Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information for:

Tunable Differentiation of Tertiary C–H Bonds in Intramolecular Transition Metal-Catalyzed Nitrene Transfer Reactions

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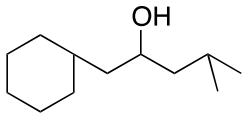
I. General Information

All glassware was either oven-dried overnight at 130 °C or flame-dried under a stream of dry nitrogen prior to use. Unless otherwise specified, reagents were used as obtained from the vendor without further purification. Tetrahydrofuran and diethyl ether were freshly distilled from purple Na/benzophenone ketyl. Dichloromethane, acetonitrile, toluene, and benzene were dried over CaH_2 and freshly distilled prior to use. All other solvents were purified in accordance with "Purification of Laboratory Chemicals".[1] Air- and moisture- sensitive reactions were performed using standard Schlenk techniques under an atmosphere of nitrogen. Analytical thin layer chromatography (TLC) was performed utilizing pre-coated silica gel 60 F_{254} plates containing a fluorescent indicator, while preparative chromatography was performed using SilicaFlash P60 silica gel (230-400 mesh) via Still's method.[2] Unless otherwise stated, the mobile phases for column chromatography were mixtures of hexanes/ethyl acetate. Columns were typically run using a gradient method, beginning with 100% hexanes and gradually increasing the polarity using ethyl acetate. Various stains were used to visualize reaction products, including *p*-anisaldehyde, $KMnO_4$, ceric ammonium molybdate (CAM stain) and iodine powder.

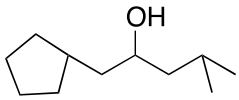
^1H NMR and ^{13}C NMR spectra were obtained using Bruker-400 or Bruker Callisto-500 spectrometers. For ^1H NMR, chemical shifts are reported relative to residual protiated solvent peaks (δ 7.26, 2.49, 7.15 and 7.09 ppm for $CDCl_3$, $(CD_3)_2SO$, C_6D_6 and $CD_3C_6D_5$ respectively). ^{13}C NMR spectra were measured at either 125 MHz, 100 MHz or 75 MHz on the same instruments noted above for recording ^1H NMR spectra. Chemical shifts were again reported in accordance to residual protiated solvent peaks (δ 77.2, 39.5, 128.0 and 137.9 ppm for $CDCl_3$, $(CD_3)_2SO$, C_6D_6, and $CD_3C_6D_5$, respectively). Accurate mass measurements were acquired at the University of Wisconsin, Madison using a Micromass LCT (electrospray ionization, time-of-flight analyzer or electron impact methods). The NMR and Mass Spectrometry facilities are funded by the NSF (CHE-9974839, CHE-9304546, CHE-9208463, CHE-9629688) and the University of Wisconsin, as well as the NIH (RR08389-01). The Q Exactive Plus mass spectrometer was funded through the NIH (1S10OD020022-1).

II. Synthesis of alcohol precursors.

General procedure for the synthesis of alcohol precursors.[3] A 250 mL round-bottom flask equipped with a reflux condenser was charged with 30 mL of diethyl ether and 0.97 g (40 mmol, 2 equiv) of Mg turnings. Alkyl bromide (40 mmol, 2 equiv) was added dropwise to keep a constant reflux, and the mixture was allowed to stir for 30 min. The reaction mixture was cooled to -78 ºC in a dry ice/acetone bath and aldehyde (20 mmol, 1 equiv) in 30 mL of was added slowly via cannula. The reaction mixture was stirred 1 h at -78 ºC, and was then quenched by the gradual addition of aqueous 0.25 M HCl (60 mL). The layers were separated and the aqueous layer was extracted with two 30 mL portions of diethyl ether. The organic layers were combined, dried over $MgSO_4$, and concentrated *in vacuo*. The crude residue was purified via column chromatography with an ethyl acetate/hexane gradient to give the pure alcohol product.



Compound S1 (1-Cyclohexyl-4-methylpentan-2-ol, precursor to Compound 1). Prepared according to the previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting colorless oil was obtained in 74% yield from isovaleraldehyde.[3] Characterization data was consistent with the previously reported synthesis.[3]

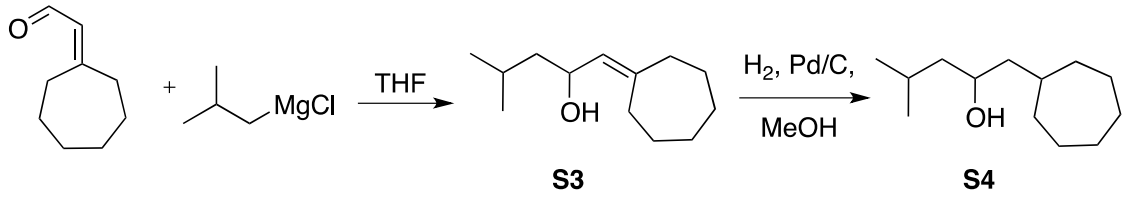


Compound S2 (1-cyclopentyl-4-methylpentan-2-ol, precursor to Compound 8). Prepared from 2-cyclopentylacetaldehyde and commercial isobutylmagnesium chloride solution as in the procedure described for Compound S3 (*vide infra)*. The compound was isolated as a clear oil in 65% yield following column chromatography using a 0%-30% ethyl acetate in hexanes gradient, with 5% increments.

^{1}H NMR (500 MHz, $CDCl_3$) δ 3.63 (m, 1H), 1.93 – 1.81 (m, 1H), 1.79 – 1.66 (m, 3H), 1.55 (m, 2H), 1.49 – 1.38 (m, 3H), 1.35 – 1.26 (m, 3H), 1.17 (m, 1H), 1.09 – 0.96 (m, 2H), 0.85 (dd, J = 6.3, 4.3 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 69.3, 47.3, 44.6, 36.7, 33.3, 32.6, 25.1, 25.0, 24.6, 23.5, 22.10.

MS (EI) m/z calculated for $C_{11}H_{22}O$ $[M-H]^-$ 169.1598; found, 169.1598.



Compound S3 (1-cycloheptylidene-4-methylpentan-2-ol, precursor to Compound S4). The aldehyde, 2-cycloheptylideneacetaldehyde, was prepared from cycloheptanone in three steps, as previously reported.[4-5] The aldehyde (9.97 mmol, 1 equiv) was dissolved in THF (0.33 M) in a dry 100 mL round-bottom flask under N_2. Commercially available isobutyl magnesium chloride (2 M in THF, 12 mmol, 1.2 equiv) was added to the stirring solution at -78 ºC, the reaction mixture brought to room temperature, then stirred for 1-2 h or until TLC indicated complete consumption of the starting material. The reaction was quenched by the addition of 0.25 M HCl (30 mL). The layers were separated and the aqueous layer was extracted with two 30 mL portions of diethyl ether. The organic layers were combined, dried over $MgSO_4$, and concentrated *in vacuo*. The crude residue was purified by column chromatography using a 0%–

30% gradient of EtOAc in hexanes with 5% increments. The pure, acid sensitive oil decomposes within hours in chloroform, and was isolated by silica column chromatography using a 0% -> 30% ethyl acetate/hexanes gradient in 84% yield, with 5% increments. The pure oil had a slight yellow hue.

^{1}H NMR (500 MHz, $CDCl_3$) δ 5.16 (dp, *J* = 8.8, 1.3 Hz, 1H), 4.44 (ddd, *J* = 8.8, 7.6, 6.1 Hz, 1H), 2.33 (td, *J* = 6.2, 1.4 Hz, 2H), 2.22 (td, *J* = 6.1, 1.2 Hz, 2H), 1.74 – 1.45 (m, 10H), 1.26 (ddd, *J* = 13.5, 7.4, 6.1 Hz, 1H), 1.19 (bs, 1H), 0.92 (dd, *J* = 9.0, 6.6 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 144.4, 128.8, 66.5, 47.0, 37.8, 30.1, 29.6, 29.0, 29.0, 27.4, 24.7, 23.2, 22.6.

