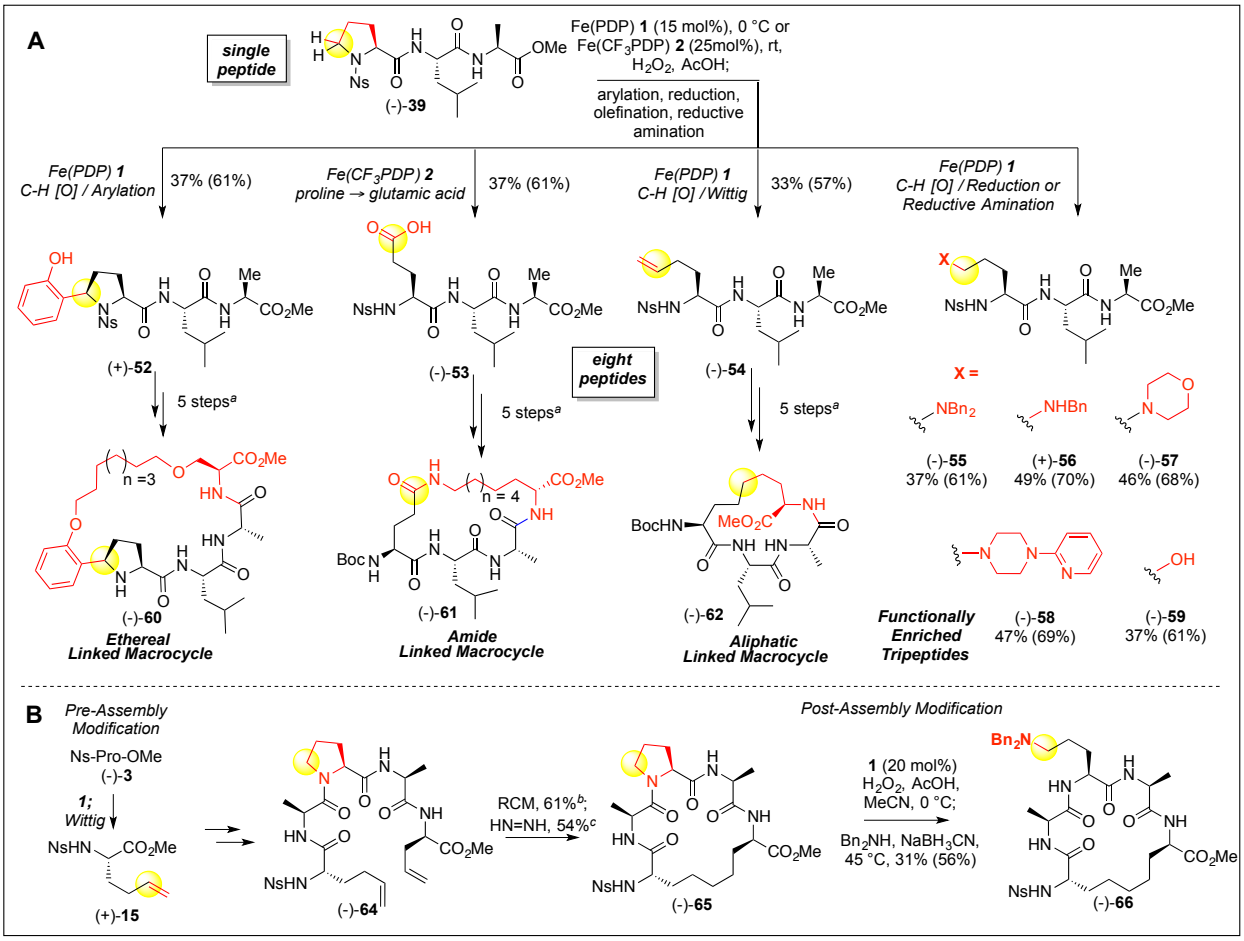


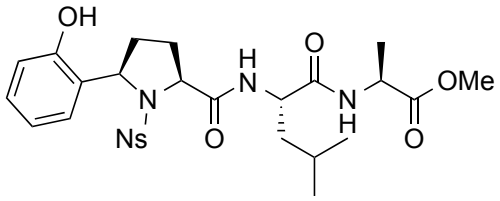
(*S*)-4-((*S*)-2-((*N*-(*tert*-butoxycarbonyl)-4-nitrophenyl)sulfonamido)propanamido)-5-(((*S*)-1-methoxy-4-methyl-1-oxopentan-2-yl)amino)-5-oxopentanoic acid (-)-51.

Substrate Ns(Boc)-Ala-Pro-Leu-OMe (-)-**50** (179.6mg, 1.0 equiv., 0.3 mmol) was reacted according to General Oxidation **Procedure B** with (*S,S*)-Fe(CF_3PDP)$(MeCN)_2(SbF_6)_2$ (101.7

mg, 0.25 equiv., 0.075 mmol), AcOH (8.6 μL, 0.5 equiv., 0.15 mmol), and H_2O_2 (86.5 μL, 5.0 equiv., 1.5 mmol) in MeCN at RT. The crude reaction mixture was concentrated onto silica gel and purified via flash chromatography, eluting with MeOH / CH_2Cl_2 2%→3%→4%→5% to afford (-)-**51**. Run 1: 104.1 mg, 55%; Run 2: 108.5 mg, 58% yield. Average: 57% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.35 (d, *J* = 9.0 Hz, 2H), 8.31 (d, *J* = 9.0 Hz, 2H), 7.15 (d, *J* = 7.4 Hz, 1H), 7.04 (d, *J* = 8.2 Hz, 1H), 5.21 (q, *J* = 6.8 Hz, 1H), 4.80 (q, *J* = 7.4 Hz, 1H), 4.51-4.47 (m, 1H), 3.69 (s, 3H), 2.59-2.45 (m, 2H), 2.21-2.16 (m, 1H), 2.00-1.93 (m, 1H), 1.77 (d, *J* = 6.9 Hz, 3H), 1.66-1.55 (m, 2H), 1.28 (s, 9H), 0.89 (d, *J* = 5.9 Hz, 3H), 0.87 (d, *J* = 5.7 Hz, 3H);
^{13}C NMR (125 MHz, $CDCl_3$) δ 176.2, 172.8, 171.1, 170.2, 150.5, 149.8, 145.2, 130.0, 123.9, 86.1, 56.4, 52.4, 51.2, 40.5, 29.8, 28.0, 27.8, 24.88, 22.8, 21.8, 16.9;
HRMS (ESI) calc'd for: $C_{26}H_{39}N_4O_{12}S$ $[M+H]^+$: 631.2285, found: 631.2289;
$[\alpha]_D^{26}$ = -11.4 ° (c = 1.1, MeOH).

Figure S 4. Fe(PDP) enables diversification of a single tripeptide and facilitates macrocycle diversification and synthesis.





Methyl ((2*S*,5*R*)-5-(2-hydroxyphenyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonyl)-*L*-leucyl-*L*-alaninate (+)-52.

Substrate Ns-P-L-A-OMe (-)-**39** (498.6 mg, 1.0 equiv., 1.0 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH, and the crude reaction mixture was passed through a plug of silica (40 mL) with EtOAc (250 mL) and concentrated. The crude residue was then subjected to the General 2-Step Oxidation / Arylation Procedure,

using Phenol (188 mg, 2.0 mmol) and BF_3OEt_2 (502 uL, 4.0 mmol) in CH_2Cl_2 (10 mL). The crude reaction mixture was concentrated onto silica gel and purified via flash chromatography, eluting with 3:1→2:1→1:1 Hexanes / EtOAc, affording (+)-**52** (217.4 mg, 37 % yield over 2 steps, 61% per step).

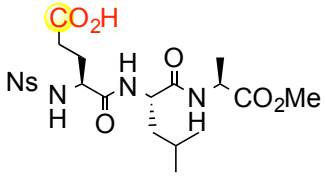
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.69 (s, 1H), 8.05 (d, *J* = 8.9 Hz, 2H), 7.91 (d, *J* = 8.7 Hz, 1H), 7.61 (d, *J* = 8.9 Hz, 2H), 7.09 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.05 – 6.97 (m, 2H), 6.79 (td, *J* = 7.4, 1.2 Hz, 1H), 6.39 (dd, *J* = 8.2, 1.2 Hz, 1H), 4.88 (dd, *J* = 10.2, 1.4 Hz, 1H), 4.72 (td, *J* = 8.7, 6.0 Hz, 1H), 4.66 (dd, *J* = 11.3, 5.9 Hz, 1H), 4.56 (p, *J* = 7.2 Hz, 1H), 3.76 (s, 3H), 2.60 – 2.42 (m, 1H), 2.28 (tdd, *J* = 12.8, 10.0, 6.6 Hz, 1H), 2.18 – 2.08 (m, 2H), 1.86 – 1.67 (m, 3H), 1.42 (d, *J* = 7.2 Hz, 3H), 1.01 (d, *J* = 6.0 Hz, 3H), 0.98 (d, *J* = 6.0 Hz, 3H);

^{13}C NMR (126 MHz, Chloroform-*d*) δ 173.7, 173.0, 172.0, 154.7, 149.9, 143.6, 131.1, 130.1, 129.1, 123.4, 122.0, 120.0, 117.6, 66.3, 62.4, 52.7, 52.1, 48.5, 41.4, 31.1, 29.8, 24.9, 23.1, 22.1, 18.0;

IR (film, cm^{-1}) 3294, 3103, 2958, 2873, 1745, 1651, 1531, 1458, 1350, 1161;

HRMS (ESI) *m/z* calc'd for $C_{27}H_{35}N_4O_9S$ $[M+H]^+$: 591.2125, found 591.2119;

$[\alpha]_D^{25}$ = +43.1° (c=1.01, CH_2Cl_2).



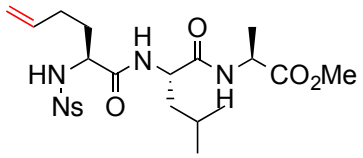
(*S*)-5-(((*S*)-1-(((*S*)-1-methoxy-1-oxopropan-2-yl)amino)-4-methyl-1-oxopentan-2-yl)amino)-4-((4-nitrophenyl)sulfonamido)-5-oxopentanoic acid (Ns-Glu(OH)-Leu-Ala-OMe) (-)-53.

Substrate Ns-Pro-Leu-Ala-OMe (-)-**39** (149.6 mg, 1.0 equiv., 0.3 mmol) was reacted according to General Oxidation **Procedure B** with (*S,S*)-Fe(CF_3PDP)(MeCN)$_2$(SbF_6)$_2$ (101.7 mg, 0.25 equiv., 0.075 mmol), AcOH (8.6 uL, 0.5 equiv., 0.15 mmol), and H_2O_2 (86.5 uL, 5.0 equiv., 1.5 mmol) in MeCN at RT. The crude material was purified via flash chromatography eluting with gradient MeOH/CH_2Cl_2 3%→10%, affording (-)-**53**. Run 1: 57.3 mg, 36%. Run 2: 58.8 mg, 37%. Average: 37%.

^{1}H NMR (500 MHz, Methanol-d_4) δ .838 (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 8.8 Hz, 2H), 4.33 (q, *J* = 7.3 Hz, 1H), 4.15 (dd, *J* = 5.3, 9.6 Hz, 1H), 3.90 (dd, *J* = 5.2, 8.9 Hz, 1H), 3.68 (s, 3H), 2.35-2.28 (m, 2H), 1.99-1.94 (m, 1H), 1.83-1.76 (m, 1H), 1.53-1.44 (m, 4H), 1.36 (d, *J* = 7.3 Hz, 3H), 0.88 (d, *J* = 6.3 Hz, 3H), 0.79 (d, *J* = 6.3 Hz, 3H);
^{13}C NMR (125 MHz, Methanol-d_4) δ 174.4, 174.1, 172.7, 151.4, 147.7, 129.7, 125.3, 57.4, 52.7, 41.9, 30.1, 25.6, 23.3, 22.0, 17.2;
HRMS (ESI) calc'd for: $C_{21}H_{31}N_4O_{10}S$ $[M+H]^+$: 531.1761, found: 531.1748;
$[\alpha]_D^{27}$ = -305.2° (c = 0.94, CH_2Cl_2).

Marfey's Reagent Analysis of Ns-Glu-Leu-Ala-OMe.
Marfey's reagent (FDAA) analysis was performed on Ns-E-L-A-OMe (-)-**53** according to a literature procedure.[7] A sample of approx. 0.1mg of purified peptide was hydrolyzed by treatment with 2 mL of 6N HCl and heating to 120°C for 24h in a sealed tube. The hydrolysate was dried under N_2. To a total of 1 μmol of amino acids in an eppendorf tube, 1.44 μmol of a 1% solution of Marfey's reagent (FDAA, N-(5-fluoro-2,4-dinitrophenyl)-D-Alaninamide) and 8 μmol of a 1 M solution of $NaHCO_3$ were added. The reaction mixture was heated at 40°C for 1 h and then cooled to RT. The reaction was quenched by adding 8 μmol of 2 M HCl and diluted with 0.2 mL MeOH. Standards (L-Ala, D-ala, L-Leu, D-Leu, L-Glu, D-Glu) were treated with the identical procedure.
Samples were analyzed by RP-HPLC on a C-18 column with detection at 340 nm. Acetonitrile/water containing 0.1% formic acid was used as the mobile phase with a linear gradient elution mode (MeCN, 10-60%, 60 min). The retention times were compared to authentic FDAA adduct samples prepared from individual samples of D- and L-amino acids. Retention times for FDAA adduct standards: L-Glu: 20.125; D-Glu: 23.959; L-Ala: 24.678; D-Ala: 27.675; L-Leu: 35.351; D-Leu: 39.368. No D-amino acids were observed for the samples of Ns-Glu(OH)-Leu-Ala-OMe that were tested, indicating no epimerization of the residues.

[7] (a) Bhushan, R.; Bruckner, H. *Amino Acids* **2004**, *27*, 231. (b) Yang, X., van der Donk, W. A. *J. Am. Chem. Soc.* **2015**, *137*, 12426.



Methyl ((*S*)-2-((4-nitrophenyl)sulfonamido)hex-5-enoyl)-*L*-leucyl-*L*-alaninate (-)-54.

Ns-P-L-A-OMe (-)-**39** (249.3 mg, 0.5 mmol, 1.0 equiv.) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH. The crude reaction mixture was plugged through silica gel, concentrated, and then added as a solution in THF to a solution of Wittig reagent at 0°C (prepared prior to the reaction using the Wittig reagent preparation above). Flash chromatography of the crude reaction mixture eluting with gradient Hexanes/EtOAc 3:2→1:1 afforded (-)-**54**. Run 1: 85.8 mg, 33%. Run 2: 81.2 mg, 32%. Average: 33% (57% per step).

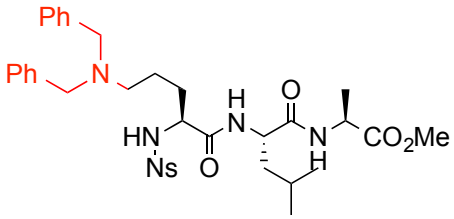
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.05 (d, *J* = 8.8 Hz, 2H), 6.33 (d, *J* = 7.2 Hz, 1H), 6.15 (d, *J* = 8.4 Hz, 1H), 5.76 – 5.64 (m, 1H), 5.60 (d, *J* = 8.2 Hz, 1H), 5.06 – 4.96 (m, 2H), 4.52 (p, *J* = 7.3 Hz, 1H), 4.28 (td, *J* = 8.5, 5.7 Hz, 1H), 3.78 (td, *J* = 8.1, 5.2 Hz, 1H), 3.75 (s, 3H), 2.10 (hept, *J* = 7.2, 6.5 Hz, 2H), 1.82 (dq, *J* = 13.5, 6.8 Hz, 1H), 1.70 (dq, *J* = 14.6, 8.1 Hz, 1H), 1.54 – 1.49 (m, 1H), 1.38 (d, *J* = 7.2 Hz, 3H), 1.36 – 1.29 (m, 2H), 0.85 (d, *J* = 6.3 Hz, 3H), 0.81 (d, *J* = 6.3 Hz, 3H);

^{13}C NMR (126 MHz, Acetone-d_6) δ 173.6 , 172.3 , 171.0 , 151.0 , 147.7 , 138.3, 129.6, 125.2, 115.8, 57.18 , 52.37 , 52.02 , 48.81 , 42.15 , 34.20 , 25.18 , 23.35 , 22.07 , 17.71;

IR (film, cm^{-1}) 3359, 3261, 3124, 2925, 1737, 1643, 1525, 1349, 1266, 1091;

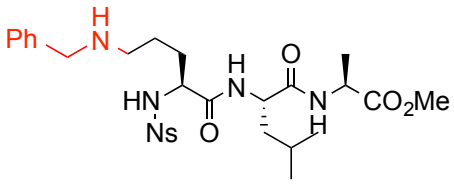
HRMS (ESI) *m/z* calc'd for $C_{22}H_{33}N_4O_8S$ $[M+H]^+$: 513.2019, found: 513.2010;

$[\alpha]_D^{24}$ = -9.3° (c = 1.02, CH_2Cl_2).



Methyl ((*S*)-5-(dibenzylamino)-2-((4-nitrophenyl)sulfonamido)pentanoyl)-*L*-leucyl-*L*-alaninate (-)-55.

Ns-P-L-A-OMe (-)-**39** (249.3 mg, 0.5 mmol, 1.0 equiv.) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH, and the crude reaction mixture was passed through a plug of silica (40 mL) with EtOAc (250 mL) and concentrated. The crude residue was dissolved in CH_2Cl_2 and reacted with dibenzylamine (98.6 mg, 0.5 mmol, 1.0 equiv.) and sodium triacetoxyborohydride (317.9 mg, 1.5 mmol, 3.0 equiv.) according to the General Procedure for Reductive Amination. Flash chromatography eluting with 2:1 $CHCl_3$/EtOAc afforded (-)-**55**. Run 1: 134.0 mg, 39%; Run 2: 119.9 mg, 35%; Avg: 37% (61% per step).
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.26 (d, *J* = 8.8 Hz, 2H), 7.93 (d, *J* = 8.8 Hz, 2H), 7.35-7.33 (m, 8H), 7.30-7.25 (m, 2H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.42 (d, *J* = 8.7 Hz, 1H), 4.54 (p, *J* = 7.2 Hz, 1H), 4.40-4.35 (m, 1H), 3.73 (s, 3H), 3.60 (d, *J* = 14.0 Hz, 2H), 3.53 (dd, *J* = 4.4, 8.1 Hz, 1H), 3.45 (d, *J* = 13.6 Hz, 2H), 2.43-2.32 (m, 2H), 1.72-1.64 (m, 1H), 1.61-1.47 (m, 4H), 1.35 (d, *J* = 7.3 Hz, 3H), 1.32-1.28 (m, 2H), 0.82 (d, *J* = 6.3 Hz, 3H), 0.77 (d, *J* = 5.9 Hz, 3H);
^{13}C NMR (125 MHz, $CDCl_3$) δ 173.2, 171.1, 170.8, 150.1, 145.5, 138.6, 129.4, 128.7, 128.5, 127.4, 124.3, 60.5, 58.3, 52.6, 51.7, 51.5, 48.2, 41.4, 31.2, 24.8, 22.8, 22.3, 21.9, 18.2, 14.3;
HRMS (ESI) calc'd for: $C_{35}H_{46}N_5O_8S$ $[M+H]^+$: 696.3067, found: 696.3072;
$[\alpha]_D^{26}$ = -27.1° (c = 1.04, $CHCl_3$).



Methyl ((*S*)-5-(benzylamino)-2-((4-nitrophenyl)sulfonamido)pentanoyl)-*L*-leucyl-*L*-alaninate (+)-56.

Ns-P-L-A-OMe (-)-**39** (249.3 mg, 0.5 mmol, 1.0 equiv.) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH, and the crude reaction mixture was passed through a plug of silica (40 mL) with EtOAc (250 mL) and concentrated. The crude residue was dissolved in CH_2Cl_2 and reacted with benzylamine (53.6 mg, 0.5 mmol, 1.0 equiv.) and sodium triacetoxyborohydride (317.9 mg, 1.5 mmol, 3.0 equiv.) according to the General Procedure for Reductive Amination. Flash chromatography eluting with MeOH/CH_2Cl_2

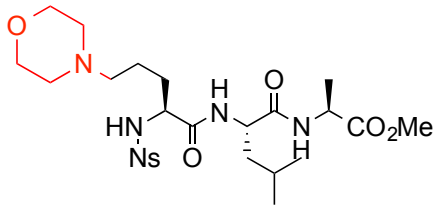
5%→10% afforded (+)-**56**. Run 1: 152.1 mg, 50%; Run 2: 144.0 mg, 48%; Average: 49% (70% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.45 Hz, 2H), 7.99 (d, *J* = 8.55 Hz, 2H), 7.96 (m, 1H), 7.44-7.41 (m, 2H), 7.39-7.32 (m, 3H), 7.04 (d, *J* = 7.4 Hz, 1H), 4.43 (p, *J* = 7.2 Hz, 1H), 4.26-4.21 (m, 1H), 4.01-3.92 (m, 3H), 3.66 (s, 3H), 2.92-2.87 (m, 1H), 2.81-2.75 (m, 1H), 1.90-1.85 (m, 2H), 1.79-1.67 (m, 2H), 1.53-1.37 (m, 3H), 1.31 (d, *J* = 7.25 Hz, 3H), 0.81 (d, *J* = 6.4 Hz, 3H), 0.71 (d, *J* = 6.35 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.4, 171.9, 170.8, 150.1, 145.6, 129.6, 129.1, 129.0, 128.7, 124.4, 55.7, 52.3, 52.5, 52.3, 48.2, 46.7, 40.7, 31.2, 24.8, 23.1, 22.9, 21.6, 18.0;

HRMS (ESI) calc'd for: $C_{28}H_{40}N_5O_8S$ $[M+H]^+$: 606.2598, found: 606.2599;

$[\alpha]_D^{25}$ = +7.4° (c = 1.11, $CHCl_3$).



Methyl ((*S*)-5-morpholino-2-((4-nitrophenyl)sulfonamido)pentanoyl)-*L*-leucyl-*L*-alaninate (-)-57.

Ns-P-L-A-OMe (-)-**39** (249.3 mg, 0.5 mmol, 1.0 equiv.) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH, and the crude reaction mixture was passed through a plug of silica (40 mL) with EtOAc (250 mL) and concentrated. The crude residue was dissolved in CH_2Cl_2 and reacted with morpholine (43.6 mg, 0.5 mmol, 1.0 equiv.) and sodium triacetoxyborohydride (317.9 mg, 1.5 mmol, 3.0 equiv.) according to the General Procedure for Reductive Amination. Flash chromatography eluting with MeOH/CH_2Cl_2 5%→7% afforded (-)-**57**. Run 1: 129.5 mg, 44%; Run 2: 137.9 mg, 47%; Avg: 46% (68% per step).

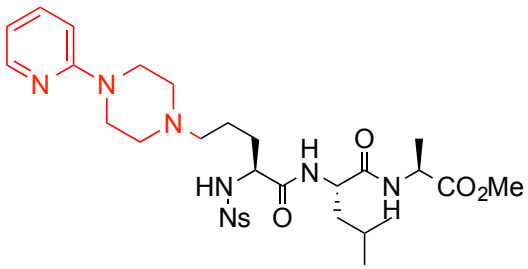
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.8 Hz, 2H), 8.04 (d, *J* = 8.8 Hz, 2H), 7.20 (d, *J* = 7.0 Hz, 1H), 6.83 (d, *J* = 7.5 Hz, 1H), 4.49 (p, *J* = 7.2 Hz, 1H), 4.38-4.33 (m, 1H), 3.89-3.79 (m, 5H), 3.71 (s, 3H), 2.68-2.57 (m, 2H), 2.56-2.42 (m, 3H), 2.41-2.30 (m, 1H), 2.13-2.06 (m, 1H),

1.66-1.52 (m, 4H), 1.48-1.38 (m, 2H), 1.35 (d, J = 7.2 Hz, 3H), 0.87 (d, J = 6.4 Hz, 3H), 0.82 (d, J = 6.3 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.1, 171.3, 170.6, 150.1, 146.0, 128.5, 124.5, 66.0, 58.1, 55.8, 53.6, 53.1, 52.6, 51.9, 48.1, 41.4, 31.8, 25.0, 22.9, 21.9, 20.9, 18.1;

HRMS (ESI) calc'd for: $C_{25}H_{40}N_5O_9S$ $[M+H]^+$: 586.2547, found: 586.2549;

$[\alpha]_D^{26}$ = -45.6° (c = 0.96, $CHCl_3$).



Methyl ((*S*)-2-((4-nitrophenyl)sulfonamido)-5-(4-(pyridin-2-yl)piperazin-1-yl)pentanoyl)-*L*-leucyl-*L*-alaninate (-)-58.

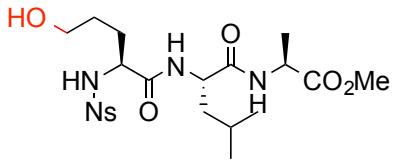
Ns-P-L-A-OMe (-)-**39** (249.3 mg, 0.5 mmol, 1.0 equiv.) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH, and the crude reaction mixture was passed through a plug of silica (40 mL) with EtOAc (250 mL) and concentrated. The crude residue was dissolved in CH_2Cl_2 and reacted with 1-(2-pyridyl)piperazine (81.6 mg, 0.5 mmol, 1.0 equiv.) and sodium triacetoxyborohydride (317.9 mg, 1.5 mmol, 3.0 equiv.) according to the General Procedure for Reductive Amination.. Flash chromatography (MeOH / CH_2Cl_2 5%→7%) afforded (-)-**58**. Run 1: 163.0 mg, 49%; Run 2: 149.1 mg, 45%; Average: 47% (69% per step).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.31 (d, J = 8.8 Hz, 2H), 8.19 (d, J = 4.8 Hz, 1H), 8.04 (d, J = 8.7 Hz, 2H), 7.52-7.49 (m, 1H), 6.83 (d, J = 7.4 Hz, 1H), 6.68-6.65 (m, 2H), 4.51 (p, 7.3 Hz, 1H), 4.42-4.38 (m, 1H), 3.88 (m, 1H), 3.75-3.66 (m, 6H, including s at 3.72, 3H), 2.80-2.71 (m, 2H), 2.68-2.59 (m, 2H), 2.57-2.48 (m, 1H), 2.45-2.36 (m, 1H), 2.23-2.13 (m, 1H), 1.70-1.44 (m, 6H), 1.36 (d, J = 7.3 Hz, 3H), 0.91 (d, J = 6.3 Hz, 3H), 0.86 (d, J = 6.2 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.2, 171.2, 170.6, 159.1, 150.1, 148.1, 145.8, 137.8, 128.6, 124.5, 114.1, 109.9, 107.4, 57.7, 55.9, 52.6, 52.0, 48.1, 44.4, 41.4, 31.7, 25.1, 23.0, 21.8, 21.3, 18.2, 14.3;

HRMS (ESI) calc'd for: $C_{30}H_{44}N_7O_8S$ $[M+H]^+$: 662.2972, found: 662.2963;

$[\alpha]_D^{26}$ = -16.2° (c = 1.10, $CHCl_3$).



Methyl ((*S*)-5-hydroxy-2-((4-nitrophenyl)sulfonamido)pentanoyl)-*L*-leucyl-*L*-alaninate (-)-59.

Substrate Ns-Pro-Leu-Ala-OMe (-)-**39** (149.6 g, 1.0 equiv., 0.5 mmol) was reacted according to **Procedure A** with (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$, H_2O_2, and AcOH, and the crude reaction mixture was passed through a plug of silica (40 mL) with EtOAc (250 mL) and concentrated. The crude residue was dissolved in CH_2Cl_2/ EtOH (1:1, 10 mL) and cooled to 0°C. To this stirring solution was added sodium borohydride (19 mg, 0.5 mmol, 1.0 equiv.), which caused the solution to gently bubble. The reaction was allowed to warm to RT and concentrated onto silica gel for purification. Flash chromatography (1:1 $CHCl_3$/EtOAc → 100% EtOAc) afforded (-)-**59**. Run 1: 91.4 mg, 35%; Run 2: 96.9 mg, 38%; Average: 37% (61% per step).

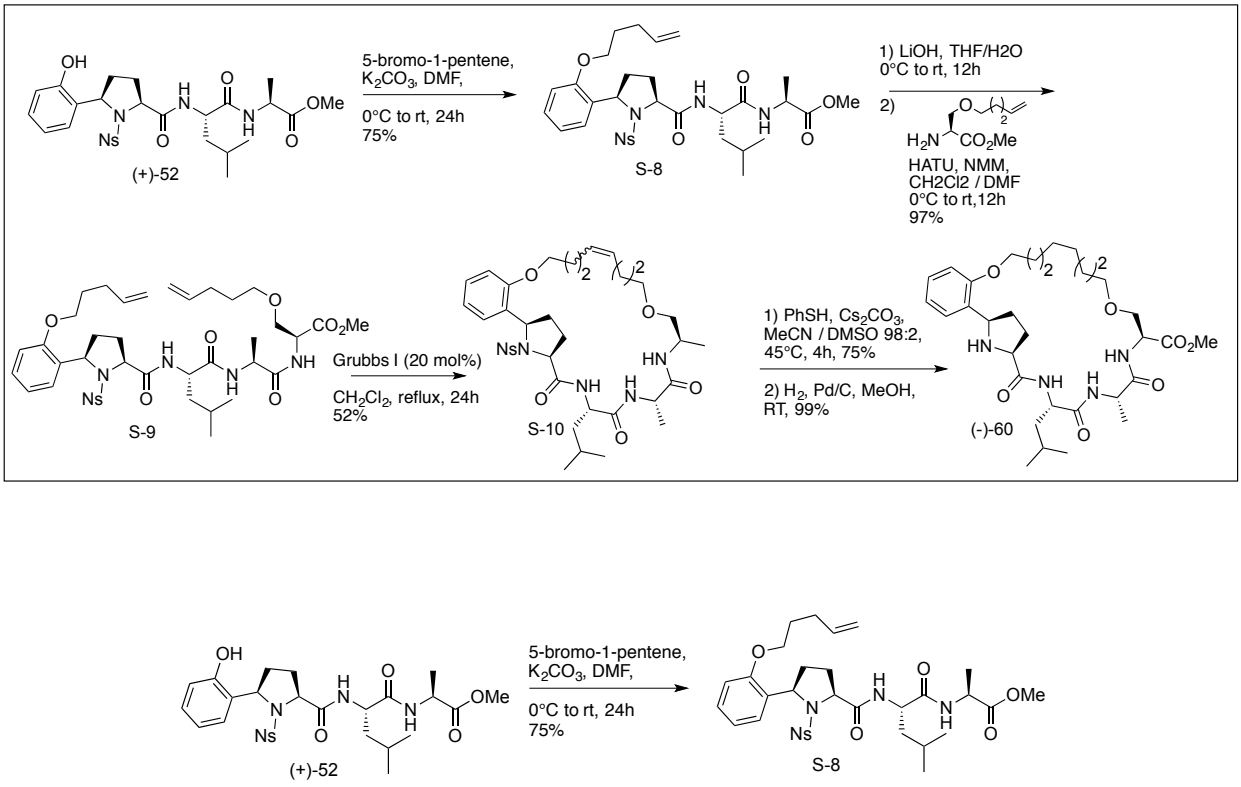
^{1}H NMR (500 MHz, Methanol-d_4) δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.08 (d, *J* = 8.8 Hz, 2H), 4.32 (q, *J* = 7.3 Hz, 1H), 4.11 (dd, *J* = 5.3, 9.5 Hz, 1H), 3.88 (dd, *J* = 5.5 8.3 Hz, 1H), 3.68 (s, 3H), 3.52 (t, *J* = 6.1 Hz, 2H), 1.79-1.72 (m, 1H), 1.64-1.36 (m, 5H), 1.34 (d, *J* = 7.3 Hz, 3H), 0.88 (d, *J* = 6.4 Hz, 3H), 0.79 (d, *J* = 6.3 Hz, 3H);

^{13}C NMR (125 MHz, Methanol-d_4) δ 174.4, 1741, 173.0, 151.4, 147.9, 129.7, 125.3, 62.1, 57.6, 52.7, 52.6, 42.0, 31.2, 29.5, 25.6, 23.2, 22.1, 17.2;

HRMS (ESI) calc'd for: $C_{21}H_{33}N_4O_9S$ $[M+H]^+$: 517.1968, found: 517.1960;

$[\alpha]_D^{27}$ = -39.7 ° (c = 1.17, MeOH).

Figure S 5. Synthesis of aryl-linked macrocycle (-)-60.



Methyl ((2*S*,5*R*)-1-((4-nitrophenyl)sulfonyl)-5-(2-(pent-4-en-1-yloxy)phenyl)pyrrolidine-2-carbonyl)-*L*-leucyl-*L*-alaninate

Phenol-Adduct (+)-**52** (655.3 mg, 1.0 equiv., 1.12 mmol) and 5-bromo-1-pentene (0.79 mL, 6.0 equiv., 6.6 mmol) in DMF (5 mL), were cooled to 0°C. Then K_2CO_3 (1.55 g, 10 equiv., 11.2 mmol) was added to the reaction and the resulting suspension stirred rapidly at 0°C for 2h, then gradually allowed to warm to RT and stirred for 22h. The reaction mixture was partitioned between EtOAc and sat. aq. $NaHCO_3$ solution, the layers separated and the organic layer washed once with additional sat. aq. $NaHCO_3$, dried over Na_2SO_4, and concentrated onto silica gel for purification. Flash chromatography on silica gel, eluting with 2:1 to 1:1 Hexanes / EtOAc afforded **S-8** (550.2 mg, 0.84 mmol, 75%).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.08 (d, *J* = 8.8 Hz, 2H), 7.37 (d, *J* = 7.6 Hz, 1H), 7.20 (t, *J* = 7.0 Hz, 1H), 7.12 (d, *J* = 8.5 Hz, 1H), 6.84 (dt, *J* = 14.5, 7.3 Hz, 3H), 5.89 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.20 (t, *J* = 7.1 Hz, 1H), 5.13 – 5.02 (m, 2H), 4.66 – 4.55 (m, 2H), 4.37 – 4.31 (m, 1H), 4.12 – 3.98 (m, 2H), 3.77 (s, 3H), 2.27 (q, *J* = 6.6 Hz, 3H), 2.18 –

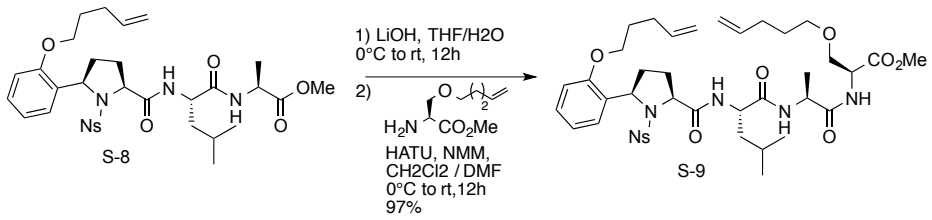
2.08 (m, 1H), 1.95 (p, J = 6.9 Hz, 2H), 1.91-1.78 (m, 4H), 1.75 – 1.66 (m, 1H), 1.42 (d, J = 7.2 Hz, 3H), 1.02 (dd, J = 6.4, 3.1 Hz, 6H);

^{13}C NMR (126 MHz, Chloroform-*d*) δ 173.3, 171.3, 170.7, 155.4, 150.4, 141.8, 137.5, 129.6, 128.9, 128.8, 127.1, 124.2, 120.5, 115.6, 111.3, 67.3, 64.0, 60.3, 52.5, 52.3, 48.1, 41.3, 34.1, 30.3, 28.9, 28.5, 25.0, 23.3, 21.7, 18.2;

IR (film, cm^{-1}) 3284, 3079, 2954, 2873, 2252, 1739, 1666, 1604, 155, 1535, 1492, 1454, 1351, 1288, 1240, 1207, 1170, 1093, 1054, 1010, 912, 856, 736;

HRMS (ESI) *m/z* calc'd for $C_{32}H_{42}N_4O_9S$ $[M+H]^+$: 659.2751, found 659.2746;

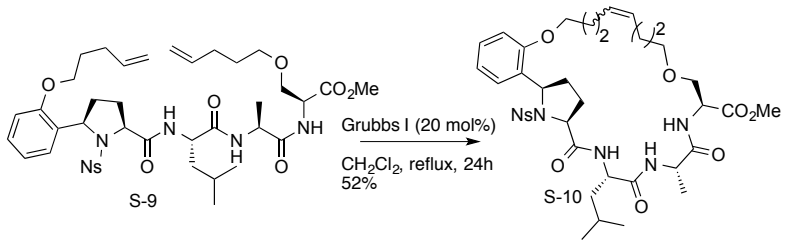
$[\alpha]_D^{29}$ = +24.1˚ (c=1.14, CH_2Cl_2).



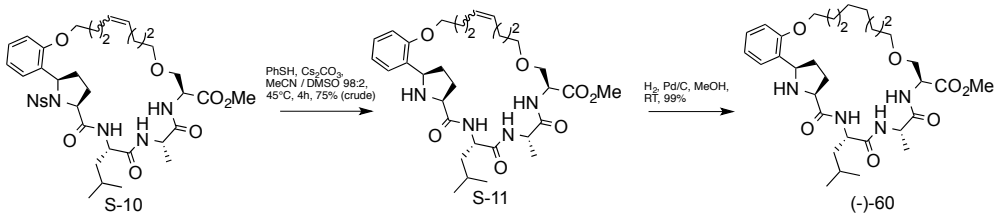
methyl *N*-((2*S*,5*R*)-1-((4-nitrophenyl)sulfonyl)-5-(2-(pent-4-en-1-yloxy)phenyl)pyrrolidine-2-carbonyl)-*L*-leucyl-*L*-alanyl-*O*-(pent-4-en-1-yl)-*L*-serinate

To a solution of peptide **S-8** (380 mg, 1.0 equiv., 0.577 mmol) in 3:1 THF/H_2O (5.8 mL) at 0°C was added LiOH-H_2O (121 mg, 5.0 equiv., 2.89 mmol). The resulting solution was allowed to gradually warm to RT while stirring overnight. The solution was quenched by paritioning between EtOAc and 1M $KHSO_4$; the layers were separated and the aqueous layer was extracted with EtOAc (3 x 20 mL). Combined organics were dried over Na_2SO_4 and concentrated, yielding crude free acid (213.7 mg, 0.332 mmol, approx. 58%) which was taken on without further purification. The crude acid (213.7 mg, 1.0 equiv., 0.332 mmol) was dissolved in 1:1 CH_2Cl_2 / DMF and cooled to 0°C. To this stirring solution were added HATU (176.7 mg, 1.4 equiv., 0.465 mmol), pentenyl-serine-OMe (88.9 mg, 1.2 equiv., 0.398 mmol), and N-methylmorpholine (109.5 uL, 3.0 equiv., 0.996 mmol). The reaction was stirred overnight and gradually allowed to warm to RT. Flash chromatography of the crude reaction mixture, eluting with 3:1 to 2:1 hexanes / acetone, afforded **S-9** (275.5 mg, 0.32 mmol, 97%).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.8 Hz, 2H), 7.38 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.24 – 7.19 (m, 1H), 7.13 (d, *J* = 8.4 Hz, 1H), 6.93 (d, *J* = 7.6 Hz, 1H), 6.86 (dd, *J* = 13.2, 7.7 Hz, 2H), 6.73 (d, *J* = 8.2 Hz, 1H), 5.89 (ddt, *J* = 16.9, 10.2, 6.6 Hz, 1H), 5.79 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H), 5.19 (t, *J* = 7.0 Hz, 1H), 5.13 – 4.92 (m, 4H), 4.76 – 4.66 (m, 1H), 4.57 (dt, *J* = 14.5, 6.6 Hz, 2H), 4.30 (dd, *J* = 7.5, 4.7 Hz, 1H), 4.12 – 3.96 (m, 2H), 3.88 (dd, *J* = 9.6, 3.4 Hz, 1H), 3.77 (s, 3H), 3.65 (dd, *J* = 9.6, 3.4 Hz, 1H), 3.51-3.45 (m, 1H), 3.42 (dt, *J* = 9.5, 6.5 Hz, 1H), 2.27 (q, *J* = 6.6 Hz, 3H), 2.07 (q, *J* = 6.9 Hz, 3H), 1.96 (q, *J* = 6.8 Hz, 2H), 1.91 – 1.76 (m, 4H), 1.67 – 1.60 (m, 3H), 1.43 (d, *J* = 7.1 Hz, 3H), 1.02 (t, *J* = 6.0 Hz, 6H);
^{13}C NMR (126 MHz, Chloroform-*d*) δ 172.1, 171.5, 170.8, 170.7, 155.5, 150.5, 141.8, 138.1, 137.5, 129.7, 129.0, 128.8, 127.1, 124.3, 120.6, 115.7, 115.0, 111.4, 70.9, 70.2, 67.4, 64.1, 60.2, 52.8, 52.7, 52.4, 48.9, 41.4, 34.2, 30.3, 30.2, 28.9, 28.6, 28.6, 25.1, 23.4, 21.7, 18.5;
IR (film, cm^{-1}) 3307, 3102, 2952, 2871, 1745, 1643, 1604, 1531, 1494, 1454, 1349, 1311, 1290, 1243, 1211, 1162, 1106, 1054, 1010, 914, 854;
HRMS (ESI) *m/z* calc'd for $C_{40}H_{56}N_5O_{11}S$ $[M+H]^+$: 814.3697, found 814.3702;
$[\alpha]_D^{25}$ = +16.8° (c=0.97, CH_2Cl_2).



Diene **S-9** (47 mg, 1.0 equiv., 0.0577 mmol) was dissolved in CH_2Cl_2 (11.5 mL, [diene] = 0.005 M), and to this solution was added Benzylidene-bis(tricyclohexylphosphine)dichlororuthenium (Grubb's I catalyst) (9.5 mg, 0.2 equiv., 0.0115 mmol). The resulting solution was heated to reflux overnight, then concentrated onto silica gel for purification. Flash chromatography, eluting with 3:1→2:1 Hexanes / Acetone, afforded alkene macrocycle **S-10** (23.5 mg, 0.03 mmol, 52%), which was taken on to the next step.



(1^2*R*,1^5*S*,14*R*,17*S*,20*S*)-20-isobutyl-14,17-dimethyl-1^1-((4-nitrophenyl)sulfonyl)-3,12-dioxa-15,18,21-triaza-1(2,5)-pyrrolidina-2(1,2)-benzenacyclodocosaphane-16,19,22-trione (-)-60.

To nosyl-amine containing macrocycle **S-10** (70.6 mg, 1.0 equiv., 0.0898 mmol) in 98:2 MeCN / DMSO was added thiophenol (99.0 mg, 10.0 equiv., 0.898 mmol), and Cs_2CO_3 (438.9 mg, 15.0 equiv., 1.347 mmol). The resulting slurry was stirred rapidly and heated to 45°C for 4h. The reaction was poured into sat. aq. $NaHCO_3$ and extracted with EtOAc (3 x 20 mL). The combined organics were dried over K_2CO_3 and concentrated onto silica gel for purification. Flash chromatography, eluting with 5% to 10% MeOH / CH_2Cl_2 afforded free amine intermediate **S-11** (40.2 mg, 0.067 mmol, 75%). Free amine intermediate **S-11** was dissolved in MeOH (6 mL), and to this solution was added 5% Pd/C (20.1 mg, 50 wt% relative to substrate). Two balloons of H_2 gas were bubbled through the resulting slurry and a third full balloon left static to maintain H_2 atmosphere, as the mixture was stirred at RT overnight. The crude mixture was passed through a plug of Celite with MeOH to remove Pd/C, and then concentrated onto silica gel for purification. Flash chromatography, eluting with 3% MeOH / CH_2Cl_2 afforded (-)-**60** (42.0 mg, 0.067 mmol, 99% from **S-11**).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.18 (s, 1H), 7.31 – 7.19 (m, 2H), 7.06 (d, *J* = 8.1 Hz, 1H), 6.98 – 6.86 (m, 2H), 6.63 (s, 1H), 4.73 (td, *J* = 7.3, 6.0, 3.5 Hz, 1H), 4.56 – 4.44 (m, 2H), 4.28 (dt, *J* = 10.3, 5.5 Hz, 1H), 4.12 (d, *J* = 5.5 Hz, 1H), 4.07 (t, *J* = 5.7 Hz, 2H), 3.86 (dd, *J* = 10.2, 6.0 Hz, 1H), 3.72 (s, 3H), 3.63 (dd, *J* = 10.3, 3.5 Hz, 1H), 3.42 (t, *J* = 6.2 Hz, 2H), 2.41 – 2.29 (m, 1H), 2.25 – 2.16 (m, 1H), 2.15 – 1.97 (m, 2H), 1.91-1.77 (m, 2H), 1.72 – 1.60 (m, 1H), 1.60 – 1.22 (m, 16H), 0.87 (dd, *J* = 6.1, 4.4 Hz, 6H);

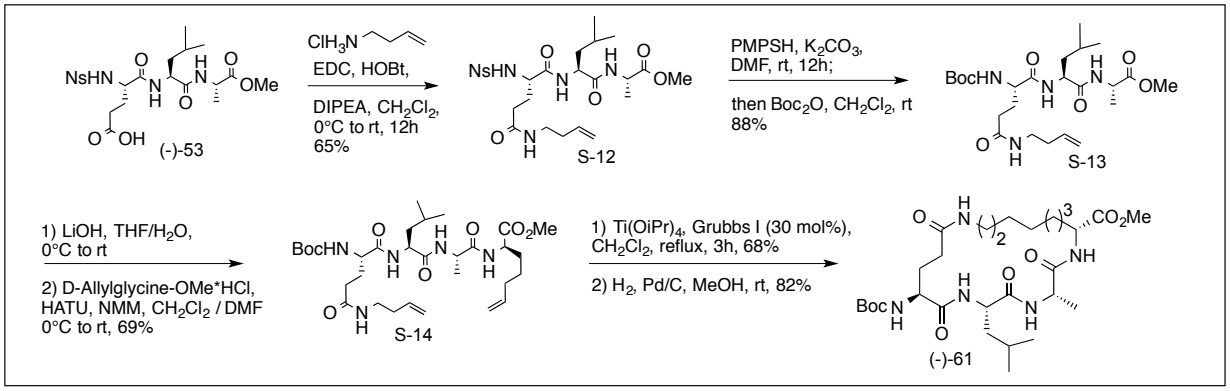
^{13}C NMR (126 MHz, Chloroform-*d*) δ 176.5, 172.1, 170.6, 157.1, 129.9, 129.0, 121.0, 111.7, 71.3, 69.9, 68.5, 66.0, 59.5, 53.0, 52.8, 52.7, 48.9, 40.4, 29.6, 29.5, 29.2, 29.04, 29.02, 28.8, 26.6, 25.7, 25.0, 23.2, 21.7, 17.3 (2 peaks overlapping or obscured);

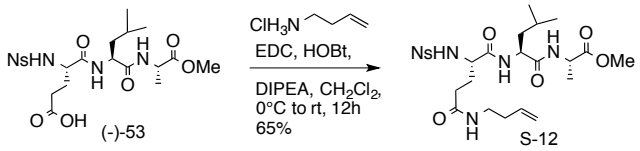
IR (film, cm^{-1}) 3295, 3054, 2933, 2859, 1747, 1658, 1602, 1523, 1454, 1386, 1369, 1241, 1162, 1118, 1051;

HRMS (ESI) *m/z* calc'd for $C_{32}H_{51}N_4O_7$ $[M+H]^+$: 603.3758, found 603.3749;

$[\alpha]_D^{25}$ = -29.6° (c=1.28, CH_2Cl_2).

Figure S 6. Synthesis of amide-linked macrocycle (-)-61.





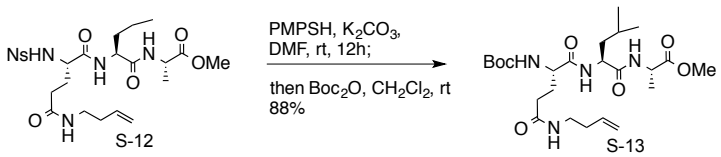
methyl N^5-(but-3-en-1-yl)-N^2-((4-nitrophenyl)sulfonyl)-*L*-glutaminyl-*L*-leucyl-*L*-alaninate

Acid (-)-**53** (500 mg, 0.94 mmol, 1.0 equiv.) was dissolved in DMF (2.3 mL, 0.4 M) at RT. 3-Butenylamine hydrochloride (500 mg, 4.71 mmol, 5.0 equiv.), DIPEA (0.82 mL, 4.71 mmol, 5.0 equiv.), HOBt (238.1 mg, 1.41 mmol, 1.5 equiv.), and EDC (180.2 mg, 0.94 mmol, 1.0 equiv.) were added sequentially to the reaction, and stirred at 45°C for 48 h. The crude mixture was then concentrated via rotary evaporation at 60°C to remove DMF solvent by several additions of toluene as an azeotrope, and purified via flash chromatography (MeOH / CH_2Cl_2 3%→5%) to afford **S-12** (355.1 mg, 0.61 mmol, 65%).

^{1}H NMR (500 MHz, Acetone-d6) δ 8.43 (d, *J* = 8.7 Hz, 2H), 8.13 (d, *J* = 8.7 Hz, 2H), 7.65 (d, *J* = 8.5 Hz, 1H), 7.62 (d, *J* = 7.3 Hz, 1H), 7.30 (br s, 1H), 5.81 (ddt, *J* = 6.8, 10.3, 17.1 Hz, 1H), 5.07 (dd, *J* = 1.6, 17.2 Hz, 1H), 5.01-4.98 (m, 1H), 4.38 (p, *J* = 7.3 Hz, 1H), 4.33-4.28 (m, 1H), 3.93 (dd, *J* = 6.0, 7.7 Hz, 1H), 3.65 (s, 3H), 3.31-3.18 (m, 2H), 2.31-2.18 (m, 4H), 1.97-1.84 (m, 2H), 1.58-1.52 (m, 1H), .50-1.39 (m, 2H), 1.32 (d, *J* = 7.3 Hz, 3H), 0.84 (d, *J* = 6.4 Hz, 3H), 0.76 (d, *J* = 6.4 Hz, 3H);

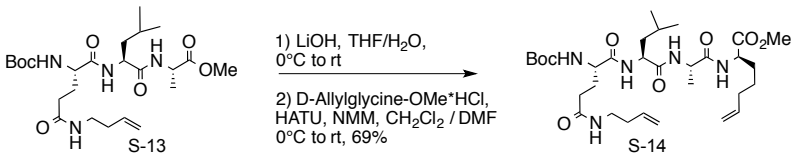
^{13}C NMR (125 MHz, Acetone-d_6) δ 173.7, 173.2, 172.6, 171.0, 151.0, 147.4, 136.9, 129.6, 125.3, 116.8, 57.5, 52.4, 48.9, 42.0, 39.6, 34.7, 32.5, 25.3, 23.5, 22.0, 17.7;

HRMS (ESI) calc'd for: $C_{25}H_{38}N_5O_9S$ $[M+H]^+$: 584.2390, found: 584.2388;
$[\alpha]_D^{26}$ = +2.8° (c = 1.12, DMF).



methyl N^5-(but-3-en-1-yl)-N^2-(*tert*-butoxycarbonyl)-*L*-glutaminyl-*L*-leucyl-*L*-alaninate

Nosyl tripeptide **S-12** (351.4 mg, 0.6 mmol, 1.0 equiv.) was dissolved in DMF (6 mL, 0.1 M). p-Methoxyphenylthiol (221 μL, 1.8 mmol, 3.0 equiv.) was added, followed by K_2CO_3 (332 mg, 2.4 mmol, 4.0 equiv.). The reaction was stirred at RT for approx. 3.5 h, and diluted with CH_2Cl_2 (15 mL). Boc_2O (655 mg, 3.0 mmol, 5.0 equiv.) was added to the mixture and was stirred overnight. The crude reaction mixture was partitioned between CH_2Cl_2 and H_2O. The aqueous layer was extracted with CH_2Cl_2 (3 x 20 mL) and combined organic layers were washed with brine (3 x 20 mL), dried over Na_2SO_4, and concentrated. Residual DMF was removed via rotary evaporation at 60°C with several additions of toluene as an azeotrope. The crude residue was purified via flash chromatography (0%→5% MeOH / CH_2Cl_2) to afford **S-13** (263.1 mg, 0.53 mmol, 88%).
^{1}H NMR (500 MHz, $CDCl_3$) δ 6.95 (d, *J* = 7.0 Hz, 1H), 6.90 (d, *J* = 7.9 Hz, 1H), 6.28 (t, *J* = 4.6 Hz, 1H), 5.77 (ddt, *J* = 6.8, 10.2, 17.0 Hz, 1H), 5.68 (d, *J* = 6.1 Hz, 1H), 5.17-5.05 (m, 2H), 4.53 (p, *J* = 7.3 Hz, 1H), 4.48-4.41 (m, 1H), 4.10 (q, *J* = 6.7 Hz, 1H), 3.73 (s, 3H), 2.35-2.23 (m, 4H), 2.06-1.99 (m, 2H), 1.73-1.63 (m, 2H), 1.59-1.52 (m, 1H), 1.42 (s, 9H), 1.39 (d, *J* = 7.2 Hz, 3H), 0.93 (d, *J* = 6.2 Hz, 3H), 0.90 (d, *J* = 6.1 Hz, 3H);
^{13}C NMR (125 MHz, $CDCl_3$) δ 173.3, 172.7, 172.0, 171.9, 156.0, 135.5, 117.4, 80.2, 54.1, 52.6, 52.1, 48.2, 40.9, 38.7, 33.8, 32.9, 28.6, 28.4, 24.8, 23.1, 21.8, 18.2;
HRMS (ESI) calc'd for: $C_{24}H_{42}N_4O_7Na$ $[M+Na]^+$: 521.2951, found: 521.2952;
$[\alpha]_D^{26}$ = -47.3° (c = 0.9, MeOH).



methyl (6*S*,9*S*,12*S*,15*R*)-6-(3-(but-3-en-1-ylamino)-3-oxopropyl)-9-isobutyl-2,2,12-trimethyl-4,7,10,13-tetraoxo-15-(pent-4-en-1-yl)-3-oxa-5,8,11,14-tetraazahexadecan-16-oate

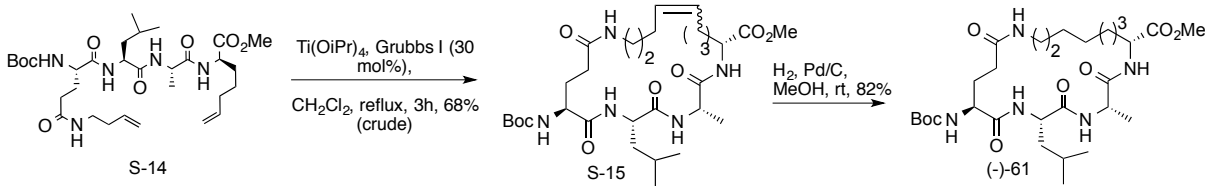
Tripeptide **S-13** (263 mg, 0.53 mmol, 1.0 equiv.) was dissolved in 3:1 THF/H_2O and cooled to 0°C. LiOH-H_2O (111 mg, 2.64 mmol, 5.0 equiv.) was added and the reaction was stirred overnight and warmed to RT. The crude reaction mixture was partitioned between EtOAc and 1M $KHSO_4$, and the aqueous layer was extracted with EtOAc (3 x 20 mL) and concentrated. The crude carboxylic acid material was dissolved in 1:1 DMF / CH_2Cl_2 (5.3 mL, 0.1 M) and HATU (281.4 mg, 0.74 mmol, 1.4 equiv.), D-bishomoallylglycine methyl ester (83 mg, 0.53 mmol, 1.0 equiv.), and N-methylmorpholine (174 uL, 1.58 mmol, 3.0 equiv.) were added sequentially. The reaction was stirred overnight at RT. The reaction was concentrated via rotary evaporation at 60°C with several additions of toluene as an azeotrope to remove residual DMF, and the residue was purified via flash chromatography (1%→3% MeOH / CH_2Cl_2) to afford diene **S-14** (226.2 mg, 0.37 mmol, 69% over two steps), with a minor HATU-derived impurity (1-hydroxy-7-azabenzotriazole).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (d, *J* = 7.05 Hz, 1H), 7.01 (d, *J* = 7.5 Hz, 1H), 6.88 (d, *J* = 5.85 Hz, 1H), 6.27 (br s, 1H), 6.22 (d, *J* = 5.1 Hz, 1H), 5.80-5.71 (m, 2H), 5.11-5.06 (m, 2H), 5.01-4.92 (m, 2H), 4.50-4.46 (m, 2H), 4.30-4.27 (m, 1H), 4.05 (q, *J* = 6.6 Hz, 1H), 3.69 (s, 3H), 3.38-3.26 (m, 2H), 2.39-2.24 (m, 4H) 2.10-1.96 (m, 4H), 1.88-1.80 (m, 1H), 1.76-1.63 (m, 3H), 1.58-1.52 (m, 1H), 1.47-1.44 (m, 2H), 1.42 (s, 9H), 1.39 (d, *J* =7.2 Hz, 3H), 0.93 (d, *J* = 6.2 Hz, 3H), 0.89 (d, *J* = 6.1 Hz, 3H). (Additional resonances corresponding to minor HATU derived impurity, 1-hydroxy-7-azabenzotriazole: 8.68 (d, *J* = 3.8 Hz), 8.34 (d, *J* = 8.2 Hz));

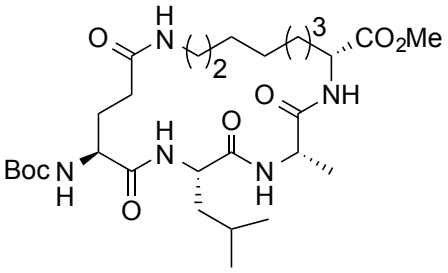
^{13}C NMR (125 MHz, MeOH-d_4) δ 175.0, 174.9, 174.6, 173.9, 157.9, 139.2, 136.7, 117.0, 115.5, 80.8, 55.7, 53.7, 52.7, 50.5, 41.6, 40.0, 34.8, 34.2, 33.3, 32.0, 28.9, 28.7, 26.0, 25.8, 23.5, 21.8, 18.2. 2 peaks obscured or overlapping. (Additional resonances corresponding to minor HATU derived impurity, 1-hydroxy-7-azabenzotriazole: 152.0, 129.9, 122.1);

HRMS (ESI) calc'd for: $C_{31}H_{54}N_5O_8$ [M+H]+: 624.3972, found: 624.3964;

$[\alpha]_D^{26}$ = -68.6° (c = 1.07, CH_2Cl_2).



Diene **S-14** (75 mg, 0.12 mmol, 1.0 equiv.) was dissolved in CH_2Cl_2 (25 mL, 0.0047 M) in a round-bottomed flask under N_2 atmosphere. To this solution was added $Ti(OiPr)_4$ (36 μL, 0.12 mmol, 1.0 equiv.), and the colorless solution turned a light yellow. The mixture was stirred for 30 min, then Grubbs I catalyst (29.6 mg, 0.036 mmol, 0.3 equiv.) was added in 1 mL of CH_2Cl_2. The flask was fitted with a water-cooled condenser and an N_2 inlet, and heated to gentle reflux for 3h. The reaction was cooled to RT and purified via flash chromatography (25% Acetone / Hexanes to 60%) to afford alkene-containing macrocycle **S-15** (53.9 mg, 0.082 mmol, 68%) as an inconsequential ~1:1 E/Z isomer mixture, which was taken through to the next step.



Methyl (3*S*,6*S*,9*S*,21*R*)-9-((*tert*-butoxycarbonyl)amino)-6-isobutyl-3-methyl-2,5,8,12-tetraoxo-1,4,7,13-tetraazacyclohenicosane-21-carboxylate (-)-61.

Alkene-containing macrocycle **S-15** (53.9 mg, 0.09 mmol, 1.0 equiv.) was dissolved in MeOH (5mL). 5%Pd/C (25 mg, 50% wt) was added to the solution. H_2 was bubbled through the solution (2 balloons, ~ 20 min), and a third balloon was added to maintain H_2 atmosphere. The H_2 balloon was recharged after 8h and the reaction stirred overnight. The crude mixture was purified by eluting through a plug of Celite with MeOH, and concentrated to afford hydrogenated product (-)-**61** (44.0 mg, 0.074 mmol, 82%).

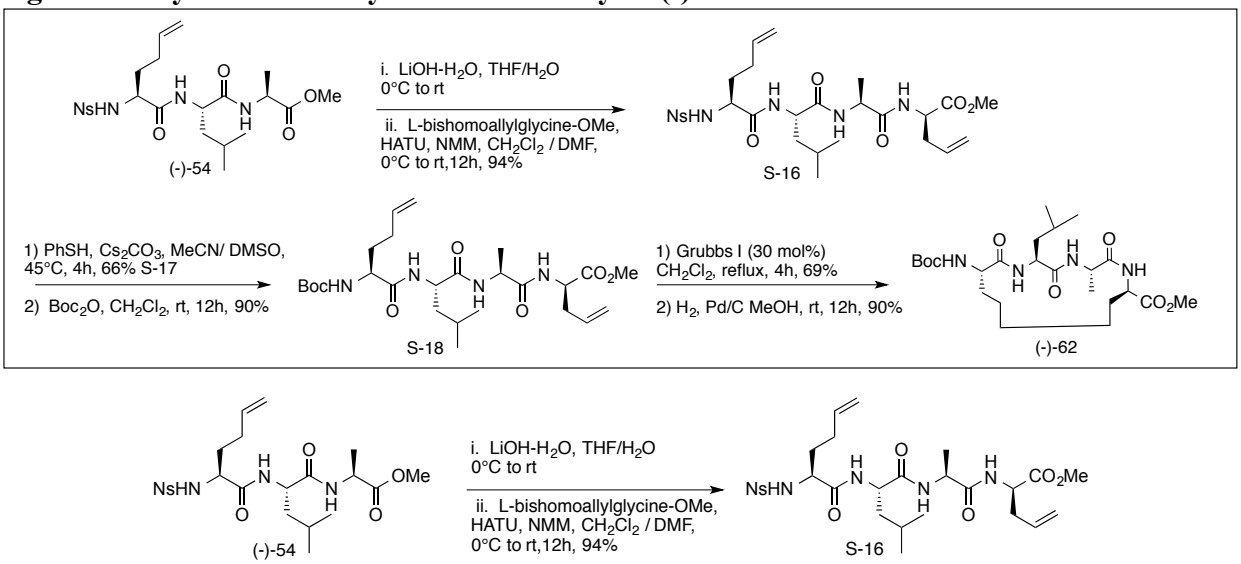
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52-7.45 (m, 1H), 7.06-7.00 (m, 1H), 6.84 (d, J = 7.6 Hz, 1H), 6.76 (d, J = 6.1 Hz, 1H), 5.30 (d, J = 6.65 Hz, 1H), 4.57-4.52 (m, 1H), 4.50-4.42 (m, 2H), 4.09-4.04 (m, 1H), 3.73 (s, 3H), 3.35-3.24 (m, 2H), 2.30-2.08 (m, 4H), 2.07-1.80 (m, 5H), 1.78-1.42 (m, 9H), 1.41 (s, 9H), 1.35 (d, J = 7.2 Hz, 3H), 0.96 (d J = 6.1 Hz, 3H), 0.89 (d, J = 5.95 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.4, 173.0, 172.8, 172.3, 171.9, 155.7, 80.4, 53.5, 52.6, 52.4, 52.0, 49.8, 41.0, 39.6, 32.1, 31.7, 28.4, 27.8, 25.8, 24.9, 23.5, 23.1, 21.4, 17.7 (3 peaks overlapping or obscured);

HRMS (ESI) calc'd for: $C_{29}H_{52}N_5O_8$ $[M+H]^+$: 598.3816, found: 598.3820;

$[\alpha]_D^{27}$ = -40.3° (c = 0.51, MeOH).

Figure S 7. Synthesis of alkyl-linked macrocycle (-)-62.

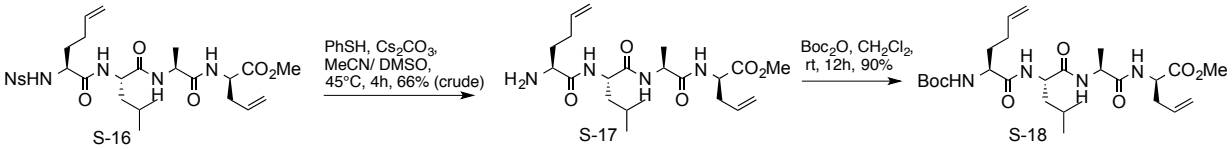


Tripeptide Ns-Hag-Leu-Ala-OMe (-)-**54** (613.2 mg, 1.20 mmol, 1.0 equiv.) was dissolved in 3:1 THF / H_2O (7 mL) and cooled to 0°C. To this was added LiOH-H_2O (250.9 mg, 5.98 mmol, 5.0 equiv.), and the reaction was stirred overnight, allowing it to warm to RT. The crude reaction mixture was partitioned between EtOAc and 1M $KHSO_4$ (100 mL each) and the aqueous layer extracted with EtOAc (3 x 30 mL). A precipitate formed in the organic layer, and the combined organics (including the precipitate) were concentrated without further purification. The crude acid obtained from the hydrolysis was dissolved in 1:1 DMF / CH_2Cl_2 (12 mL), and HATU (638.8 mg, 1.68 mmol, 1.4 equiv.), D-allylglycine methyl ester hydrochloride (238.2 mg, 1.44 mmol, 1.2 equiv.) and N-methylmorpholine were added sequentially to the reaction. The solution turned from a light yellow color to dark red. The reaction was stirred at RT for 8h, and the crude reaction mixture was plugged through a pad of silica (approx. 50 mL dry volume) with 10% MeOH / DCM (1 L). The plug eluent was diluted to a total volume of approx. 1.5 L with

CH_2Cl_2 to prevent precipitation of product, transferred to a 2L separatory funnel, and washed with sat. $NaHCO_3$ solution (500 mL), with further dilution by CH_2Cl_2 (300 mL). The combined organics were diluted to a volume of ~2 L, and split into two 1 L portions. Each organic portion was washed with 1M HCl (300 mL), dried over Na_2SO_4, and concentrated. Residual DMF was removed via rotary evaporation at 60°C with several additions of toluene as an azeotrope, to afford diene **S-16** (683.3 mg, 1.13 mmol, 94%). This highly insoluble diene was characterized by ^{1}H NMR and HRMS and then carried on to further steps.

^{1}H NMR (500 MHz, Acetone-d_6) δ 8.43 (d, *J* = 8.8 Hz, 2H), 8.17 (d, *J* = 8.8 Hz, 2H), 7.66 (d, *J* = 7.3 Hz, 1H), 7.42 (d, *J* = 7.1 Hz, 1H), 7.37 (d, *J* = 7.3 Hz, 1H), 5.76 (dddd, *J* = 2.8, 6.9, 9.9, 16.9 Hz, 2H), 5.17-5.02 (m, 2H), 5.00-4.86 (m, 2H), 4.47 (td, *J* = 5.4, 7.9 Hz, 1H), 4.38 (p, *J* = 7.1 Hz, 1H), 4.23-4.19 (m, 1H), 3.96 (dd, *J* = 5.1, 8.5 Hz, 1H), 3.68 (s, 3H), 2.54 (dt, *J* = 6.1, 12.5 Hz, 1H), 2.46 (dt, *J* = 7.5, 14.2 Hz, 1H), 2.20-2.11 (m, 1H), 1.89-1.79 (m, 1H), 1.72 (ddt, *J* = 5.5, 9.3, 18.9 Hz, 1H), 1.54-1.40 (m, 3H), 1.27 (d, *J* = 7.1 Hz, 3H), 0.83 (d, *J* = 6.2 Hz, 3H), 0.75 (d, *J* = 6.2 Hz, 3H);

HRMS (ESI) calc'd for $C_{27}H_{40}N_5O_9S$ [M+H]+: 610.2547, found: 610.2540.



Diene **S-16** (357 mg, 0.586 mmol, 1.0 equiv.) was dissolved in 98:2 MeCN / DMSO (10 mL). To this solution was added thiophenol (209 uL, 2.05 mmol, 3.5 equiv.), followed by Cs_2CO_3 (762 mg, 2.34 mmol, 4.0 equiv.). The reaction was stirred rapidly and heated to 45°C for 3.5 h. The reaction was partitioned between EtOAc and sat. $NaHCO_3$ solution. The aqueous layer was extracted with EtOAc (3 x 25 mL), and combined organics were dried over K_2CO_3 and concentrated. The crude residue was purified via flash chromatography (MeOH / CH_2Cl_2 1%→5%) to afford crude free amine **S-17** (165.1 mg, 0.387 mmol, 66%).

Crude free amine **S-17** was dissolved in CH_2Cl_2 (15 mL), and Boc_2O was added in 2 mL of CH_2Cl_2. The reaction was stirred at RT overnight, and concentrated. The crude residue was

purified via flash chromatography (2% MeOH / CH_2Cl_2) to afford Boc protected diene **S-18** (183.1 mg, 0.348 mmol, 90%).

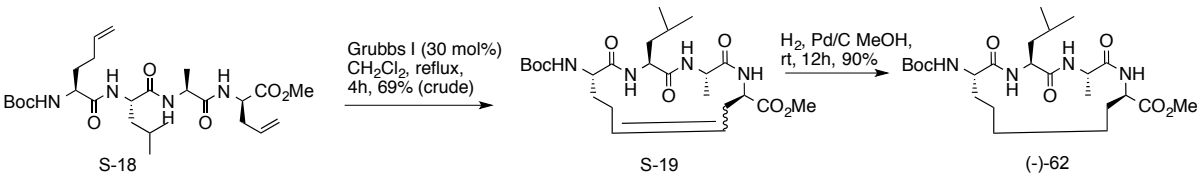
methyl (6*S*,9*S*,12*S*,15*R*)-15-allyl-6-(but-3-en-1-yl)-9-isobutyl-2,2,12-trimethyl-4,7,10,13-tetraoxo-3-oxa-5,8,11,14-tetraazahexadecan-16-oate S-18

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.87 (d, *J* = 6.3 Hz, 1H), 6.76 (d, *J* = 7.2 Hz, 1H), 6.45 (d, *J* = 7.0 Hz, 1H), 5.83-5.68 (m, 2H), 5.16-5.02 (m, 4H), 5.00-4.91 (m, 1H), 4.60 (q, *J* = 7.3 Hz, 1H), 4.48 (p *J* = 7.2 Hz, 1H), 4.40-4.31 (m, 1H), 4.06 (q, *J* = 6.2 Hz, 1H), 3.72 (s, 3H), 2.61 (dt, *J* = 6.3, 12.7 Hz, 1H), 2.52 (dt, *J* = 7.1, 14.2 Hz, 1H), 2.14 (q, *J* = 7.3 Hz, 2H), 1.94 (dq, *J* = 7.5, 13.7 Hz, 1H), 1.75-1.63 (m, 6H), 1.45 (s, 9H), 1.39 (d, *J* = 7.1 Hz, 1H), 0.95 (d, *J* = 6.4 Hz, 1H), 0.92 (*J* = 6.3 Hz, 1H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.5, 172.1, 171.8, 156.0, 137.2, 132.5, 119.1, 115.9, 80.3, 54.5, 52.4, 52.1, 51.9, 48.9, 41.5, 36.6, 31.7, 29.9, 28.4, 24.9, 23.1, 22.1, 18.8;

HRMS (ESI) calc'd for $C_{26}H_{45}N_4O_7^+$ $[M+H]^+$: 525.3288, found: 525.3286;

$[a]_D^{23}$ = -50.7° (c 0.99, $CHCl_3$).



A flame dried flask under Ar atmosphere was charged with diene **S-18** (47.2 mg, 0.090 mmol, 1.0 equiv.) in CH_2Cl_2 (17 mL). To this mixture was added Grubbs I catalyst (14.8 mg, 0.018 mmol, 0.2 equiv.) in 3 mL CH_2Cl_2 (total volume ~20 mL, [diene] ~ 0.0048M). The flask was fitted with a water-cooled condenser with an Ar inlet, and the reaction was heated to gentle reflux for 2h. The reaction was recharged with Grubbs I catalyst (7.4 mg, 0.009 mmol, 0.1 equiv.) in 2 mL CH2Cl2 through the top of the condenser, and refluxed for 2 h. The crude reaction mixture was purified via flash chromatography (2% MeOH / CH_2Cl_2 to 3%) to afford alkene-containing macrocycle **S-19** as an inconsequential ~1:1 E/Z isomer mixture (31.0 mg, 0.062 mmol, 69%). Note: in some cases it was observed that tricyclohexyl phosphine oxide (a byproduct of the Grubbs catalyst) elutes with the desired product. This impurity may be removed by passing the material through a silica plug with EtOAc.

Alkene-containing macrocycle **S-19** (31.0mg, 1.0 equiv., 0.062 mmol,) was dissolved in MeOH (5 mL), and 5% Pd/C (15.5 mg, 50% wt) was added. The flask was capped with a rubber septum and H_2 was bubbled through the solution (2 large balloons, ~20 min), with a third H_2 balloon kept over the solution to maintain hydrogen atmosphere. The solution was stirred overnight, and the crude reaction mixture was plugged through a pad of Celite with MeOH to afford hydrogenated product (-)-**62** (20.8 mg, 0.056 mmol, 90%).

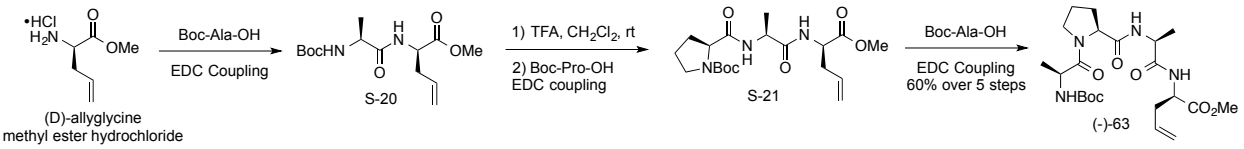
Methyl (2*S*,5*S*,8*R*,14*S*)-14-((*tert*-butoxycarbonyl)amino)-2-isobutyl-5-methyl-3,6,15-trioxo-1,4,7-triazacyclopentadecane-8-carboxylate (-)-62.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.9 Hz, 1H), 7.76 (d, *J* = 6.5 Hz, 1H), 6.69 (d, *J* = 7.4 Hz, 1H), 5.75 (d, *J* = 7.8 Hz, 1H), 4.52 (q, *J* = 7.6 Hz, 1H), 4.46-4.37 (m, 1H), 4.15-4.05 (m, 2H), 3.72 (s, 3H), 1.83-1.64 (m, 5H), 1.60 (d, *J* = 7.3 Hz, 3H), 1.41 (s, 9H), 1.35-1.20 (m, 8H), 0.94 (d, *J* = 6.3 Hz, 3H), 0.92 (d, *J* = 6.3 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.6, 172.9, 172.54, 172.47, 155.6, 79.9, 54.2, 53.8, 52.53, 52.49, 52.4, 41.1, 31.8, 30.6, 29.8, 28.5, 26.9, 24.9, 23.0, 22.2, 16.6 (1 peak overlapping or obscured);

HRMS (ESI) calc'd for: $C_{24}H_{43}N_4O_7$ [M+H]+: 499.3132, found: 499.3133;

$[\alpha]_D^{26}$ = -18.9° (c = 0.98, CH_2Cl_2).



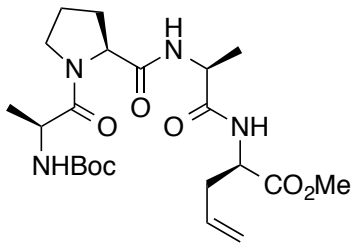
(D)-Allylglycine methyl ester hydrochloride (495.3 mg, 1.0 equiv., 3.0 mmol) and Boc-Alanine (567.6 mg, 1.0 equiv., 3.0 mmol) were reacted with DIPEA (0.52 mL, 1.0 equiv., 3.0 mmol), HOBt (557.3 mg, 1.1 equiv., 3.3 mmol), and EDC (575.1 mg, 1.0 equiv., 3.0 mmol) in CH_2Cl_2 (30 mL) according to the General Peptide Coupling Procedure to afford crude **S-20**.

Boc Deprotection Procedure. Crude **S-20** was dissolved in CH_2Cl_2 (3 mL) at room temperature, and trifluoroacetic acid (3 mL, 1.0 M) was added. The reaction was monitored by TLC and when full conversion of the starting material was observed, the reaction was diluted with CH_2Cl_2 (10 mL) and concentrated via rotary evaporation to remove residual trifluoroacetic acid. Further CH_2Cl_2 (10 mL) was added and the mixture concentrated again. This dilution / rotary

evaporation procedure was repeated three more times, and the resulting residue was placed under high vacuum for 30 min, affording crude **S-20-salt**.

Crude **S-20-salt** (assumed 3.0 mmol, 1.0 equiv.) was reacted with Boc-Proline (775.1 mg, 1.2 equiv., 3.6 mmol), DIPEA (1.4 mL, 2.0 equiv., 6.0 mmol), HOBt (557.3 mg, 1.1 equiv., 3.3 mmol), and EDC (575.1 mg, 1.0 equiv., 3.0 mmol) in CH_2Cl_2 according to the General Peptide Coupling Procedure to afford crude **S-21**. Crude **S-21** was then deprotected with trifluoroacetic acid in CH_2Cl_2 according to the Boc Deprotection Procedure (above), affording crude **S-21-salt**.

Crude **S-21-salt** (assumed 3.0 mmol, 1.0 equiv.) was reacted with Boc-Alanine (851.4 mg, 1.5 equiv., 4.5 mmol), DIPEA (2.3 mL, 4.5 equiv., 13.5 mmol), HOBt (835.9 mg, 1.65 equiv., 4.95 mmol), and EDC (862.7 mg, 1.5 equiv., 4.5 mmol) in CH_2Cl_2 according to the General Peptide Coupling Procedure. The crude material was concentrated onto silica gel for purification. Flash chromatography, eluting with 3:1→2:1→3:2 CH_2Cl_2/Acetone, afforded tetrapeptide Boc-Ala-Pro-Ala-(D)-Allyglycine-OMe (-)-**63** (846.2 mg, 1.8 mmol, 60% over 5 steps).



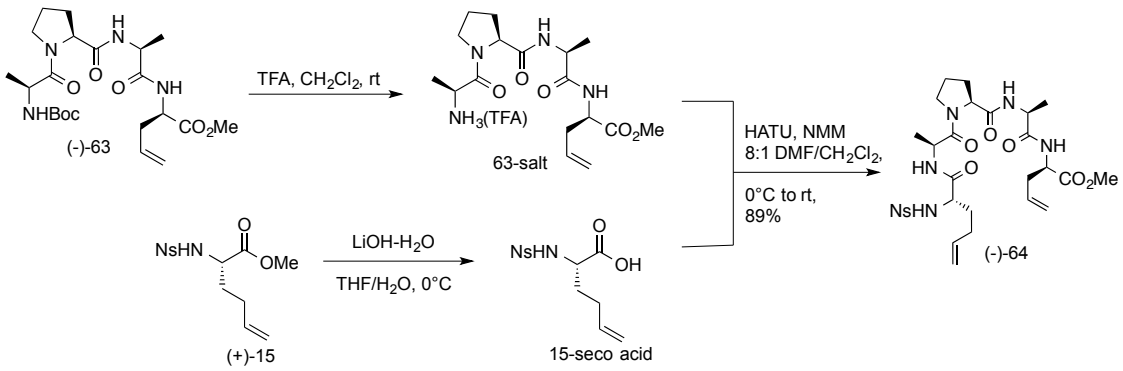
Methyl (*R*)-2-((*S*)-2-((*S*)-1-((*tert*-butoxycarbonyl)-*L*-alanyl)pyrrolidine-2-carboxamido)propanamido)pent-4-enoate (Boc-Ala-Pro-Ala-(D)-Allyglycine-OMe) (-)-63.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.06 (d, *J* = 7.4 Hz, 1H), 6.87 (d, *J* = 7.7 Hz, 1H), 5.72-5.60 (m, 1H), 5.35 (d, *J* = 7.9 Hz, 1H), 5.14-5.06 (m, 2H), 4.64-4.57 (m, 1H), 4.53 (dd, *J* = 3.7, 7.7 Hz, 1H), 4.49-4.40 (m, 2H), 3.71 (s, 3H), 3.70-3.65 (m, 1H), 3.59-3.54 (m, 1H), 2.62-2.54 (m, 1H), 2.51-2.46 (m, 1H), 2.23-2.17 (m, 1H), 2.13-1.96 (m, 3H), 1.41 (s, 9H), 1.34 (d, *J* = 6.9 Hz, 3H), 1.32 (d, *J* = 7.1 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 173.3, 172.1, 171.8, 171.2, 155.4, 132.3, 119.2, 79.9, 60.3, 52.5, 51.8, 48.9, 48.2, 47.4, 36.4, 28.5, 27.9, 25.3, 18.5, 17.9;

HRMS (ESI) calc'd for: $C_{22}H_{37}N_4O_7$ $[M+H]^+$: 469.2662, found: 469.2640;

$[\alpha]_D^{25}$ = -52.5° (c = 1.09, CH_2Cl_2).



Methyl (*R*)-2-((*S*)-2-((*S*)-1-(((*S*)-2-((4-nitrophenyl)sulfonamido)hex-5-enoyl)-*L*-alanyl)pyrrolidine-2-carboxamido)propanamido)pent-4-enoate (-)-64.

Preparation of Ns-Homoallylglycine-OH: Ns-Homoallyglycine methyl ester (+)-**15** (273.6 mg, 1.0 equiv., 0.83 mmol) was dissolved in 3:1 THF/H_2O (2 mL) and cooled to 0°C. Then, lithium hydroxide hydrate (175 mg, 5.0 equiv., 4.17 mmol) was added to the stirring solution. The solution was warmed to RT and stirred for 12h, then partitioned between EtOAc and 1M $KHSO_4$. The aqueous layer was extracted with EtOAc (5 x 20 mL) and combined organics were dried over Na_2SO_4 and concentrated to afford **15-seco acid** a crude yellow solid, which was used without further purification.

Preparation of tetrapeptide coupling partner and coupling: In a separate flask, Boc-Ala-Pro-Ala-(D)-allylglycine-OMe (-)-**63** (374.9 mg, 1.0 equiv., 0.8 mmol) was dissolved in CH_2Cl_2 (1 mL), and trifluoroacetic acid (1 mL) was added dropwise to the mixture. The resulting solution was stirred at RT for 12h, then concentrated by addition of CH_2Cl_2 and subsequent rotary evaporation, which was repeated 5 times to remove residual trifluoroacetic acid. The resulting clear gum of **63-salt** was dissolved in CH_2Cl_2 (2 mL), added to a solution containing crude **15-seco acid** (previously prepared, approx.. 0.8 mmol) in 8:1 CH_2Cl_2/DMF (9 mL) and cooled to 0°C. N-methylmorpholine (0.93 mL, approx. 9 equiv., 8.4 mmol) was added dropwise to the stirring solution, followed by HATU (456.3 mg, 1.5 equiv, 1.2 mmol), and the solution was stirred at 0°C for 1h, then warmed to RT and stirred overnight. The reaction was partitioned between EtOAc and 1M HCl, the aqueous layer extracted with EtOAc (1 x 20 mL), and combined organics were washed with brine (3 x 20 mL), dried over Na_2SO_4, and concentrated.

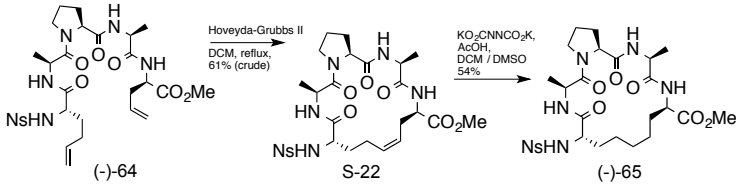
Purification via flash chromatography, eluting with 3%→4% MeOH / CH_2Cl_2, afforded (-)-**64** (475.2 mg, 89%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.6 Hz, 2H), 8.01 (d, *J* = 8.7 Hz, 2H), 7.50 (d, *J* = 6.7 Hz, 1H), 7.30 (d, *J* = 6.8 Hz, 1H), 6.97 (d, *J* = 7.8 Hz, 1H), 6.75 (d, *J* = 8.2 Hz, 1H), 5.66 (dq, *J* = 7.0, 17.0 Hz, 2H), 5.09 (d, *J* = 12.1 Hz, 2H), 4.98-4.88 (m, 2H), 4.67 (q, *J* = 6.8 Hz, 1H), 4.56-4.46 (m, 3H), 3.99 (q, *J* = 8.5 Hz, 1H), 3.72 (s, 3H), 3.65-3.45 (m, 2H), 2.59 (dt, *J* = 6.0, 12.6 Hz, 1H), 2.48 (dt, *J* = 6.9, 14.0 Hz, 1H), 2.17-2.07 (m, 4H), 2.03-1.92 (m, 2H), 1.77-1.60 (m, 2H), 1.30 (d, *J* = 7.0 Hz, 3H), 1.09 (d, *J* = 6.7 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 172.3, 172.2, 171.4, 171.2, 170.0, 150.0, 146.2, 136.5, 132.1, 128.6, 124.3, 119.4, 116.1, 60.4, 56.6, 52.6, 51.8, 48.8, 47.4, 47.1, 36.6, 33.3, 29.4, 28.8, 25.1, 18.4, 18.2;

HRMS (ESI) calc'd for: $C_{29}H_{41}N_6O_{10}S$ [M+H]+: 665.2605, found: 665.2621;

$[\alpha]_D^{26}$ = -86.9° (c = 0.52, MeOH).



Methyl (3*S*,6*R*,12*S*,15*S*,20a*S*)-3,15-dimethyl-12-((4-nitrophenyl)sulfonamido)-1,4,13,16-tetraoxoicosahydropyrrolo[1,2-*d*][1,4,7,10]tetraazacyclooctadecine-6-carboxylate (-)-65.

A round bottom flask was charged with diene (-)-**64** (200 mg, 1.0 equiv., 0.3 mmol) in CH_2Cl_2 (57.5 mL) and equipped with an N_2 inlet. Then, Hoveyda-Grubbs-II catalyst (9.5 mg, 0.05 equiv., 0.015 mmol) in CH_2Cl_2 (5 mL) was added to the flask, the flask equipped with a water-cooled condenser with N_2 inlet, and heated to gentle reflux for 4h. The green solution was concentrated onto silica gel and purified via flash chromatography, eluting with 2:1 CH_2Cl_2 / Acetone to 1:1, affording the crude cyclized product **S-22** (117.4 mg, 61%). The crude cyclized product **S-22** (117.4 mg, 1.0 equiv., 0.18 mmol) was dissolved in 1:1 CH_2Cl_2 / DMSO (4 mL)

and cooled to 0°C. Freshly prepared dipotassium azodicarboxylate[8] ($KO_2CN{=}NCO_2K$, 713 mg, 20.0 equiv., 3.67 mmol) was added in one portion, followed by dropwise addition of AcOH (0.42 mL, 40.0 equiv., 7.35 mmol), and the solution was allowed to warm to rt and stirred for 12h. The reaction was again cooled to 0°C and recharged with dipotassium azodicarboxylate and AcOH equivalent amounts to previous), and warmed to RT and stirred for 48h. The crude yellow mixture was poured into 20 mL of brine and stirred for 10 min until the solution was clear and colorless, then extracted with EtOAc (3 x 20 mL), dried over Na_2SO_4, and concentrated. The crude residue was redissolved in CH_2Cl_2 / DMSO and resubjected to dipotassium azodicarboxylate and AcOH, and worked up as described above. The resulting crude liquid was dissolved in EtOAc and washed with brine (5 x 15 mL), dried over Na_2SO_4, and concentrated. The crude mixture was purified via PTLC, eluting 2x with 2:1 CH_2Cl_2 / Acetone, to afford (-)-**65** as an apparent ~4:1 mixture of conformers (62.0 mg, 54%).

^{1}H NMR (500 MHz, $CDCl_3$) Major conformer: δ 8.33 (d, *J* = 8.9 Hz, 2H), 8.03 (d, *J* = 8.9 Hz, 2H), 7.60 (d, *J* = 8.5 Hz, 1H), 6.60 (d, *J* = 8.3 Hz, 1H), 6.26 (d, *J* = 8.8 Hz, 1H), 5.59 (d, *J* =9.0 Hz, 1H), 4.72 (dt, *J* = 5.5, 8.5 Hz, 1H), 4.60-4.49 (m, 2H), 4.29 (dd, *J* = 9.4, 7.8 Hz, 1H), 3.88-3.83 (m, 1H), 3.79 (s, 3H), 3.77-3.71 (m, 1H), 3.57-3.52 (m, 1H), 2.44-2.38 (m, 1H), 2.02-1.73 (m, 8H), 1.72-1.52 (m, 3H), 1.40 (d, *J* = 7.3 Hz, 3H), 1.37 (d, *J* = 7.3 Hz, 3H), 1.27-1.19 (m, 2H);

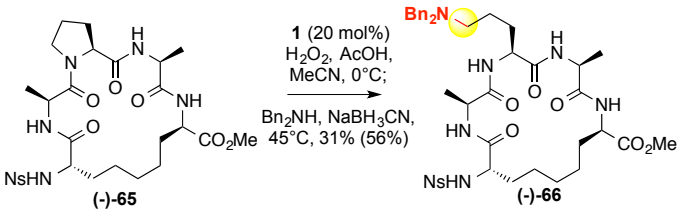
Minor conformer (only clearly visible, non-overlapping peaks are listed): δ 8.27 (d, *J* = 8.9 Hz), 8.08 (d, *J* = 8.7 Hz), 7.99 (d, 8.9 Hz), 7.49 (d, *J* = 8.9 Hz), 6.99-6.93 (m), 4.45-4.38 (m), 4.07-3.91 (m), 3.72 (s)1,48 (d, *J* = 7.0 Hz);

^{13}C NMR (125 MHz, $CDCl_3$) δ 176.0, 173.2, 171.7, 170.3, 150.1, 146.7, 128.4, 124.3, 109.9, 63.3, 55.9, 52.5, 51.4, 48.7, 47.9, 47.7, 32.9, 30.7, 29.4, 26.2, 25.8, 23.5, 22.9, 18.1, 16.3;

HRMS (ESI) calc'd for: $C_{27}H_{39}N_6O_{10}S$ $[M+H]^+$: 639.2448, found: 639.2459;

$[\alpha]_D^{25}$ = -46.9° (c = 0.98, $CHCl_3$).

[8] Wullschleger, C. W., Gertsch, J.; Altmann, K.-H. *Org. Lett.* **2010**, *12*, 1120-1123.



Methyl (2*S*,5*S*,8*S*,11*R*,17*S*)-5-(3-(dibenzylamino)propyl)-2,8-dimethyl-17-((4-nitrophenyl)sulfonamido)-3,6,9,18-tetraoxo-1,4,7,10-tetraazacyclooctadecane-11-carboxylate (-)-66.

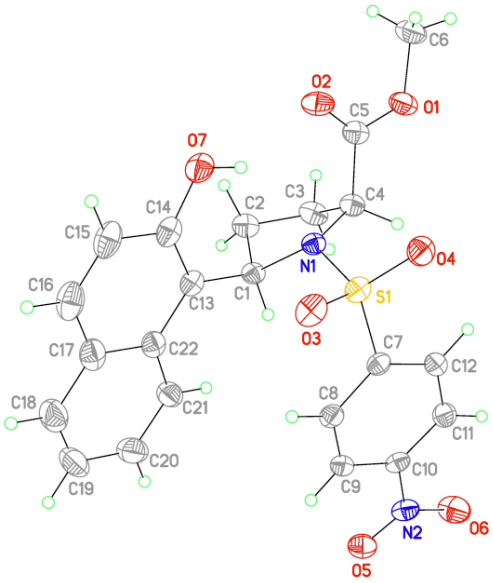
The reaction was performed using a modified **Procedure A**, employing and additional iterative addition of catalyst, AcOH, and H_2O_2. Prior to beginning the reaction, a stock solution of (*S,S*)-Fe(PDP)$(MeCN)_2(SbF_6)_2$ (9.0mg) and AcOH (11 µL) in MeCN (200 µL) was prepared. Four vials of H_2O_2 (4.2 µL, 1.9 equiv., 0.074 mmol) in 350 µL MeCN were prepared and cooled to 0°C. Then, macrocyclic pentapeptide (-)-**65** (25 mg, 1.0 equiv., 0.039 mmol) was dissolved in MeCN (0.2 mL) in a 2-dram vial, and cooled to 0°C. Catalyst / AcOH stock solution (42 µL) was added, followed by dropwise addition of one H_2O_2 solution over 2-3 minutes, and the reaction was allowed to stir for 10 min. The addition of catalyst / AcOH followed by H_2O_2 solution dropwise and stirring for 10 min was iterated three more times, amounting to a total addition of catalyst (4 x [1.8 mg, 0.05 equiv., 0.0020 mmol]), AcOH (4 x [2.2 µL, 1.0 equiv., 0.039 mmol]), and H_2O_2 (4 x [4.2 µL, 1.9 equiv., 0.074 mmol]). Immediately after the completion of the oxidation, the reaction was diluted with MeOH (1 mL) and dibenzylamine (46.2 mg, 6.0 equiv., 0.234 mmol) in MeOH (1 mL) was added, followed by sodium cyanoborohydride (14.7 mg, 6.0 equiv., 0.234 mmol). The vial was capped and heated to 45°C for 48h. The crude reaction mixture was purified via PTLC eluting 2x with 3:2 CH_2Cl_2 / Acetone to afford (-)-66 (10.2 mg, 31% yield, 56% per step).

^{1}H NMR (500 MHz, Acetone-d_6) δ 8.40 (d, J = 8.8 Hz, 2H), 8.10 (d, J = 8.8 Hz, 2H), 7.80-7.61 (m, 2H), 7.50-7.40 (m, 2H), 7.37 (d, J = 7.6 Hz, 4H), 7.30 (t, J = 7.5 Hz, 4H), 7.22 (t, J = 7.2 Hz, 2H), 4.29-4.21 (m, 1H), 4.13-3.99 (m, 3H), 3.96 (t, J = 7.0 Hz, 1H), 3.61 (s, 3H), 3.51 (s, 4H), 3.35-3.26 (m, 2H), 2.45-2.38 (m, 2H), 1.86-1.73 (m, 4H), 1.66-1.54 (m, 4H), 1.50-1.36 (m, 4H), 1.33 (d, J = 7.2 Hz, 3H), 1.19 (d, J = 7.2 Hz, 3H);

^{13}C NMR (125 MHz, Acetone-d_6) δ 173.4, 172.9, 172.5, 172.2, 171.4, 151.0, 148.0, 140.9, 129.8, 129.6, 129.1, 127.8, 125.1, 77.4, 58.8, 57.6, 56.1, 54.8, 53.7, 53.5, 52.3, 51.7, 50.2, 34.6, 31.5, 28.7, 25.4, 23.5, 17.9 (1 peak overlapping or obscured);

HRMS (ESI) calc'd for: $C_{41}H_{54}N_7O_{10}S$ $[M+H]^+$: 836.3653, found: 836.3652;
$[\alpha]_D^{26}$ = -27.4° (c = 0.79, MeOH).

X-Ray Crystal Structure Data for 2-Naphthol-Proline Adduct (-)-7.

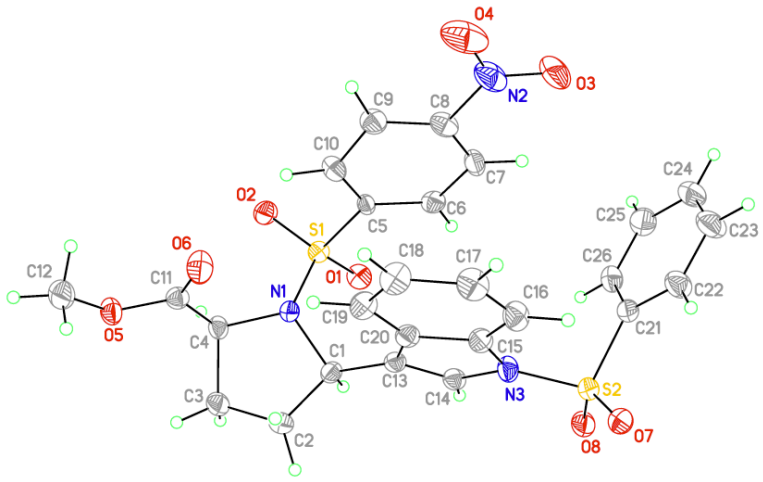


Crystal data and structure refinement for 1478941.

Identification code	1478941	
Empirical formula	C28 H26 N2 O7 S	
Formula weight	534.57	
Temperature	193(2) K	
Wavelength	0.71073 ≈	
Crystal system	Orthorhombic	
Space group	P 21 21 21	
Unit cell dimensions	a = 6.1126(9) ≈	α= 90∞.
	b = 11.1682(16) ≈	β= 90∞.
	c = 37.608(5) ≈	γ = 90∞.
Volume	2567.4(6) ≈^{3}	
Z	4	
Density (calculated)	1.383 Mg/m^3	
Absorption coefficient	0.177 mm^{-1}	
F(000)	1120	
Crystal size	0.298 x 0.26 x 0.183 mm^3	
Theta range for data collection	1.90 to 25.33∞.	
Index ranges	-7<=h<=7, -13<=k<=13, -45<=l<=45	

Reflections collected	28189
Independent reflections	4703 [R(int) = 0.0362]
Completeness to theta = 25.33∞	100.0 %
Absorption correction	Integration
Max. and min. transmission	0.9821 and 0.9512
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4703 / 0 / 350
Goodness-of-fit on F^2	1.058
Final R indices [I>2sigma(I)]	R1 = 0.0290, wR2 = 0.0701
R indices (all data)	R1 = 0.0326, wR2 = 0.0725
Absolute structure parameter	-0.06(6)
Largest diff. peak and hole	0.132 and -0.240 e.≈$^{-3}$

X-Ray Crystal Data for Indole-Proline Adduct (+)-11.

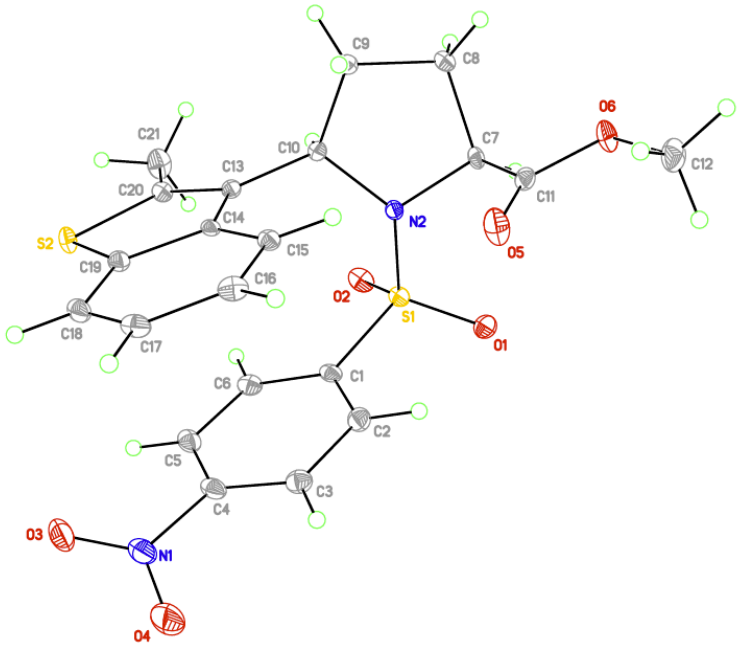


Crystal data and structure refinement for 1478940.

Identification code	1478940	
Empirical formula	C26 H23 N3 O8 S2	
Formula weight	569.59	
Temperature	183(2) K	
Wavelength	0.71073 ≈	
Crystal system	Orthorhombic	
Space group	P 21 21 21	
Unit cell dimensions	a = 9.8392(11) ≈	α= 90∞.
	b = 10.6710(12) ≈	β= 90∞.

	c = 24.909(3) ≈ γ = 90∞.
Volume	2615.3(5) ≈^{3}
Z	4
Density (calculated)	1.447 Mg/m^3
Absorption coefficient	0.259 mm^{-1}
F(000)	1184
Crystal size	0.38 x 0.359 x 0.262 mm^3
Theta range for data collection	2.08 to 25.35∞.
Index ranges	-11<=h<=11, -12<=k<=12, -30<=l<=30
Reflections collected	28691
Independent reflections	4790 [R(int) = 0.0356]
Completeness to theta = 25.35∞	99.9 %
Absorption correction	Integration
Max. and min. transmission	0.9591 and 0.9253
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4790 / 331 / 435
Goodness-of-fit on F^2	1.050
Final R indices [I>2sigma(I)]	R1 = 0.0261, wR2 = 0.0668
R indices (all data)	R1 = 0.0276, wR2 = 0.0682
Absolute structure parameter	-0.03(4)
Largest diff. peak and hole	0.135 and -0.322 e.≈$^{-3}$

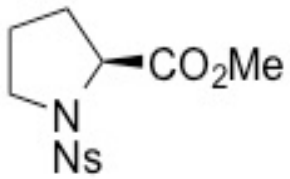
X-Ray Crystal Data for Benzothiophene-Proline Adduct (+)-12.



Crystal data and structure refinement for 1478939.