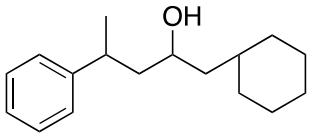
MS (EI) *m/z* calculated for $C_{13}H_{24}O$ $[M-H]^-$ 195.1743; found, 195.1742.

Compound S4 (1-cycloheptyl-4-methylpentan-2-ol, precursor to Compound 9). Compound S2 (1 equiv, 9.8 mmol, 1.93 g) was dissolved in methanol (1 M, 10 mL) in a dry 100 mL round-bottom flask. After sparging the mixture with N_2, 5% Pd/C was added (10% by weight, 0.193 g) and the atmosphere was displaced with an H_2 balloon (1 atm). The compound was isolated in 46% yield by column chromatography using a 0% to 30% ethyl acetate in hexanes gradient with 5% increments. The pure oil is slightly yellow.

^{1}H NMR (500 MHz, $CDCl_3$) δ 3.74 (tt, *J* = 8.4, 4.5 Hz, 1H), 1.76 (m, 2H), 1.70 – 1.09 (m, 17H), 0.92 (dd, *J* = 6.6, 3.5 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 67.8, 47.5, 46.6, 35.7, 35.6, 33.9, 28.6, 28.4, 26.4, 26.3, 24.64, 23.48, 22.14.

MS (EI) *m/z* calculated for $C_{13}H_{26}O$ $[M-OH]^+$ 197.1900; found, 197.1898.

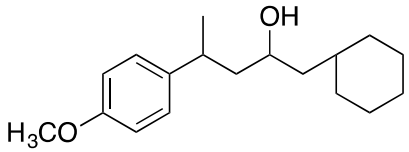


Compound S5 (1-cyclohexyl-4-phenylpentan-2-ol, precursor to Compound 10). Synthesized from 3-phenylbutanal according to the previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 73% yield as a 1.2:1 mixture of diastereomers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.29 (dd, *J* = 8.1, 7.1 Hz, 2H), 7.23 – 7.15 (m, 3H), 3.71 (tt, *J* = 8.3, 4.5 Hz, 0.5H), 3.44 (tt, *J* = 8.3, 3.8 Hz, 0.5H), 2.99 (dqd, *J* = 14.1, 7.0, 5.0 Hz, 0.5H), 2.90 (h, *J* = 7.1 Hz, 0.5H), 1.77 – 1.57 (m, 7H), 1.56 – 1.50 (m, 0.5H), 1.46 – 1.29 (m, 2.5H), 1.26 (dd, *J* = 6.9, 3.9 Hz, 3H), 1.24 – 1.04 (m, 4H), 0.99 – 0.70 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 147.7, 147.0, 128.7, 128.6, 127.3, 127.1, 126.3, 126.2, 67.8, 67.4, 47.1, 46.5, 46.2, 45.9, 37.0, 36.6, 34.5, 34.3, 34.2, 33.2, 33.0, 26.8, 26.7, 26.6, 26.5, 26.4, 23.5, 22.2.

MS (EI) *m/z* calculated for $C_{17}H_{26}O$ $[M\text{-}OH]^+$ 229.1951; found, 229.1950.

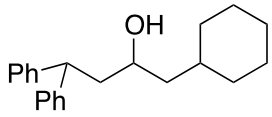


Compound S6 (1-cyclohexyl-4-(4-methoxyphenyl)pentan-2-ol, precursor to Compound 11). Synthesized from 3-(4-methoxyphenyl)butanal according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 75% yield as a 1.3:1 mixture of diastereomers.[3]

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.16 – 7.09 (m, 2H), 6.87 – 6.81 (m, 2H), 3.79 (2x s, 3H), 3.71 (tq, *J* = 8.5, 4.4 Hz, 0.5H), 3.45 (tp, *J* = 8.5, 4.1 Hz, 0.5H), 3.00 – 2.90 (m, 0.5H), 2.85 (h, *J* = 7.1 Hz, 0.5H), 1.75 – 1.63 (m, 4H), 1.62 – 1.59 (m, 2.5H), 1.54 (m, 0.5H), 1.47 – 1.21 (m, 6H), 1.20 (m, 4H), 0.99 – 0.70 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.1, 158.0, 139.7, 139.0, 128.1, 127.9, 114.1, 114.0, 68.0, 67.4, 55.43, 55.41, 47.3, 46.6, 46.2, 45.9, 36.3, 35.8, 34.5, 34.3, 34.23, 34.22, 33.2, 33.1, 26.8, 26.7, 26.6, 26.5, 26.4, 23.7, 22.5, 21.2.

MS (EI) *m/z* calculated for $C_{17}H_{26}O_2$ $[M\text{-}OH]^+$ 259.2056; found, 259.2055.

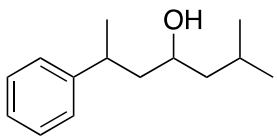


Compound S7, 1-cyclohexyl-4,4-diphenylbutan-2-ol, precursor to Compound 12. Synthesized from 3,3-diphenylpropanal according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 79% yield.

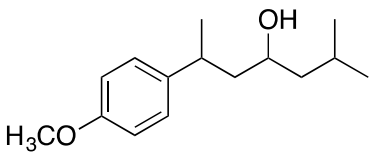
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 – 7.25 (m, 8H), 7.17 (dtt, *J* = 11.1, 6.4, 2.4 Hz, 2H), 4.22 (dd, *J* = 9.8, 6.0 Hz, 1H), 3.58 (s, 1H), 2.21 (ddd, *J* = 13.6, 9.9, 3.6 Hz, 1H), 2.13 – 2.04 (m, 1H), 1.62 (tdd, *J* = 20.4, 12.5, 4.9 Hz, 5H), 1.43 – 1.28 (m, 3H), 1.27 – 1.07 (m, 4H), 0.95 – 0.72 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 145.5, 144.3, 128.7, 128.7, 128.2, 127.9, 126.5, 126.4, 67.5, 47.9, 46.1, 44.0, 34.3, 34.3, 33.2, 26.7, 26.5, 26.4.

MS (EI) *m/z* calculated for $C_{22}H_{28}O$ [M-OH]$^+$ 291.2107; found, 291.2104.



Compound S8 (2-methyl-6-phenylheptan-4-ol, precursor to Compound 13). Synthesized according to a previously reported procedure and the characterization data was consistent with the previously reported data.[3]

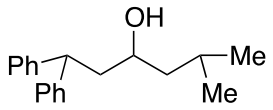


Compound S9 (2-(4-methoxyphenyl)-6-methylheptan-4-ol, precursor to Compound 14). Synthesized 3-(4-methoxyphenyl)butanal using the procedure described for S3 with a solution of isobutyl magnesium chloride.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 60% yield as a 1.1:1 mixture of diastereomers.[3]

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.15 – 7.11 (m, 2H), 6.87 – 6.82 (m, 2H), 3.78 (2x s, 3H), 3.67 (tt, *J* = 8.5, 4.3 Hz, 0.5H), 3.41 (tdd, *J* = 8.5, 4.8, 3.5 Hz, 0.5H), 2.95 (dqd, *J* = 14.0, 7.0, 5.0 Hz, 0.5H), 2.86 (h, *J* = 7.1 Hz, 0.5H), 1.79 – 1.57 (m, 3H), 1.39 – 1.22 (m, 4H), 1.18 (ddd, *J* = 13.5, 8.2, 4.8 Hz, 2H), 0.88 (dd, *J* = 26.8, 6.6 Hz, 3H), 0.81 (dd, *J* = 6.6, 1.6 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.0, 158.0, 139.7, 139.0, 128.1, 127.9, 114.1, 114.0, 68.5, 68.0, 55.38, 55.37, 53.6, 47.5, 47.22, 47.16, 46.5, 36.2, 35.7, 24.8, 24.7, 23.69, 23.65, 23.4, 22.5, 22.4, 22.2, 21.2.

MS (EI) *m/z* calculated for $C_{13}H_{24}O_2$ [M-OH]$^+$ 219.1743; found, 219.1743.



Compound S10 (5-methyl-1,1-diphenylhexan-3-ol, precursor to Compound 15). Synthesized from 3,3-diphenylpropanal and a solution of isobutyl magnesium chloride according the the above procedure for S3. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 57% yield.

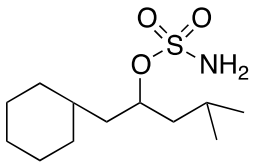
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.25 – 7.19 (m, 8H), 7.11 (dddd, *J* = 12.4, 10.5, 5.3, 2.5 Hz, 2H), 4.17 (dd, *J* = 9.9, 5.9 Hz, 1H), 3.49 (tt, *J* = 8.5, 3.9 Hz, 1H), 2.17 (ddd, *J* = 13.6, 9.9, 3.5 Hz, 1H), 2.02 (ddd, *J* = 13.9, 9.0, 5.9 Hz, 1H), 1.66 (dh, *J* = 8.5, 6.6 Hz, 1H), 1.35 (ddd, *J* = 14.0, 8.5, 5.7 Hz, 1H), 1.24 (ddd, *J* = 13.4, 8.4, 4.6 Hz, 1H), 1.16 (bs, 1H), 0.77 (dd, *J* = 20.6, 6.6 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 145.4, 144.3, 128.7, 128.7, 128.2, 127.9, 126.5, 126.4, 68.2, 47.8, 47.5, 43.9, 24.8, 23.5, 22.4.

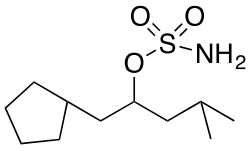
MS (EI) *m/z* calculated for $C_{19}H_{24}O$ $[M-H]^+$ 267.1743; found, 267.1739.

III. Synthesis of Sulfamate Esters.

General procedure for the synthesis of sulfamates.[3] Formic acid (0.49 mL, 13 mmol, 2.5 equiv) was added dropwise to chlorosulfonyl isocyanate (3.0 equiv) cooled in an ice bath with vigorous stirring. Gas was evolved and the reaction mixture solidified within 5 min. To the resulting solid was added 10.4 mL of CH_3CN and the clear solution stirred in an ice bath for 30 min, allowed to warm to rt and stirred for an additional 4 h. The flask was placed in an ice bath and cooled to 0 °C. To the cold solution was added 5.2 mmol of the alcohol substrate in 8.7 mL of dimethylacetamide. The solution was warmed to rt and the mixture was stirred for 1 h. The reaction was quenched by the addition of 10 mL of H_2O and the aqueous layer was extracted with 3 x 50 mL portions of Et_2O. The combined organic layers were washed with 5 x 20 mL portions of H_2O, 1 x 25 mL brine, dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude products were purified by silica gel column chromatography using a hexane/EtOAc gradient.



Compound 1. Synthesized according the the above previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 71% yield and became a white solid upon storing in a -30 ºC freezer. The characterization data was consistent with the previously reported synthesis.[3]



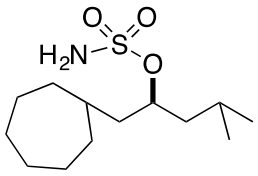
Compound 8. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes in 5%

increments. The resulting clear oil was obtained in 81% yield and became a white solid upon storing in a -30 ºC freezer.

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.66 – 4.59 (m, 3H), 1.90 – 1.52 (m, 9H), 1.51 – 1.39 (m, 3H), 1.12 – 1.00 (m, 2H), 0.88 (dd, *J* = 11.2, 6.5 Hz, 7H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 84.2, 43.8, 41.1, 36.4, 33.1, 32.9, 25.3, 25.2, 24.6, 23.0, 22.6.

MS (EI) *m/z* calculated for $C_{11}H_{23}NO_3S$ $[M-H]^-$ 248.1326, found 248.1326.

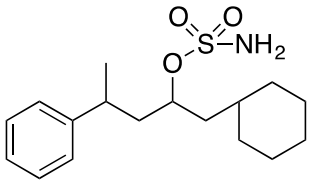


Compound 9. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 55% yield and became a white solid upon storing in a -30 ºC freezer.

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.65 (m, 3H), 1.74 – 1.48 (m, 10H), 1.48 – 1.33 (m, 6H), 1.20 – 1.08 (m, 2H), 0.88 (dd, *J* = 11.3, 6.5 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 83.2, 44.1, 43.1, 35.4, 35.1, 34.4, 28.7, 28.5, 26.5, 26.3, 24.7, 22.9, 22.7.

MS (EI) *m/z* calculated for $C_{13}H_{27}NO_3S$ $[M+NH_4]^+$ 295.2050; found, 295.2048.

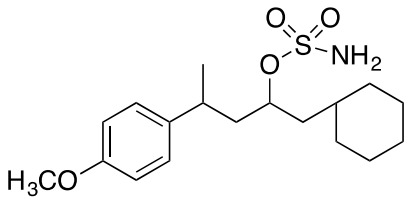


Compound 10. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 72% yield as a 1.2:1 mixture of diastereomers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (ddd, *J* = 8.5, 7.0, 1.7 Hz, 2H), 7.24 – 7.19 (m, 3H), 4.58 – 4.50 (m, 1H), 4.50 – 4.47 (m, 1H), 4.42 (s, 1H), 2.96 (dt, *J* = 8.2, 6.8 Hz, 0.5H), 2.85 (dp, *J* = 8.8, 6.8 Hz, 0.5H), 2.18 (ddd, *J* = 14.2, 8.8, 6.5 Hz, 0.5H), 2.01 – 1.97 (m, 1H), 1.87 (dt, *J* = 14.2, 6.3 Hz, 0.5H), 1.75 – 1.60 (m, 5H), 1.53 – 1.41 (m, 1=2H), 1.41 – 1.25 (m, 4H), 1.23 – 1.05 (m, 3H), 1.00 – 0.74 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 146.4, 146.3, 128.79, 128.77, 127.4, 127.2, 126.6, 82.4, 82.2, 42.9, 42.8, 42.5, 42.3, 37.0, 36.4, 34.1, 33.78, 33.77, 33.6, 33.2, 33.1, 26.6, 26.5, 26.32, 26.27, 26.22, 26.19, 23.4, 23.2, 21.3.

MS (EI) *m/z* calculated for $C_{17}H_{27}NO_3S$ $[M+NH_4]^+$ 343.2050; found, 343.2045.

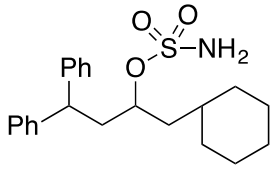


Compound 11. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 87% yield as a 1.3:1 mixture of diastereomers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.16 – 7.11 (m, 2H), 6.87 – 6.80 (m, 2H), 4.72 (s, 1H), 4.68 (s, 1H), 4.56 – 4.43 (m, 1H), 3.78 (2x s, 3H), 2.97 – 2.86 (m, 0.5H), 2.78 (dq, *J* = 8.6, 6.7 Hz, 0.5H), 2.15 (ddd, *J* = 14.0, 8.7, 6.2 Hz, 0.5H), 2.01 – 1.78 (m, 2H), 1.76 – 1.56 (m, 4.5H), 1.54 – 1.37 (m, 2H), 1.34 – 1.07 (m, 7H), 0.97 – 0.72 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.18, 158.17, 138.4, 138.2, 128.2, 128.0, 114.12, 114.10, 82.4, 82.1, 55.42, 55.41, 43.1, 43.0, 42.5, 42.2, 35.9, 35.6, 34.1, 33.8, 33.7, 33.6, 33.10, 33.05, 26.6, 26.5, 26.30, 26.25, 26.20, 26.15, 23.5, 23.2, 22.8, 21.2.

MS (EI) *m/z* calculated for $C_{18}H_{29}NO_4S$ $[M+NH_4]^+$ 373.2156; found, 373.2150.

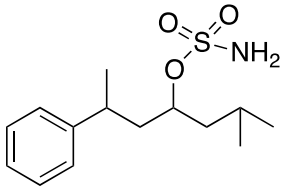


Compound 12. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 38% and became a white solid upon storing in a -30 ºC freezer.