Identification code	1478939	
Empirical formula	C21 H20 N2 O6 S2	
Formula weight	460.51	
Temperature	100(2) K	
Wavelength	0.71073 ≈	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 7.9013(3) ≈	α= 90∞.
	b = 13.6408(6) ≈	β= 90∞.
	c = 18.8526(8) ≈	γ = 90∞.
Volume	2031.93(15) ≈^{3}	
Z	4	
Density (calculated)	1.505 Mg/m^3	
Absorption coefficient	0.306 mm^{-1}	
F(000)	960	
Crystal size	0.395 x 0.278 x 0.062 mm^3	
Theta range for data collection	2.161 to 27.200∞.	
Index ranges	-10<=h<=10, -17<=k<=17, -11<=l<=24	
Reflections collected	18166	

Independent reflections	4518 [R(int) = 0.0375]
Completeness to theta = 25.242∞	99.8 %
Absorption correction	Integration
Max. and min. transmission	1.0000 and 0.9040
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4518 / 0 / 282
Goodness-of-fit on F^2	1.030
Final R indices [I>2sigma(I)]	R1 = 0.0286, wR2 = 0.0696
R indices (all data)	R1 = 0.0317, wR2 = 0.0718
Absolute structure parameter	0.01(3)
Extinction coefficient	n/a
Largest diff. peak and hole	0.303 and -0.259 e.≈$^{-3}$



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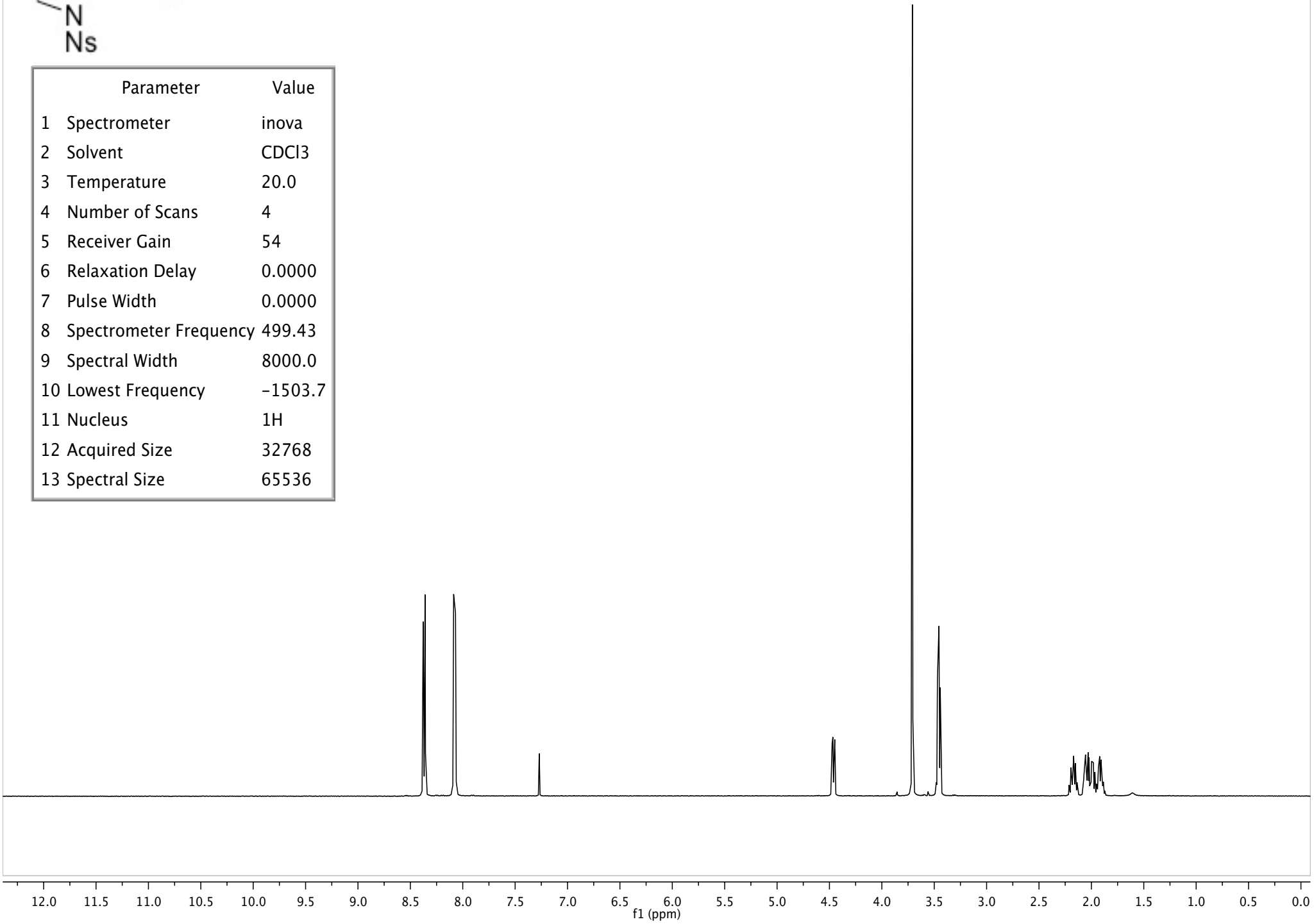
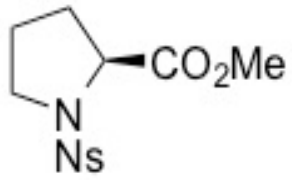
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536





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11	Nucleus	13C
12	Acquired Size	32768
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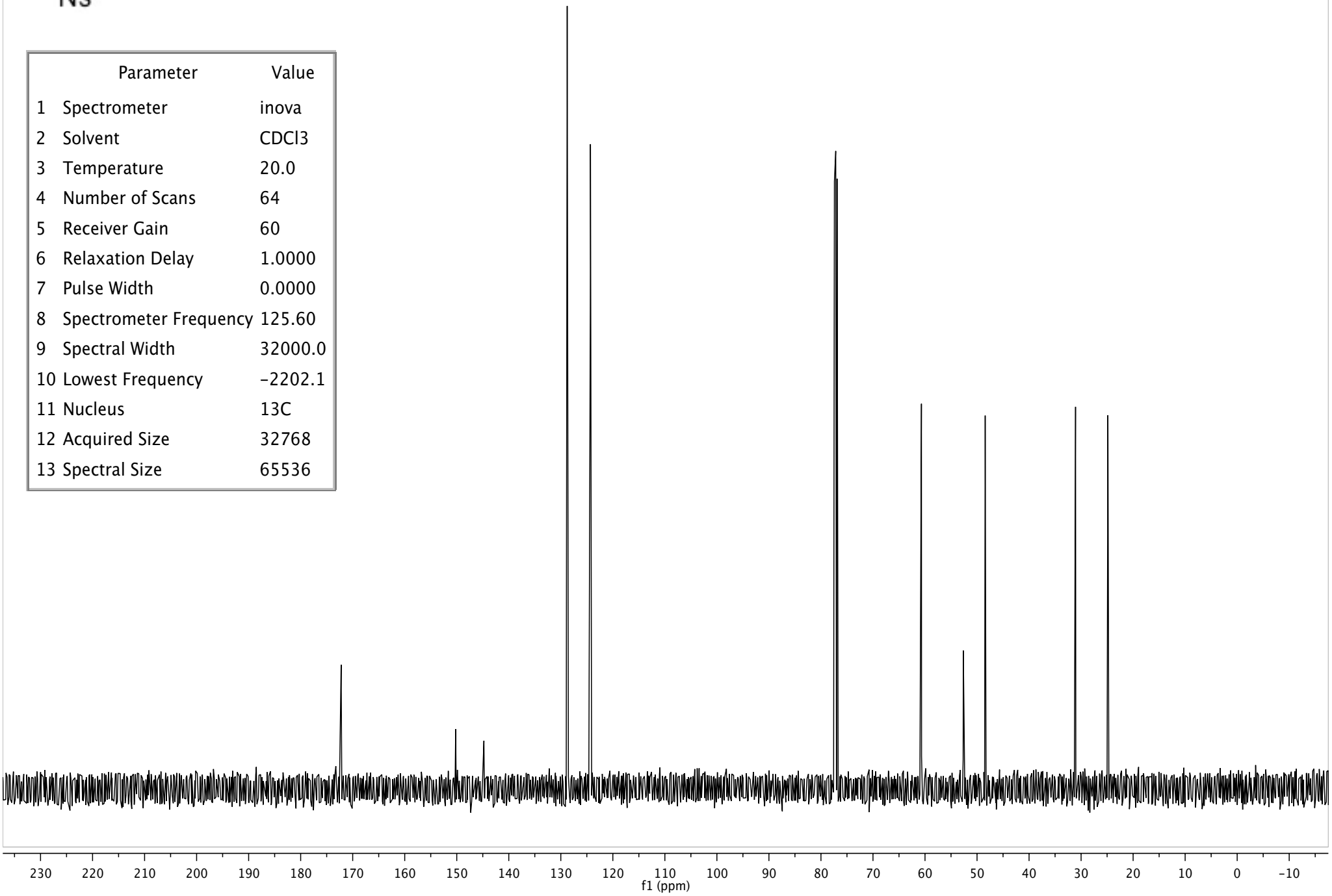

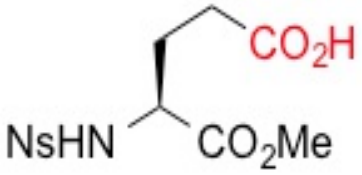

	Parameter	Value
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12	Acquired Size	32768
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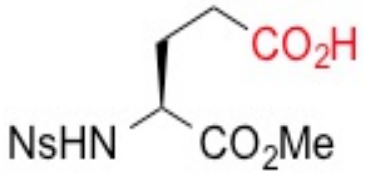

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3	Temperature	20.0
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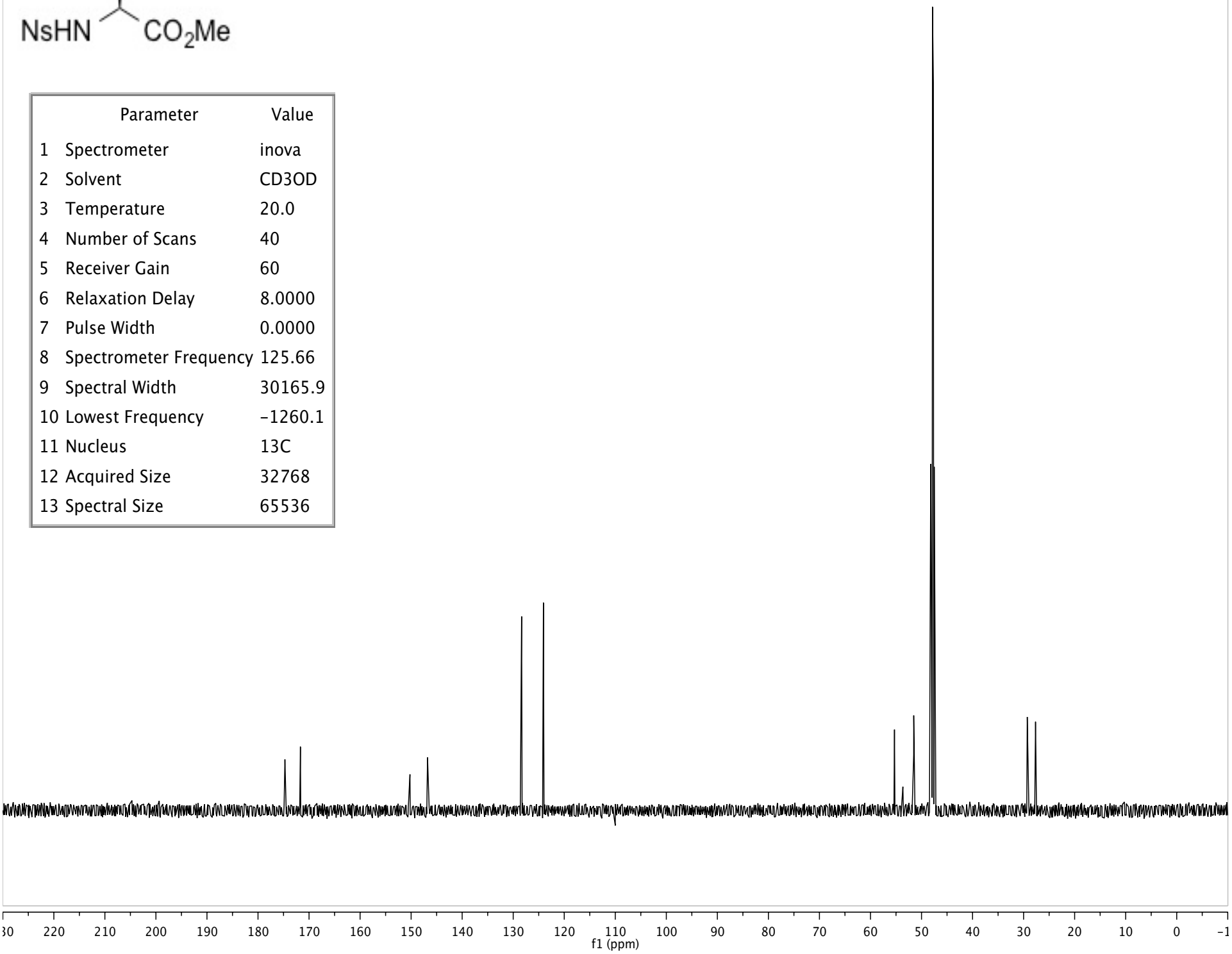

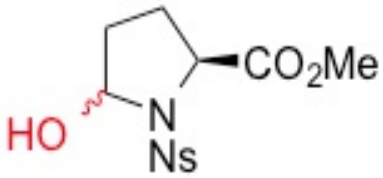

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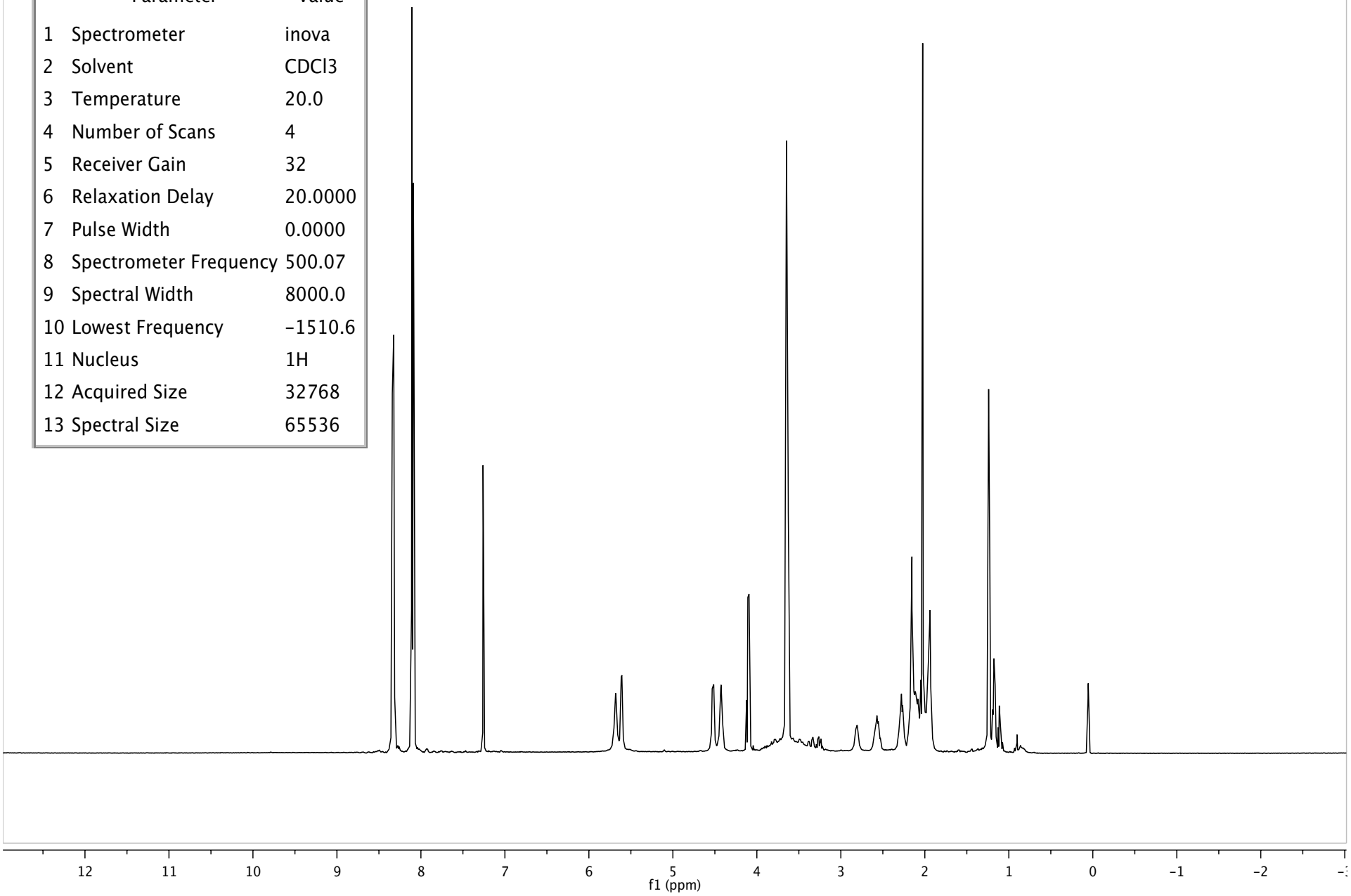

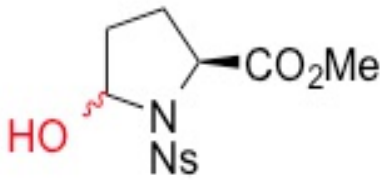

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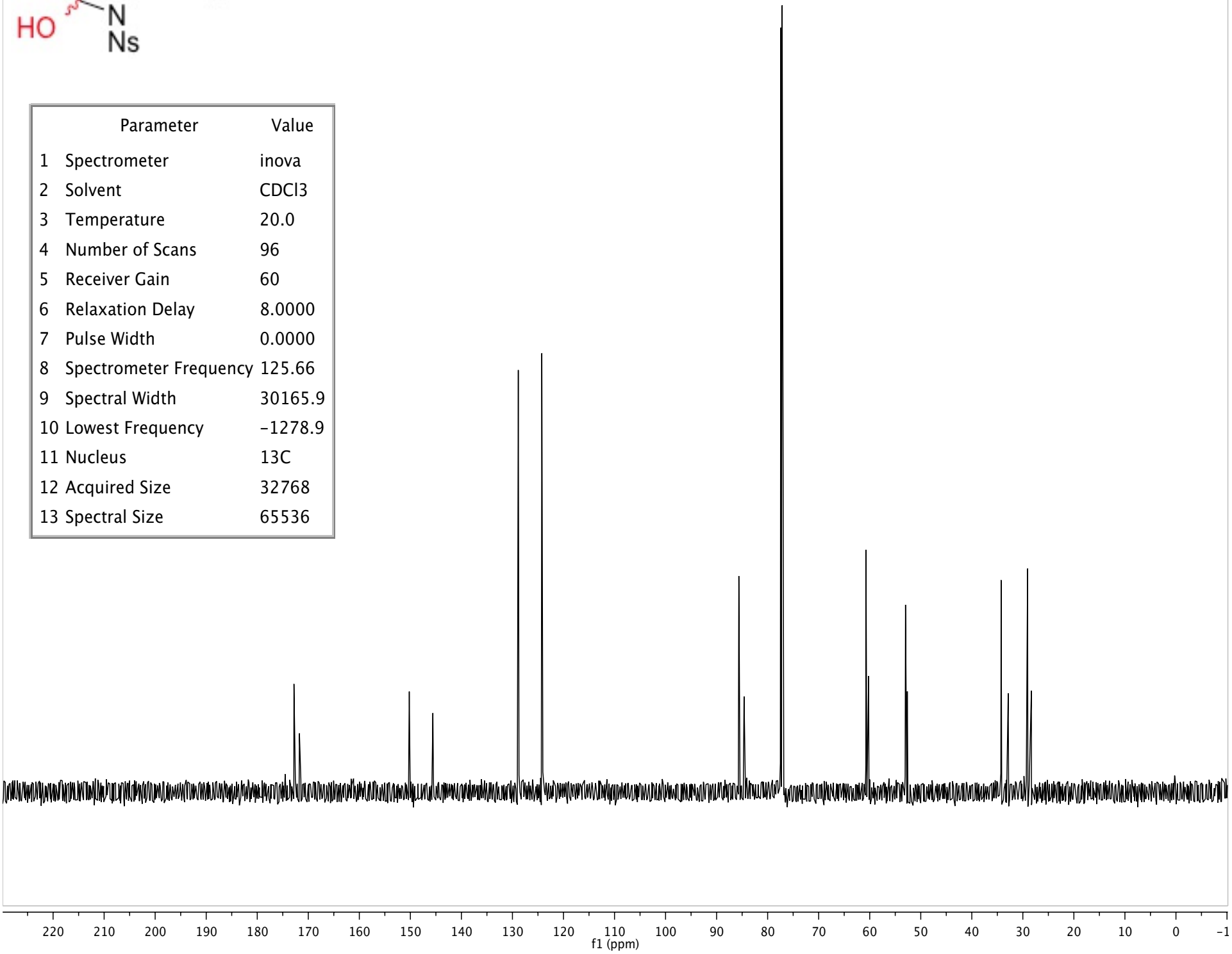
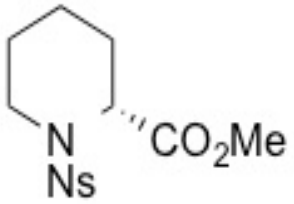
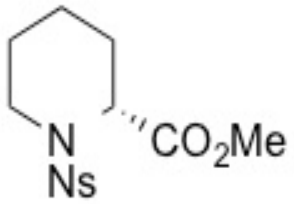
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1278.9
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

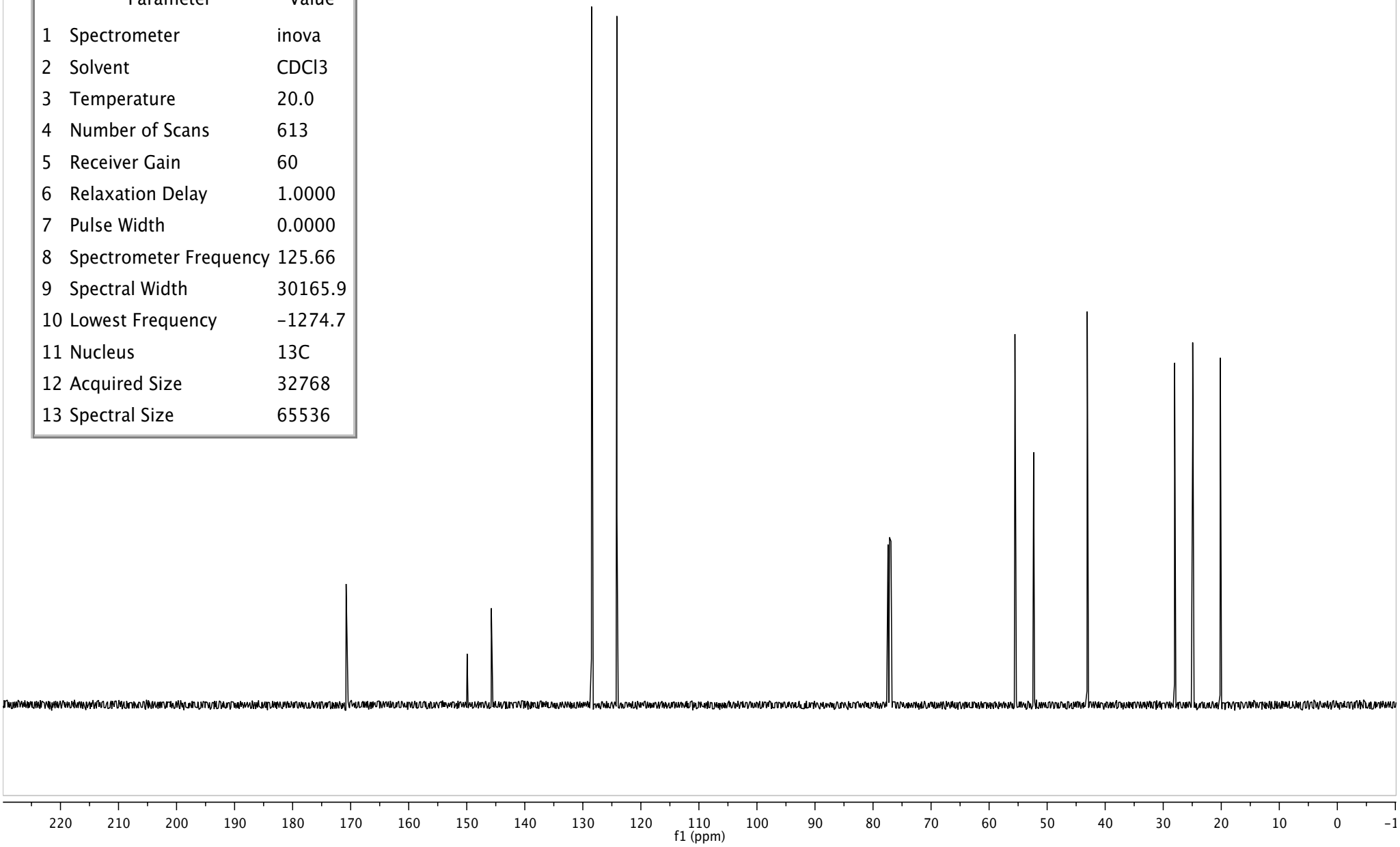


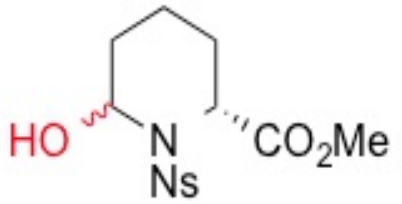


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	26
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1510.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

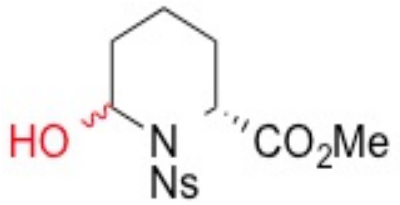


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	613
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.7
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

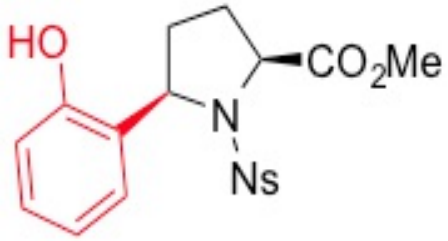




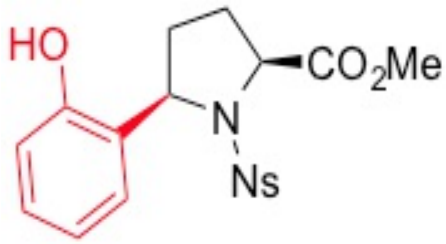
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.43
9	Spectral Width	8000.0
10	Lowest Frequency	-1508.7
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



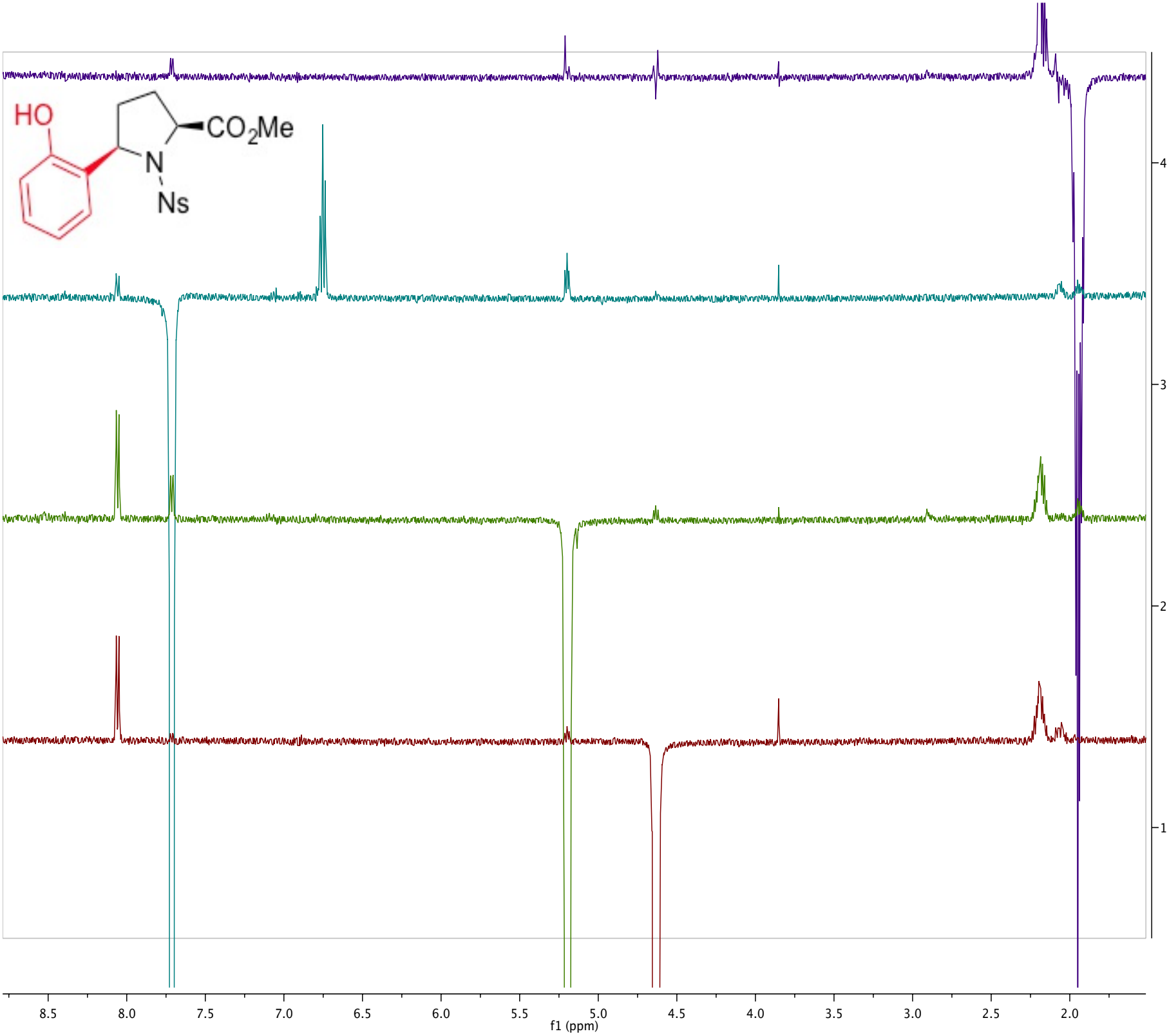
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	144
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

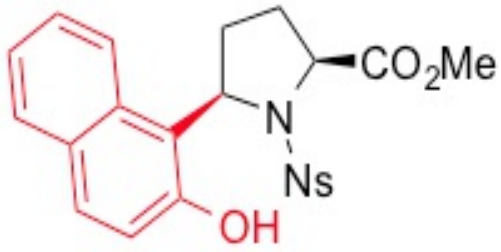


	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	25.0
4	Number of Scans	4
5	Receiver Gain	38
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

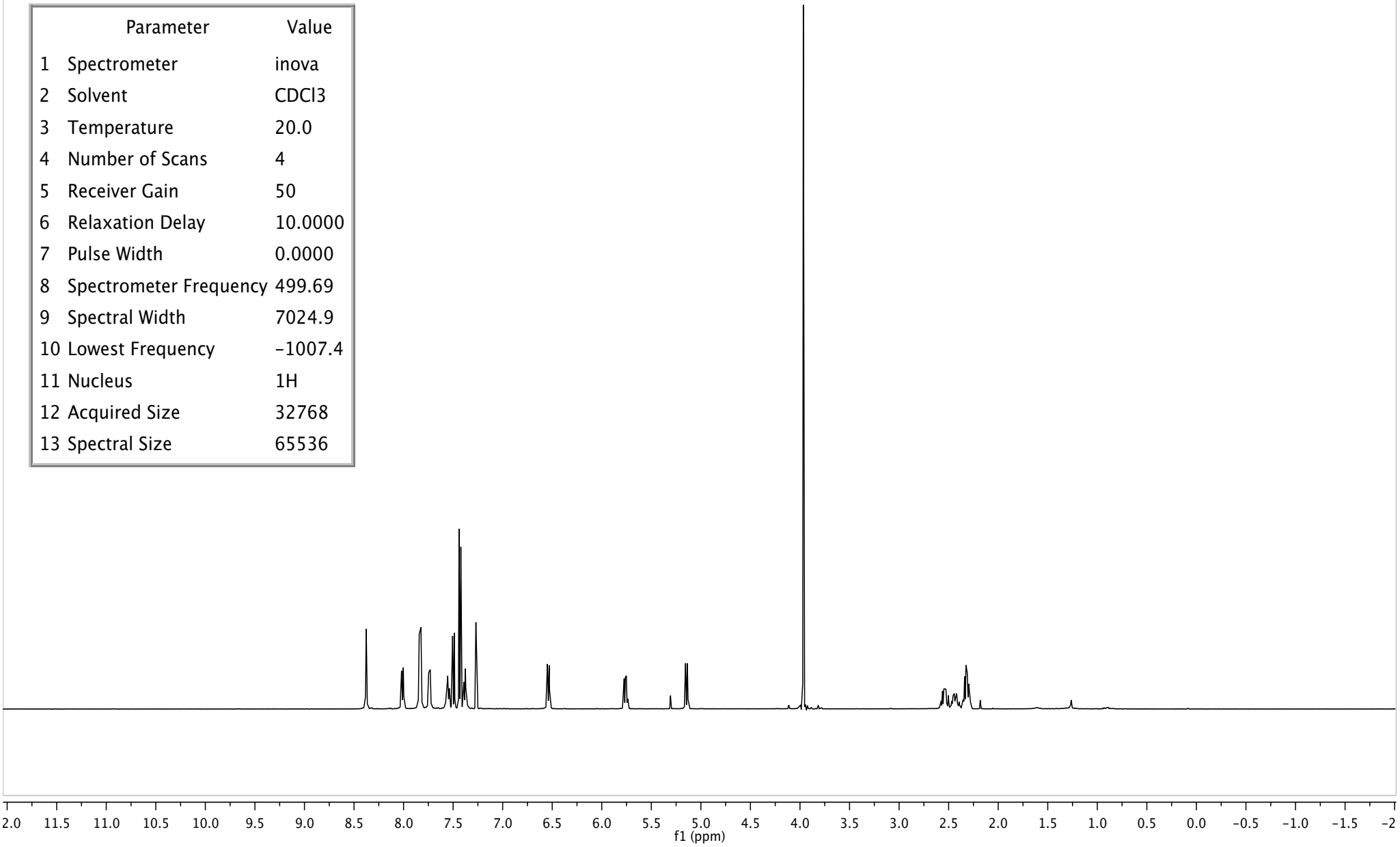


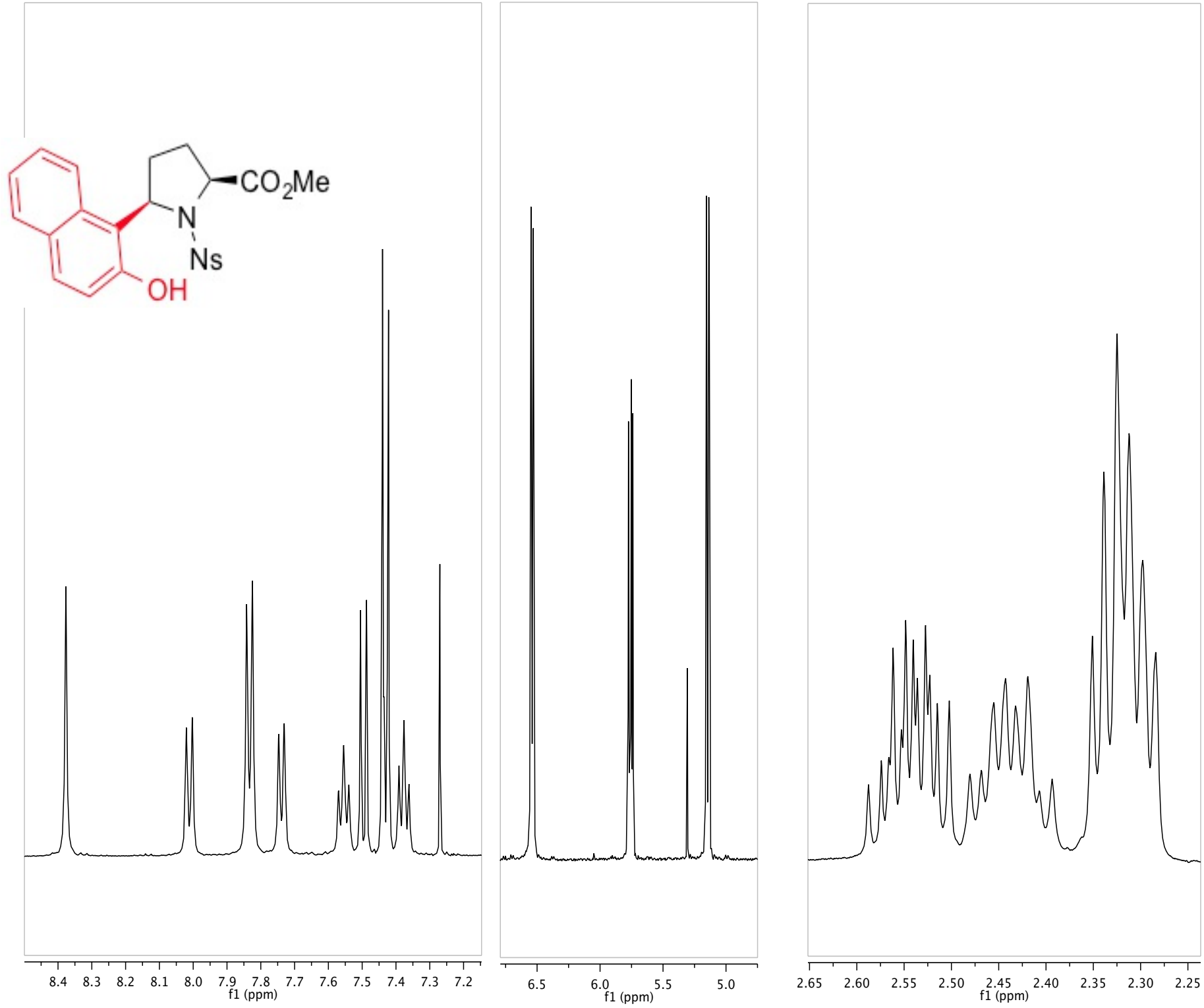
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.3
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

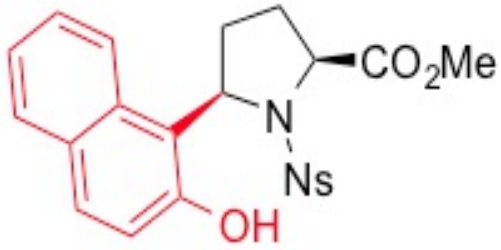

HO
CO2Me
N
Ns
4
3
2
1
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
f1 (ppm)



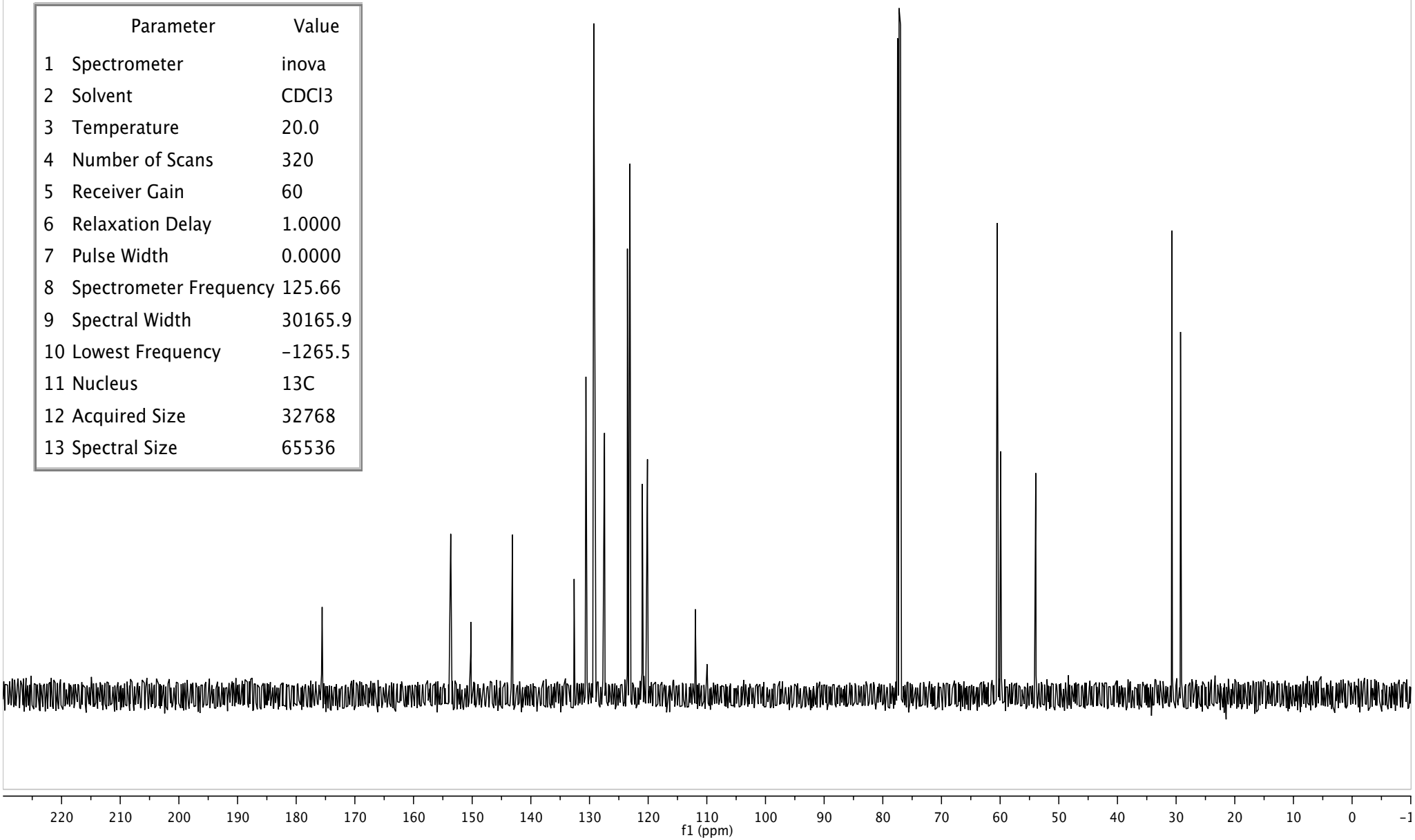
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	50
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

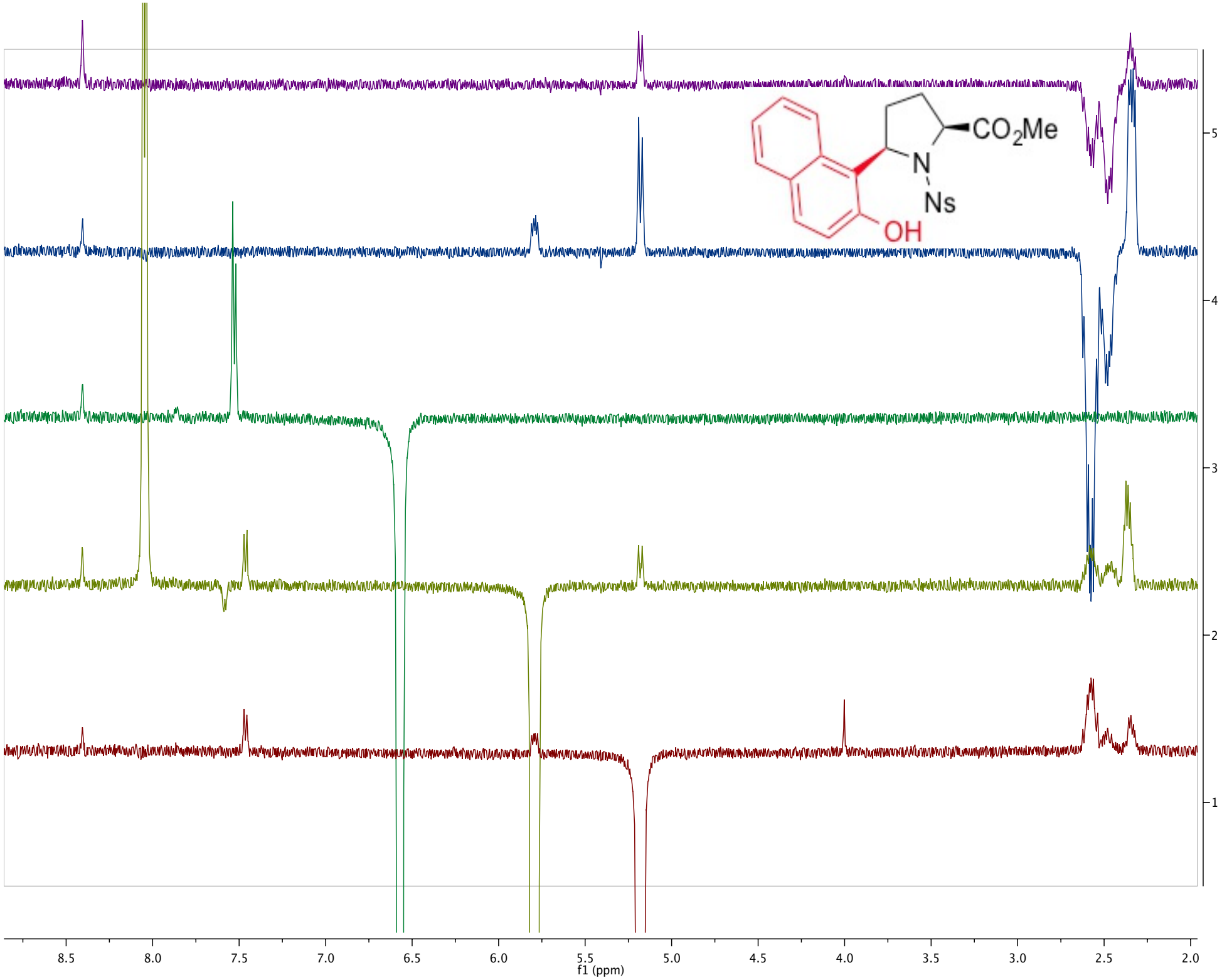


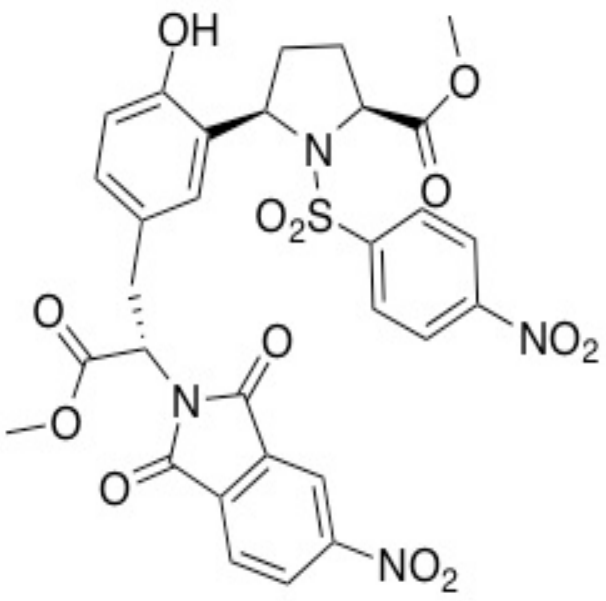

CO2Me
N
Ns
OH
8.4 8.3 8.2 8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2
f1 (ppm)
6.5 6.0 5.5 5.0
f1 (ppm)
2.65 2.60 2.55 2.50 2.45 2.40 2.35 2.30 2.25
f1 (ppm)



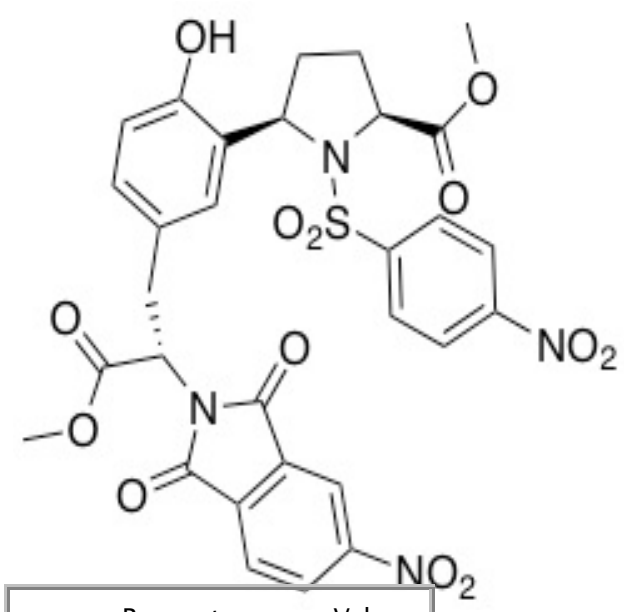
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	320
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1265.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



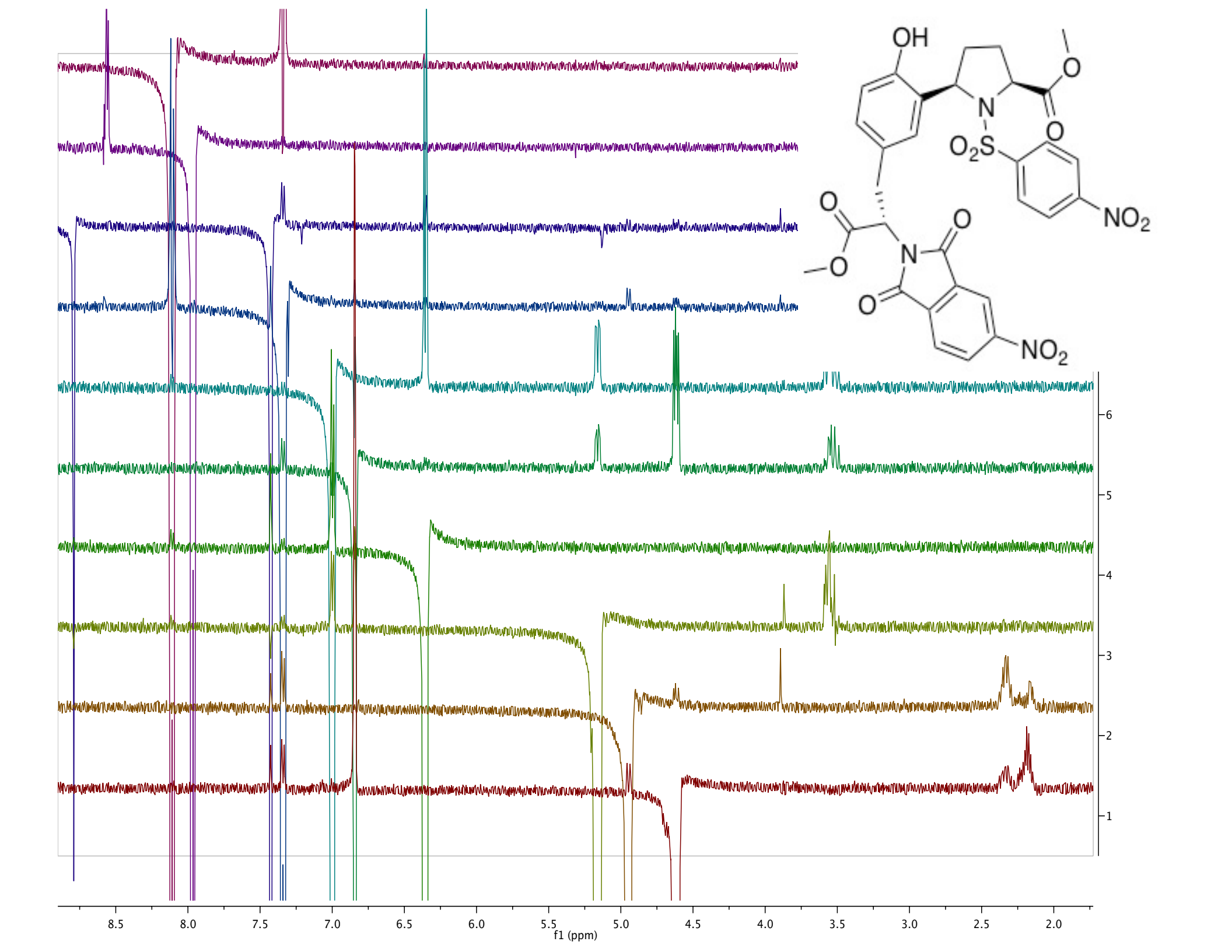

CO2Me
N
Ns
OH
5
4
3
2
1
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
f1 (ppm)

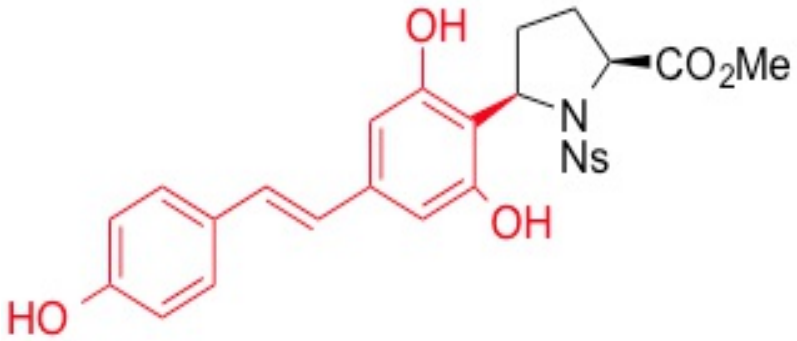


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	54
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1521.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

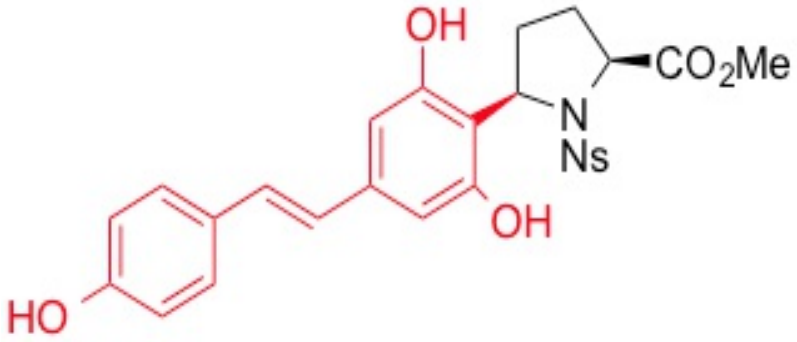


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1267.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

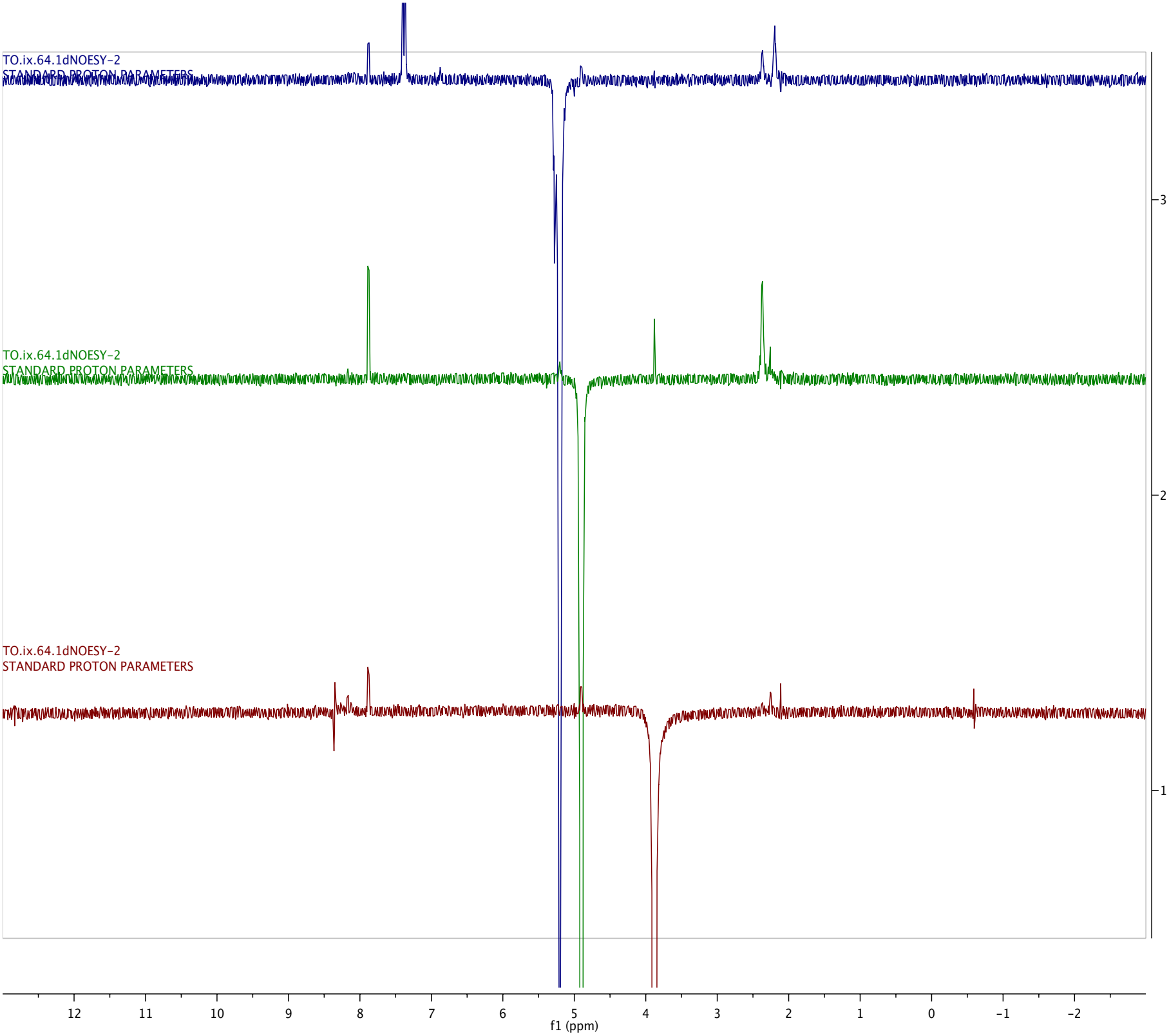

OH
O
N
O
O_2S
NO_2
O
O
N
O
O
O
NO_2
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
f1 (ppm)
6
5
4
3
2
1

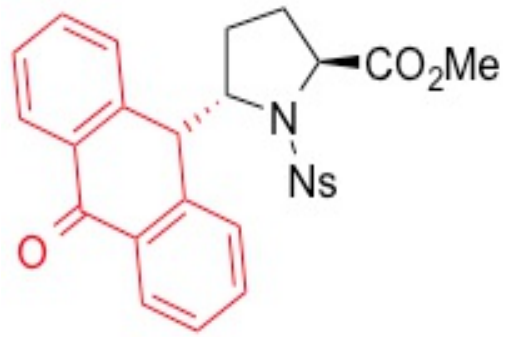


	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	42
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

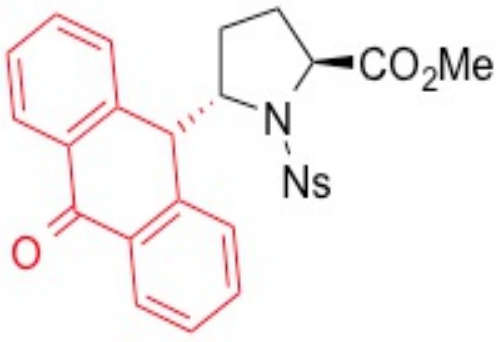


	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	3968
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1176.8
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

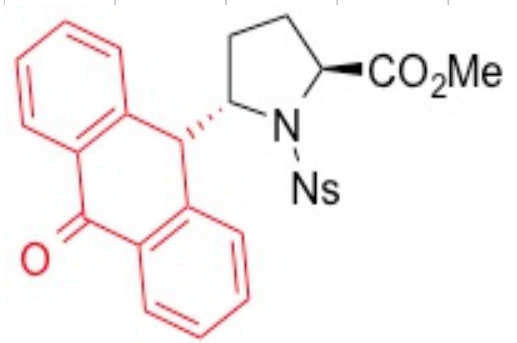

TO.ix.64.1dNOESY-2
STANDARD PROTON PARAMETERS
TO.ix.64.1dNOESY-2
STANDARD PROTON PARAMETERS
TO.ix.64.1dNOESY-2
STANDARD PROTON PARAMETERS
3
2
1
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
f1 (ppm)



	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	2
5	Receiver Gain	26
6	Relaxation Delay	0.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

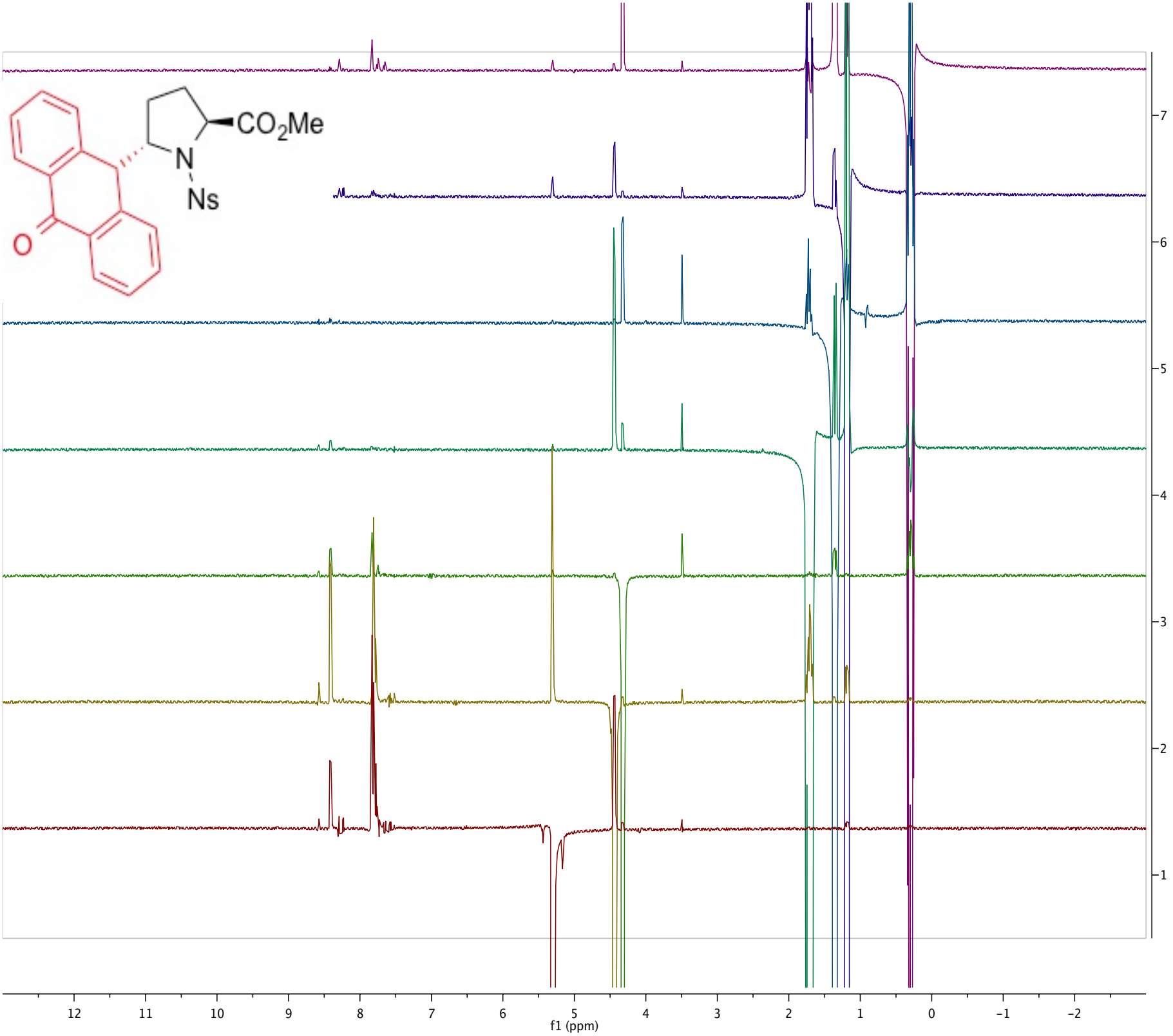


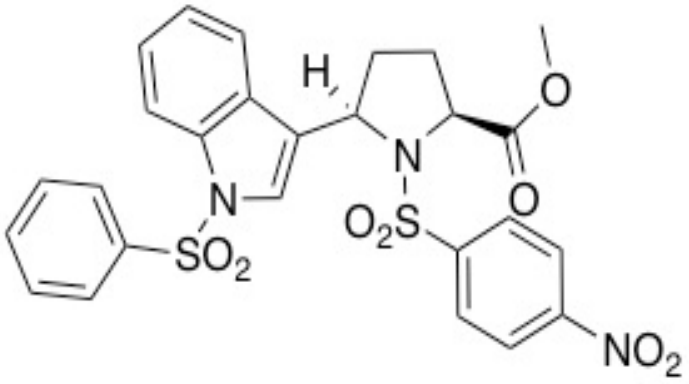
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1280.3
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



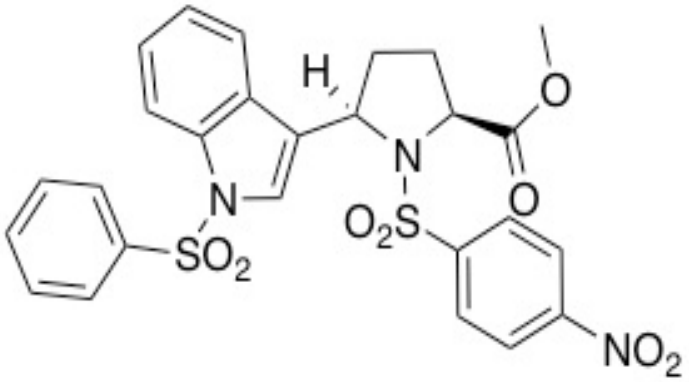
f2 (ppm)

f1 (ppm)

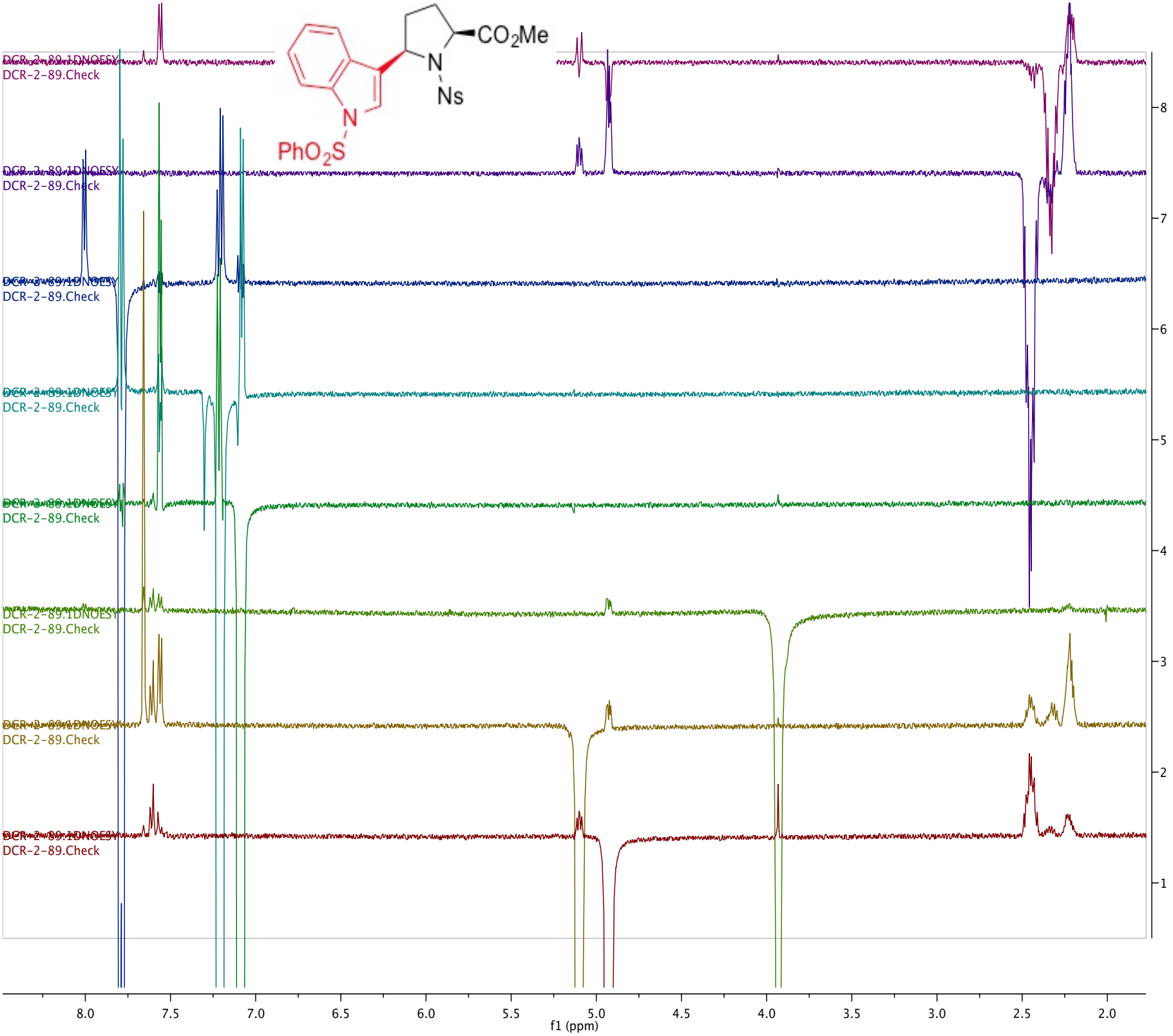

CO2Me
N
Ns
O
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
f1 (ppm)
7
6
5
4
3
2
1

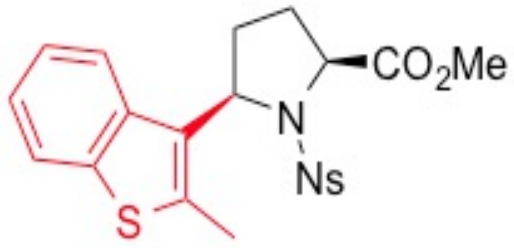


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	48
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

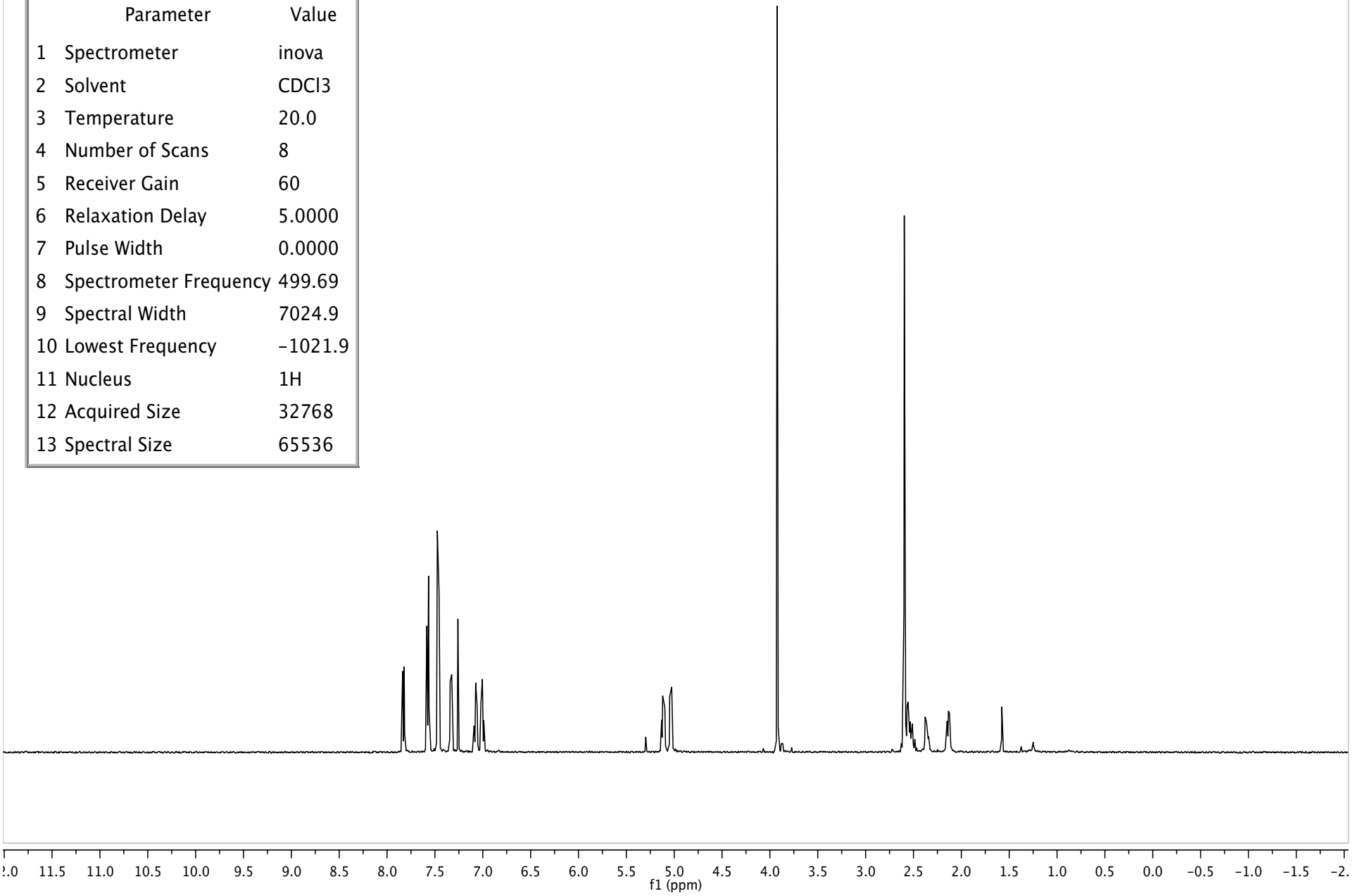


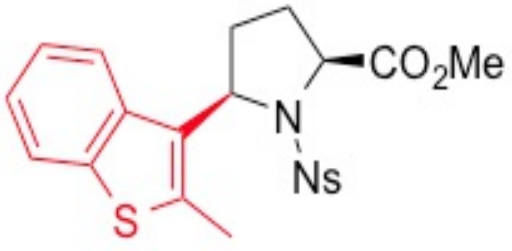
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	80
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1265.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536


DCR-2-89.1DNOESY
DCR-2-89.Check
DCR-2-89.1DNOESY
DCR-2-89.Check
DCR-2-89.1DNOESY
DCR-2-89.Check
DCR-2-89.1DNOESY
DCR-2-89.Check
DCR-2-89.1DNOESY
DCR-2-89.Check
DCR-2-89.1DNOESY
DCR-2-89.Check
DCR-2-89.1DNOESY
DCR-2-89.Check
CO2Me
N
Ns
N
PhO2S
8
7
6
5
4
3
2
1
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
f1 (ppm)

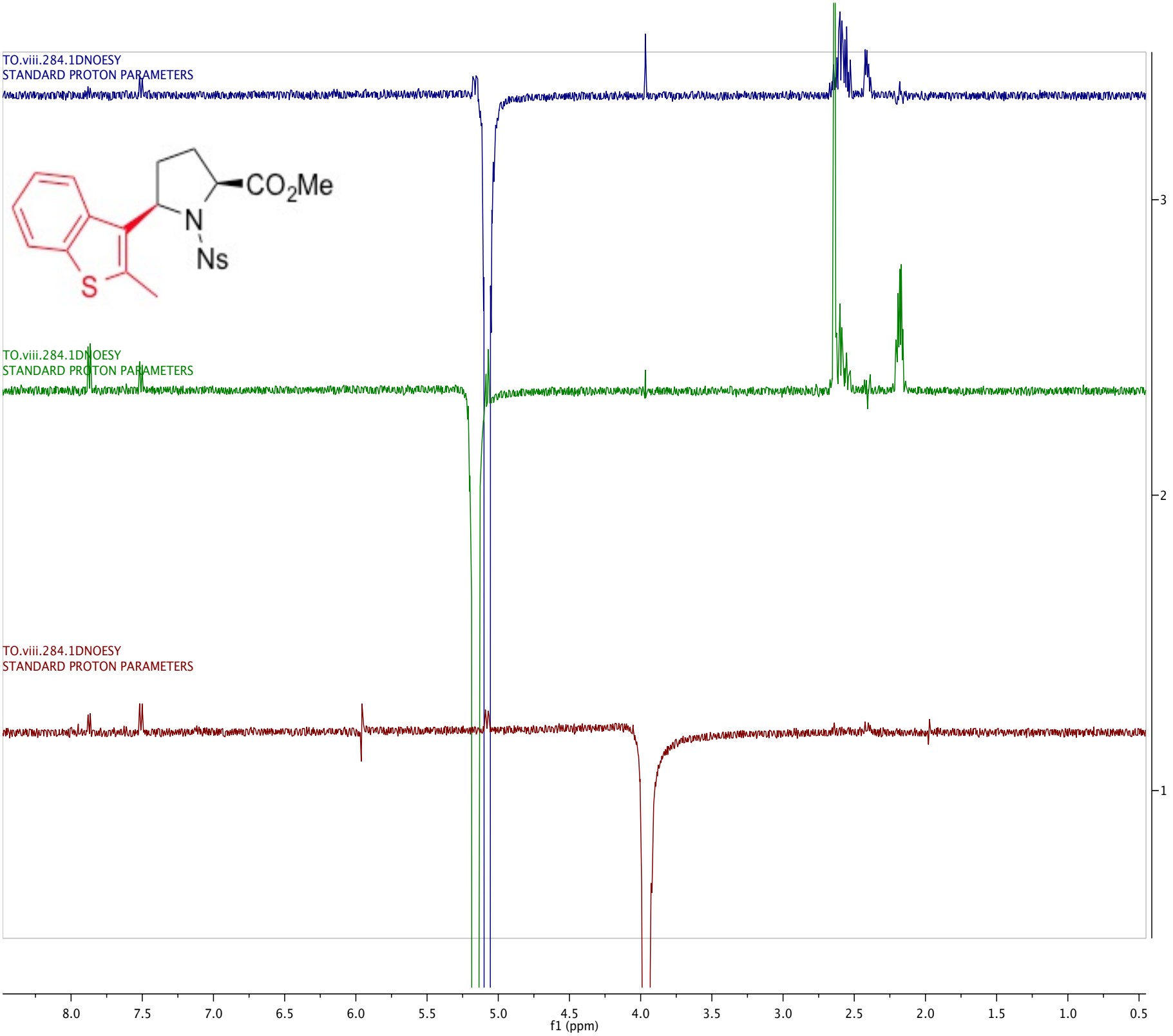


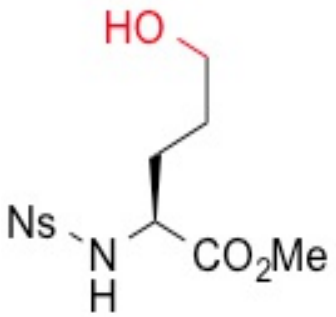
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	8
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



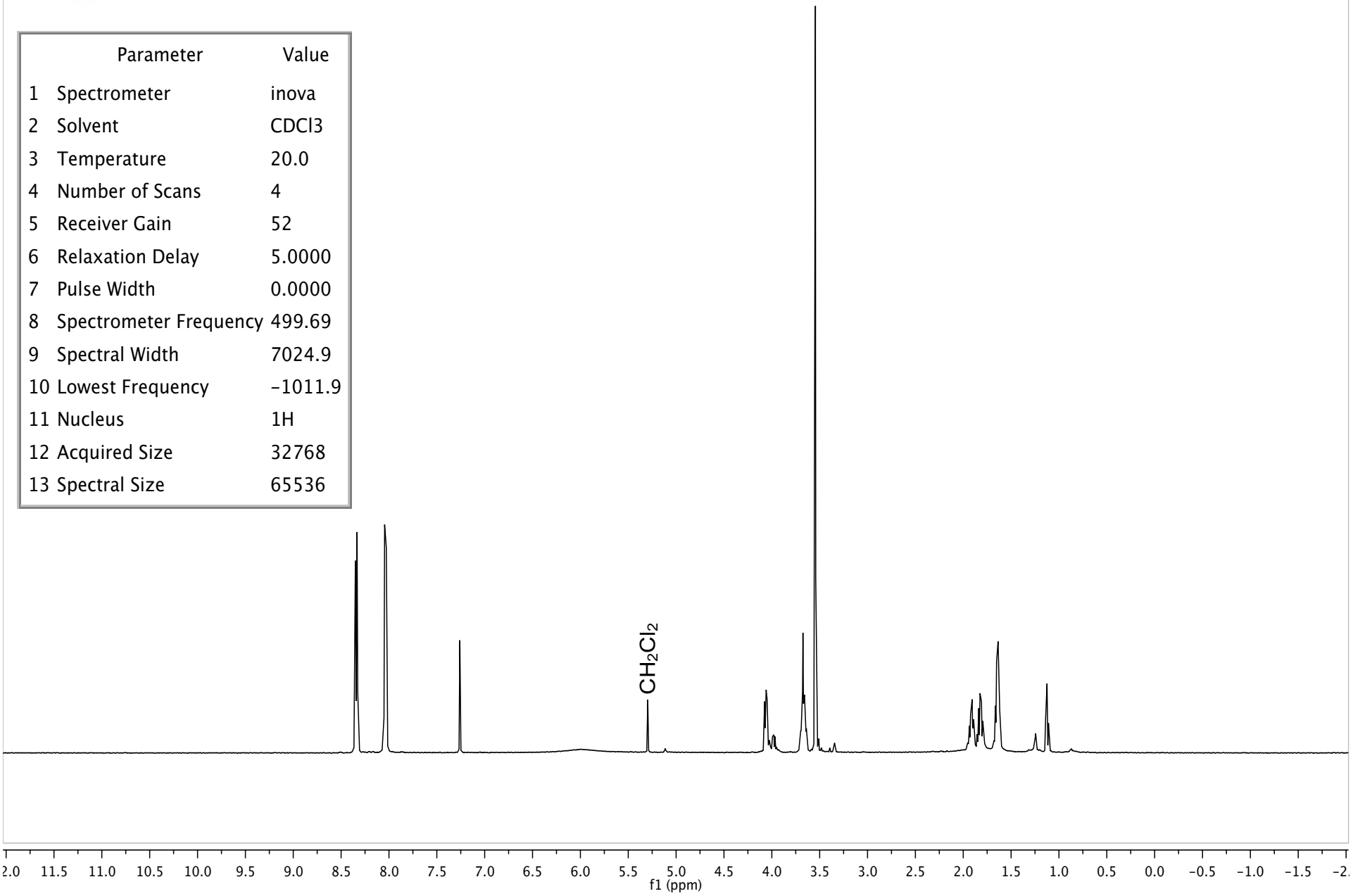


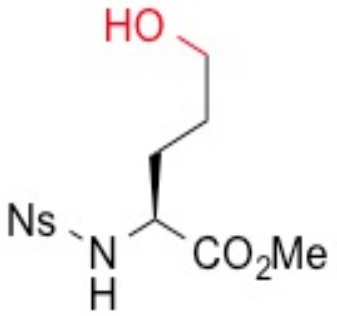
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	288
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.8
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536


TO.viii.284.1DNOESY
STANDARD PROTON PARAMETERS
CO2Me
N
Ns
S
TO.viii.284.1DNOESY
STANDARD PROTON PARAMETERS
TO.viii.284.1DNOESY
STANDARD PROTON PARAMETERS
3
2
1
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

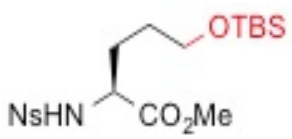


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	52
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

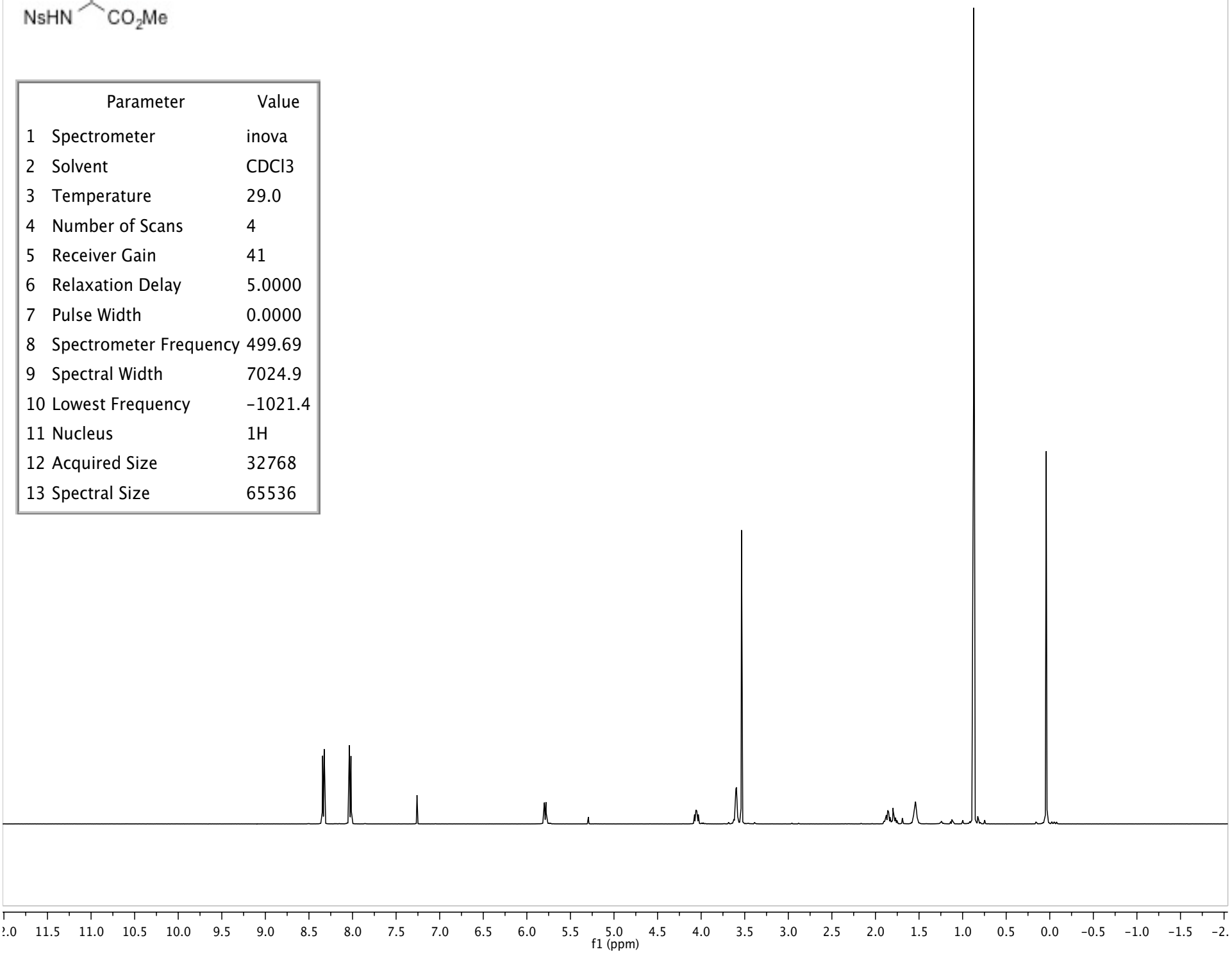


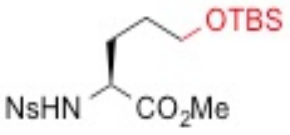


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	48
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

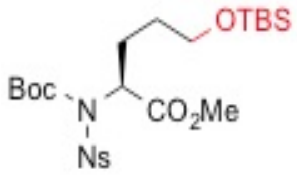


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	29.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

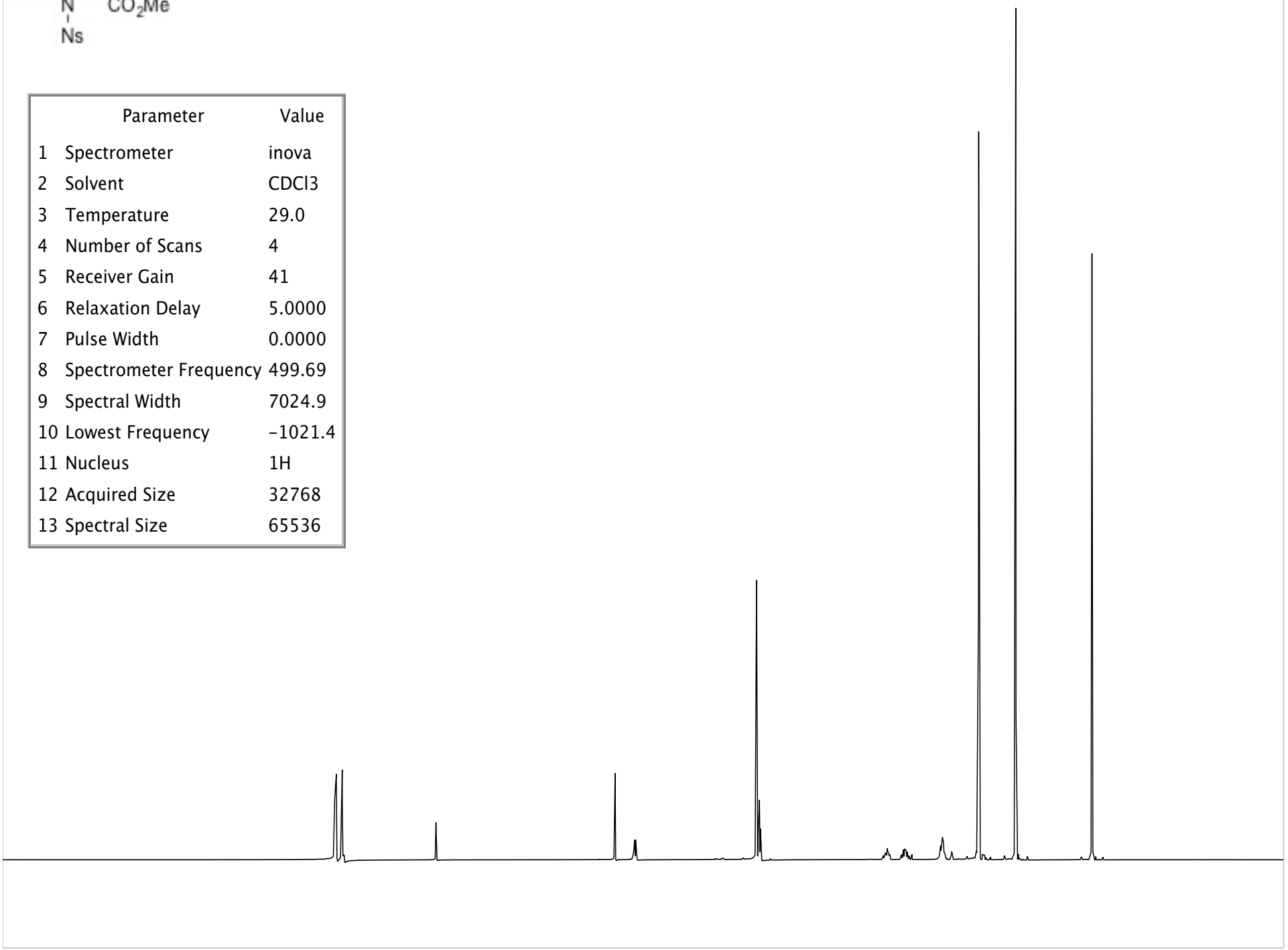


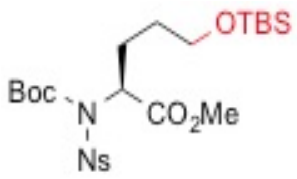


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	22.0
4	Number of Scans	128
5	Receiver Gain	60
6	Relaxation Delay	3.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

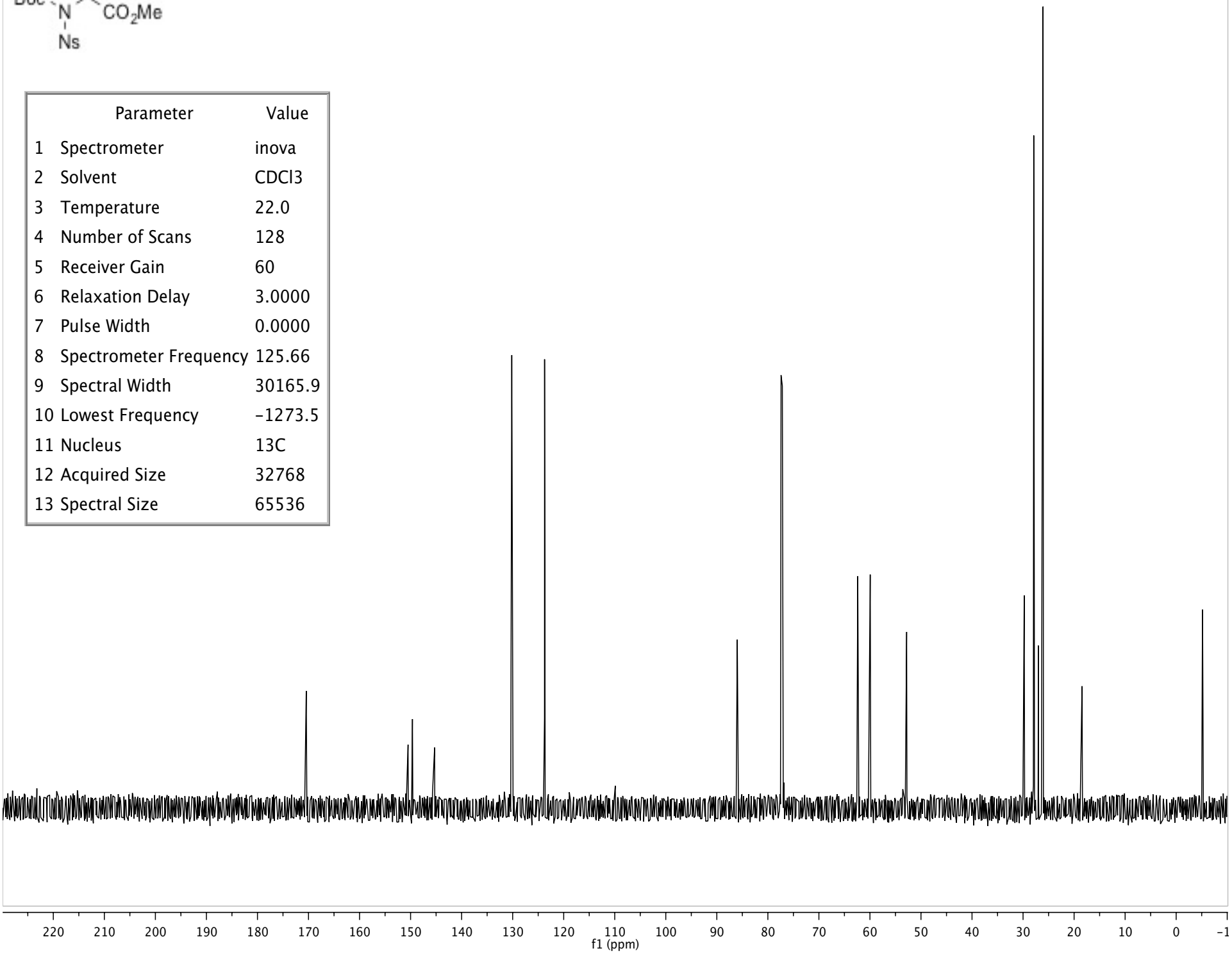


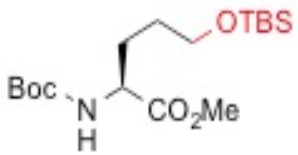
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	29.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



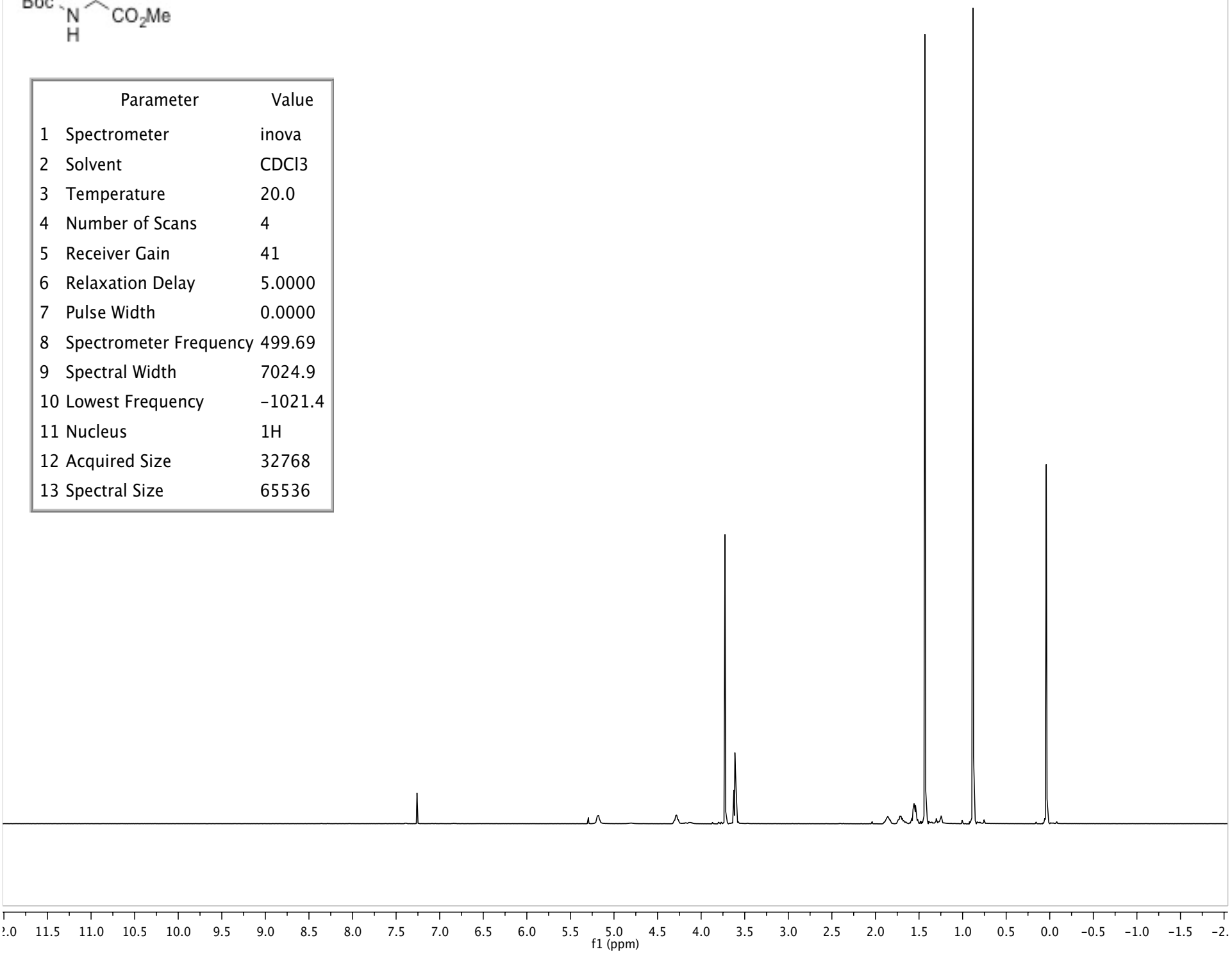


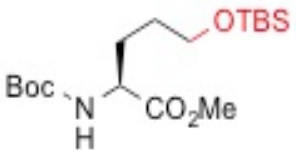
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	22.0
4	Number of Scans	128
5	Receiver Gain	60
6	Relaxation Delay	3.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



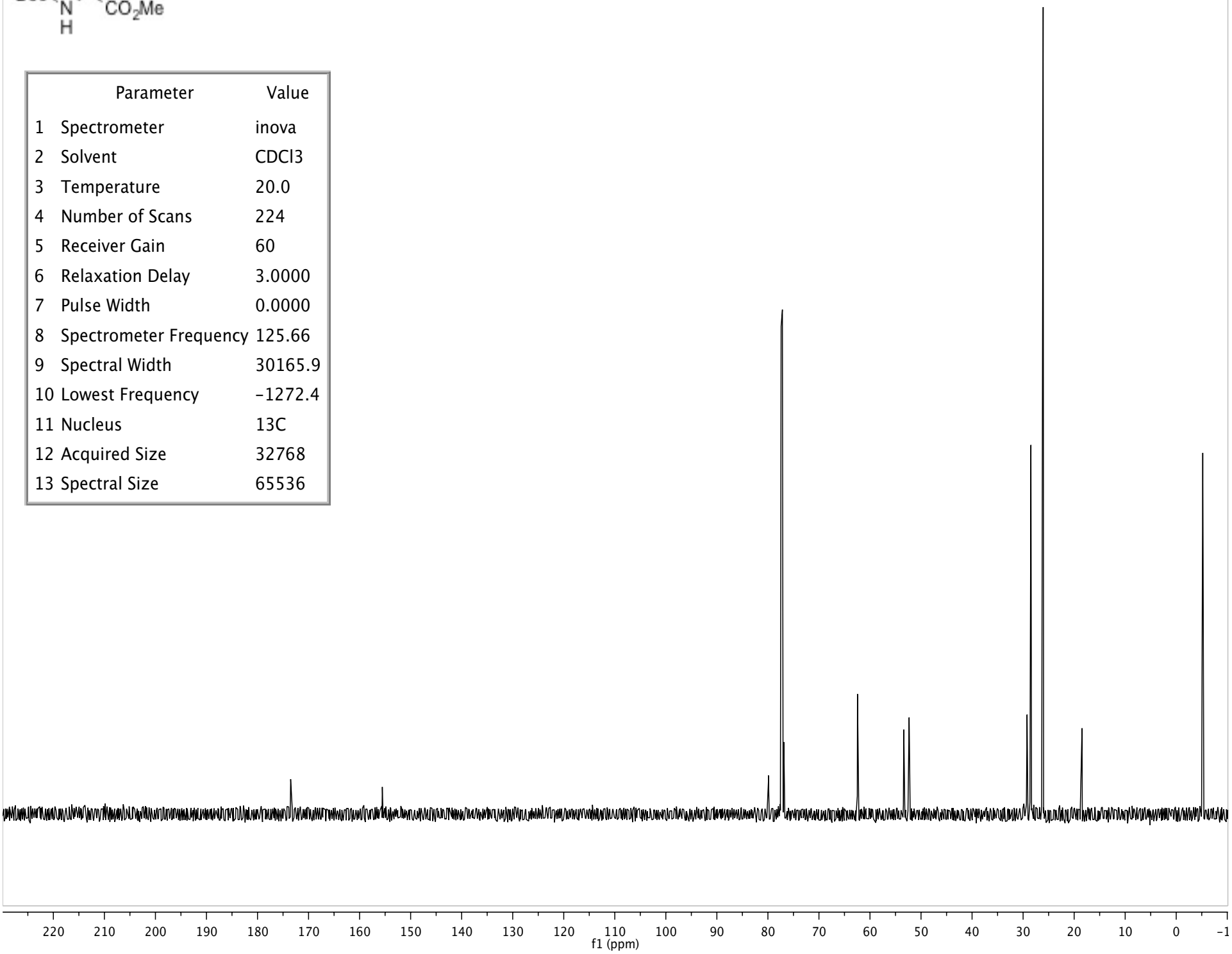


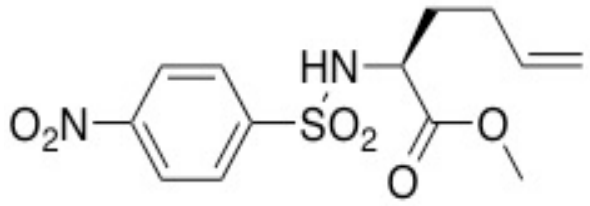
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