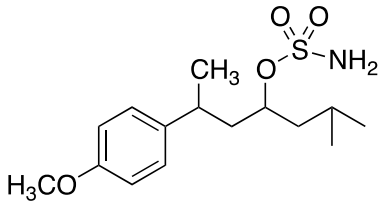
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.26 (m, 8H), 7.21 – 7.17 (m, 2H), 4.57 (qd, *J* = 6.6, 5.0 Hz, 1H), 4.33 (s, 2H), 4.14 (dt, *J* = 8.3, 7.6 Hz, 1H), 2.54 (dt, *J* = 14.6, 7.3 Hz, 1H), 2.40 (ddd, *J* = 14.5, 8.3, 5.0 Hz, 1H), 1.71 (dt, *J* = 13.6, 6.6 Hz, 1H), 1.68 – 1.59 (m, 4H), 1.56 – 1.49 (m, 2H), 1.37 (tqd, *J* = 9.3, 6.0, 2.7 Hz, 1H), 1.23 – 1.08 (m, 3H), 0.94 – 0.76 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 144.04, 143.86, 128.90, 128.82, 128.06, 127.98, 126.81, 126.72, 82.00, 47.76, 42.48, 40.56, 33.97, 33.42, 33.38, 26.53, 26.25, 26.22.

MS (EI) *m/z* calculated for $C_{22}H_{29}NO_3S$ $[M+NH_4]^+$ 405.2206; found, 405.2206.



Compound 13. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 72% yield as a 1.2:1 mixture of diastereomers. Characterization data consistent with the previously reported synthesis.[3]

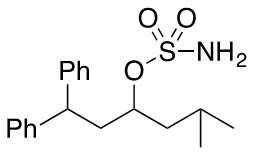


Compound 14. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 83% yield as a 1.1:1 mixture of diastereomers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.19 – 7.08 (m, 2H), 6.92 – 6.76 (m, 2H), 4.64 (m, 2H), 4.53 – 4.42 (m, 1H), 3.79 (2x s, 3H), 2.92 (dp, *J* = 9.0, 6.8 Hz, 0.5H), 2.80 (dp, *J* = 8.7, 6.8 Hz, 0.5H), 2.19 – 2.11 (m, 0.5H), 2.00 – 1.89 (m, 1H), 1.84 (dt, *J* = 14.1, 6.6 Hz, 0.5H), 1.76 – 1.59 (m, 3H), 1.46 (ddd, *J* = 14.1, 8.1, 5.1 Hz, 1H), 1.30 – 1.21 (m, 4H), 0.90 (dd, *J* = 10.5, 6.4 Hz, 3H), 0.79 (dd, *J* = 29.2, 6.3 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.22, 158.21, 138.3, 138.2, 128.2, 128.0, 114.14, 114.12, 82.9, 82.7, 55.4, 44.0, 43.6, 43.1, 43.0, 36.0, 35.5, 24.7, 24.4, 23.6, 23.3, 23.2, 23.0, 22.4, 22.3, 21.2.

MS (EI) *m/z* calculated for $C_{15}H_{25}NO_4S$ $[M+NH_4]^+$ 333.1843; found, 333.1837.



Compound 15. Synthesized according to a previously reported general procedure.[3] The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments. The resulting clear oil was obtained in 30% and became a white solid upon storing in a -30 ºC freezer.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 8H), 7.20 (m, 2H), 4.54 (td, *J* = 7.0, 5.3 Hz, 1H), 4.32 (bs, 2H), 4.15 (t, *J* = 7.9 Hz, 1H), 2.54 (dt, *J* = 14.6, 7.3 Hz, 1H), 2.41 (ddd, *J* = 14.4, 8.3, 5.1 Hz, 1H), 1.77 – 1.67 (m, 2H), 1.55 – 1.52 (m, 1H), 0.85 (dd, *J* = 6.4, 2.9 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 144.0, 143.9, 128.9, 128.8, 128.1, 128.0, 126.8, 126.7, 82.5, 53.6, 47.7, 43.9, 40.5, 24.7, 22.7.

MS (EI) *m/z* calculated for $C_{19}H_{25}NO_3S$ $[M+NH_4]^+$ 365.1893; found, 365.1891.

IV. Characterization of the amination products.

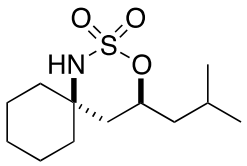
General procedure for the Ag-catalyzed C–H amination.[3] A pre-dried reaction flask was charged with silver triflate (6.4 mg, 0.025 mmol, 0.1 equiv) and ligand (7.4 mg Me_4phen, 0.03125 mmol, 0.125 equiv, or 9.1 mg tpa, 0.03125 mmol, 0.125 equiv, or 13.8 mg Py_5Me_2, 0.03125 mmol, 0.125 equiv). Dichloromethane (2.5 mL) was added and the mixture was stirred vigorously for 30 minutes. Then, 4Å molecular sieves (1 mmol substrate/g of sieves) were added, followed by a solution of the sulfamate substrate (0.25 mmol, 1 equiv) in dichloromethane (2.5 mL). Iodosobenzene (194 mg, 0.88 mmol, 3.5 equiv) was added in one portion and the reaction mixture was allowed to stir at room temperature for 30 minutes. The reaction mixture was filtered through a glass frit with dichloromethane and the filtrate was concentrated under reduced pressure. The crude products were purified by silica gel column chromatography using an EtOAc/hexane gradient (0–30% EtOAc/hexane unless otherwise specified). The reported yields were from the higher-yielding conditions for each product or by ^{1}H-NMR of the crude reaction mixture.

General procedure for Rh-catalyzed C–H amination. Procedures for $Rh_2(OAc)_4$ (2 mol% catalyst loading), $Rh_2(TPA)_4$ (2 mol% catalyst loading), and $Rh_2(esp)_2$ (1 mol% catalyst loading) have been reported by the Du Bois group using $PhI(OAc)_2$ as the oxidant (1.1 equiv), activated MgO as the base (2.3 equiv) and CH_2Cl_2 as the solvent (0.156 M). The reaction is refluxed at 45-50 ºC for 1-2 h or until TLC indicates complete consumption of the starting material.[6]

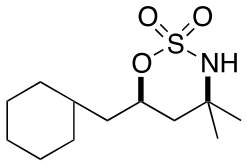
General procedure for Mn-catalyzed C–H amination. The White-Paradine catalyst was used according to the previously reported procedure. The reactions were done in the dark using 10 mol% [Mn(*t*BuPc)]Cl and 10 mol% $AgSbF_6$ that were stored in the glovebox prior to use. The reactions use $PhI(OPiv)_2$ as the oxidant (2 equiv), 4 Å mol sieves (40 mg) with a 9:1 solvent mixture of benzene:acetonitrile (0.5 M) using 0.15 mmol of substrate (1 equiv). The reaction takes place at room temperature over 8-24 h.[7]

General procedure for Ru-catalyzed C–H amination.

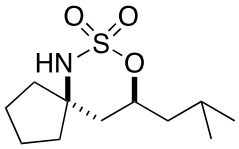
The procedure for $[Ru(hp)_4]Cl$ catalyzed amination (2.5 mol% catalyst loading) was followed as previously reported. The reaction uses $PhI(OPiv)_2$ as the oxidant (1.4 equiv), 4 Å mol sieves as the dessicant (60 mg), and CH_2Cl_2 as the solvent (0.05 M). The reactions were refluxed at 45-50 ºC for 24 h.[8]



Compound $\mathbf{1_{Cy}}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers as previously reported.[3] The compound is a white solid. Characterization data consistent with the previously reported synthesis.[3]



Compound $\mathbf{1_{iPr}}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers as previously reported.[3] The compound is a white solid. Characterization data consistent with the previously reported synthesis.[3]

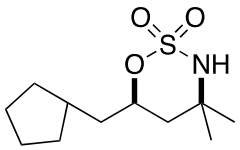


Compound $\mathbf{8_{Cy}}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers as previously reported.[3] The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.78 (dddd, J = 11.3, 9.0, 4.3, 2.0 Hz, 1H), 4.07 (s, 1H), 2.48 – 2.40 (m, 1H), 1.90 – 1.76 (m, 2H), 1.75 – 1.50 (m, 9H), 1.29 (ddd, J = 14.2, 8.6, 4.3 Hz, 1H), 0.88 (dd, J = 9.9, 6.7 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 81.0, 66.6, 44.3, 42.7, 40.4, 35.6, 24.3, 24.0, 23.0, 22.7, 22.0.