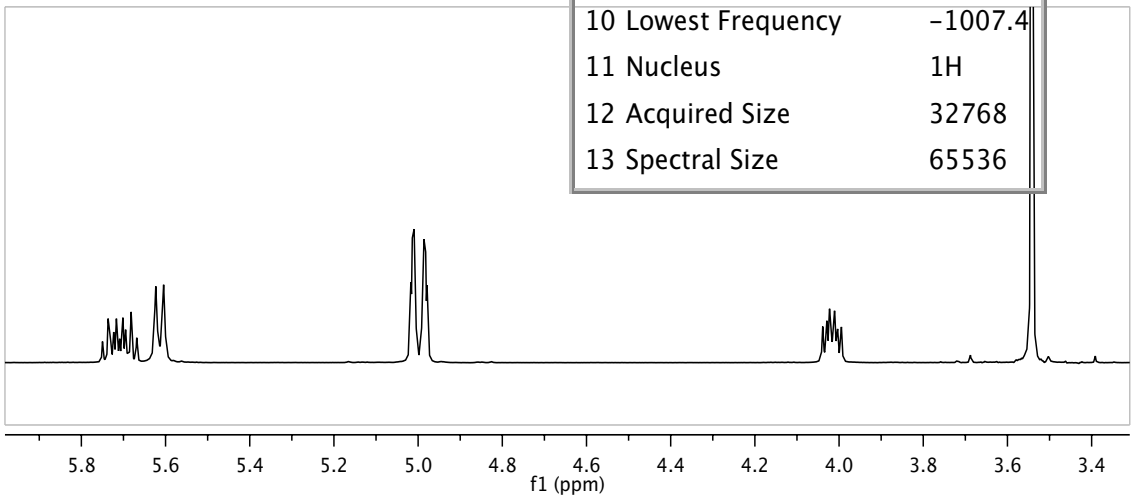


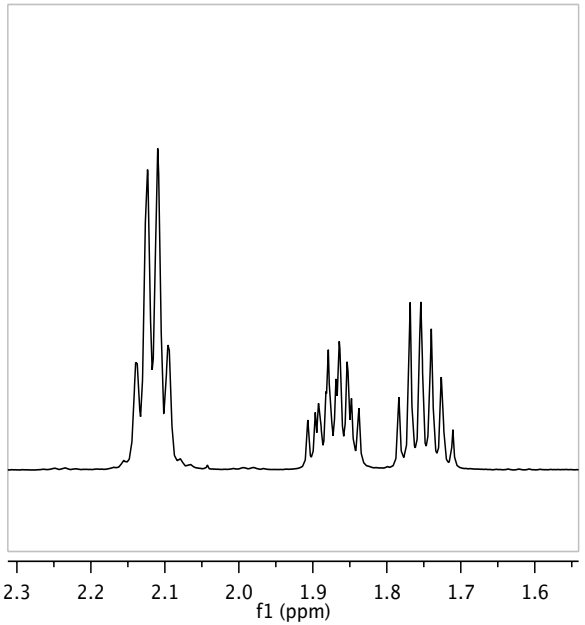
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	224
5	Receiver Gain	60
6	Relaxation Delay	3.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

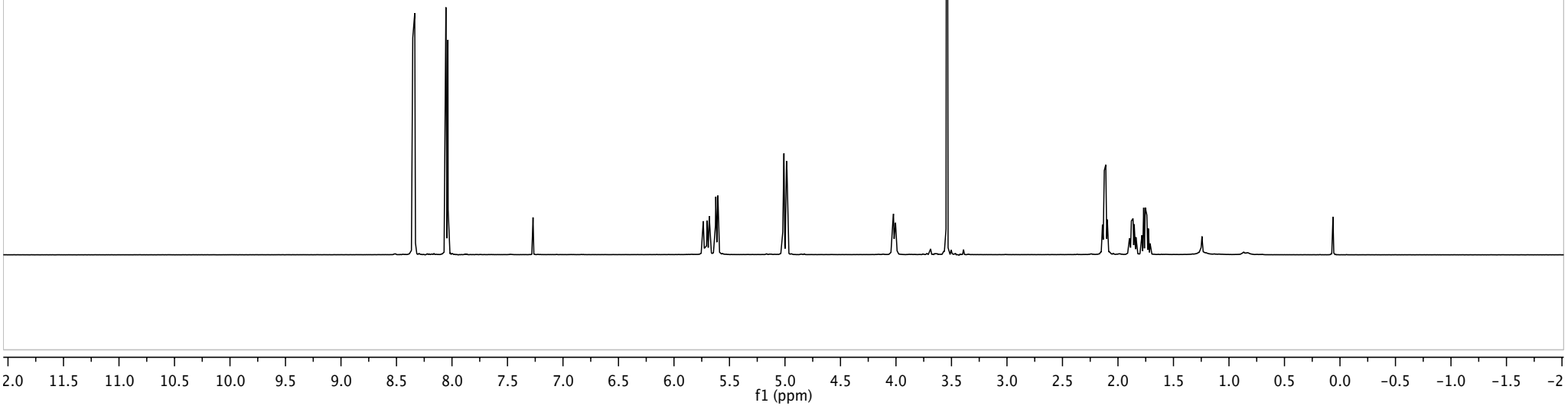


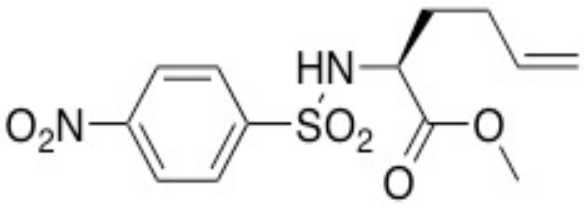


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

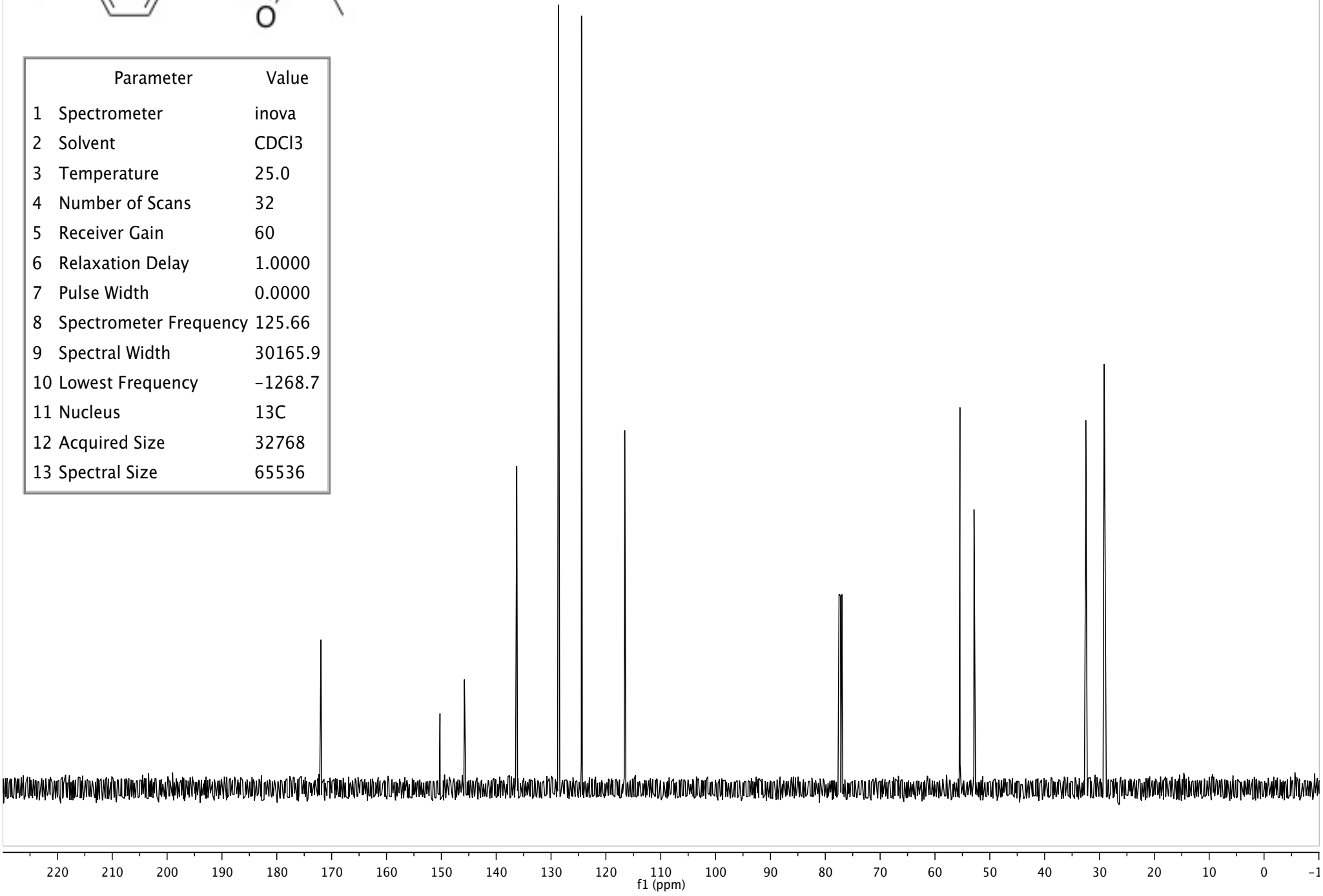


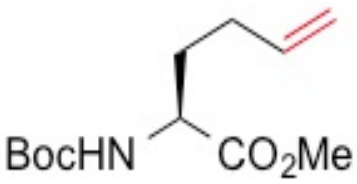




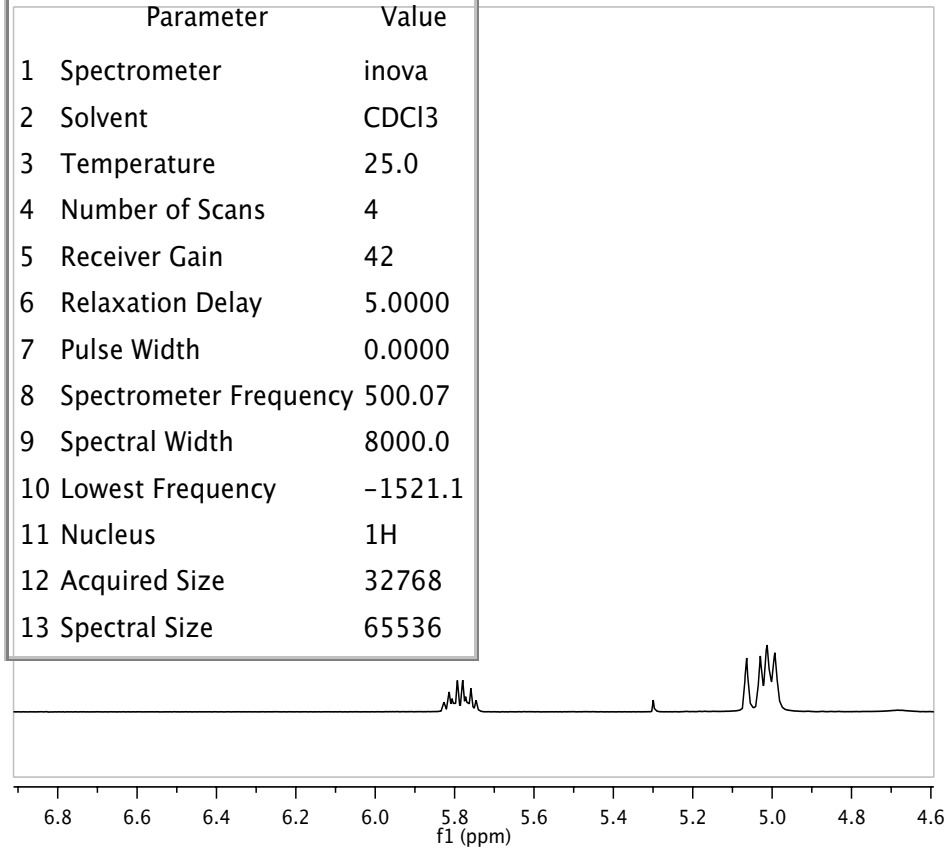


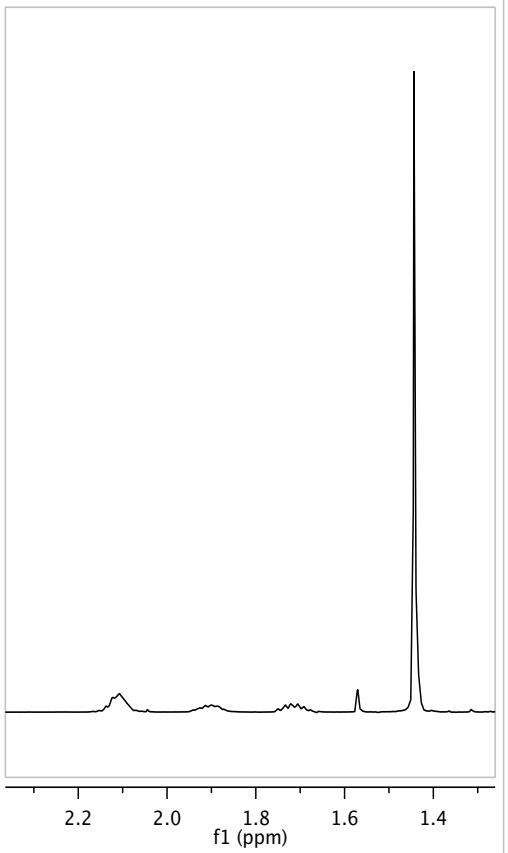
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	32
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1268.7
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

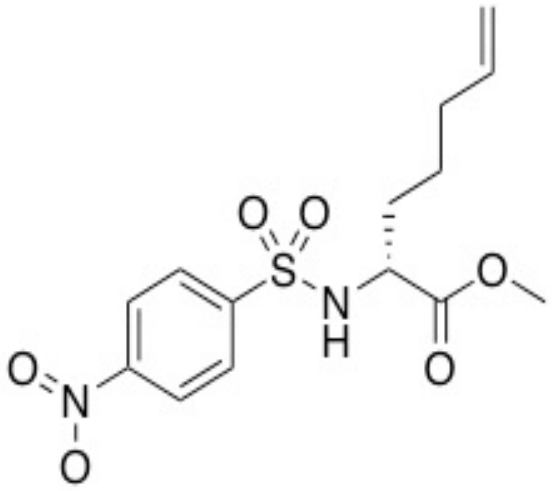




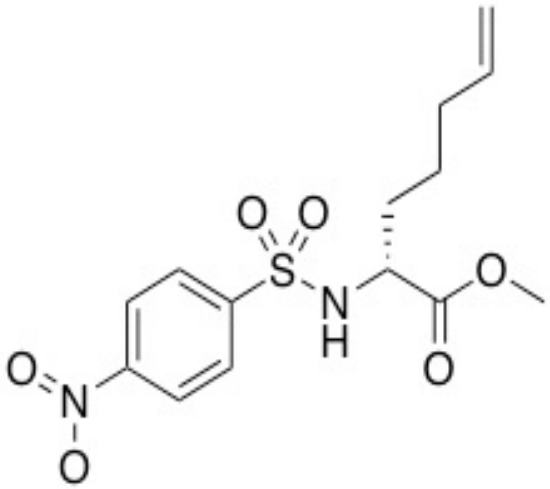
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	4
5	Receiver Gain	42
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1521.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



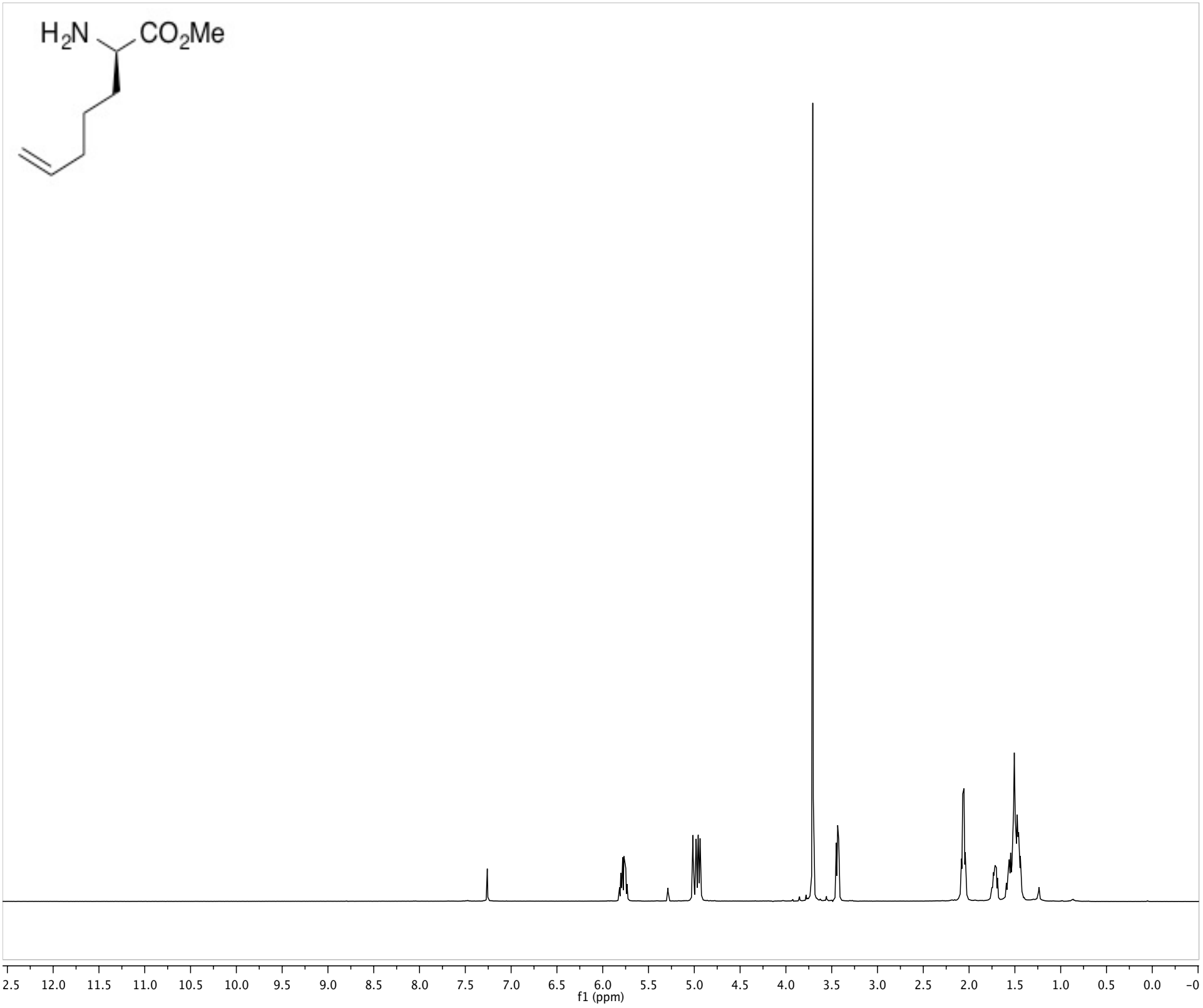


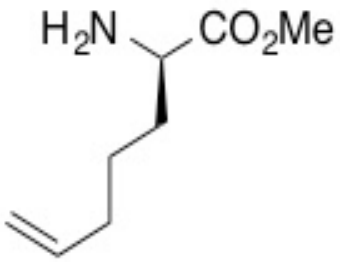


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

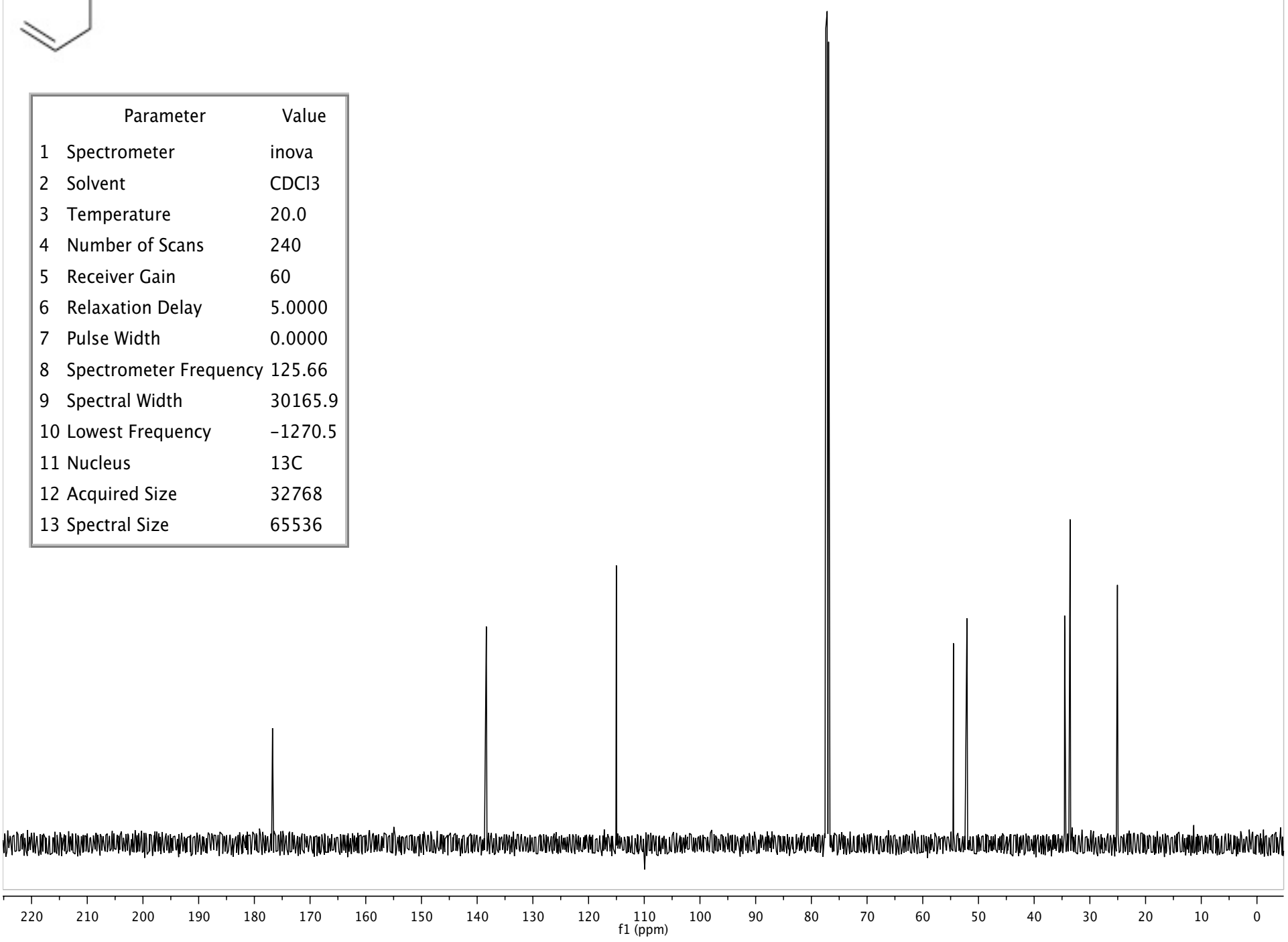


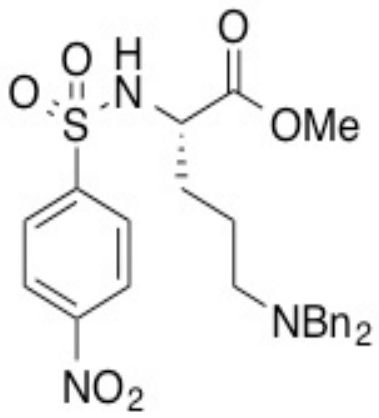
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	48
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536


H2N
CO2Me
2.5 12.0 11.5 11.0 10.5 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
f1 (ppm)

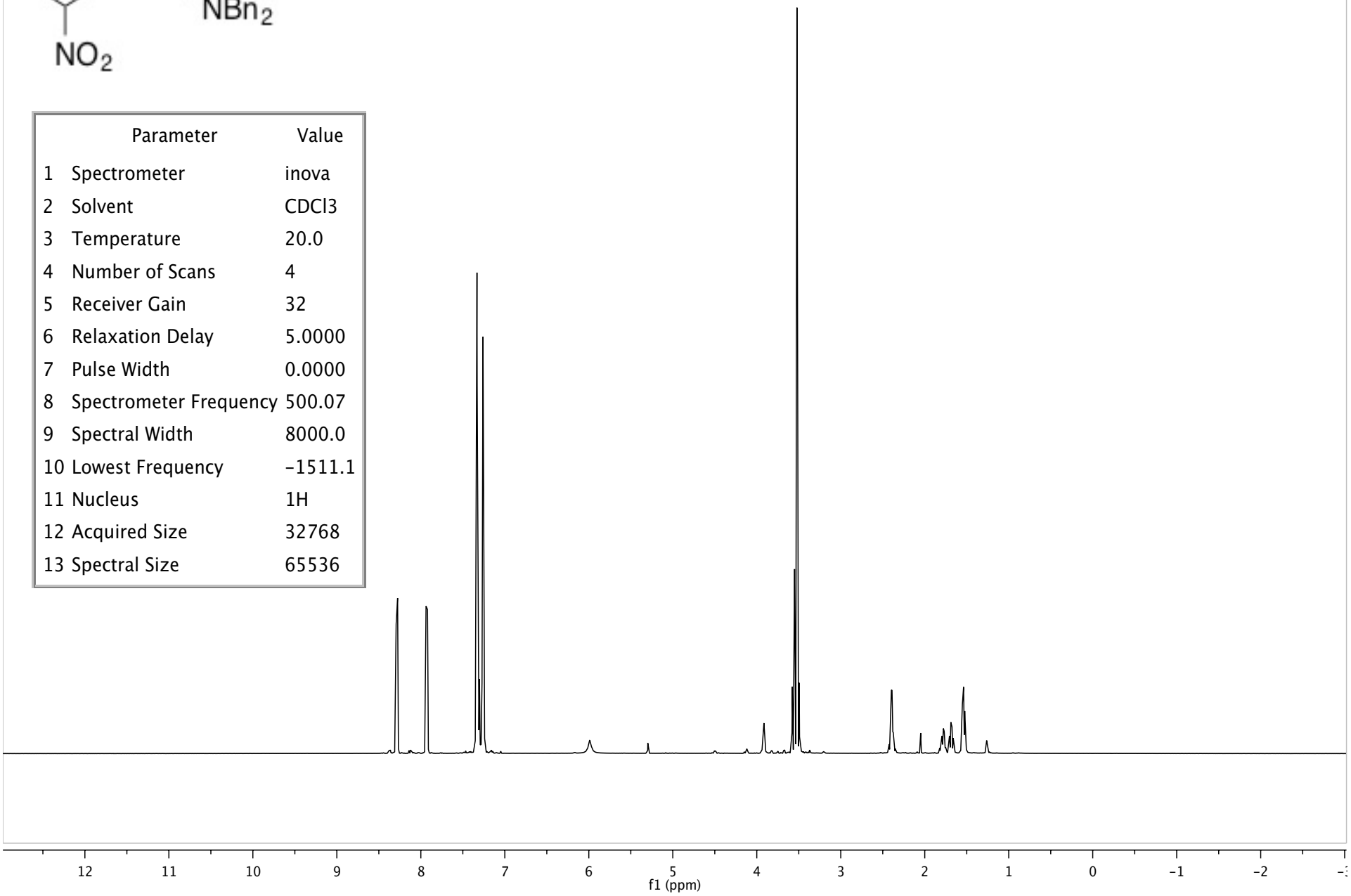


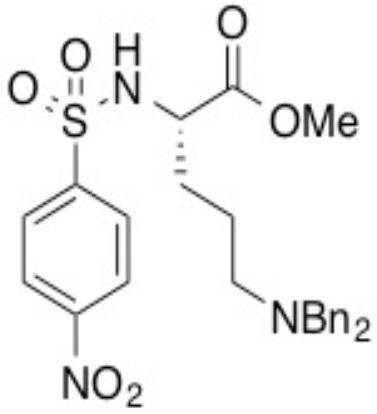
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	240
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1270.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



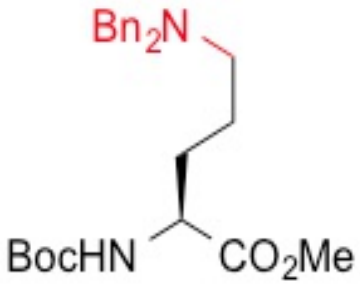


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

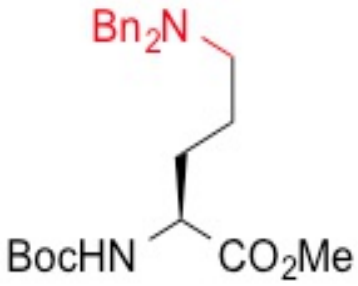




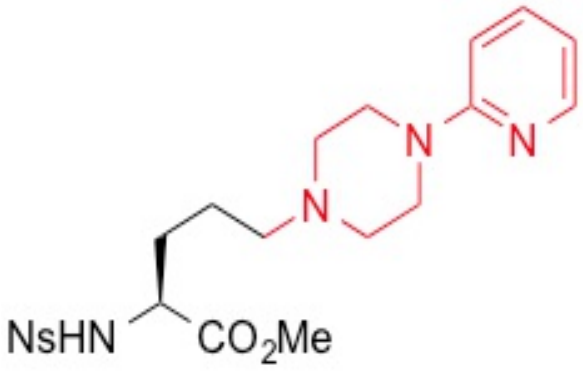
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	176
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



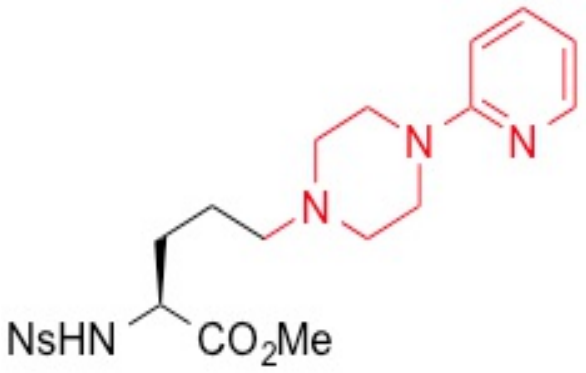
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	44
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.43
9	Spectral Width	8000.0
10	Lowest Frequency	-1518.2
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



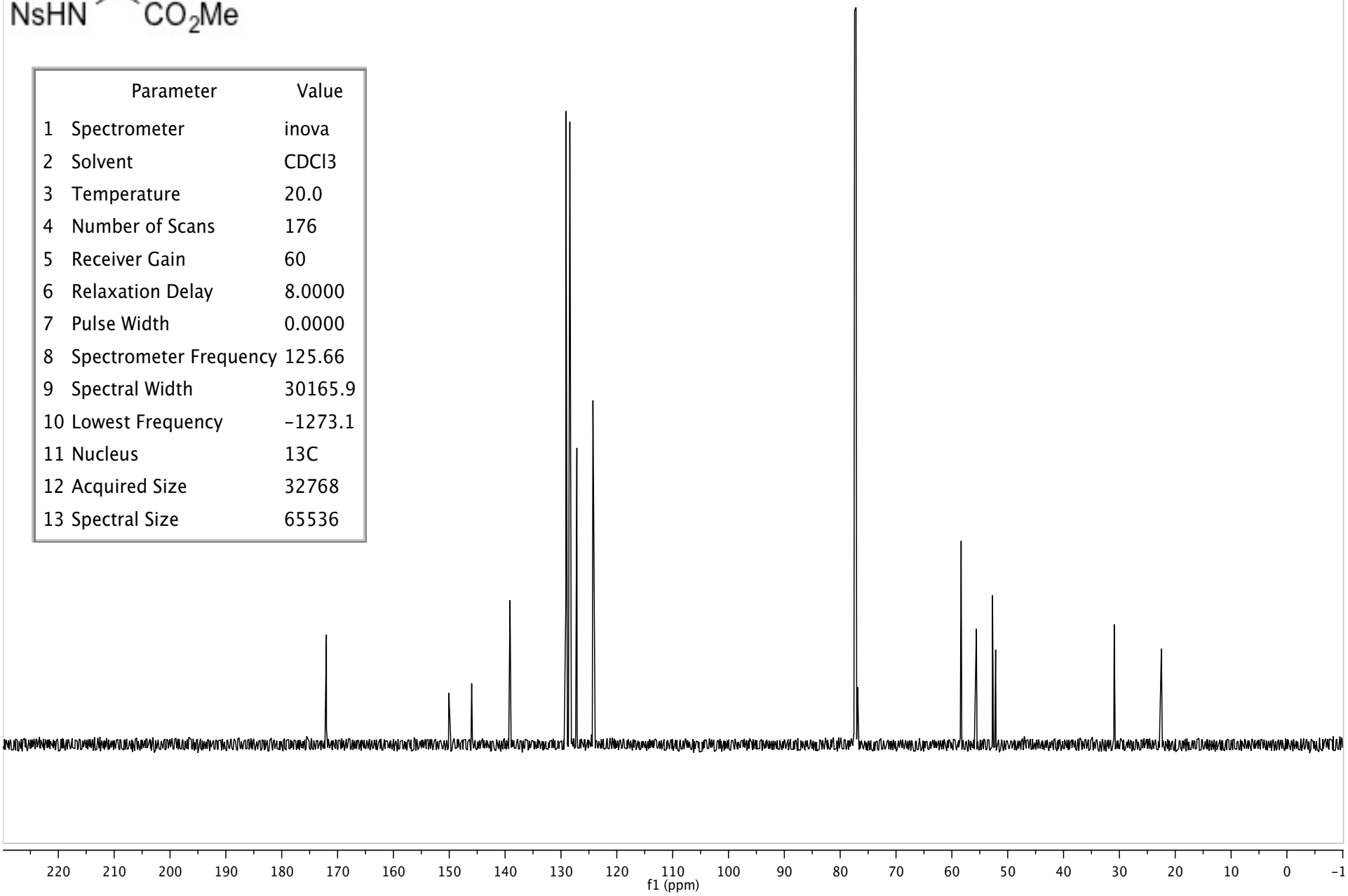
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	45.0
4	Number of Scans	3856
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.6
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



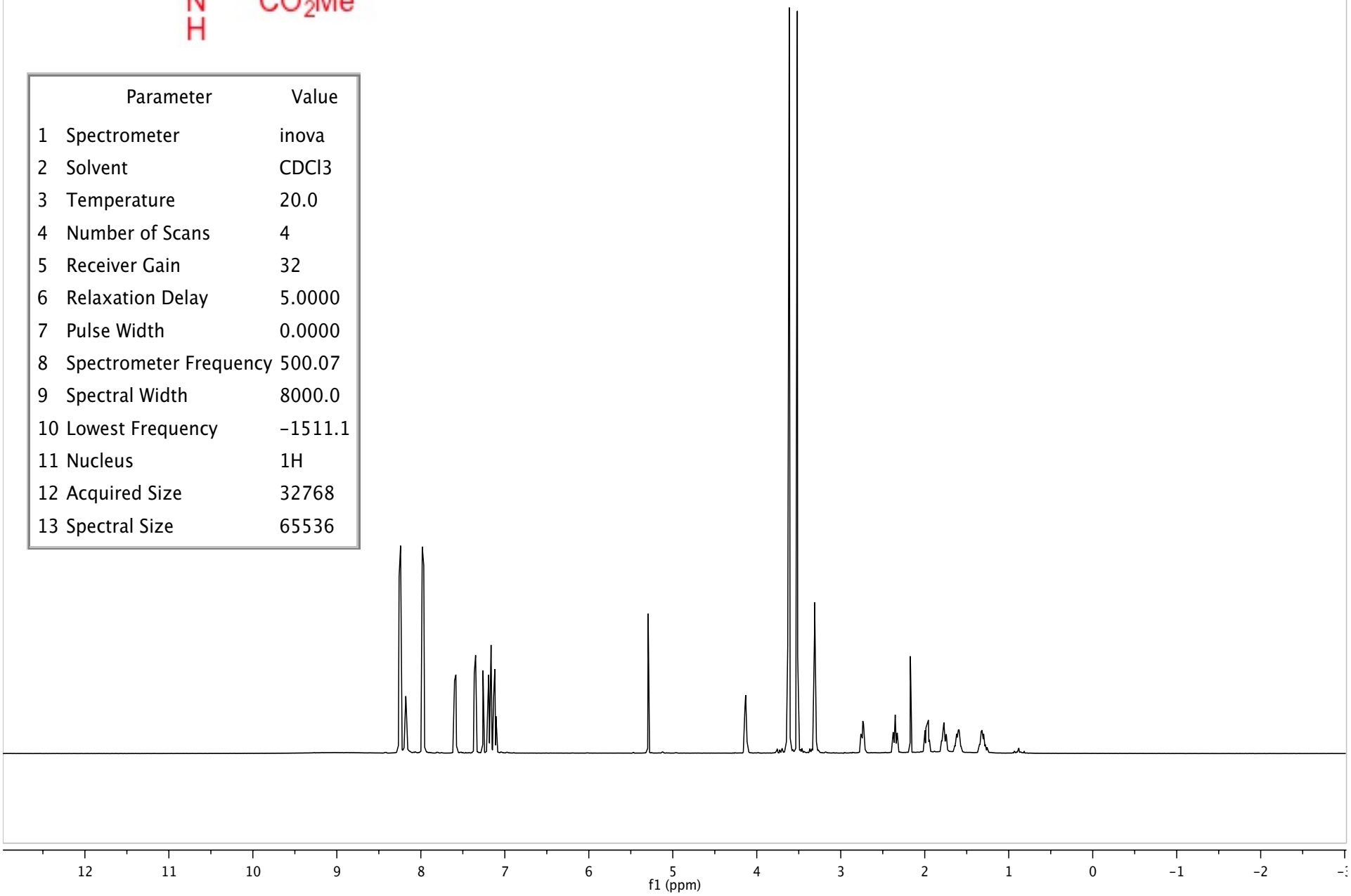
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	50
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.43
9	Spectral Width	8000.0
10	Lowest Frequency	-1509.2
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

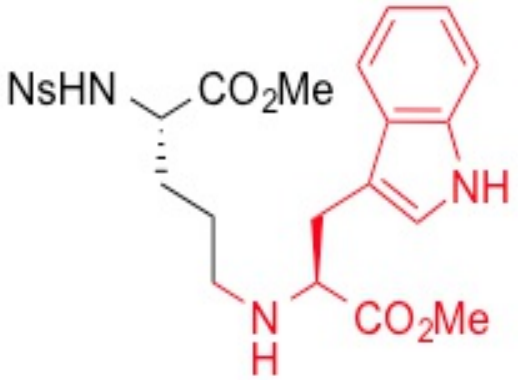


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	176
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

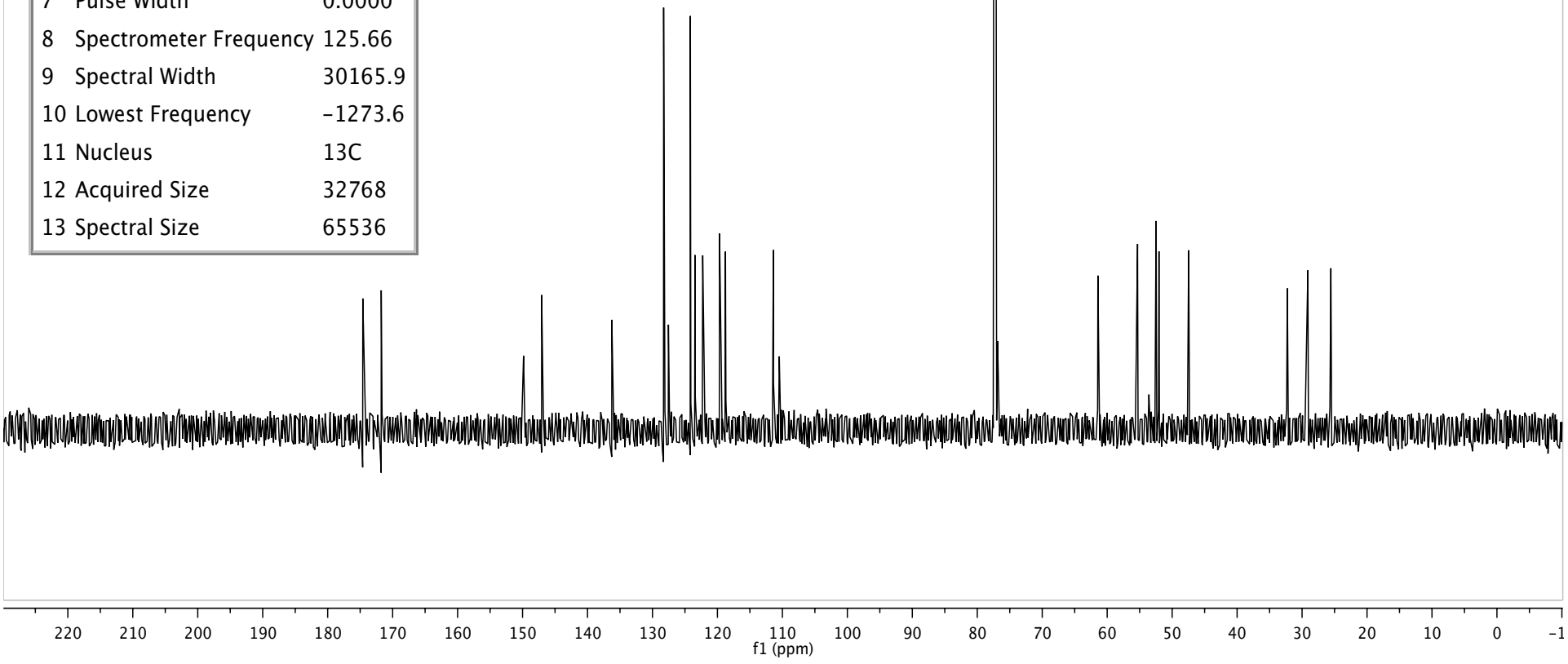


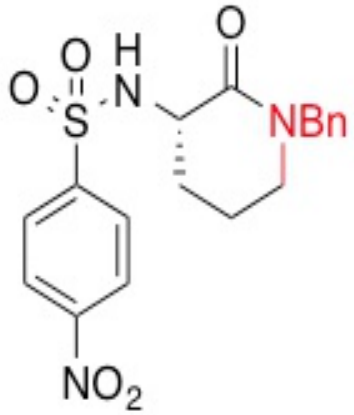
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



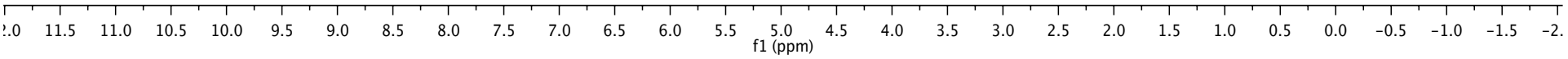


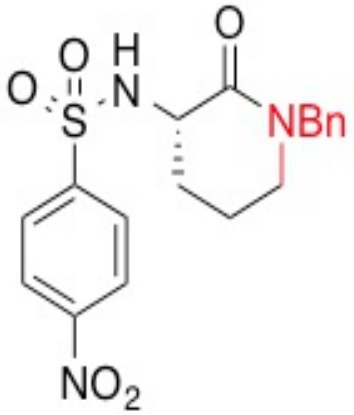
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	184
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.6
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



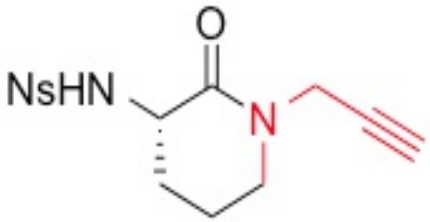


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1022.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

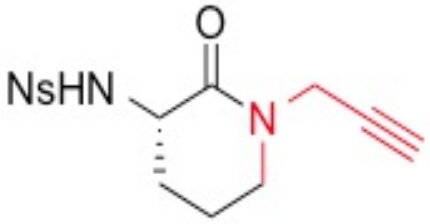




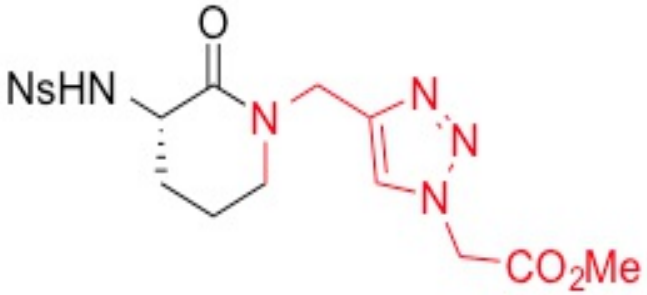
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	32
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1277.0
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



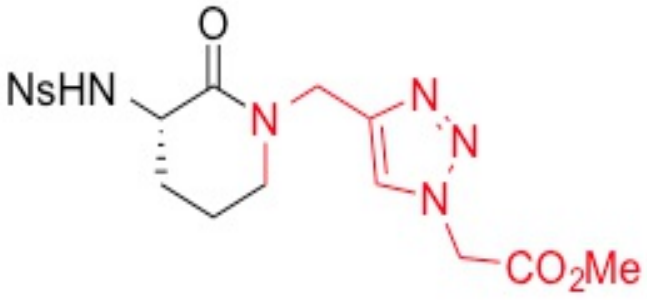
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	35.0
4	Number of Scans	4
5	Receiver Gain	46
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



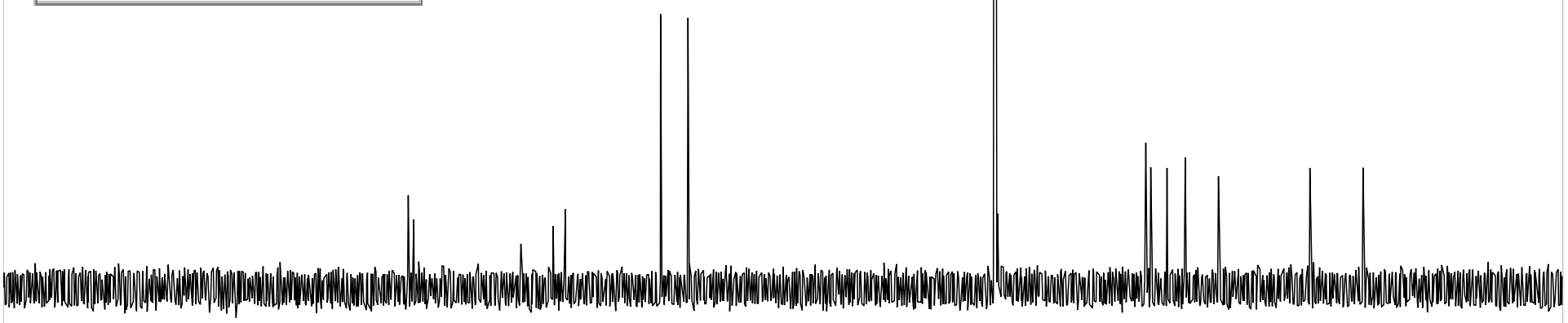
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	35.0
4	Number of Scans	40
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

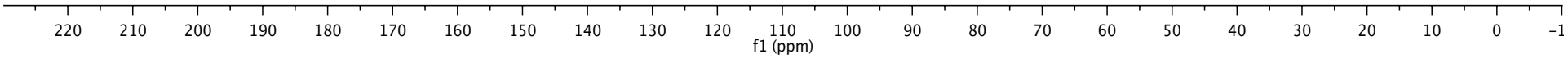


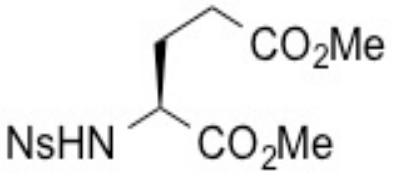
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	38
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1521.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



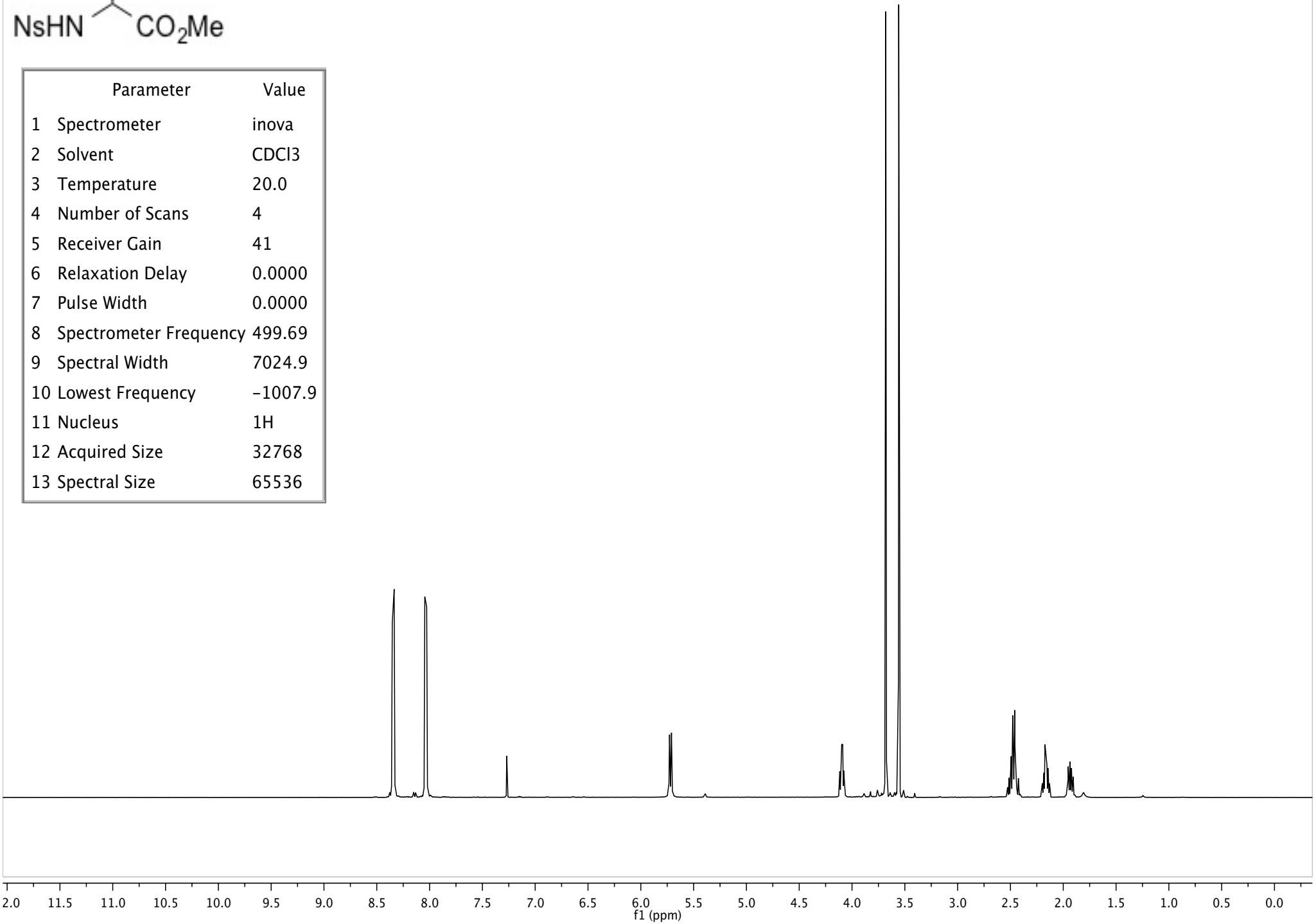
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	160
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

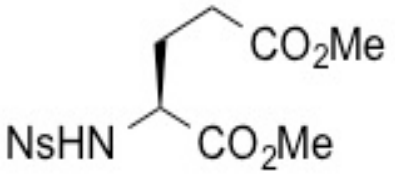




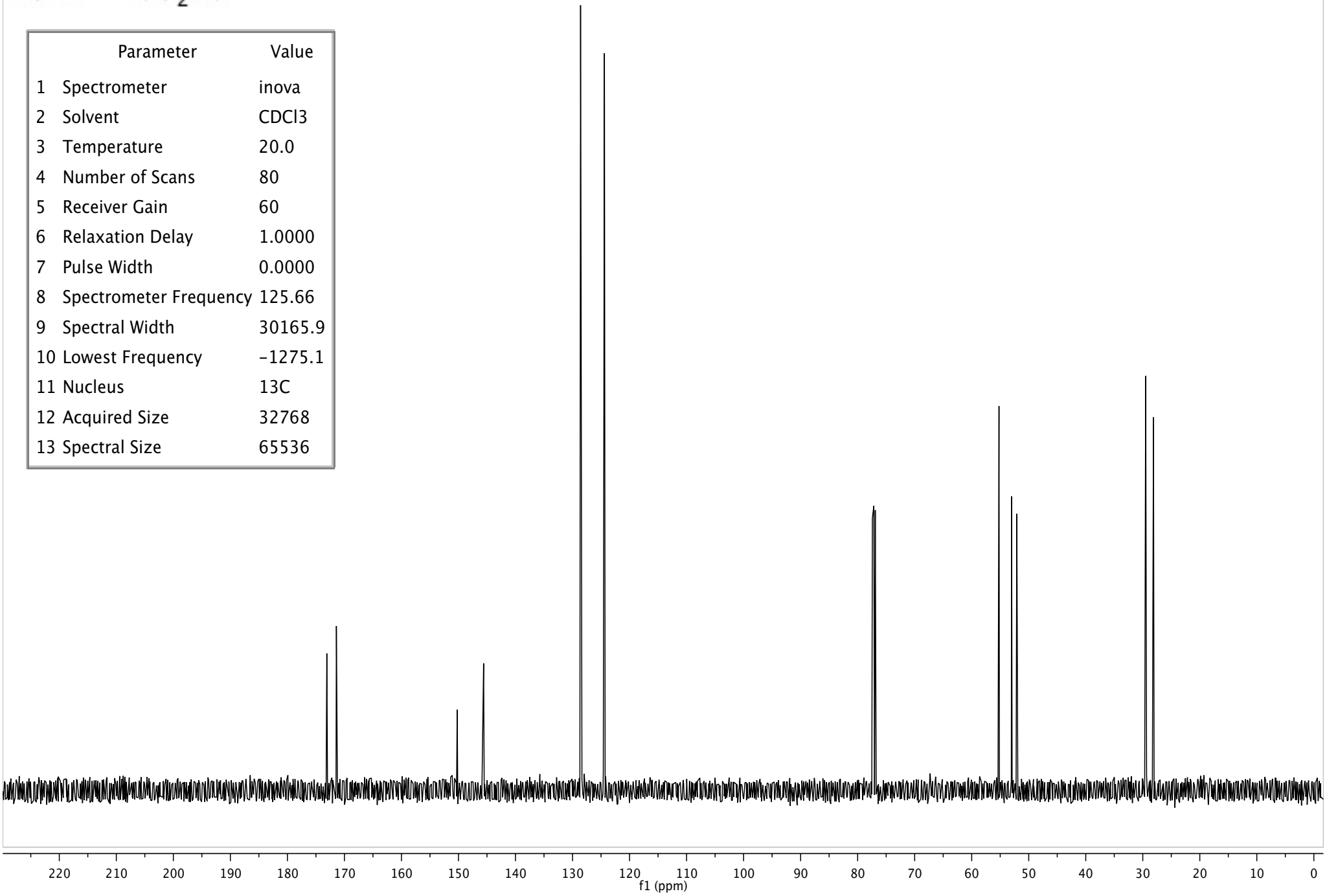


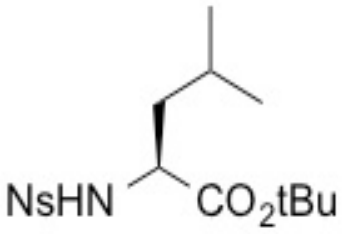
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	0.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



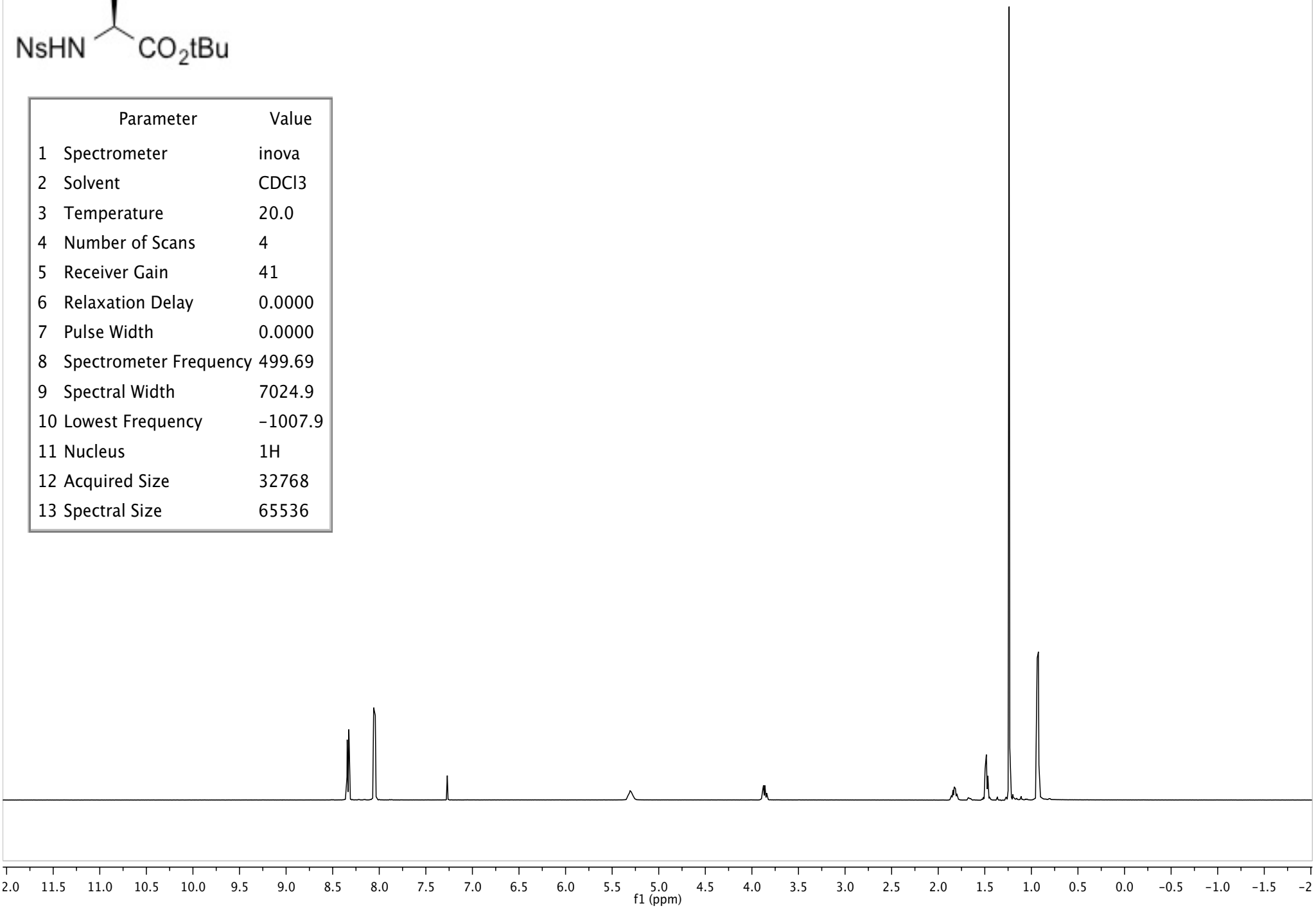


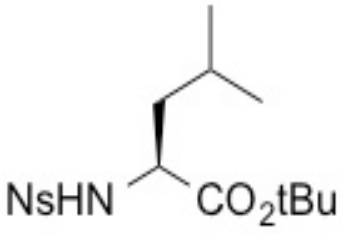
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	80
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



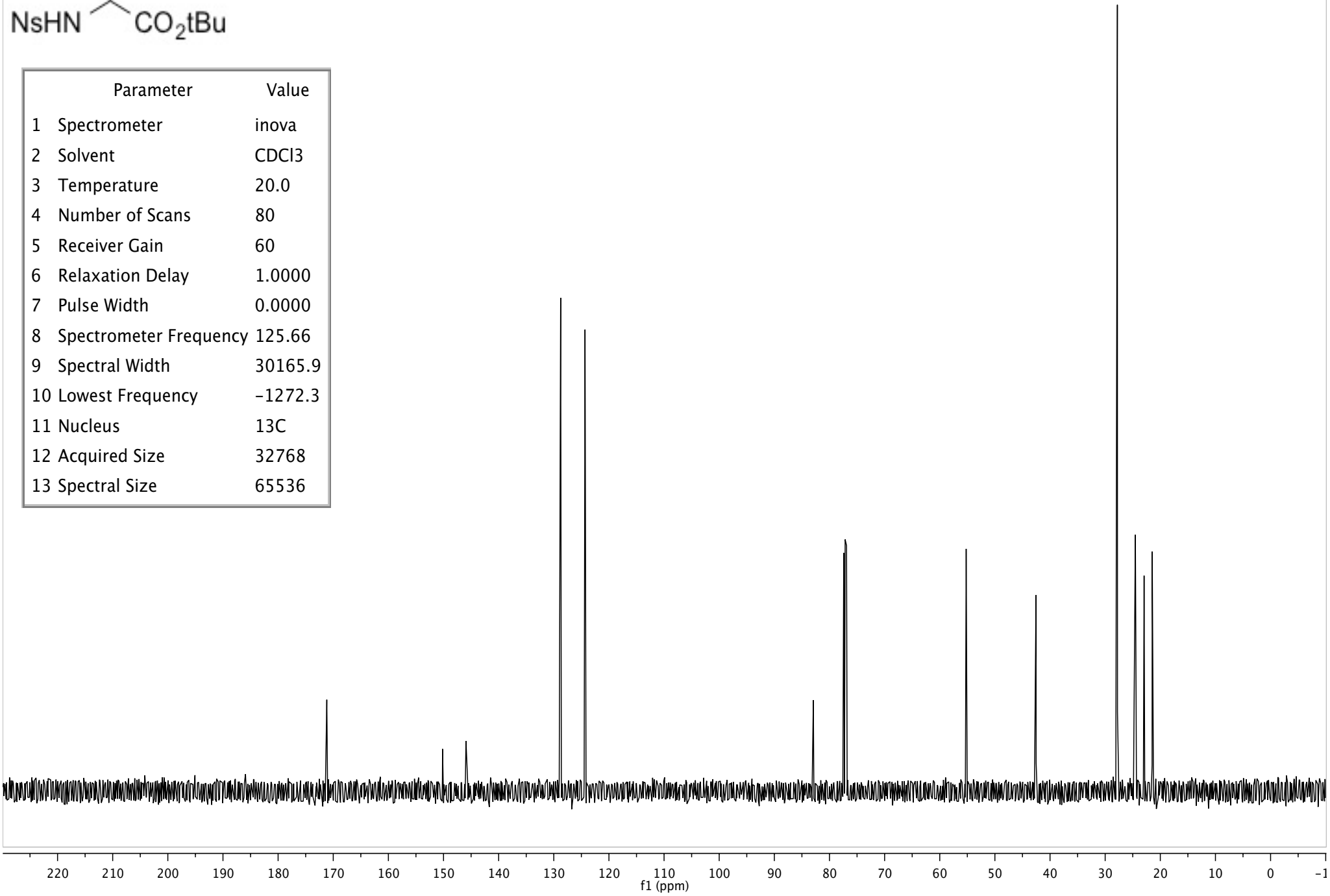


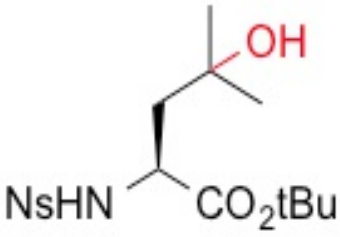
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	0.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



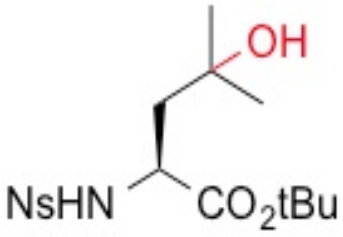


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	80
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.3
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

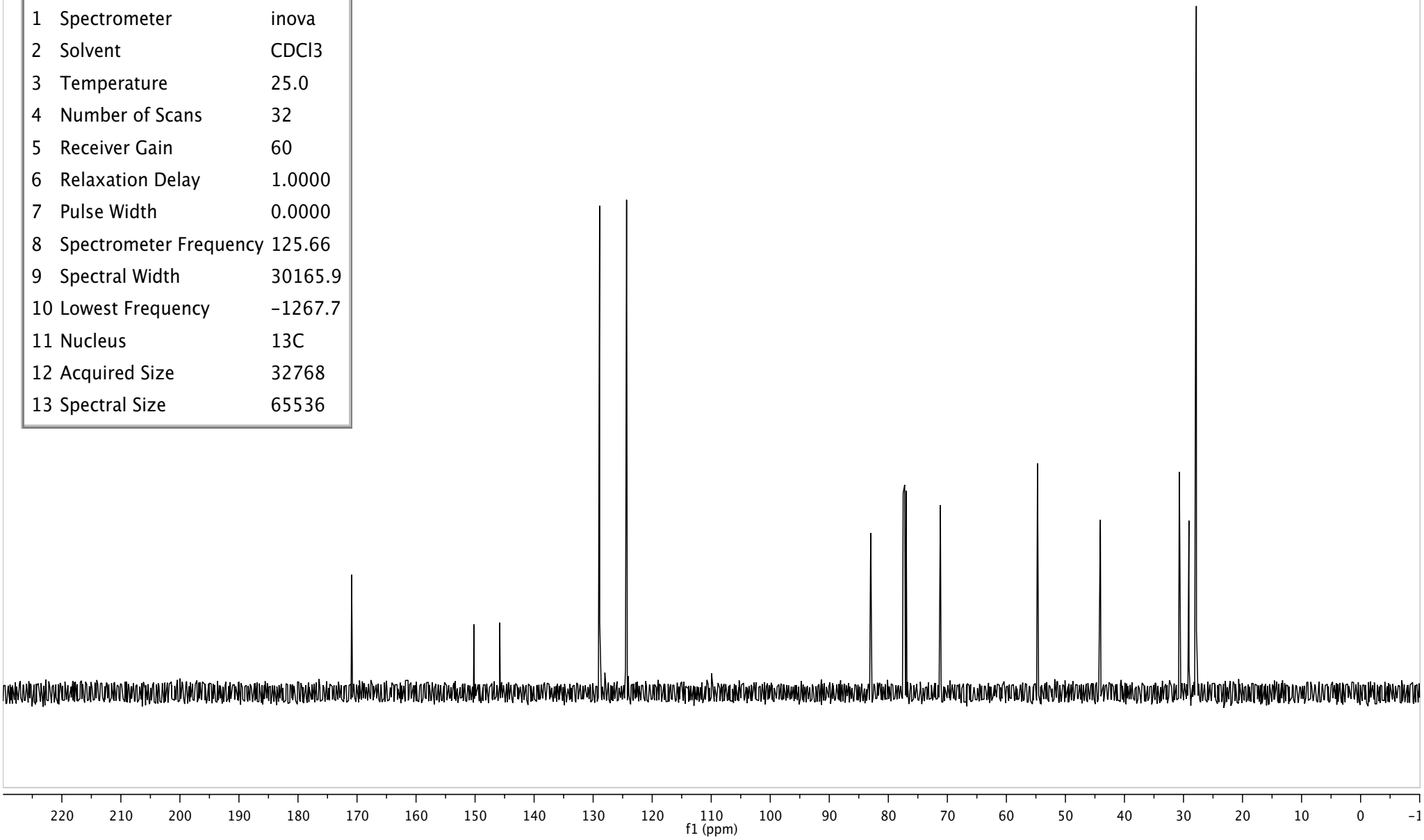


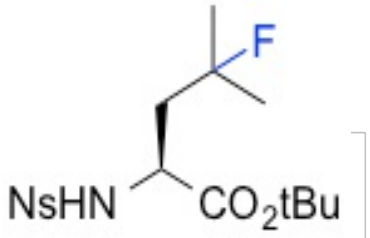


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	8
5	Receiver Gain	54
6	Relaxation Delay	20.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1506.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

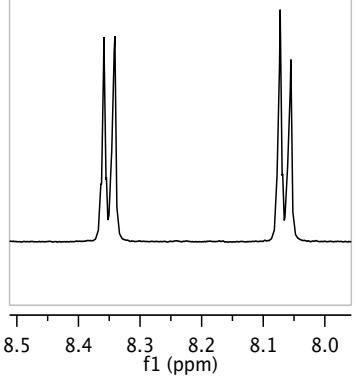


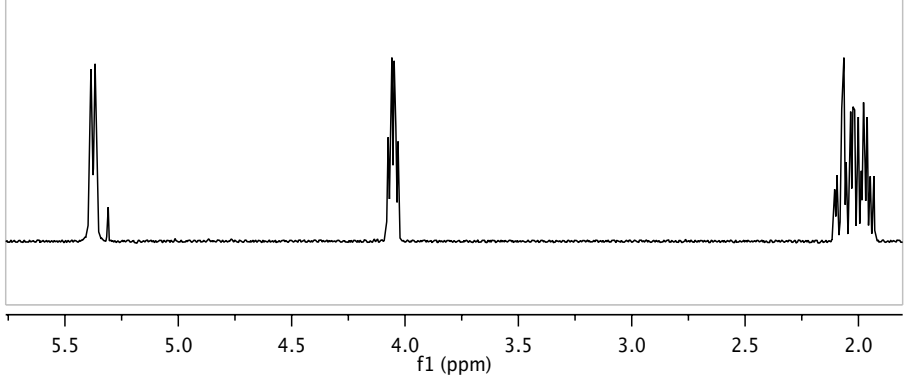
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	32
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1267.7
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

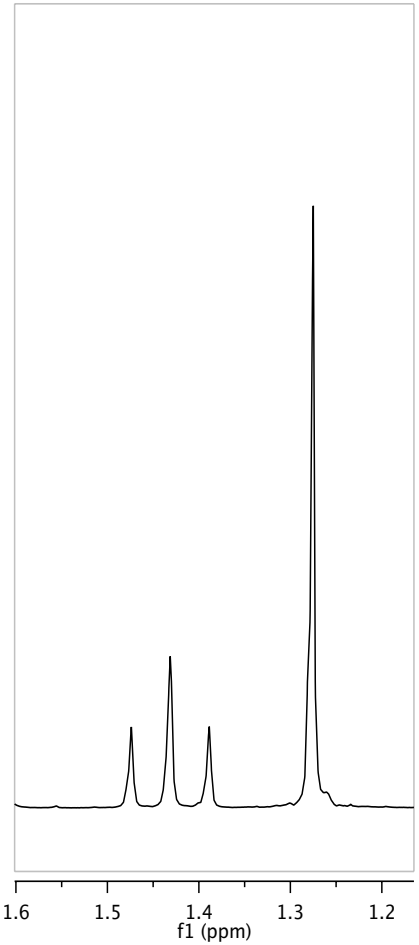


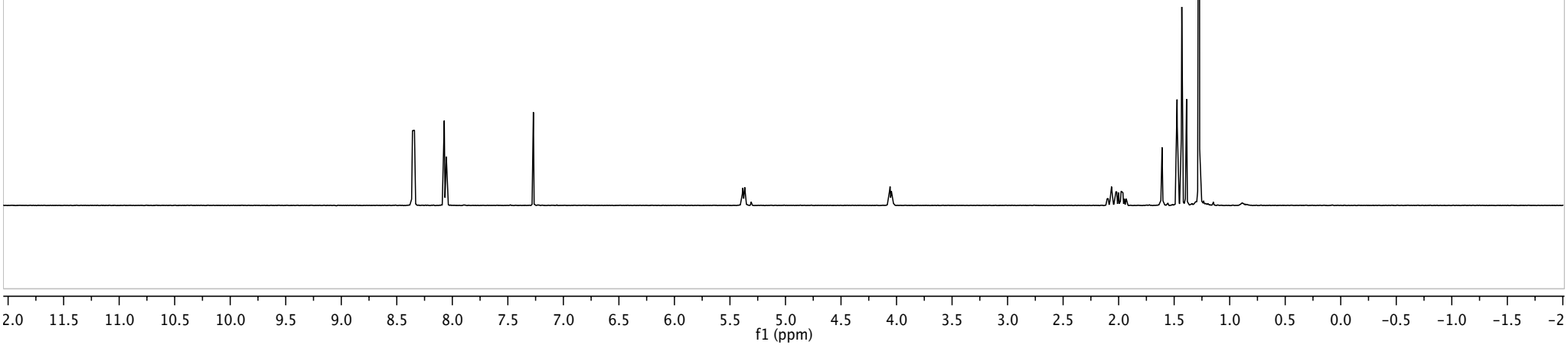


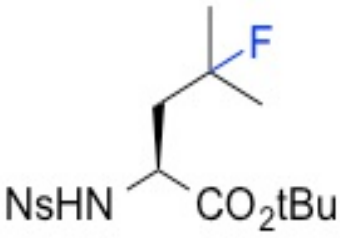
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	4
5	Receiver Gain	52
6	Relaxation Delay	20.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1006.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



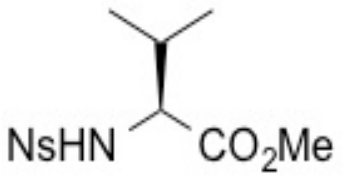




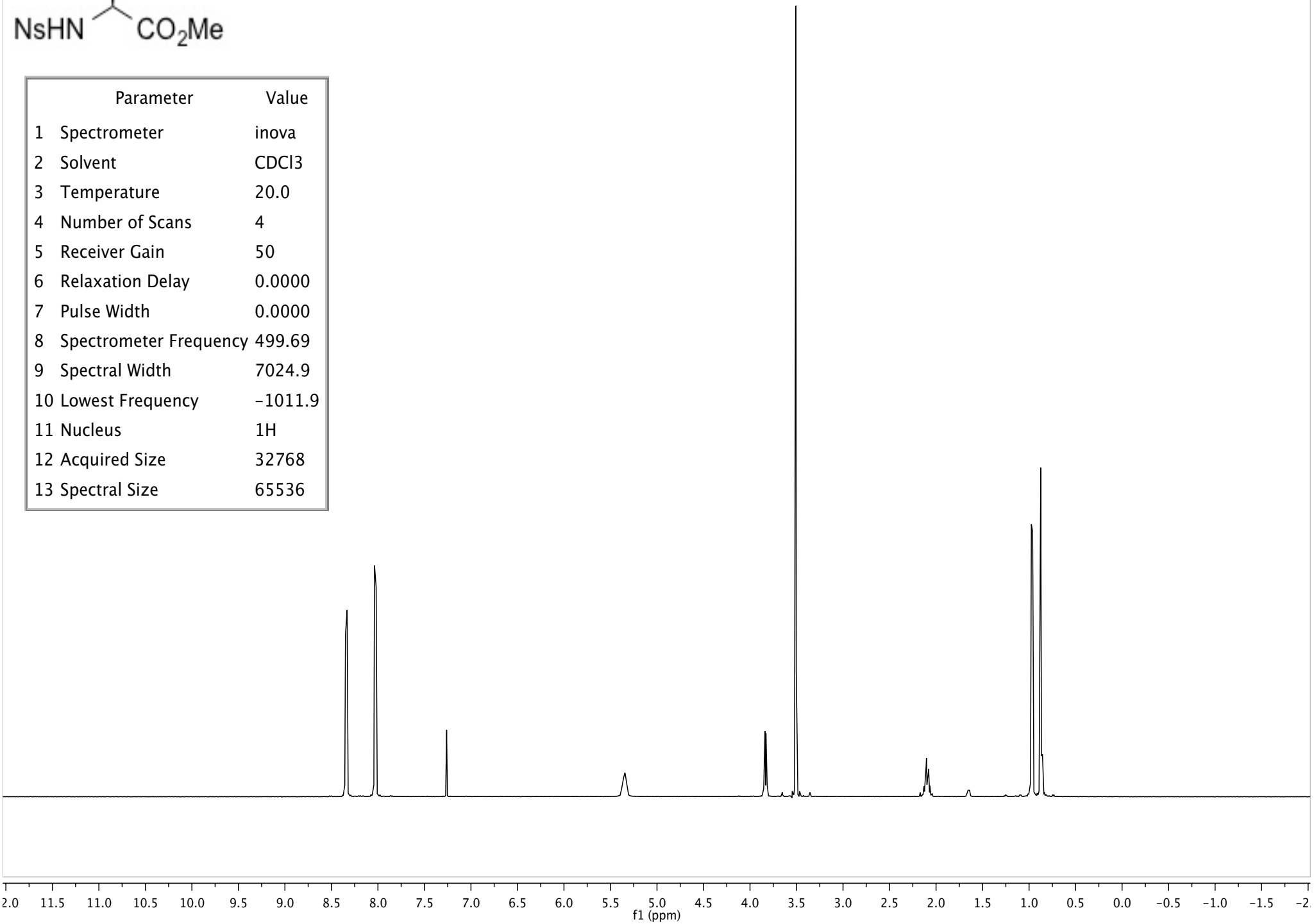


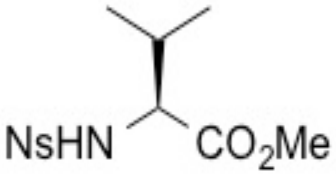


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	1000
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1262.3
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

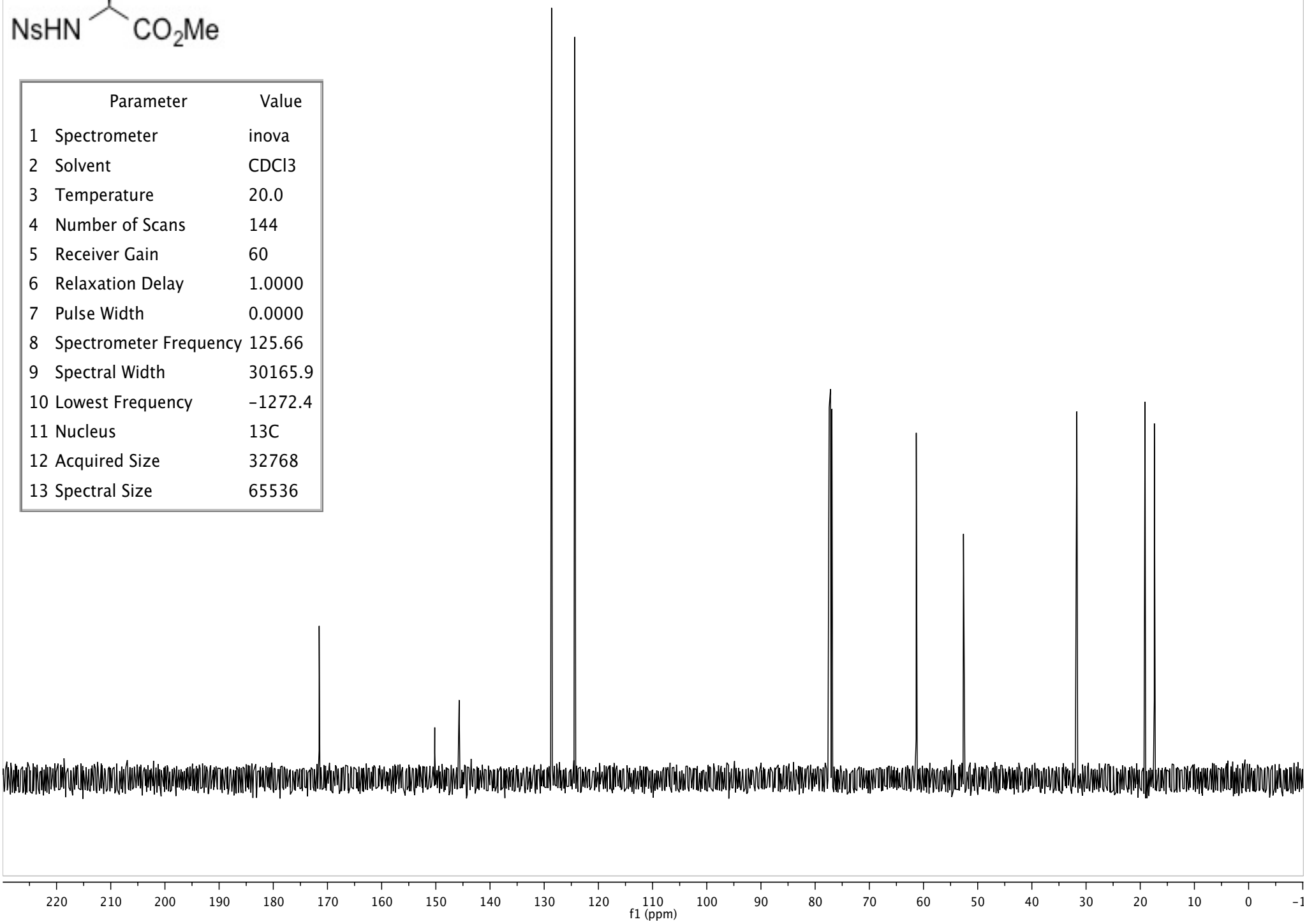


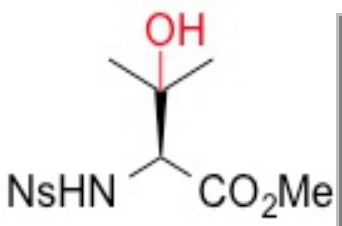
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	50
6	Relaxation Delay	0.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



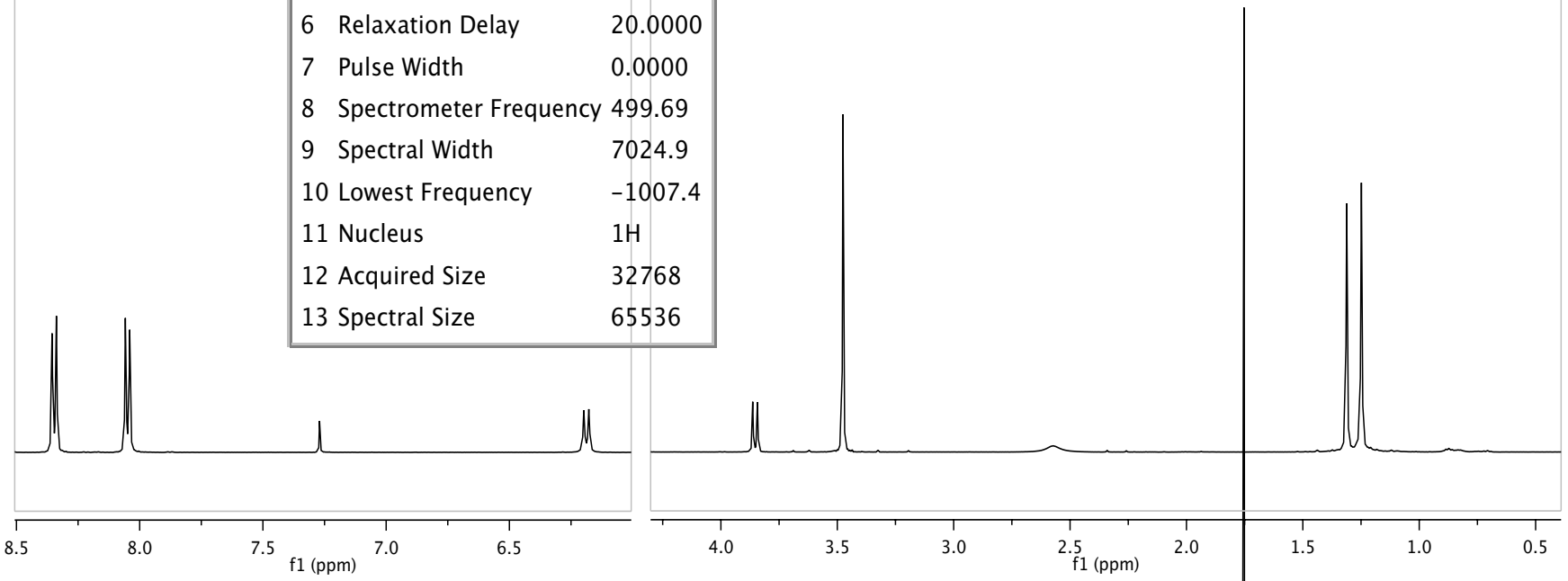


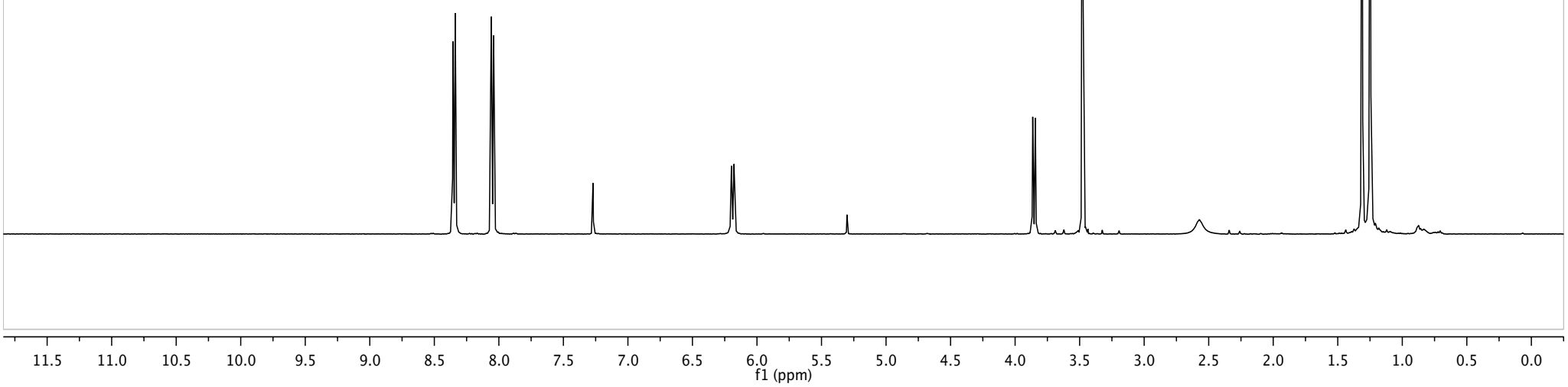
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	144
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

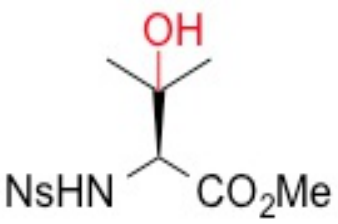




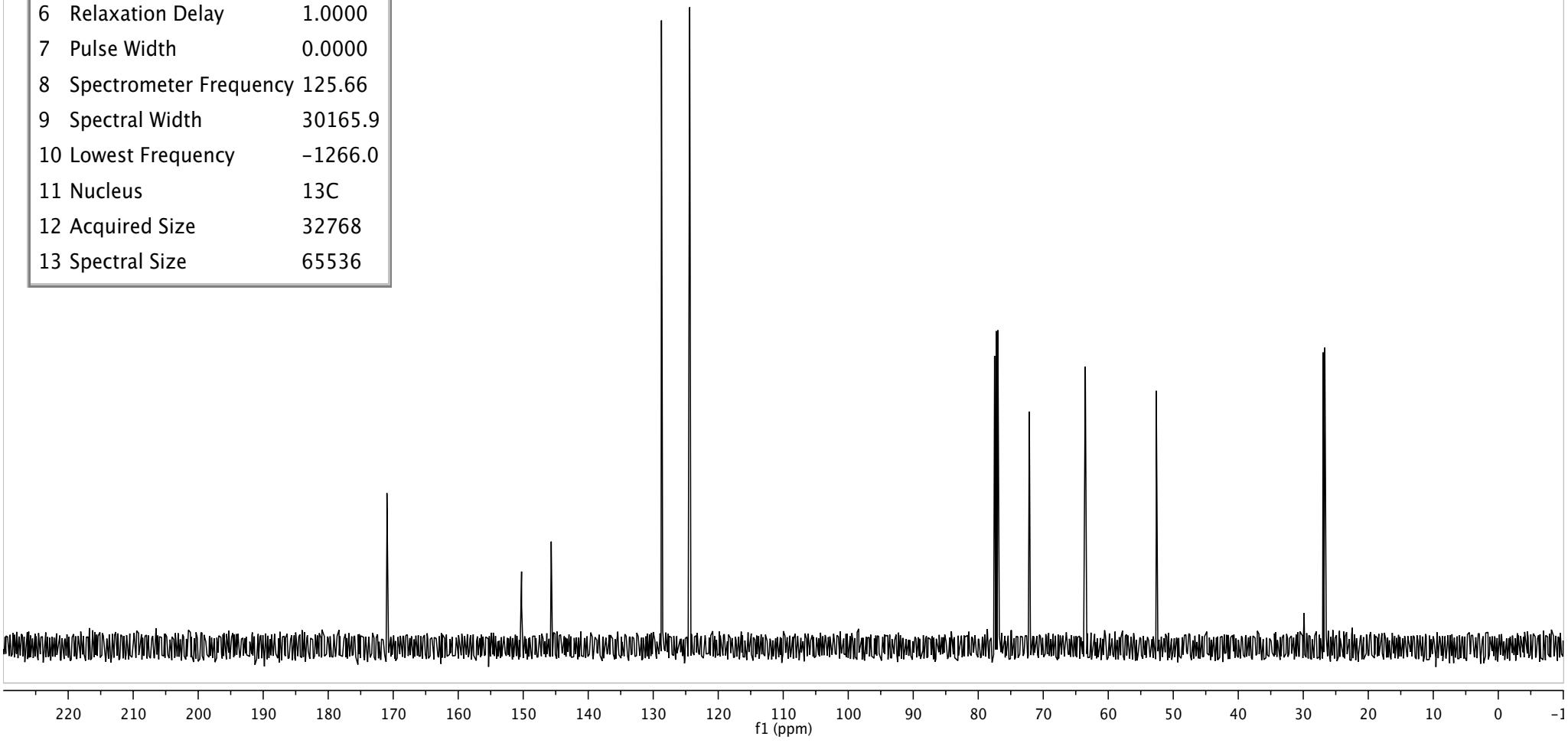
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	2
5	Receiver Gain	41
6	Relaxation Delay	20.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

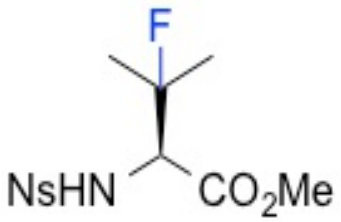




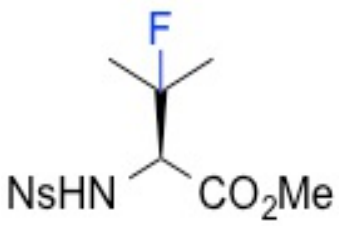


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1266.0
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

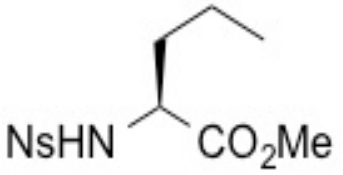




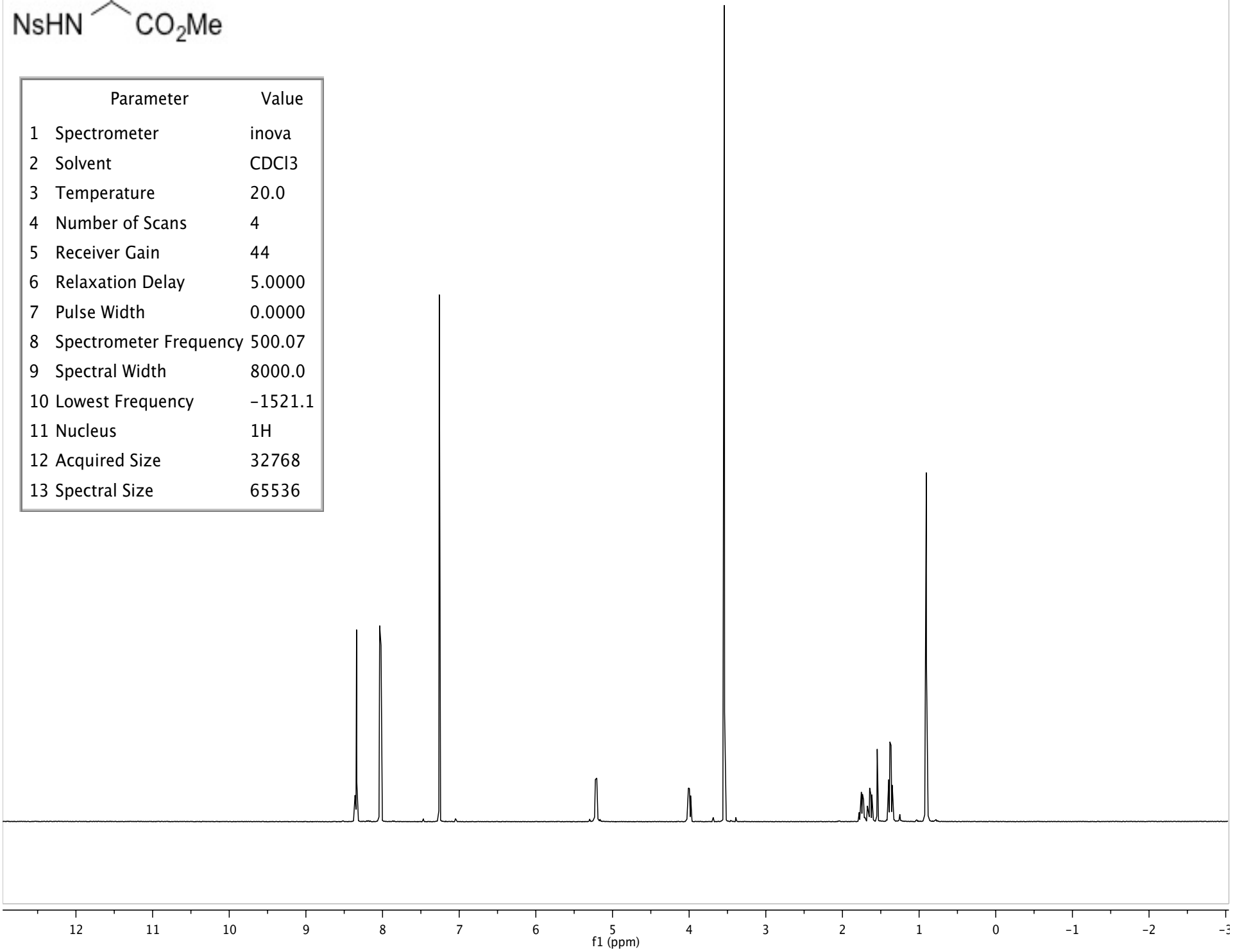
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.43
9	Spectral Width	8000.0
10	Lowest Frequency	-1518.7
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

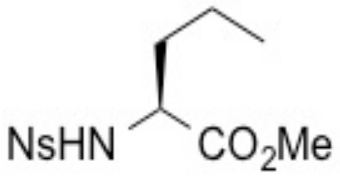


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	168
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.60
9	Spectral Width	32000.0
10	Lowest Frequency	-2202.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

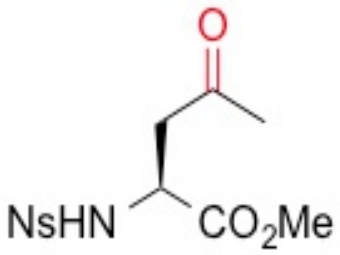


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	44
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1521.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

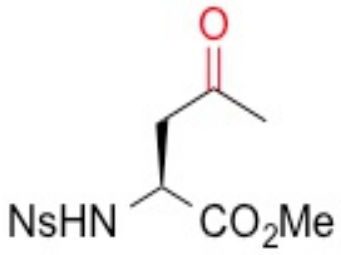




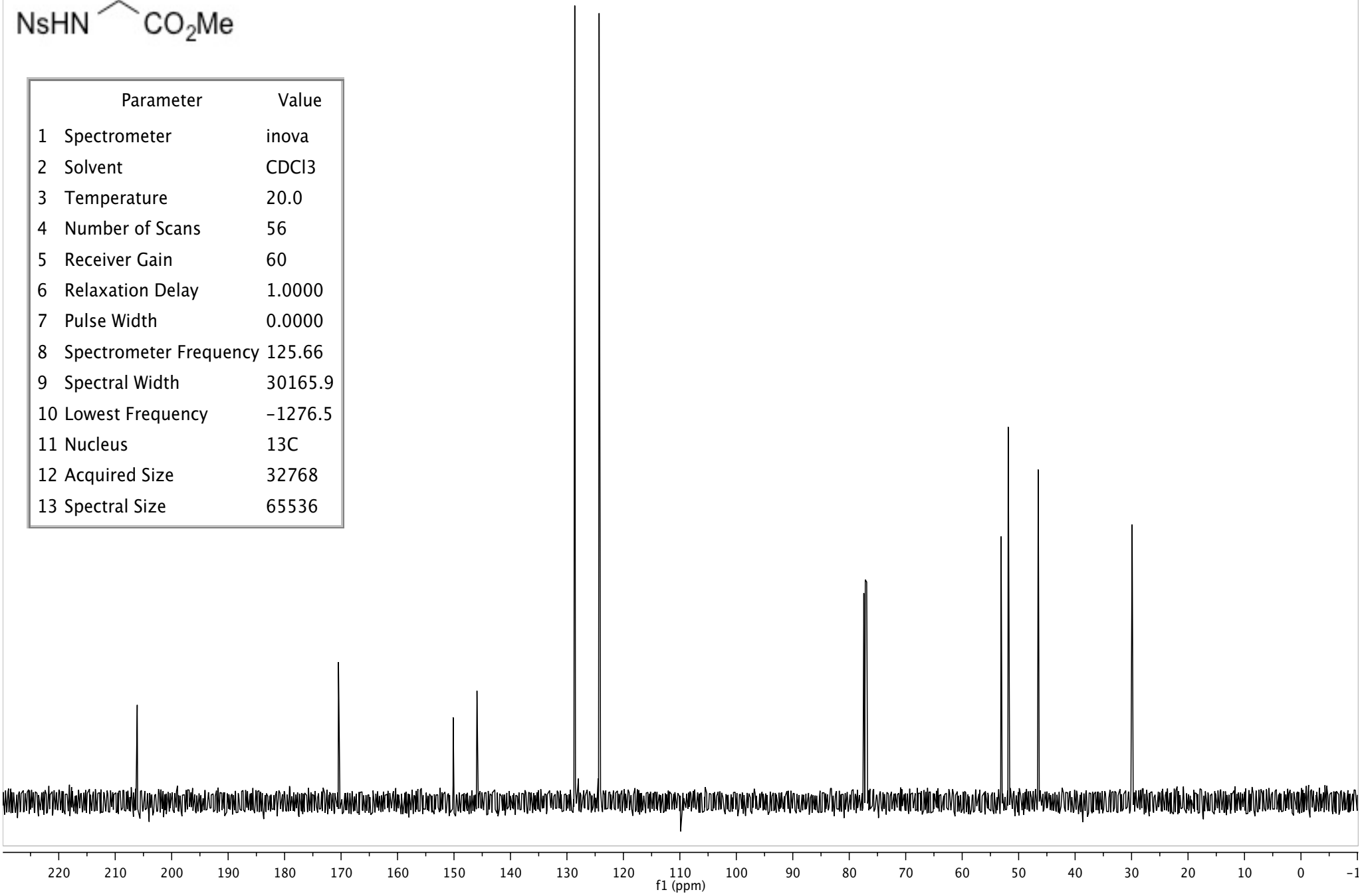
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	22.0
4	Number of Scans	248
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

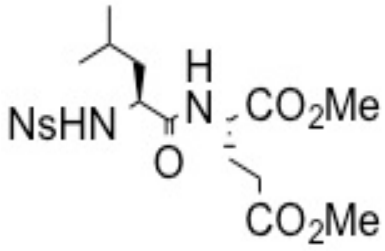


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

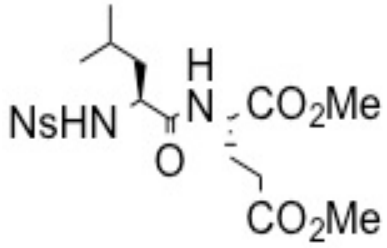


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	56
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1276.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

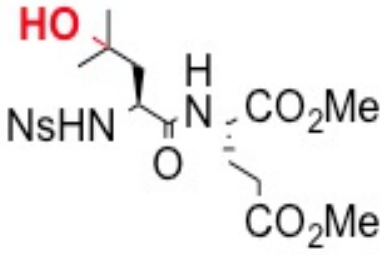




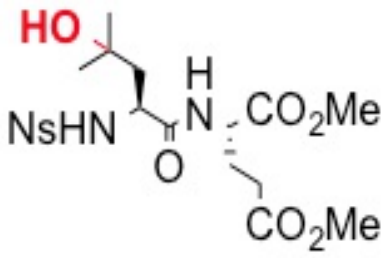
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	21.1
4	Number of Scans	16
5	Receiver Gain	48
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



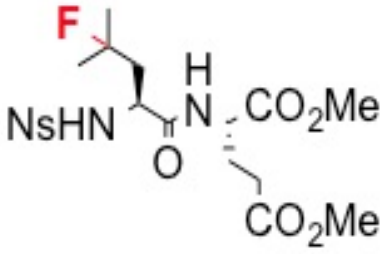
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	22.0
4	Number of Scans	48
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1276.6
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