MS (EI) *m/z* calculated for $C_{11}H_{21}NO_3S$ $[M+NH_4]^+$ 265.1580; found, 265.1578.

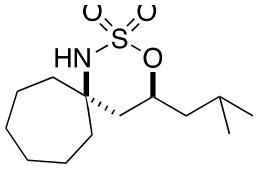


Compound 8_{iPr}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.79 (dddd, J = 11.5, 8.4, 4.6, 2.2 Hz, 1H), 3.95 (s, 1H), 1.99 – 1.87 (m, 1H), 1.85 – 1.68 (m, 3H), 1.62 – 1.45 (m, 7H), 1.44 (s, 3H), 1.23 (s, 3H), 1.11 – 0.99 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 81.0, 56.0, 42.1, 41.6, 35.9, 33.0, 32.6, 32.2, 25.3, 25.2, 25.0.

MS (EI) *m/z* calculated for $C_{11}H_{21}NO_3S$ $[M+NH_4]^+$ 265.1580; found, 265.1578.

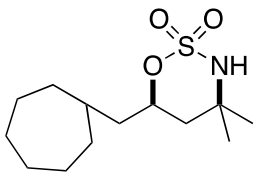


Compound 9_{Cy}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.82 (dddd, J = 11.8, 9.0, 4.2, 1.9 Hz, 1H), 3.76 (s, 1H), 2.25 (dd, J = 14.6, 9.1 Hz, 1H), 1.88 – 1.51 (m, 11H), 1.49 – 1.31 (m, 4H), 1.31 – 1.24 (m, 1H), 0.88 (dd, J = 10.0, 6.6 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 79.4, 61.8, 45.0, 44.4, 42.1, 35.3, 29.4, 29.1, 24.0, 23.1, 22.2, 22.1, 21.9.

MS (EI) *m/z* calculated for $C_{13}H_{25}NO_3S$ $[M+NH_4]^+$ 293.1893; found, 293.1890.

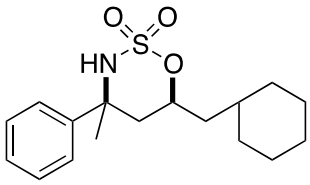


Compound 9_{iPr}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.89 (dddd, J = 11.1, 8.7, 4.1, 2.3 Hz, 1H), 3.90 (s, 1H), 1.82 – 1.75 (m, 2H), 1.75 – 1.67 (m, 2H), 1.67 – 1.57 (m, 6H), 1.51 (s, 3H), 1.49 – 1.39 (m, 5H), 1.29 (s, 3H), 1.18 (m, 1H), 0.94 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 79.7, 56.1, 43.7, 42.4, 35.2, 34.6, 33.9, 32.3, 28.6, 28.6, 26.3, 26.2, 25.4.

MS (EI) *m/z* calculated for $C_{13}H_{25}NO_3S$ $[M+NH_4]^+$ 293.1893; found, 293.1890.

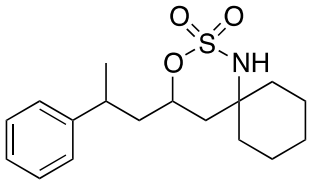


Compound $10_{Bn\text{-}syn}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain this pure diastereomer with nOe observed between the methyl group and O-methine. The compound is a white solid. The minor *anti*-diastereomer co-elutes as a mixture with $\mathbf{10_{Bn\text{-}syn}}$ and $\mathbf{10_{alk}}$ diastereomers with a clean ^{1}H-NMR signal at 4.93 (td, J = 8.7, 4.4, 1H) suitable for quantitative ^{1}H-NMR analysis.

Major ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.46 – 7.37 (m, 4H), 7.35 – 7.30 (m, 1H), 5.10 (dddd, J = 11.2, 9.0, 4.1, 2.0 Hz, 1H), 4.28 (s, 1H), 2.13 (dd, J = 14.1, 2.0 Hz, 1H), 2.08 – 2.00 (m, 1H), 1.87 (dtt, J = 12.6, 3.7, 1.9 Hz, 1H), 1.80 (s, 3H), 1.77 – 1.65 (m, 4H), 1.64 – 1.58 (m, 1H), 1.50 (ddd, J = 14.0, 8.4, 4.0 Hz, 1H), 1.33 – 1.24 (m, 3H), 1.17 (qt, J = 12.8, 3.6 Hz, 1H), 1.05 – 0.92 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 146.2, 129.3, 129.2, 128.4, 124.1, 78.9, 60.9, 53.6, 43.3, 40.6, 33.8, 33.3, 32.8, 27.5, 26.5, 26.3, 26.2.

MS (EI) *m/z* calculated for $C_{17}H_{25}NO_3S$ $[M+NH_4]^+$ 341.1893; found, 341.1892.



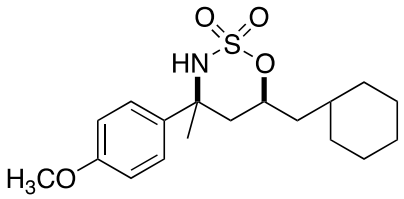
Compound 10_{alk}. The product was passed through column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain this pure regioisomer as a mixture of diastereomers. The compounds are white solids and were characterized as a 2.5:1 mixture of diastereomers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.28 (m, 2H), 7.24 – 7.16 (m, 3H), 4.81 (dddd, J = 11.8, 8.3, 5.2, 1.8 Hz, 0.3H), 4.61 – 4.51 (m, 0.7H), 3.99 (s, 0.3H), 3.95 (s, 0.7H), 3.09 – 3.02 (m,

0.7H), 2.98 (dq, *J* = 8.7, 6.9 Hz, 0.3H), 2.36 – 2.31 (m, 0.3H), 2.26 – 2.19 (m, 0.7H), 2.11 – 2.04 (m, 0.3H), 2.00 (ddd, *J* = 14.1, 9.3, 4.6 Hz, 0.7H), 1.81 – 1.54 (m, 5H), 1.53 – 1.40 (m, 5H), 1.31 (d, *J* = 7.3 Hz, 2H), 1.29 – 1.18 (m, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 146.1, 145.3, 128.8, 127.3, 126.9, 126.73, 126.65, 78.8, 78.4, 58.1, 58.0, 44.5, 43.67, 41.73, 40.6, 40.5, 35.5, 35.0, 32.94, 32.92, 25.72, 25.68, 22.44, 21.38, 21.2, 21.1, 21.0, 20.9.

MS (EI) *m/z* calculated for $C_{17}H_{25}NO_3S$ $[M+NH_4]^+$ 341.1893; found, 341.1892.

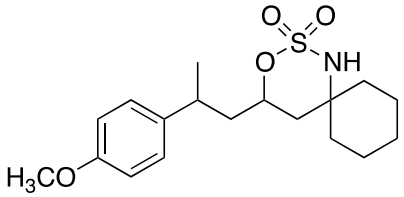


Compound 11$_{\text{Bn-syn}}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain this pure diastereomer with nOe observed between the methyl group and O-methine. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40 – 7.36 (m, 2H), 6.96 – 6.92 (m, 2H), 5.11 (dddd, *J* = 11.4, 9.0, 4.0, 2.5 Hz, 1H), 4.21 (s, 1H), 3.84 (s, 3H), 2.13 – 2.01 (m, 2H), 1.92 – 1.86 (m, 1H), 1.81 (s, 3H), 1.80 – 1.60 (m, 6H), 1.55 – 1.48 (m, 1H), 1.30 (qq, *J* = 14.7, 4.3, 3.9 Hz, 2H), 1.24 – 1.13 (m, 1H), 1.06 – 0.90 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 159.4, 138.3, 125.5, 114.4, 78.9, 60.5, 55.6, 43.3, 40.7, 33.9, 33.3, 32.8, 27.4, 26.57, 26.3, 26.2.