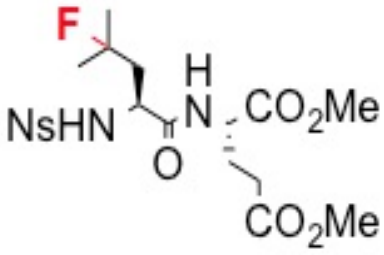
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



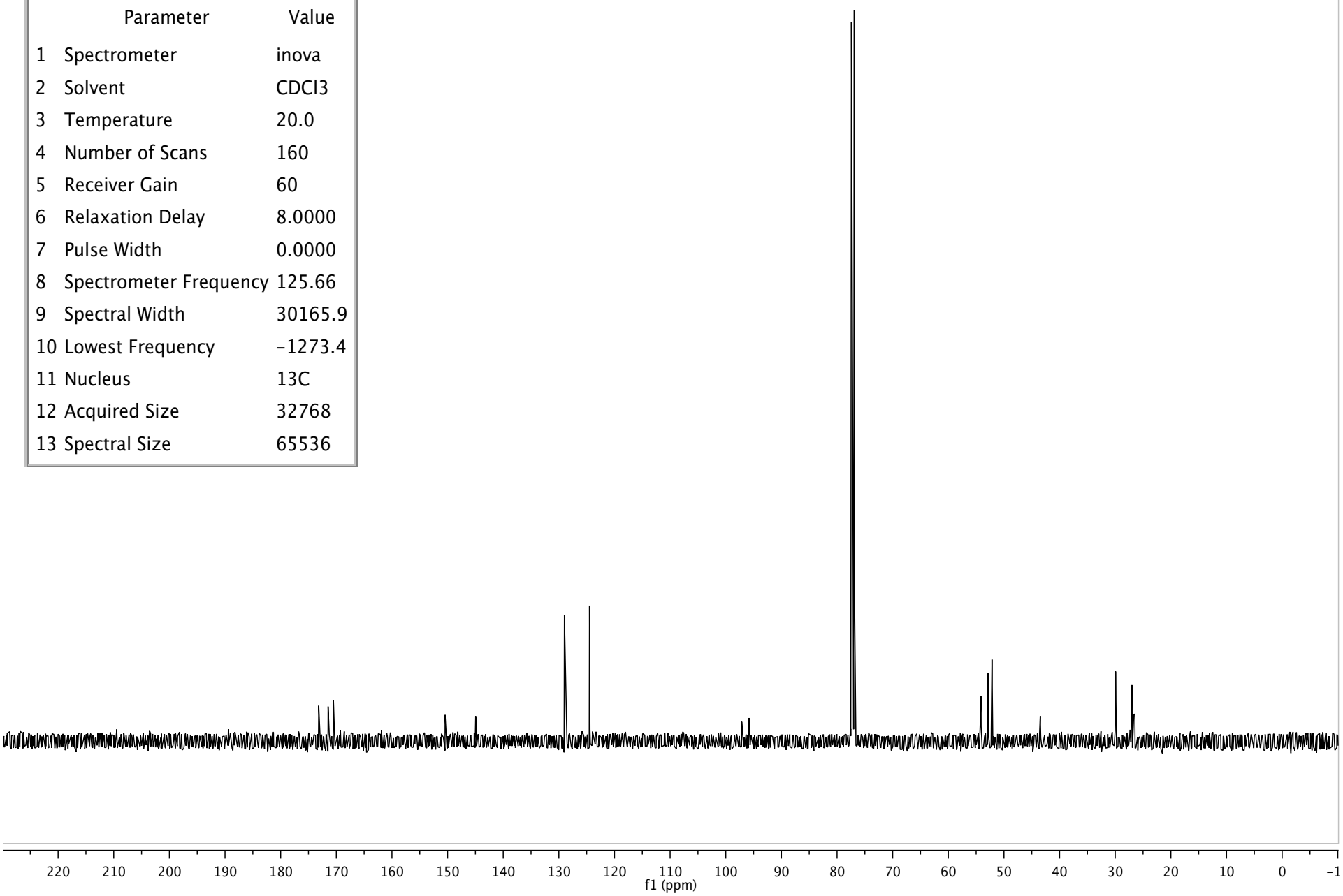
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	184
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1271.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

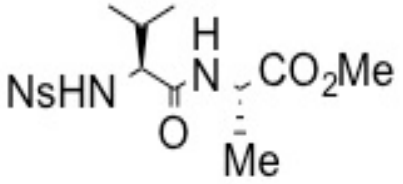


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1521.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

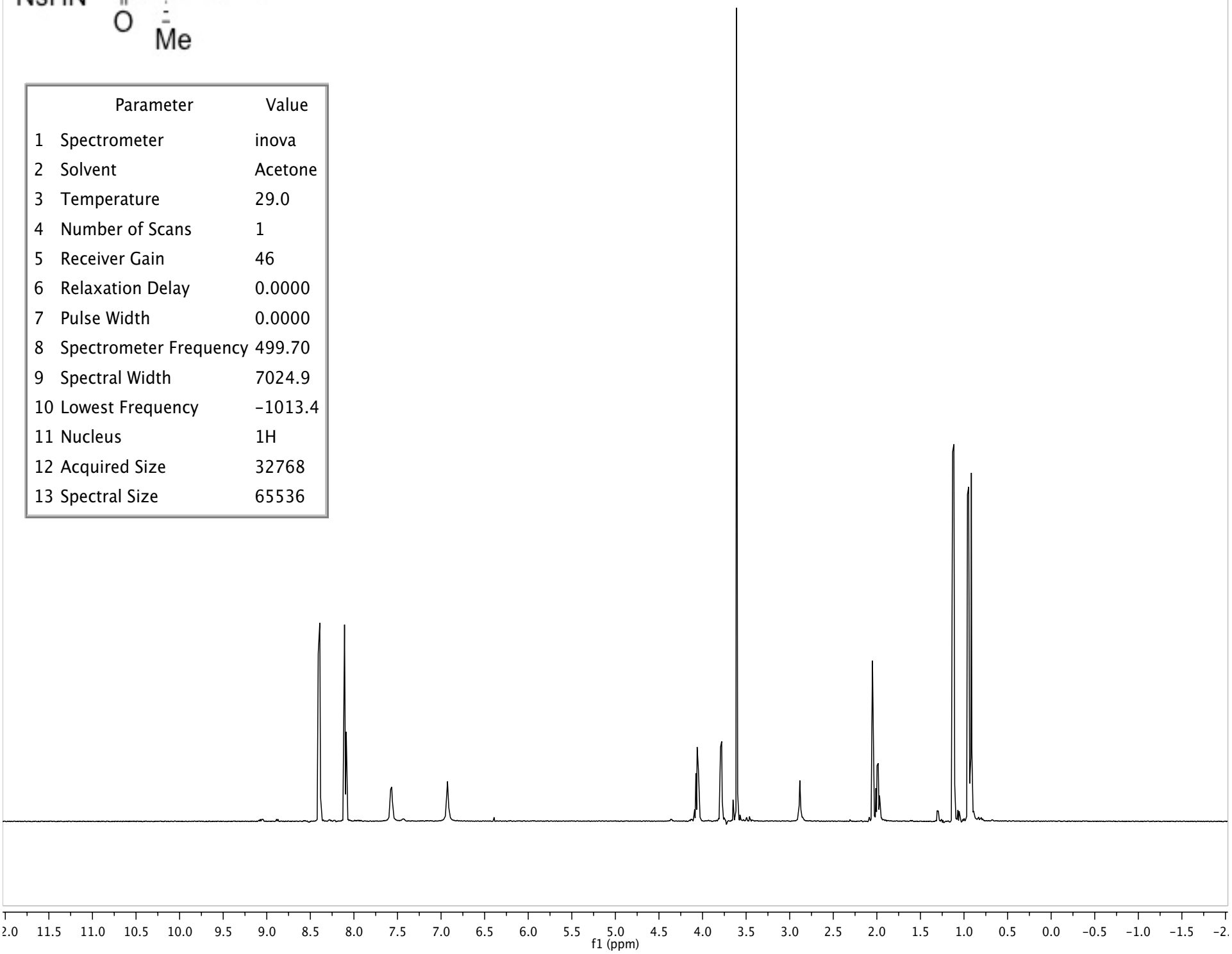


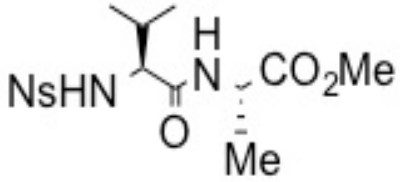
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	160
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



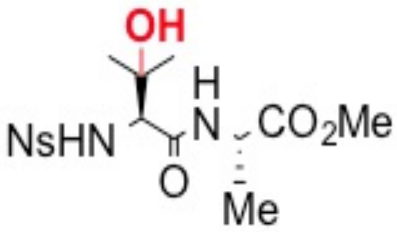


	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	29.0
4	Number of Scans	1
5	Receiver Gain	46
6	Relaxation Delay	0.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.70
9	Spectral Width	7024.9
10	Lowest Frequency	-1013.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

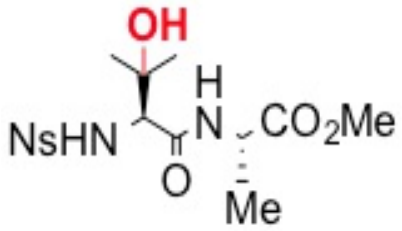




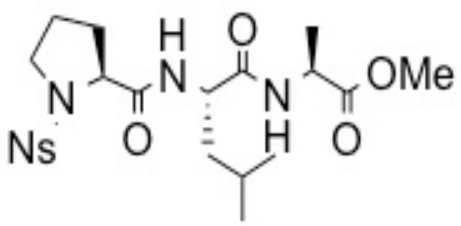
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	22.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1170.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



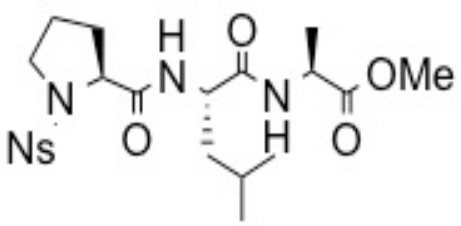
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1521.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



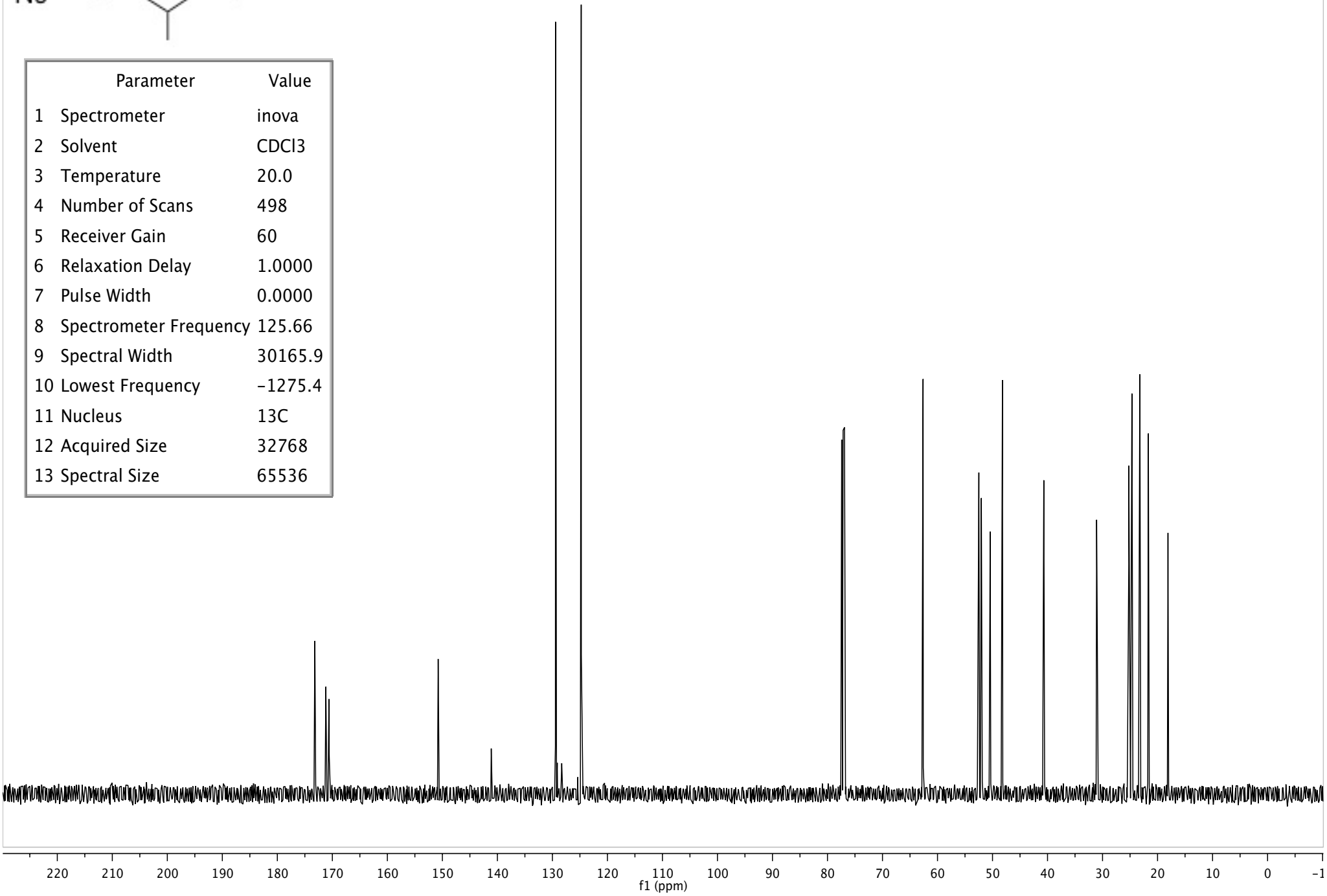
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	1600
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

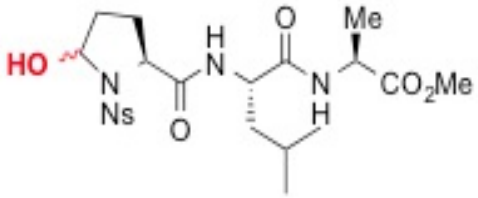


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	38
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1510.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

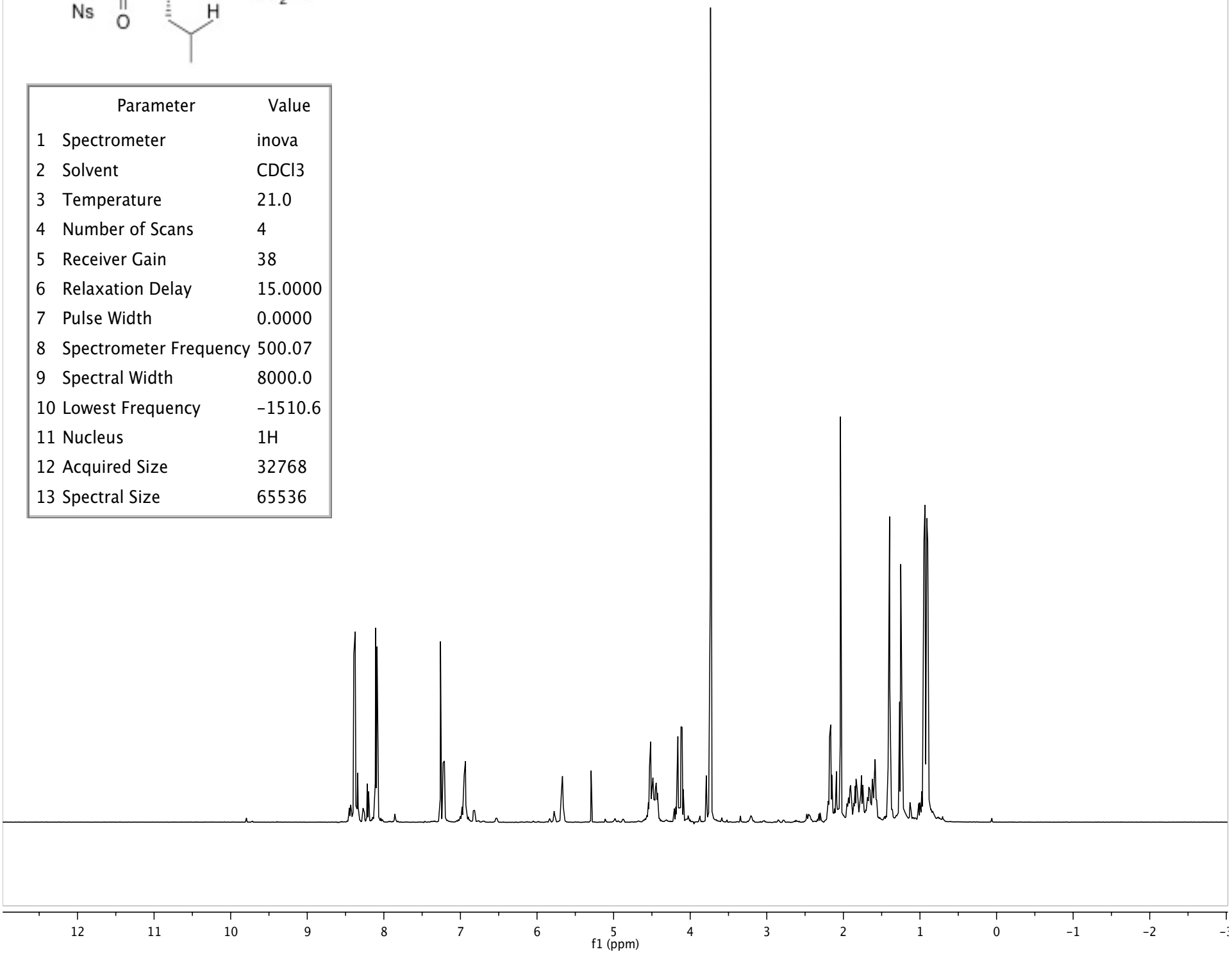


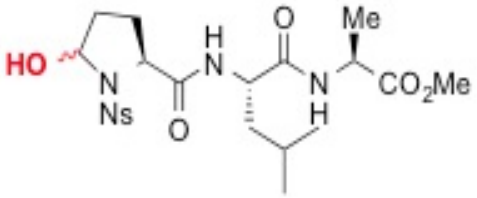
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	498
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



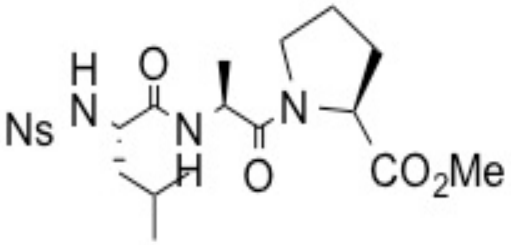


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	21.0
4	Number of Scans	4
5	Receiver Gain	38
6	Relaxation Delay	15.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1510.6
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

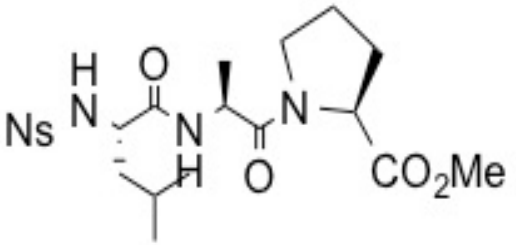




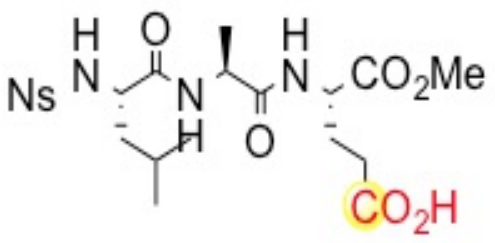
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	304
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



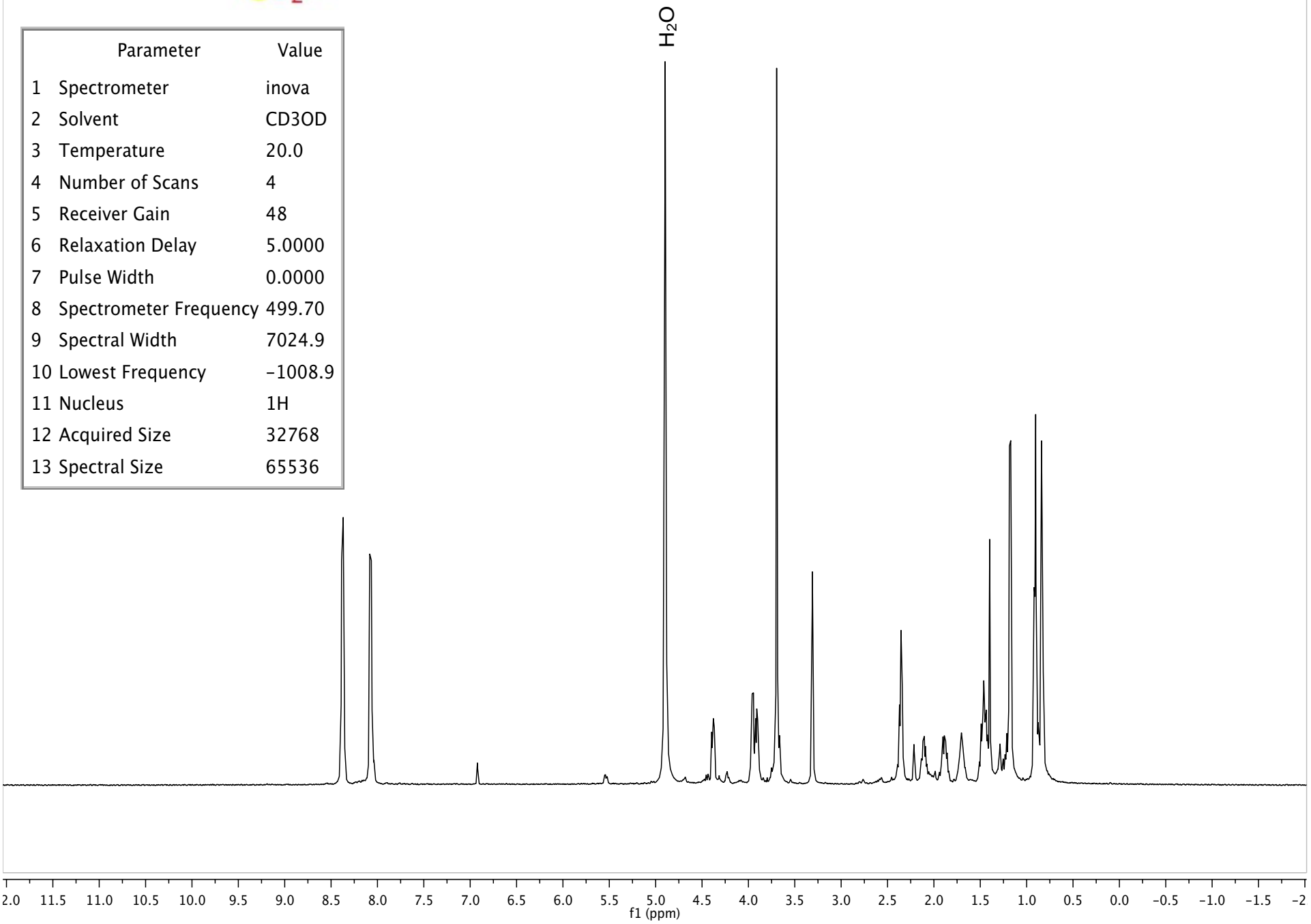
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

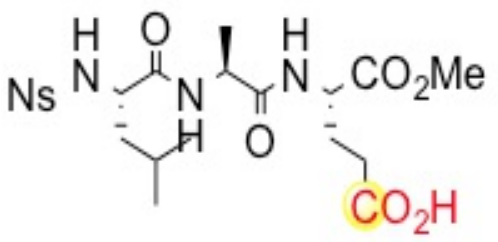


	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	40
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1260.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

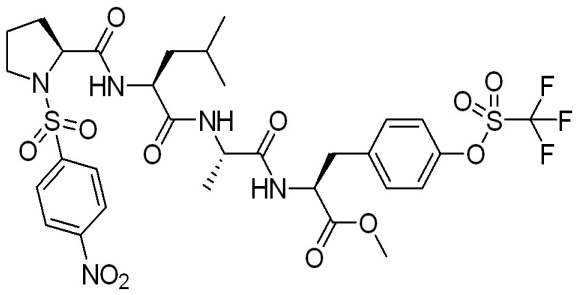


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	48
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.70
9	Spectral Width	7024.9
10	Lowest Frequency	-1008.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

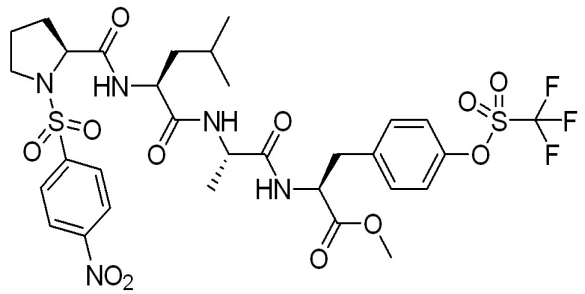




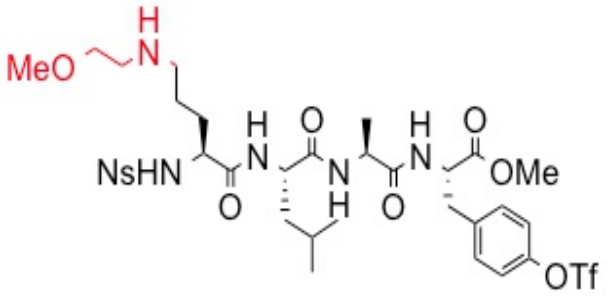
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	224
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1113.0
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



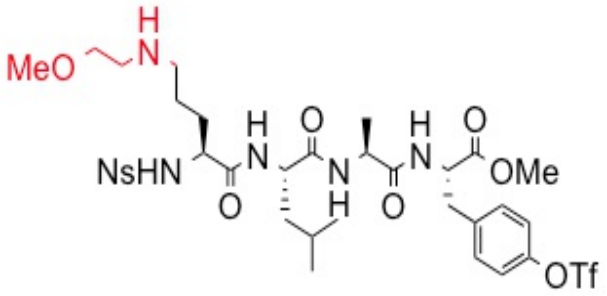
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	32
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1510.6
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



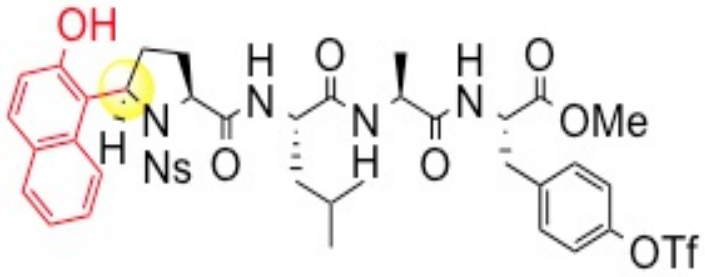
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	229
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1260.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



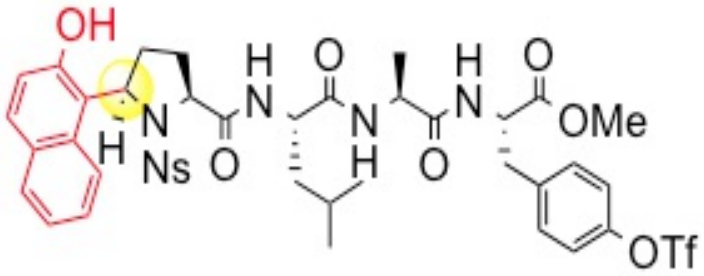
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	29.0
4	Number of Scans	4
5	Receiver Gain	52
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



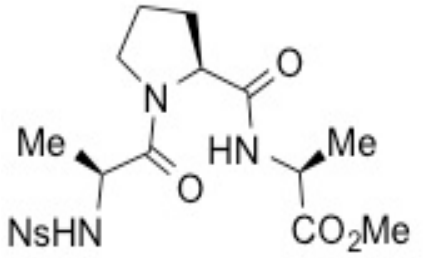
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	1440
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.6
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



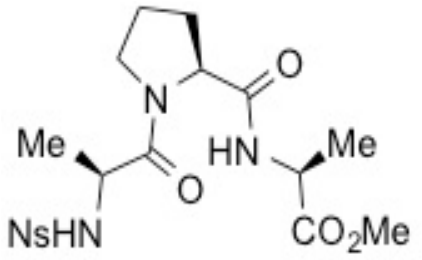
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	48
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



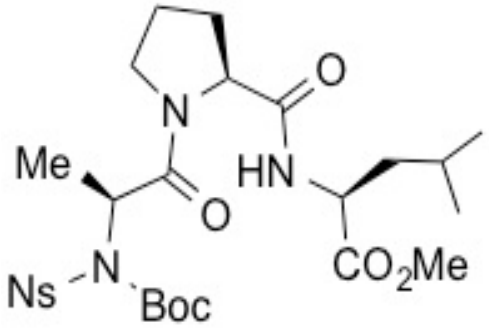
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	240
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1216.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



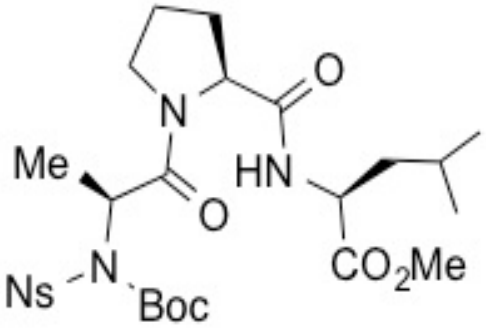
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



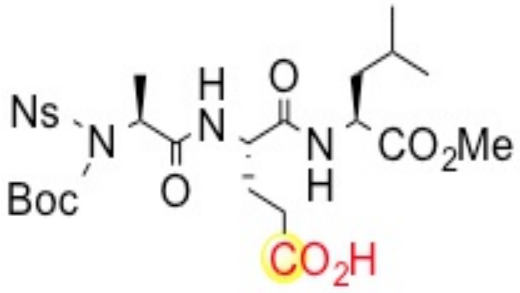
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	240
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.8
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



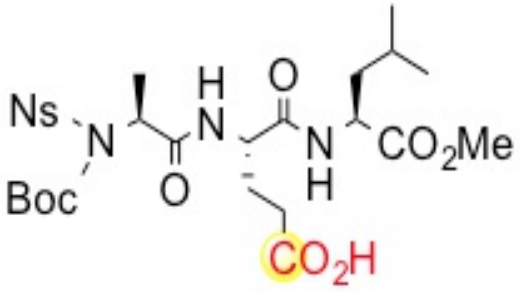
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



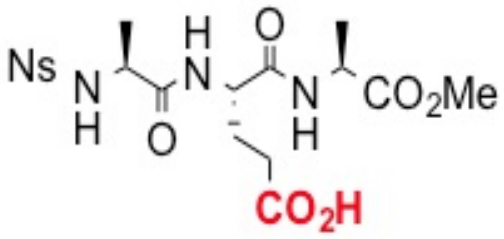
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	160
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.6
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



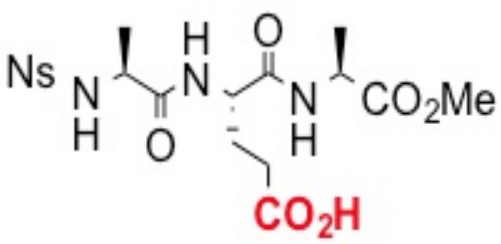
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	52
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1012.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



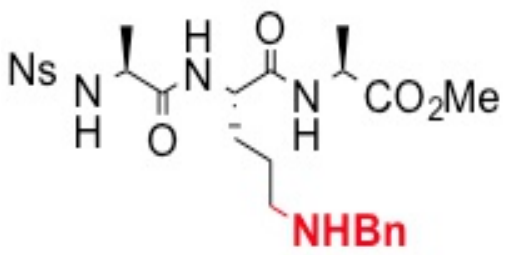
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	248
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1260.2
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



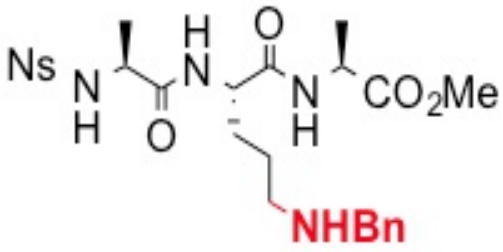
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	52
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.70
9	Spectral Width	7024.9
10	Lowest Frequency	-1009.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



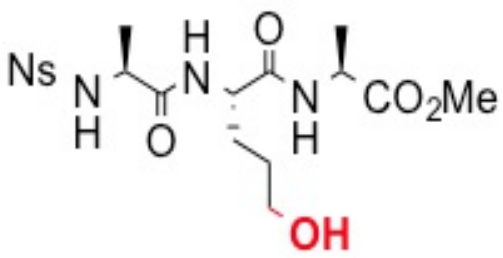
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	120
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1111.9
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



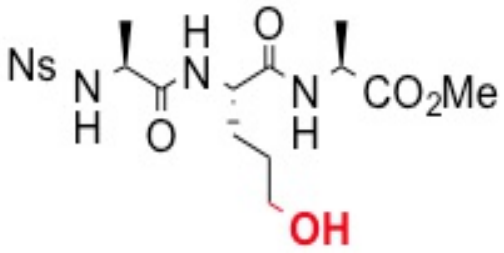
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	45.0
4	Number of Scans	16
5	Receiver Gain	50
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.70
9	Spectral Width	7024.9
10	Lowest Frequency	-1009.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



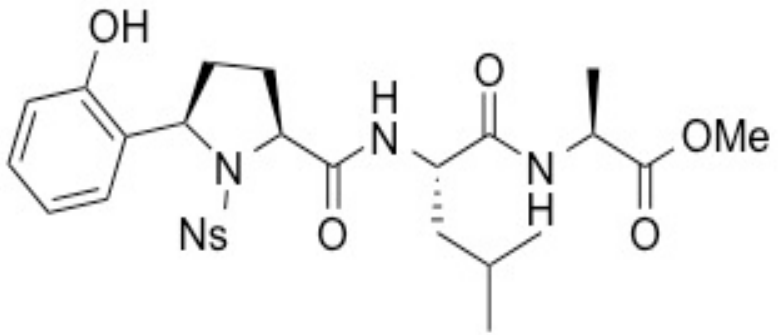
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	45.0
4	Number of Scans	3632
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1113.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



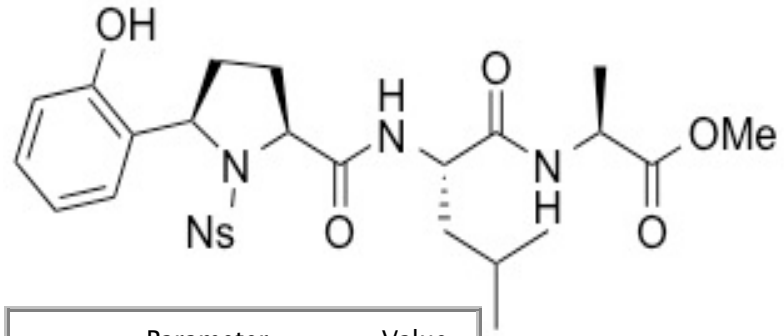
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	32
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1508.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



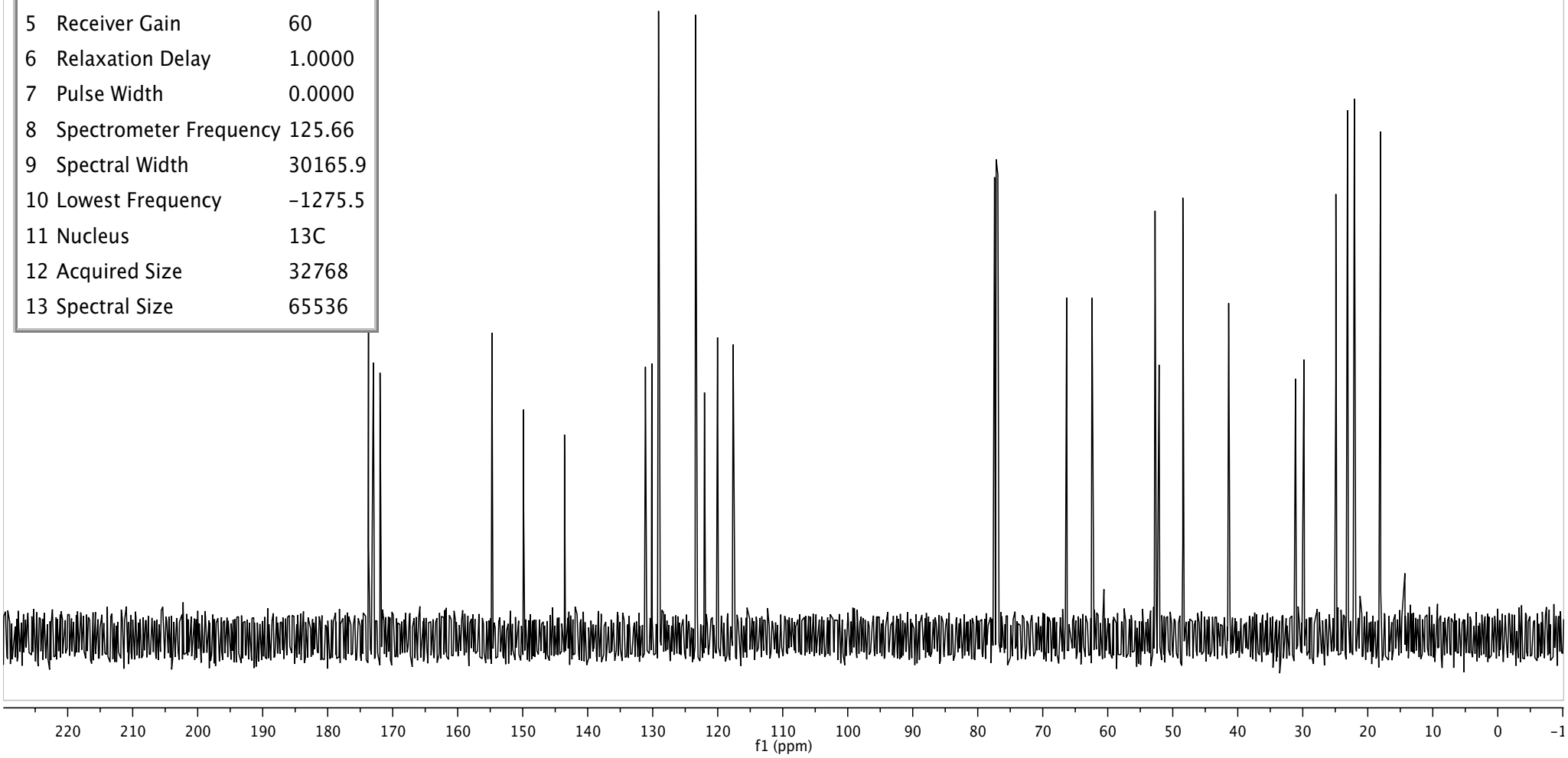
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	45.0
4	Number of Scans	3840
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1111.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

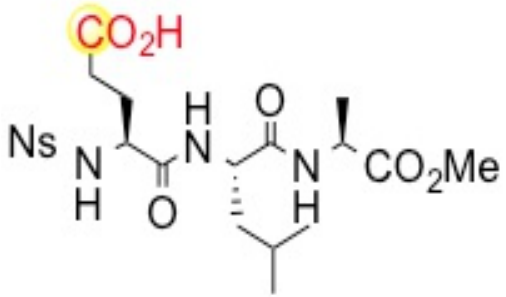


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1007.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

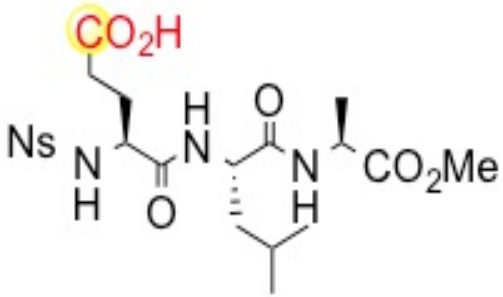


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	80
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

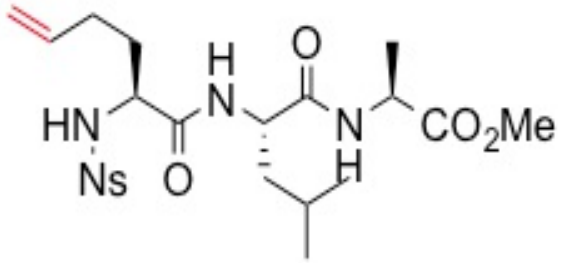




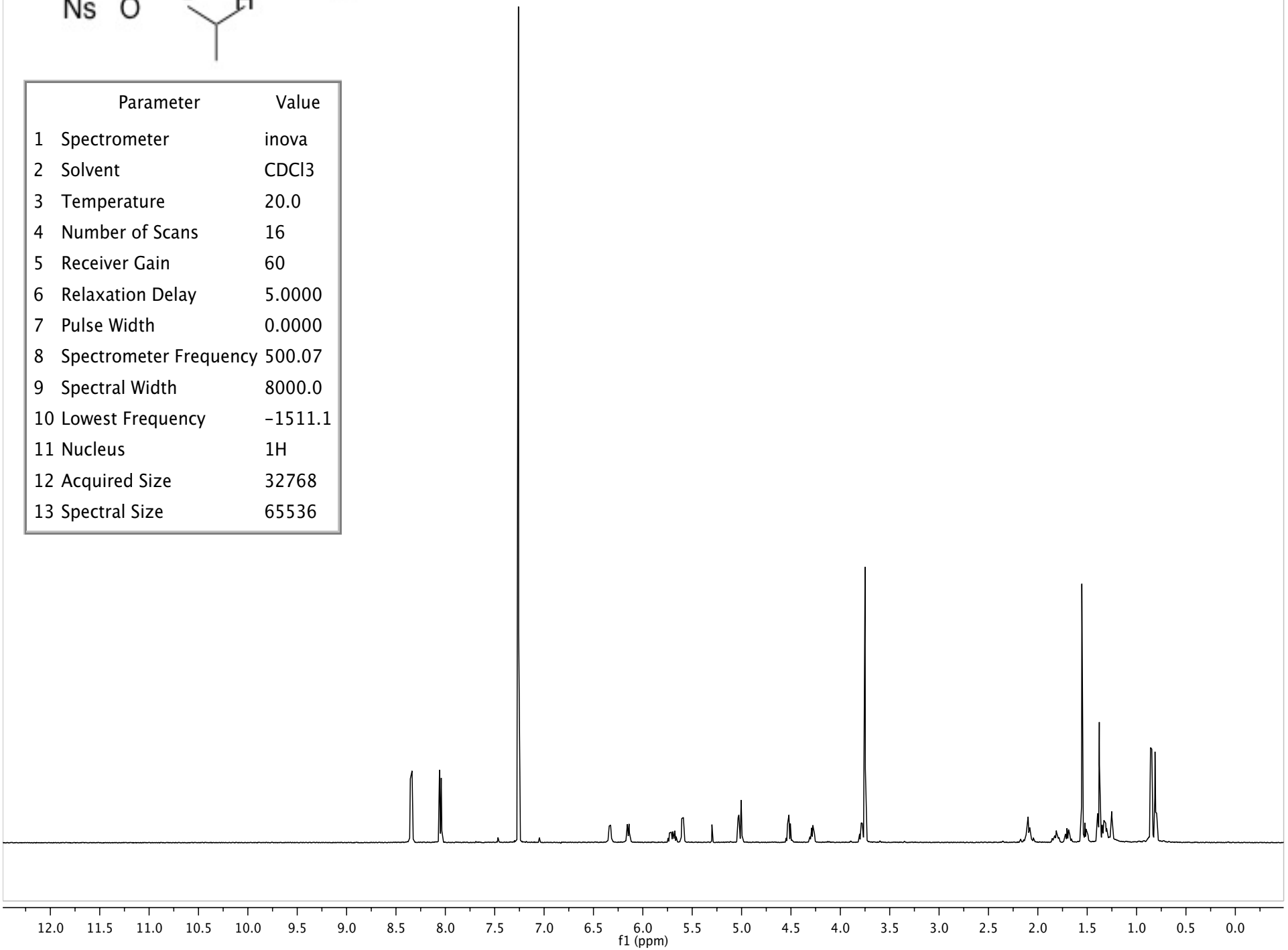
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	38
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1508.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

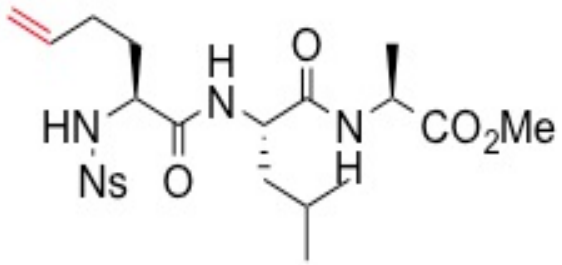


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	296
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1111.7
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

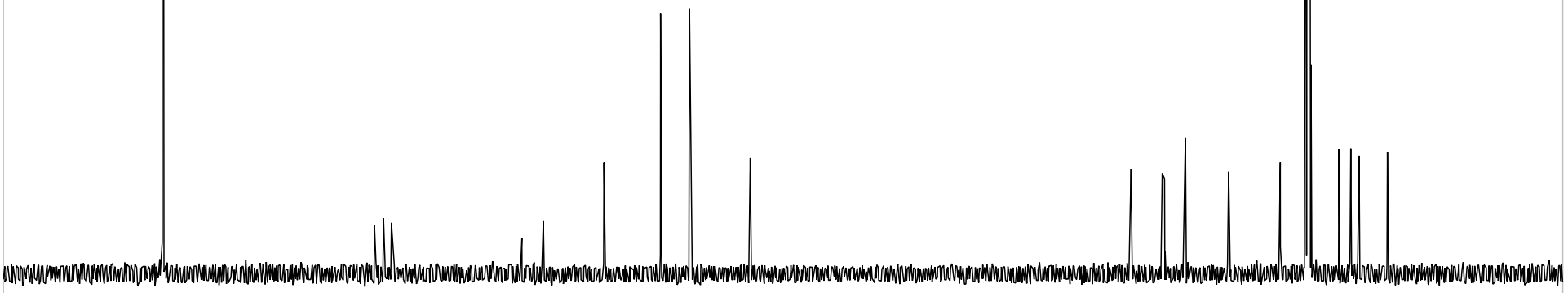


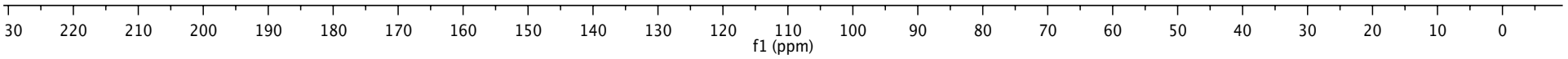
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

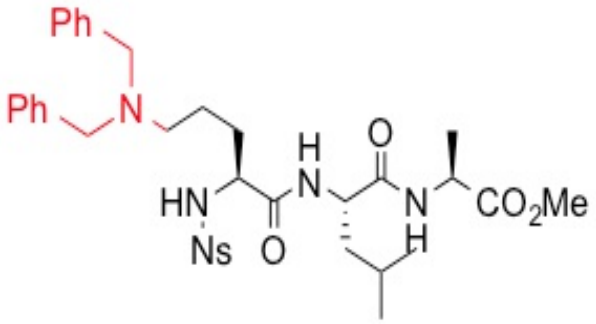




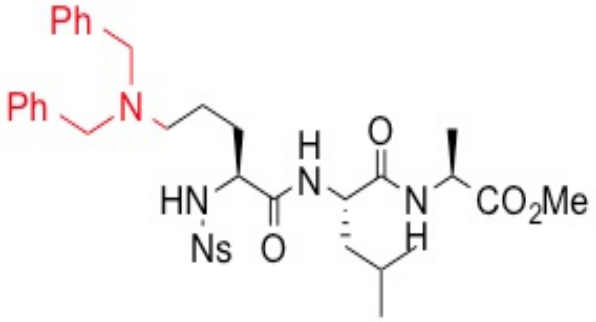
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	21.0
4	Number of Scans	111
5	Receiver Gain	60
6	Relaxation Delay	3.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1167.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



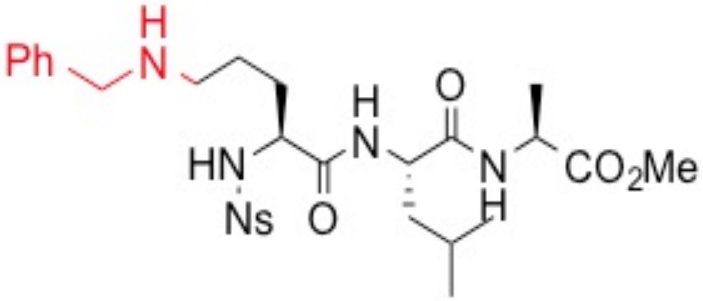




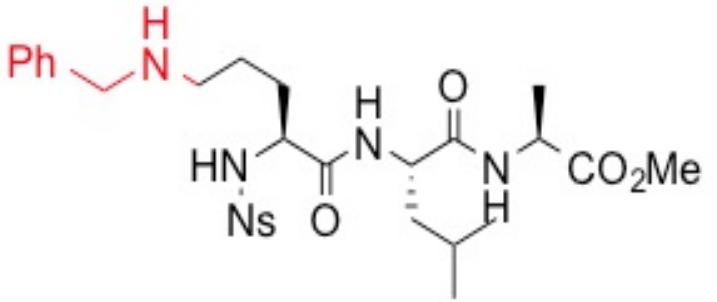
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



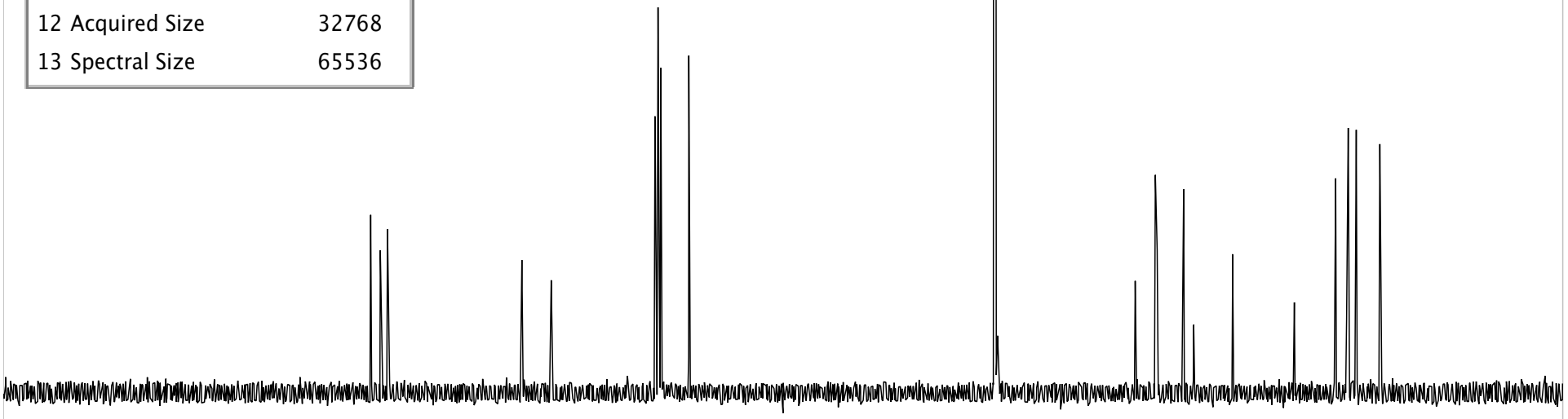
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	24
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.0
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

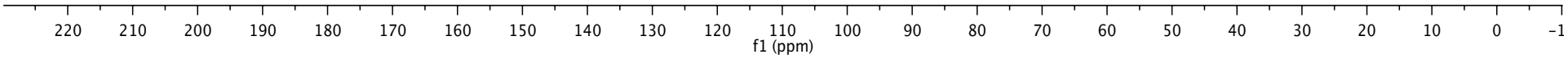


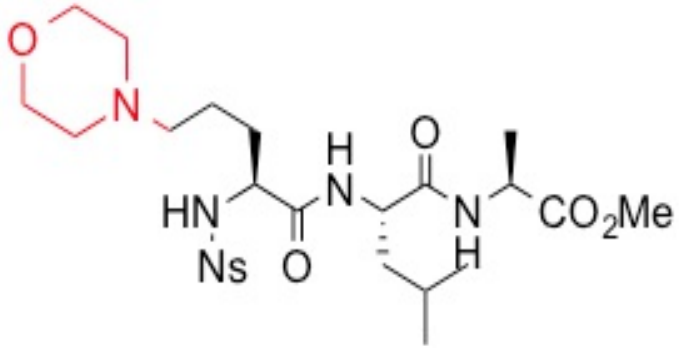
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	26
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1520.6
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



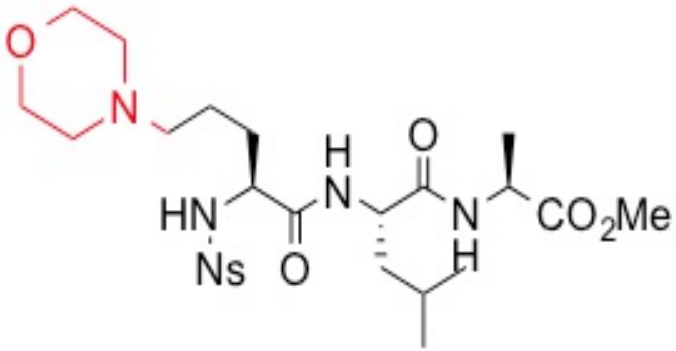
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	320
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.9
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



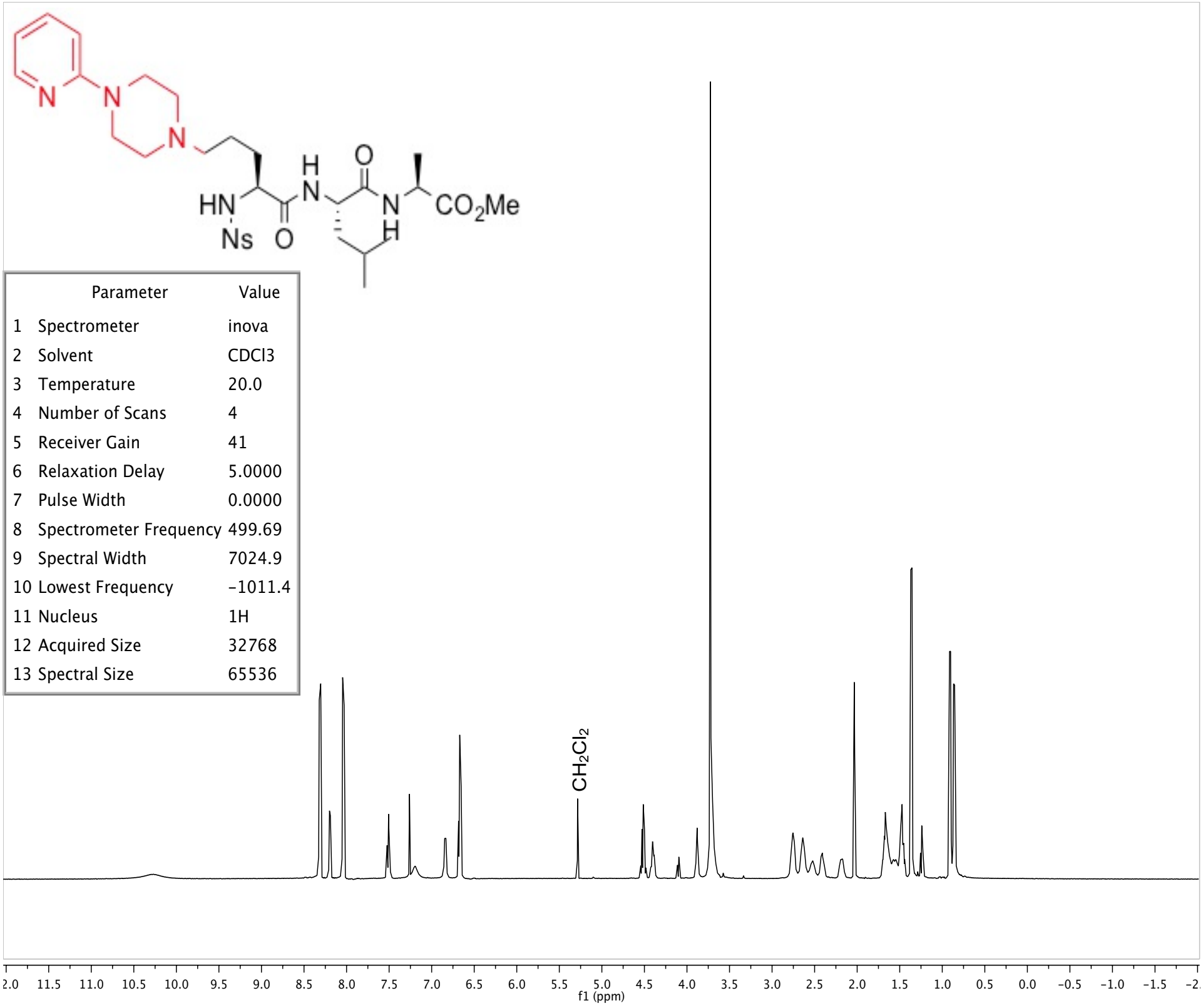




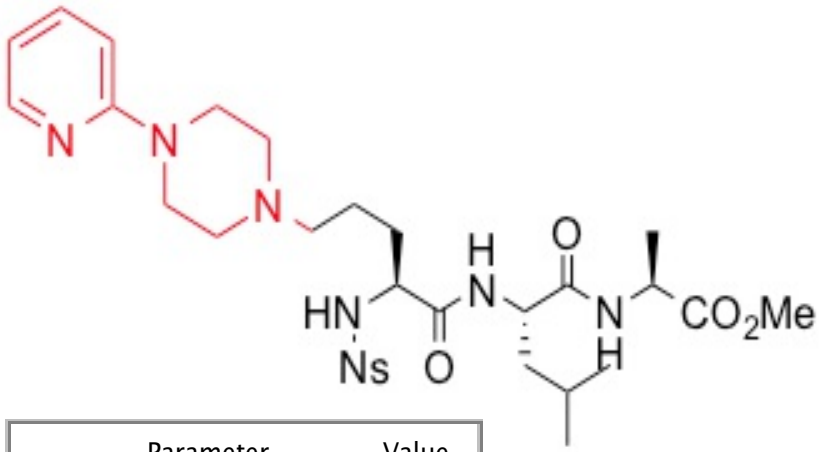
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	26
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



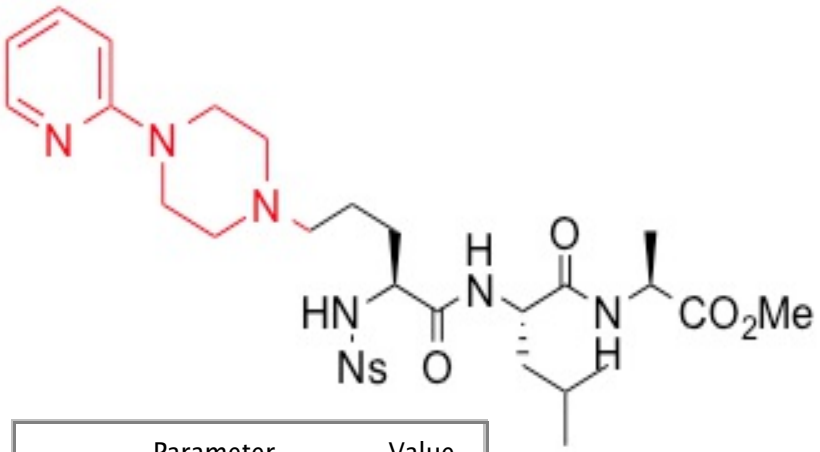
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1276.0
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



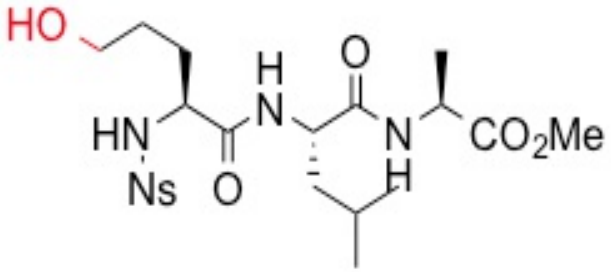
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



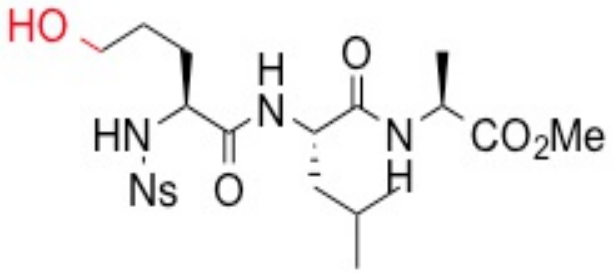
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	32
6	Relaxation Delay	15.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



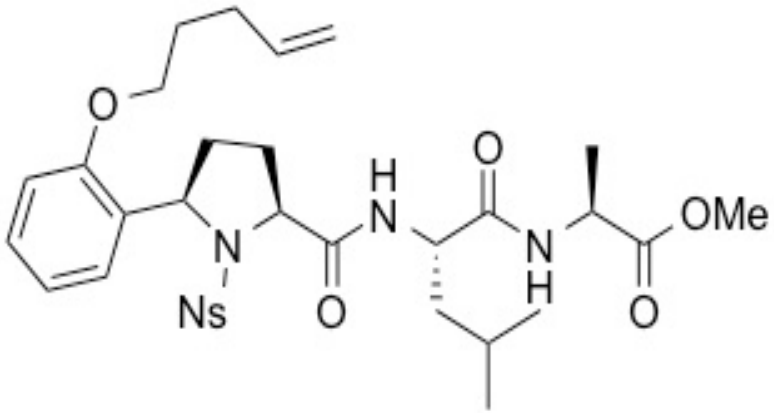
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	72
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1274.9
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



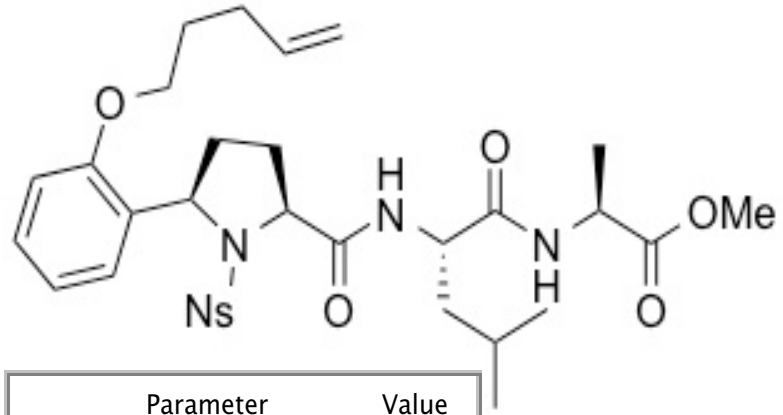
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	21.0
4	Number of Scans	4
5	Receiver Gain	32
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1508.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



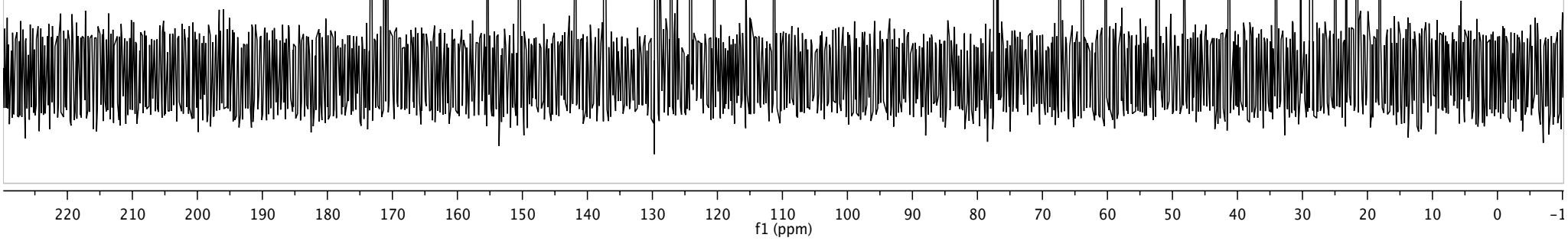
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	64
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1112.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

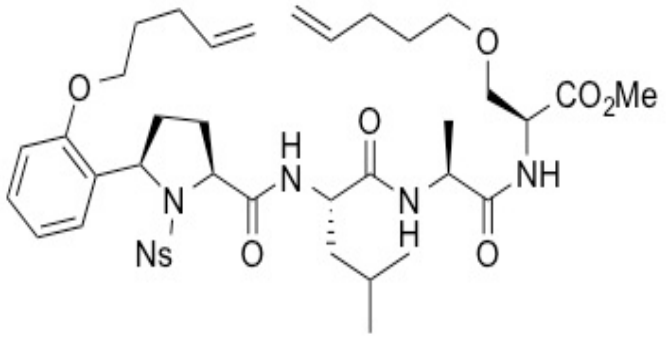


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	-20.0
4	Number of Scans	16
5	Receiver Gain	38
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

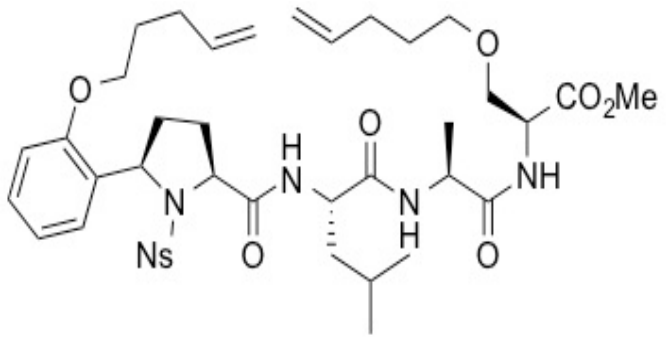


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	16
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1281.7
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

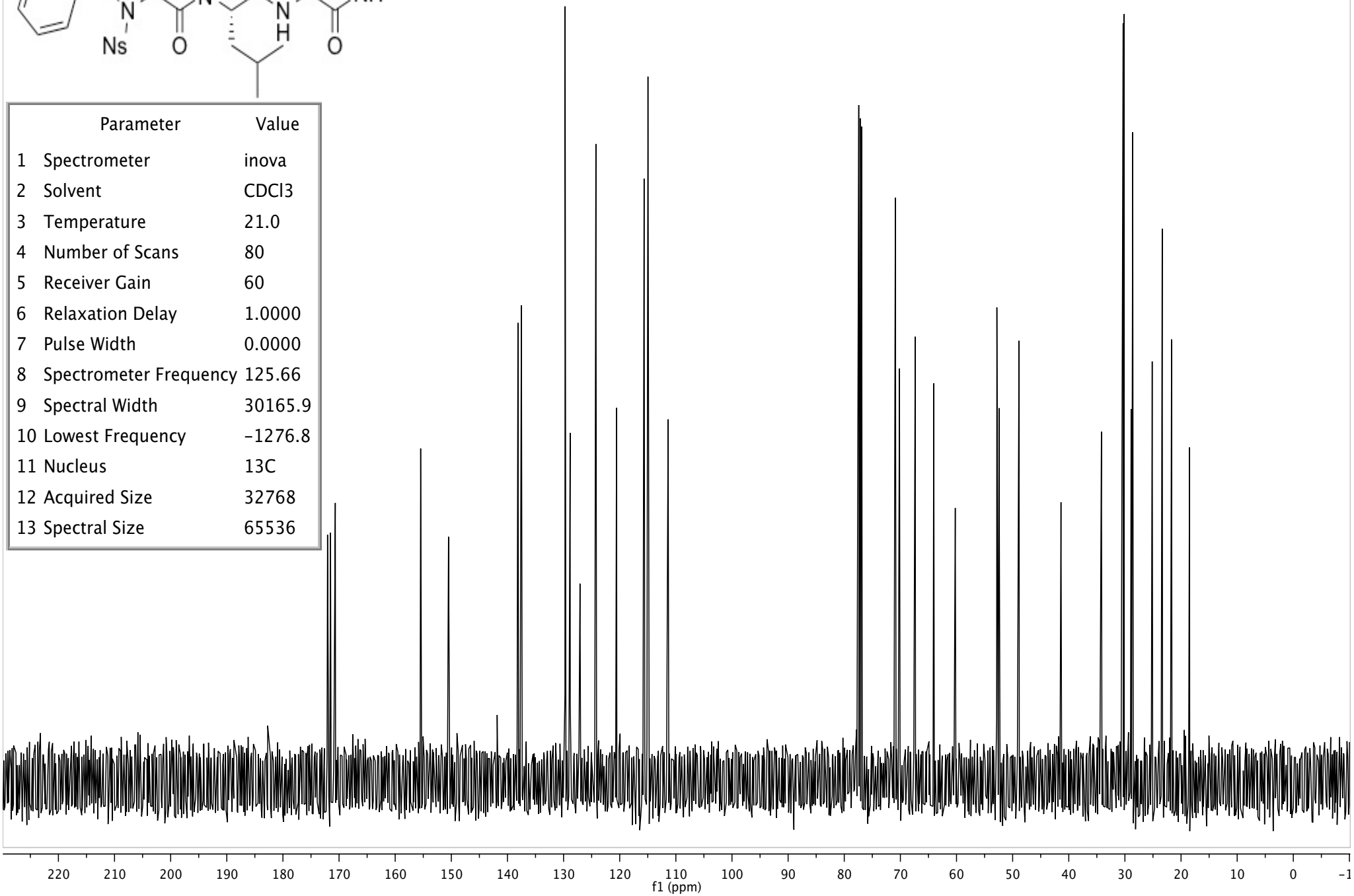


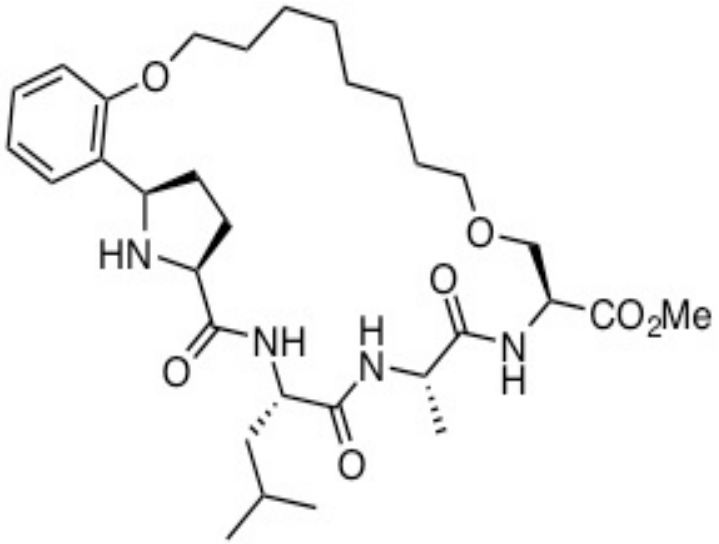


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	21.0
4	Number of Scans	4
5	Receiver Gain	58
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1012.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

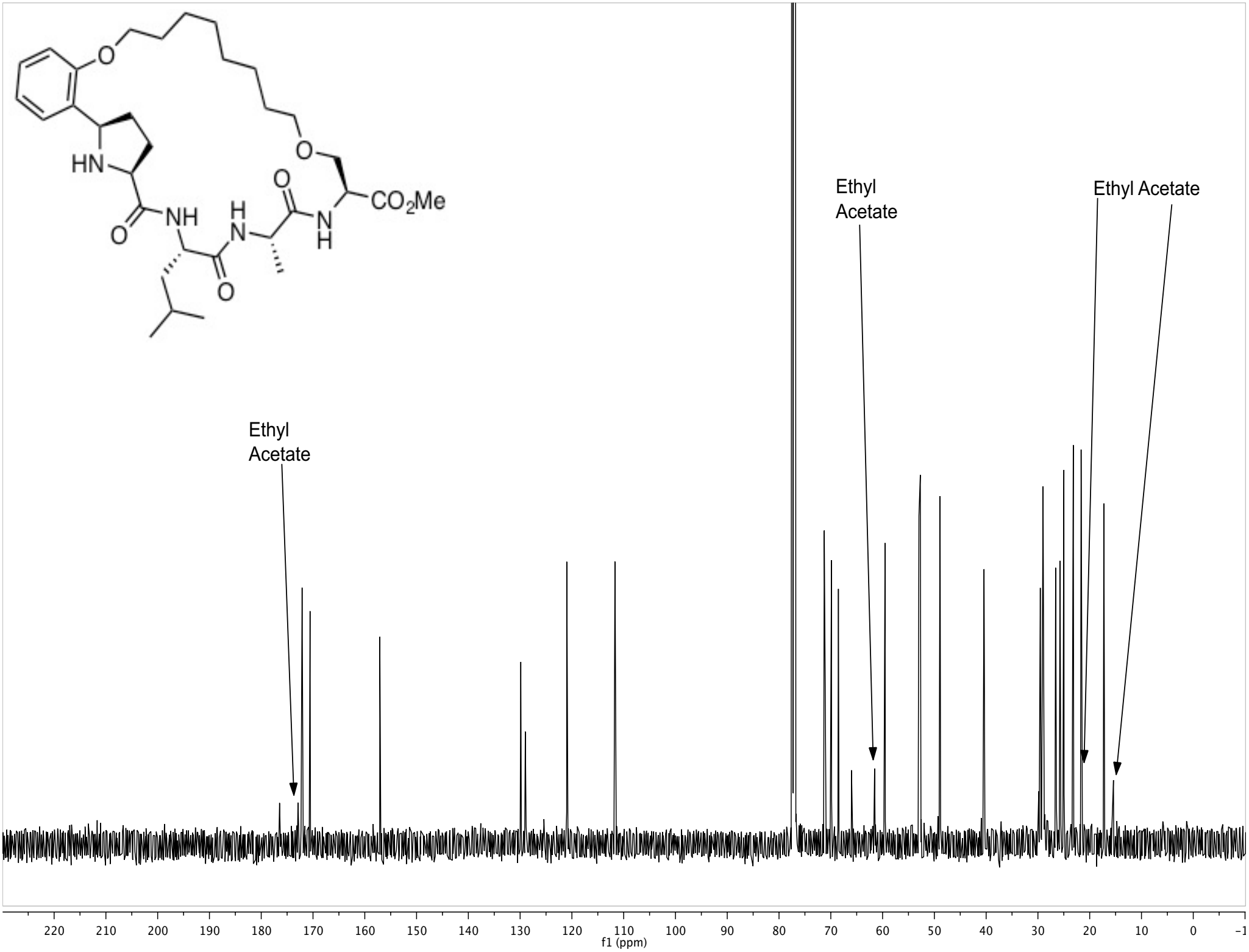


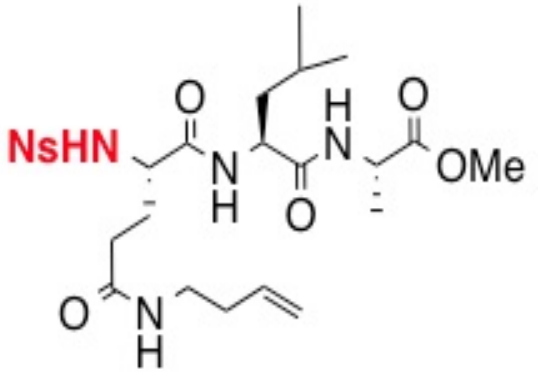
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	21.0
4	Number of Scans	80
5	Receiver Gain	60
6	Relaxation Delay	1.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1276.8
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



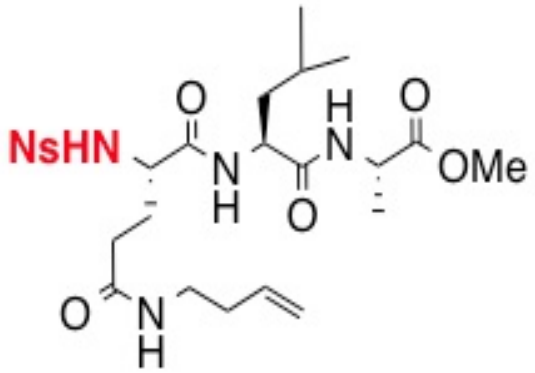


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	38
6	Relaxation Delay	10.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

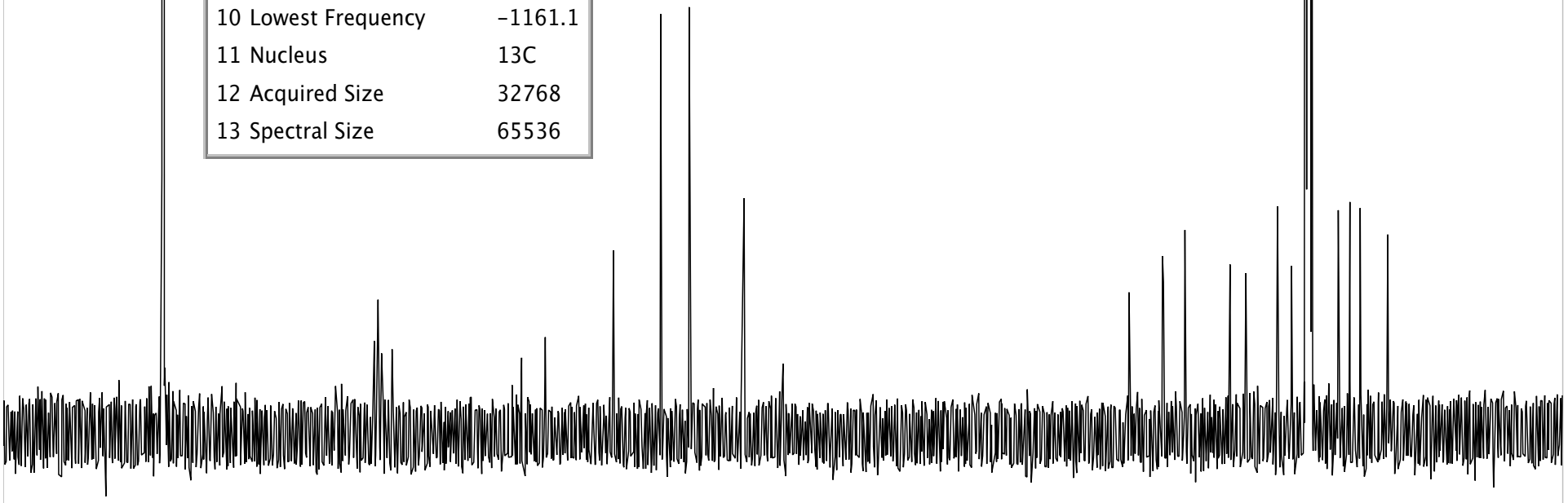

Ethyl
Acetate
Ethyl
Acetate
Ethyl Acetate
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-1
f1 (ppm)

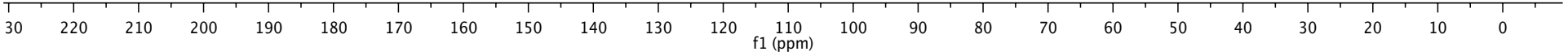


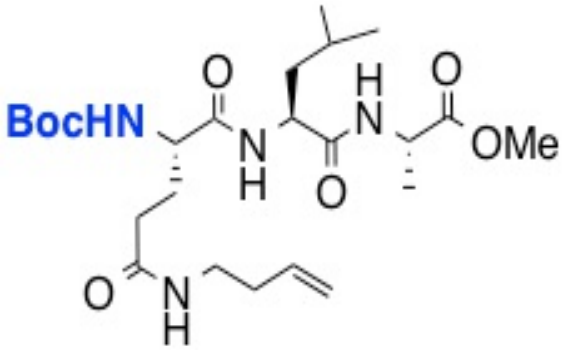
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	22.0
4	Number of Scans	16
5	Receiver Gain	38
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1512.5
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



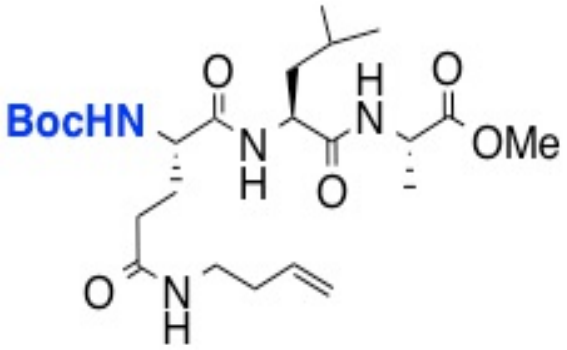
	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	20.0
4	Number of Scans	471
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1161.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



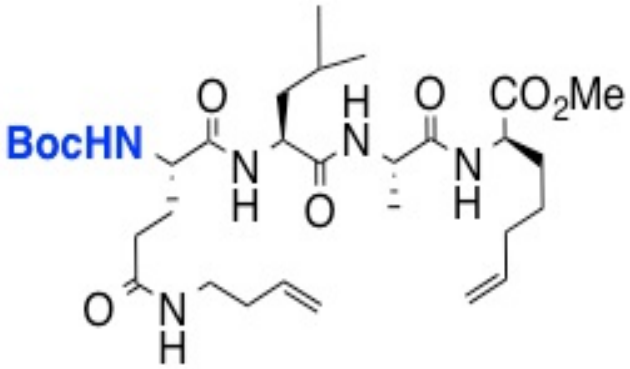




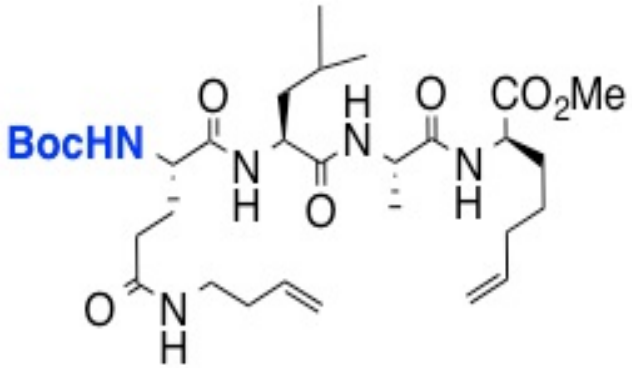
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	45.0
4	Number of Scans	8
5	Receiver Gain	50
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



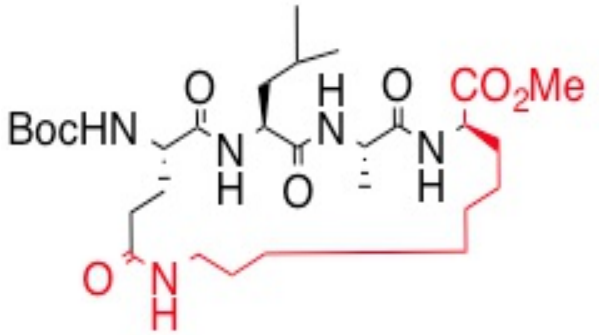
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	45.0
4	Number of Scans	3888
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1273.0
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



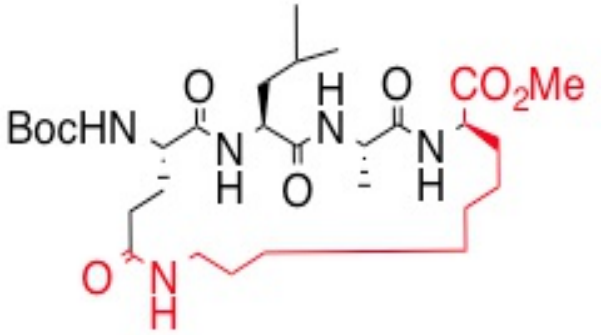
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1011.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



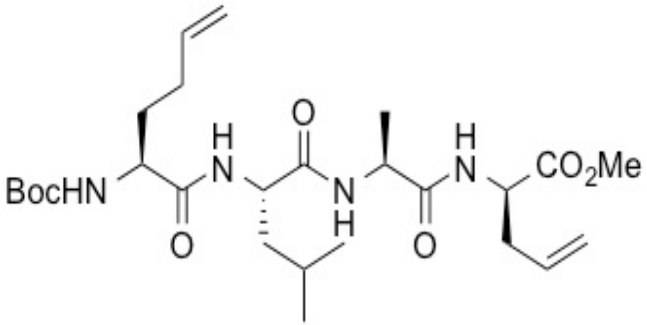
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CD3OD
3	Temperature	20.0
4	Number of Scans	128
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1113.4
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



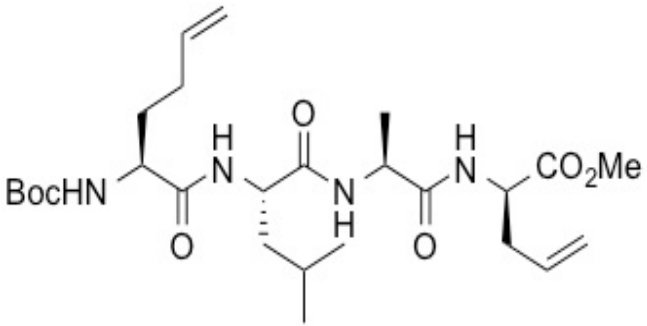
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	48
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1012.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



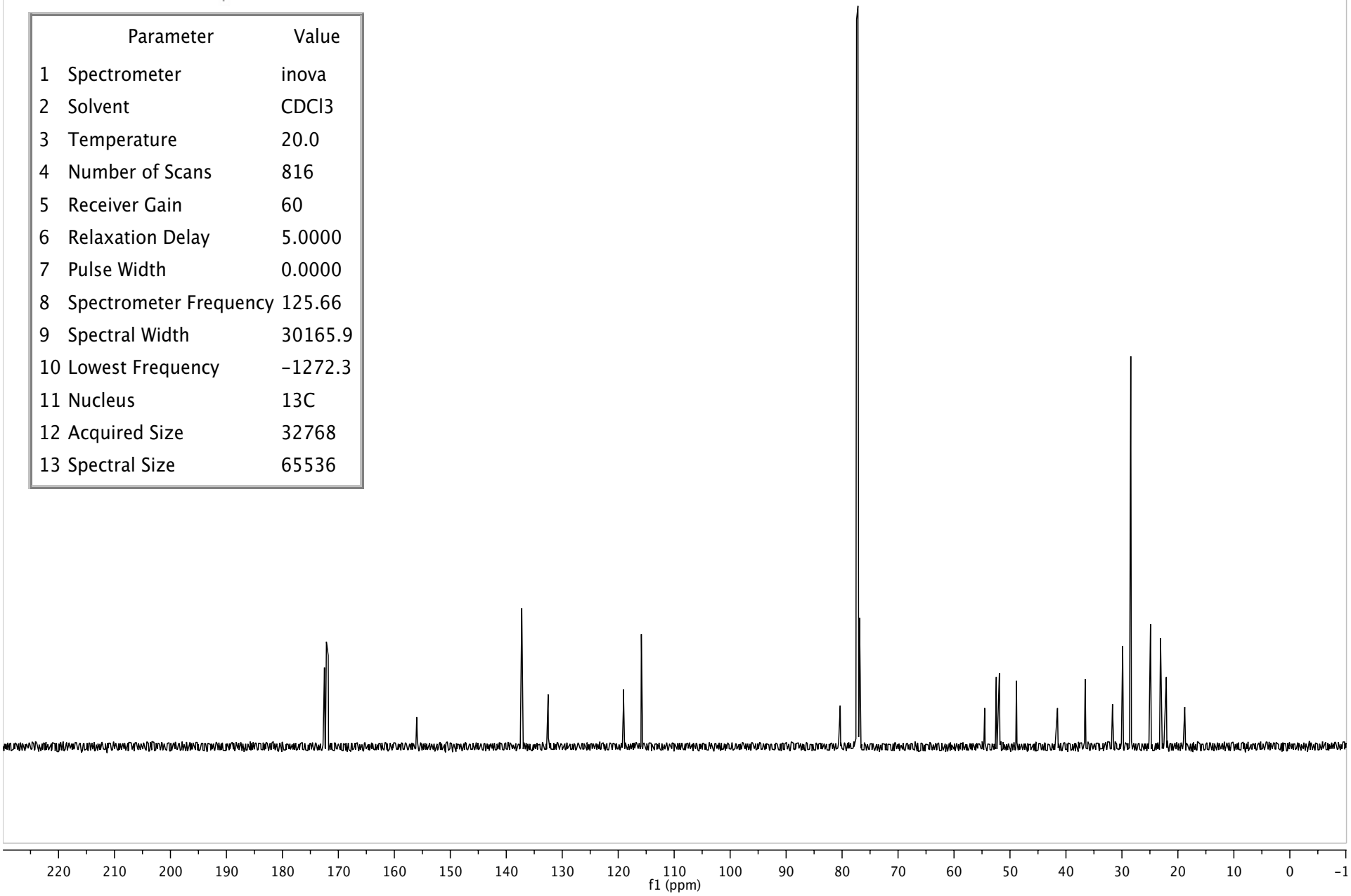
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	304
5	Receiver Gain	60
6	Relaxation Delay	3.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1271.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

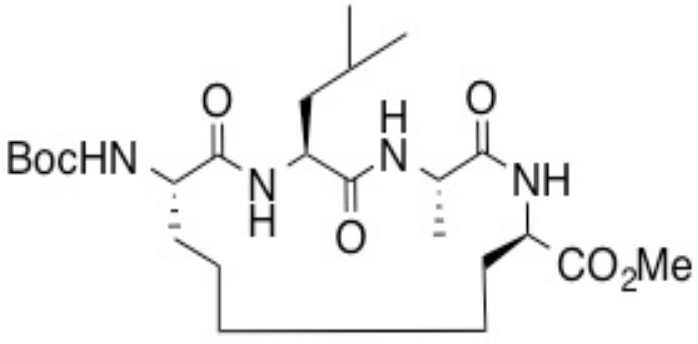


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	25.0
4	Number of Scans	16
5	Receiver Gain	54
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

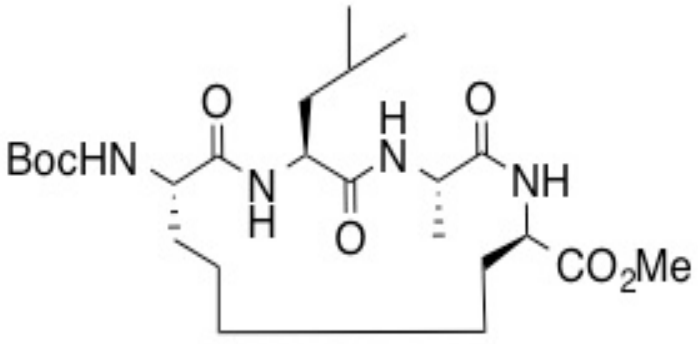


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	816
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1272.3
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

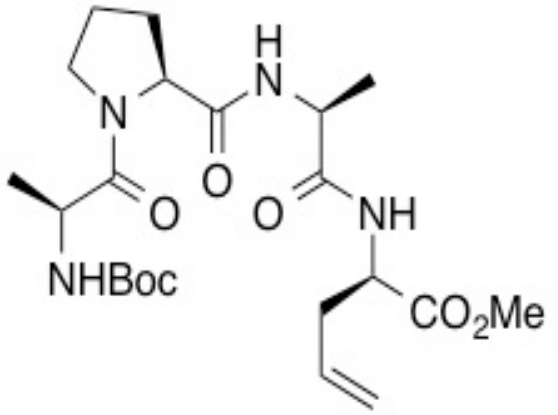




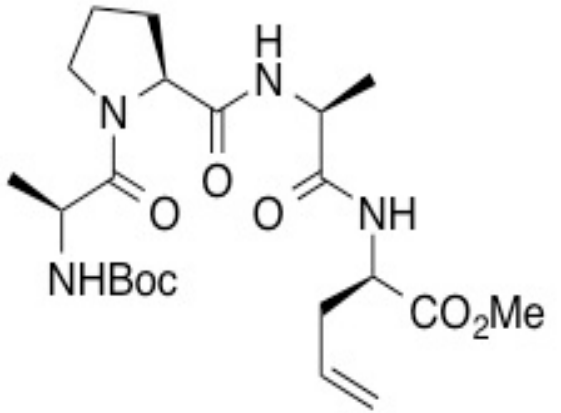
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	23.0
4	Number of Scans	16
5	Receiver Gain	26
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1511.1
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



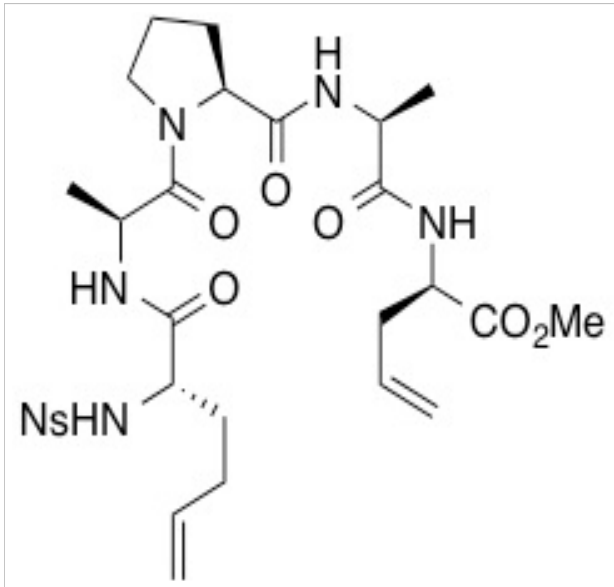
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	224
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1271.6
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



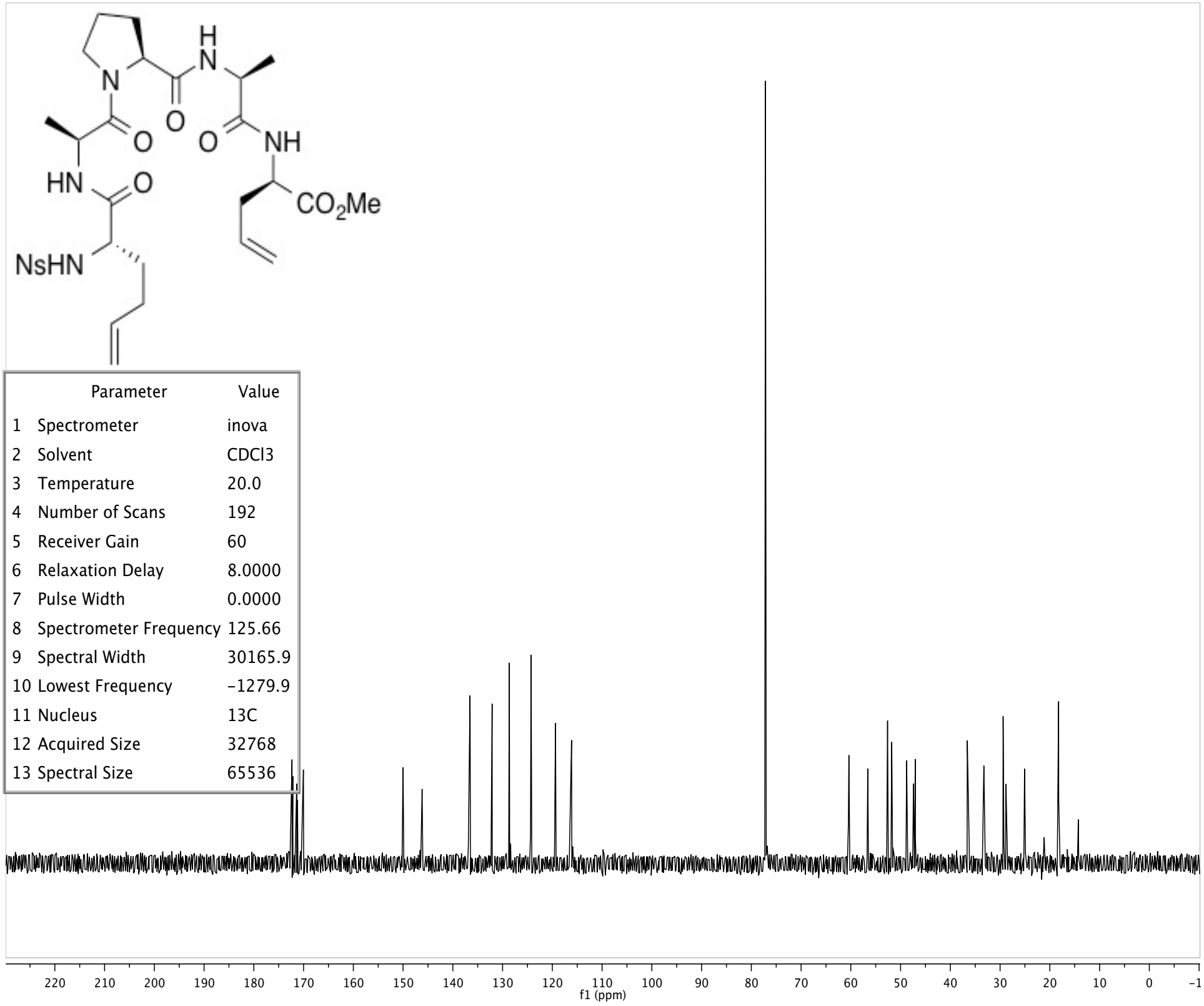
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	29.0
4	Number of Scans	4
5	Receiver Gain	41
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



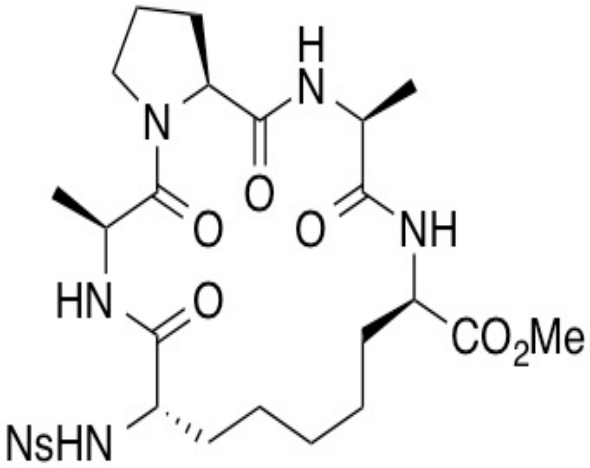
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	22.0
4	Number of Scans	288
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.9
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



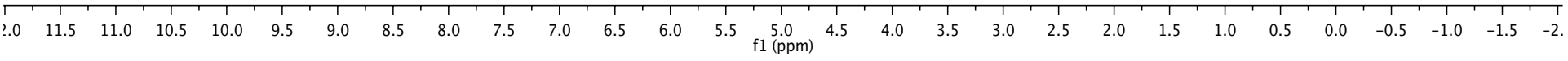
	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	4
5	Receiver Gain	20
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	500.07
9	Spectral Width	8000.0
10	Lowest Frequency	-1499.6
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

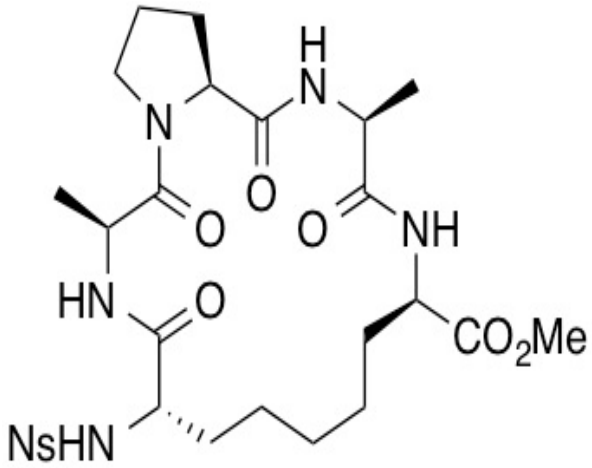


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	192
5	Receiver Gain	60
6	Relaxation Delay	8.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1279.9
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536

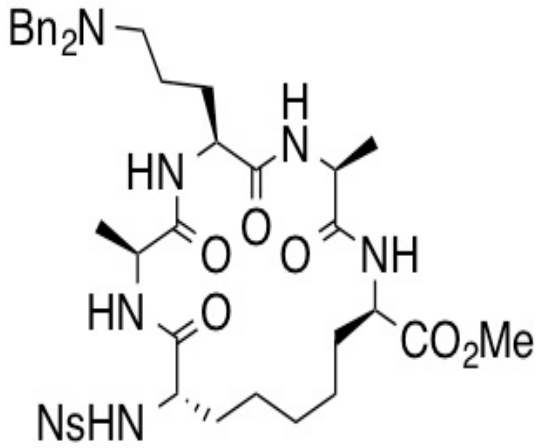


	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	8
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.69
9	Spectral Width	7024.9
10	Lowest Frequency	-1021.9
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536

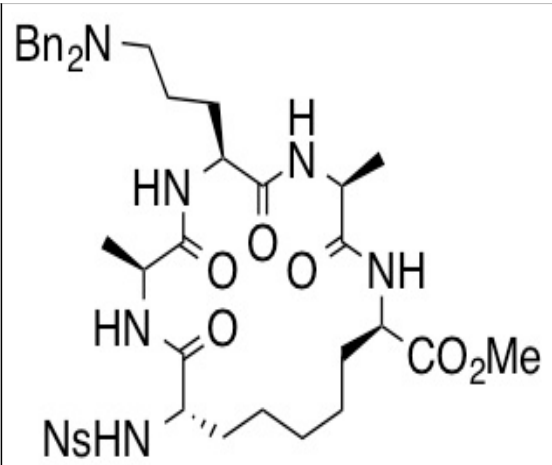




	Parameter	Value
1	Spectrometer	inova
2	Solvent	CDCl3
3	Temperature	20.0
4	Number of Scans	312
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1275.1
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536



	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	29.0
4	Number of Scans	8
5	Receiver Gain	58
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	499.70
9	Spectral Width	7024.9
10	Lowest Frequency	-1013.4
11	Nucleus	1H
12	Acquired Size	32768
13	Spectral Size	65536



	Parameter	Value
1	Spectrometer	inova
2	Solvent	Acetone
3	Temperature	22.0
4	Number of Scans	7072
5	Receiver Gain	60
6	Relaxation Delay	5.0000
7	Pulse Width	0.0000
8	Spectrometer Frequency	125.66
9	Spectral Width	30165.9
10	Lowest Frequency	-1159.5
11	Nucleus	13C
12	Acquired Size	32768
13	Spectral Size	65536