MS (EI) *m/z* calculated for $C_{18}H_{27}NO_4S$ $[M+NH_4]^+$ 371.1999; found, 371.1997.

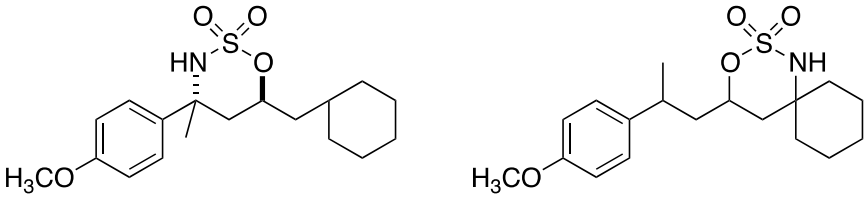


Compound 11$_{\text{alk-major diastereomer}}$. The product was passed through column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain this pure regioisomer as a mixture of diastereomers. The compounds are white solids. Characterized as a 2.5:1 mixture of diastereomers. Characterized as a 2:1 mix of regioisomers with **11$_{\text{Bn-syn}}$**.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.17 – 7.13 (m, 2H), 6.97 – 6.85 (m, 2H), 4.58 (tt, *J* = 9.6, 3.5 Hz, 1H), 3.82 (s, 3H), 3.77 (s, 1H), 3.08 – 3.00 (m, 1H), 1.79 – 1.60 (m, 6H), 1.55 – 1.47 (m, 3H), 1.33 (m, 3H), 1.17 – 1.05 (m, 2H), 0.99 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.3, 137.3, 128.2, 114.2, 78.8, 58.1, 55.4, 44.8, 40.8, 34.9, 34.6, 33.0, 25.7, 25.5, 22.6, 21.1, 20.9.

MS (EI) *m/z* calculated for $C_{18}H_{27}NO_4S$ $[M+NH_4]^+$ 371.1999; found, 371.1995.

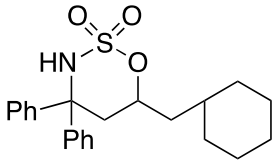


Compound $11_{Bn\text{-}anti}$+Compound $11_{alk\text{-}minor\ diastereomer}$·(3:1 Bn:alk). The product was passed through column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain the minor diastereomers of each regioisomer as a mixture. The compounds are white solids. Characterized as a 2.5:1 mixture of diastereomers and a 2:1 mix of regioisomers with $\mathbf{11}_{Bn\text{-}syn}$.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40 – 7.36 (m, 1.4H), 7.11 – 7.08 (m, 0.4H), 6.93 – 6.83 (m, 2H), 4.80 (ddt, *J* = 10.1, 6.5, 2.0 Hz, 0.15H), 4.74 (dddd, *J* = 11.5, 9.0, 4.2, 1.4 Hz, 0.7H), 3.81 (s, 2H), 3.79 (s, 0.8H), 2.97 – 2.91 (m, 0.2H), 2.58 (dd, *J* = 14.9, 1.4 Hz, 0.7H), 1.84 (m, 1H), 1.77 – 1.58 (m, 7H), 1.54 – 1.47 (m, 2.4H), 1.45 (s, 2H), 1.43 (d, *J* = 1.3 Hz, 0.75H), 1.29 (m, 2H), 1.21 – 1.01 (m, 2H), 0.97 (d, *J* = 6.7 Hz, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 133.4, 127.8, 127.0, 114.3, 114.0, 79.7, 78.5, 58.2, 55.4, 43.9, 43.1, 40.8, 40.4, 35.7, 34.9, 34.7, 34.3, 33.8, 33.3, 33.0, 32.8, 27.1, 26.5, 26.3, 26.1, 25.7, 25.5, 21.7.

MS (EI) *m/z* calculated for $C_{18}H_{27}NO_4S$ $[M+NH_4]^+$ 371.1999; found, 371.1995.

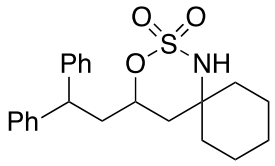


Compound 12_{Bn}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 – 7.29 (m, 8H), 7.28 – 7.20 (m, 2H), 4.86 (dddd, *J* = 11.5, 8.9, 4.1, 1.4 Hz, 1H), 4.81 (s, 1H), 3.02 (dd, *J* = 15.0, 1.3 Hz, 1H), 2.31 (dd, *J* = 14.9, 11.4 Hz, 1H), 1.86 – 1.77 (m, 1H), 1.77 – 1.61 (m, 5H), 1.61 – 1.51 (m, 2H), 1.31 – 1.20 (m, 3H), 1.20 – 1.08 (m, 1H), 1.00 – 0.91 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 145.5, 140.1, 129.1, 128.6, 128.0, 127.7, 126.6, 124.6, 79.4, 66.7, 43.0, 39.6, 33.6, 33.2, 32.6, 26.3, 26.1, 25.9.

MS (EI) *m/z* calculated for $C_{22}H_{27}NO_3S$ $[M+NH_4]^+$ 403.2050; found, 403.2050.

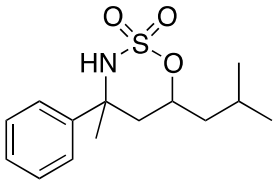


Compound 12_{alk}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

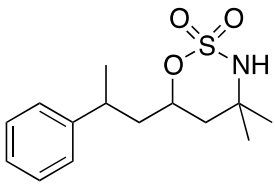
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.23 (m, 8H), 7.22 – 7.17 (m, 2H), 4.69 – 4.60 (m, 1H), 4.26 (dd, *J* = 10.6, 5.2 Hz, 1H), 3.84 (s, 1H), 2.45 (ddd, *J* = 14.0, 8.9, 5.2 Hz, 1H), 2.28 (ddd, *J* = 14.3, 10.6, 4.0 Hz, 1H), 2.21 (d, *J* = 13.9 Hz, 1H), 1.63 (dd, *J* = 14.4, 2.3 Hz, 2H), 1.57 – 1.53 (m, 2H), 1.49 (m, 4H), 1.40 – 1.32 (m, 1H), 1.24 – 1.15 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 143.8, 143.1, 129.0, 128.8, 128.2, 127.7, 126.9, 126.7, 78.4, 58.1, 46.0, 41.7, 41.5, 40.7, 32.9, 25.7, 21.1, 20.9.

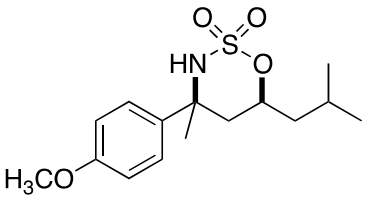
MS (EI) *m/z* calculated for $C_{22}H_{27}NO_3S$ $[M+NH_4]^+$ 403.2050; found, 403.2050.



Compound 13_{Bn}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments and isolated as a mixture of diastereomers.[3] The characterization data was consistent with the previously reported synthesis.[3]



Compound 13_{alk}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments and isolated as a mixture of diastereomers.[3] The characterization data was consistent with the previously reported synthesis.[3]

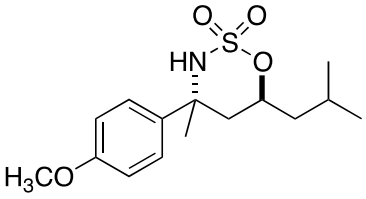


Compound $14_{Bn\text{-}syn}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain this pure diastereomer with nOe observed between the methyl group and O-methine. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39 – 7.32 (m, 2H), 6.95 – 6.89 (m, 2H), 5.06 (dddd, J = 11.3, 9.0, 4.1, 2.4 Hz, 1H), 4.21 (s, 1H), 3.82 (s, 3H), 2.09 (dd, J = 14.1, 2.4 Hz, 1H), 1.99 – 1.81 (m, 2H), 1.79 (s, 3H), 1.53 – 1.43 (m, 2H), 0.99 (dd, J = 13.2, 6.4 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 159.4, 138.3, 125.5, 114.4, 79.4, 55.5, 44.5, 40.7, 34.9, 27.4, 24.0, 23.1, 22.1.

MS (EI) *m/z* calculated for $C_{15}H_{23}NO_4S$ $[M+NH_4]^+$ 331.1686; found, 331.1683.

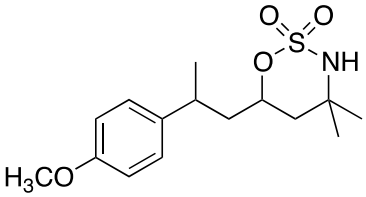


Compound $14_{Bn\text{-}anti}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain this pure diastereomer with no nOe observed between the methyl group and O-methine. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39 (d, J = 8.9 Hz, 2H), 6.98 – 6.83 (m, 2H), 4.71 (dddd, J = 11.5, 8.7, 4.6, 1.4 Hz, 1H), 4.39 (s, 1H), 3.81 (s, 3H), 2.59 (dd, J = 15.0, 1.5 Hz, 1H), 1.91 – 1.82 (m, 2H), 1.79 – 1.69 (m, 2H), 1.45 (s, 3H), 0.95 (dd, J = 19.0, 6.6 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 159.0, 133.4, 127.0, 114.0, 80.2, 61.5, 55.4, 44.3, 40.2, 34.9, 25.5, 24.1, 23.0.

MS (EI) *m/z* calculated for $C_{15}H_{23}NO_4S$ $[M+NH_4]^+$ 331.1686; found, 331.1681.

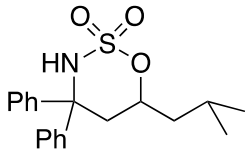


Compound $14_{\text{alk-major diastereomer}}$. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain the major diastereomer. The compound is a white solid. The minor diastereomer co-elutes as a mixture with $\mathbf{14}_{\text{Bn-anti}}$ and $\mathbf{14}_{\text{alk-major diastereomer}}$ isomers with a clean ^{1}H-NMR signal at 4.80 (dddd, J = 11.6, 8.3, 5.2, 2.0 Hz, 1H) suitablef or quantitative ^{1}H-NMR analysis.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.15 – 7.12 (m, 2H), 6.88 – 6.84 (m, 2H), 4.59 – 4.52 (m, 1H), 3.94 (s, 1H), 3.80 (s, 3H), 3.02 (dtt, J = 11.3, 7.0, 3.5 Hz, 1H), 1.99 (ddd, J = 14.1, 9.6, 4.3 Hz, 1H), 1.67 (ddd, J = 14.0, 10.7, 3.1 Hz, 1H), 1.55 – 1.42 (m, 2H), 1.34 (s, 3H), 1.27 (d, J = 7.0 Hz, 3H), 1.24 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.4, 137.3, 128.2, 114.2, 79.7, 56.0, 55.4, 44.7, 42.1, 34.5, 32.2, 25.3, 22.6.

MS (EI) *m/z* calculated for $C_{15}H_{23}NO_4S$ $[M+NH_4]^+$ 331.1686; found, 331.1684.

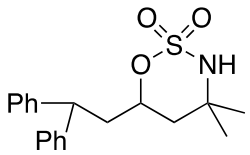


Compound 15_{Bn}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.47 – 7.42 (m, 2H), 7.30 – 7.25 (m, 2H), 7.24 – 7.11 (m, 6H), 4.77 – 4.66 (m, 2H), 2.94 (dd, J = 14.8, 1.3 Hz, 1H), 2.22 (dd, J = 14.9, 11.4 Hz, 1H), 1.86 – 1.69 (m, 2H), 1.47 – 1.40 (m, 1H), 0.84 (dd, J = 10.1, 6.6 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 145.7, 140.3, 129.3, 128.7, 128.2, 127.9, 126.8, 124.8, 80.0, 66.9, 44.4, 39.7, 24.1, 23.0, 22.2.

MS (EI) *m/z* calculated for $C_{19}H_{23}NO_3S$ $[M+NH_4]^+$ 363.1736; found, 363.1737.



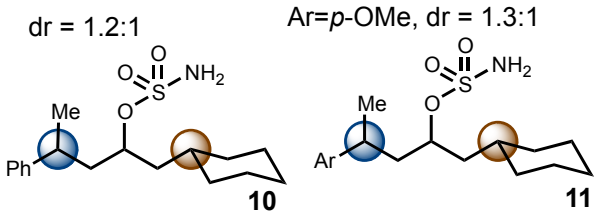
Compound 15_{alk}. The product was purified by column chromatography using a 0%–30% gradient of EtOAc in hexanes with 5% increments to obtain pure regioisomers. The compound is a white solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.29 – 7.20 (m, 6H), 7.19 – 7.12 (m, 4H), 4.60 (ddt, *J* = 10.8, 9.0, 3.4 Hz, 1H), 4.23 (dd, *J* = 10.6, 5.1 Hz, 1H), 3.96 (s, 1H), 2.41 (ddd, *J* = 14.2, 9.0, 5.1 Hz, 1H), 2.24 (ddd, *J* = 14.3, 10.7, 3.8 Hz, 1H), 1.59 (m, 1H), 1.55 – 1.51 (m, 1H), 1.27 (s, 3H), 1.21 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 143.8, 143.1, 129.0, 128.8, 128.2, 127.8, 127.0, 126.7, 79.2, 56.0, 45.9, 41.9, 41.4, 32.1, 25.2.

MS (EI) *m/z* calculated for $C_{19}H_{23}NO_3S$ $[M+NH_4]^+$ 363.1736; found, 363.1735.

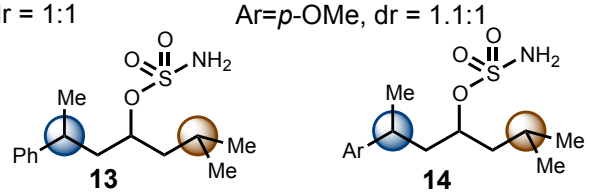
V. Diastereomeric ratio data for insertion products arising from substrates 10-15.



Entry	Catalyst	Yield[a]	Bn:*c*Hex [Bn dr]:[*c*Hex dr]	Yield[a]	Bn:*c*Hex [Bn dr]:[*c*Hex dr]
1	AgOTf:Py_5Me_2	84%	**2.2:1** [1.5:1]:[3.9:1]	89%	**3.4:1** [1.6:1]:[4.3:1]
2	AgOTf:Me_4phen	95%	**1:3.8** [2.3:1]:[1.4:1]	90%	**1:2.2** [2.1:1]:[2.1:1]
3	AgOTf:tpa	85%	**1:1.1** [3.6:1]:[2.4:1]	91%	**1.7:1** [1.8:1]:[6.2:1]
4	$Rh_2(OAc)_4$	93%	**1:1.2** [2.1:1]:[2.4:1]	91%	**1.4:1** [1.4:1]:[3.3:1]
5	$Rh_2(esp)_2$	99%	**1.0:1** [1.8:1]:[3:1]	93%	**1.6:1** [1.3:1]:[3.7:1]
6	$Rh_2(TPA)_4$	93%	**1.1:1** [1.1:1]:[2.7:1]	92%	**1.8:1** [1.1:1]:[2.4:1]

[a]NMR yield and regioisomeric ratio and dr, mesitylene internal standard.

dr = 1:1 Ar=*p*-OMe, dr = 1.1:1



Entry	Catalyst	Yield[a]	Bn:^{i}Pr [Bn dr]:[^{i}Pr dr]	Yield[a]	Bn:^{i}Pr [Bn dr]:[^{i}Pr dr]
1	Ag:OTfMe$_4$phen	89%	**1.3:1** [1.4:1]:[2.6:1]	73%	**2.6:1** [1.4:1]:[4.6:1]
2	AgOTf:Py$_5$Me$_2$	91%	**1.0:1** [3.4:1]:[2.6:1]	90%	**1.4:1** [2.1:1]:[4:1]
3	AgOTf:tpa	99%[b]	**1.0:1** [2.5:1]:[1.6:1]	89%	**1.6:1** [2.0:1]:[5.0:1]
4	Rh$_2$(OAc)$_4$	90%[c]	**1:1.6** [3.6:1]:[1.7:1]	-	-
5	Rh$_2$(esp)$_2$	91%[c]	**1:2.1** [4.9:1]:[1.6:1]	-	-
6	Rh$_2$(TPA)$_4$	94%[c]	**1:8.3** [2.3:1]:[2.1:1]	-	-

[a]NMR yield and regioisomeric ratio and dr, mesitylene internal standard.

VI. References.

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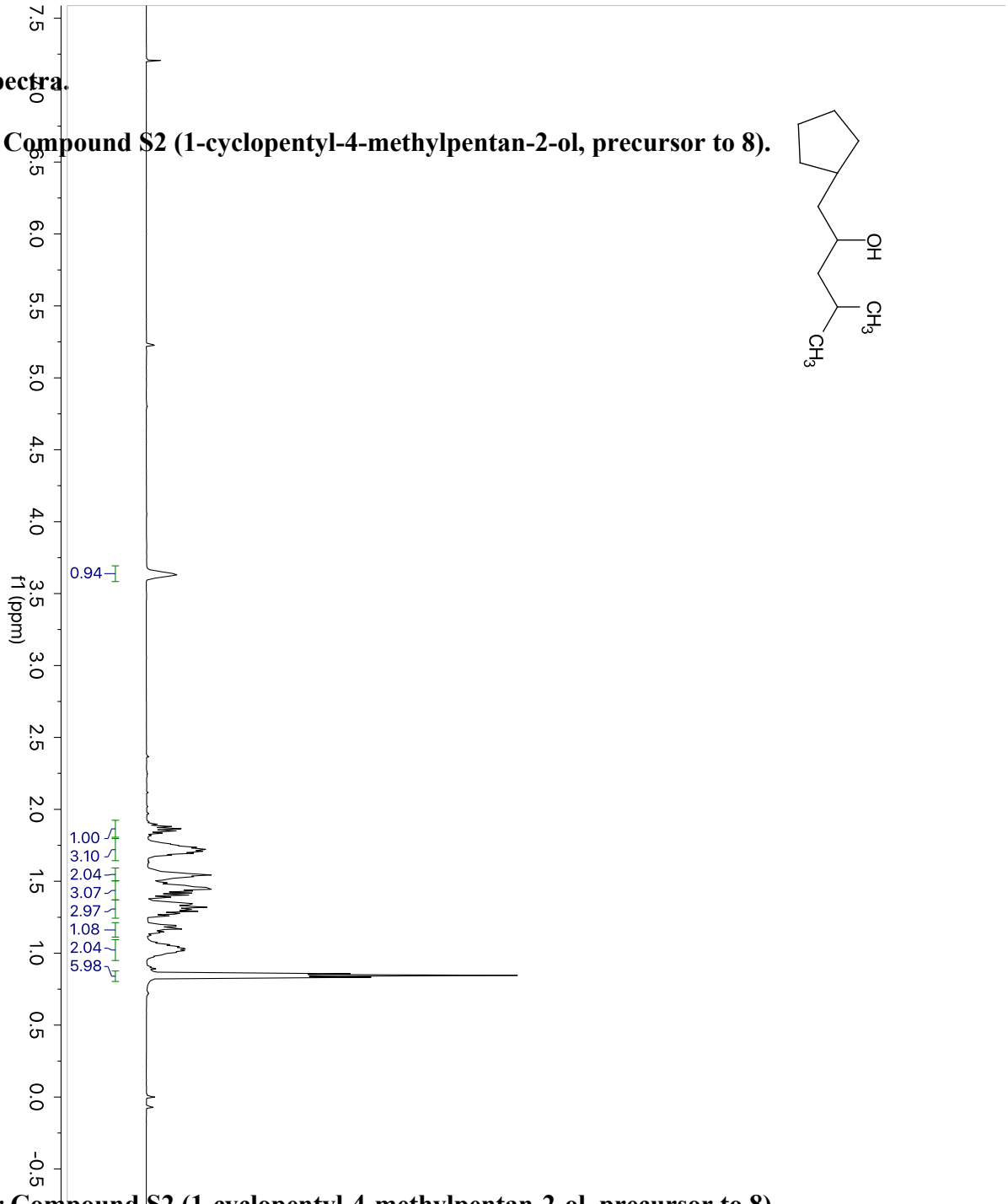
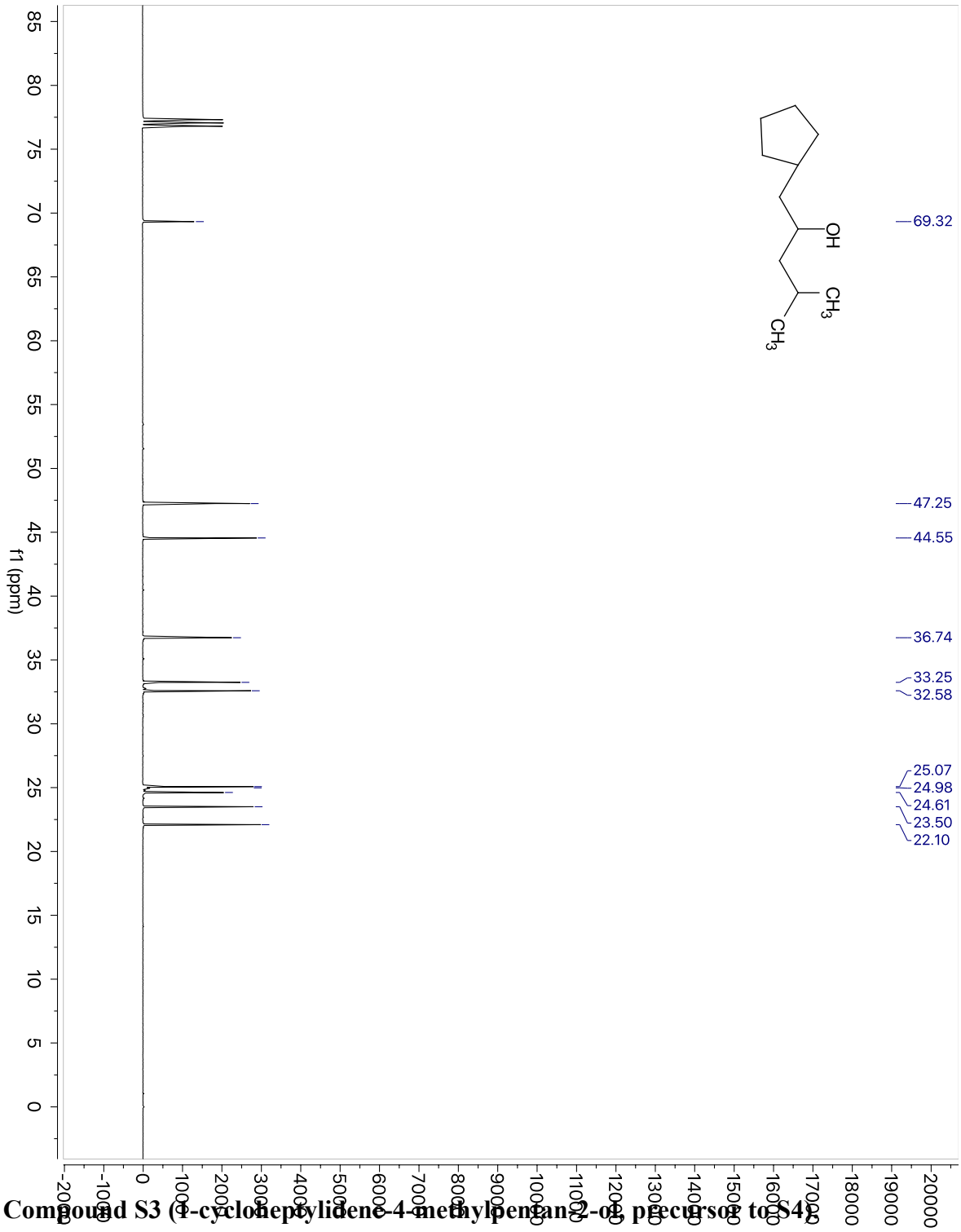
VII. NMR spectra.

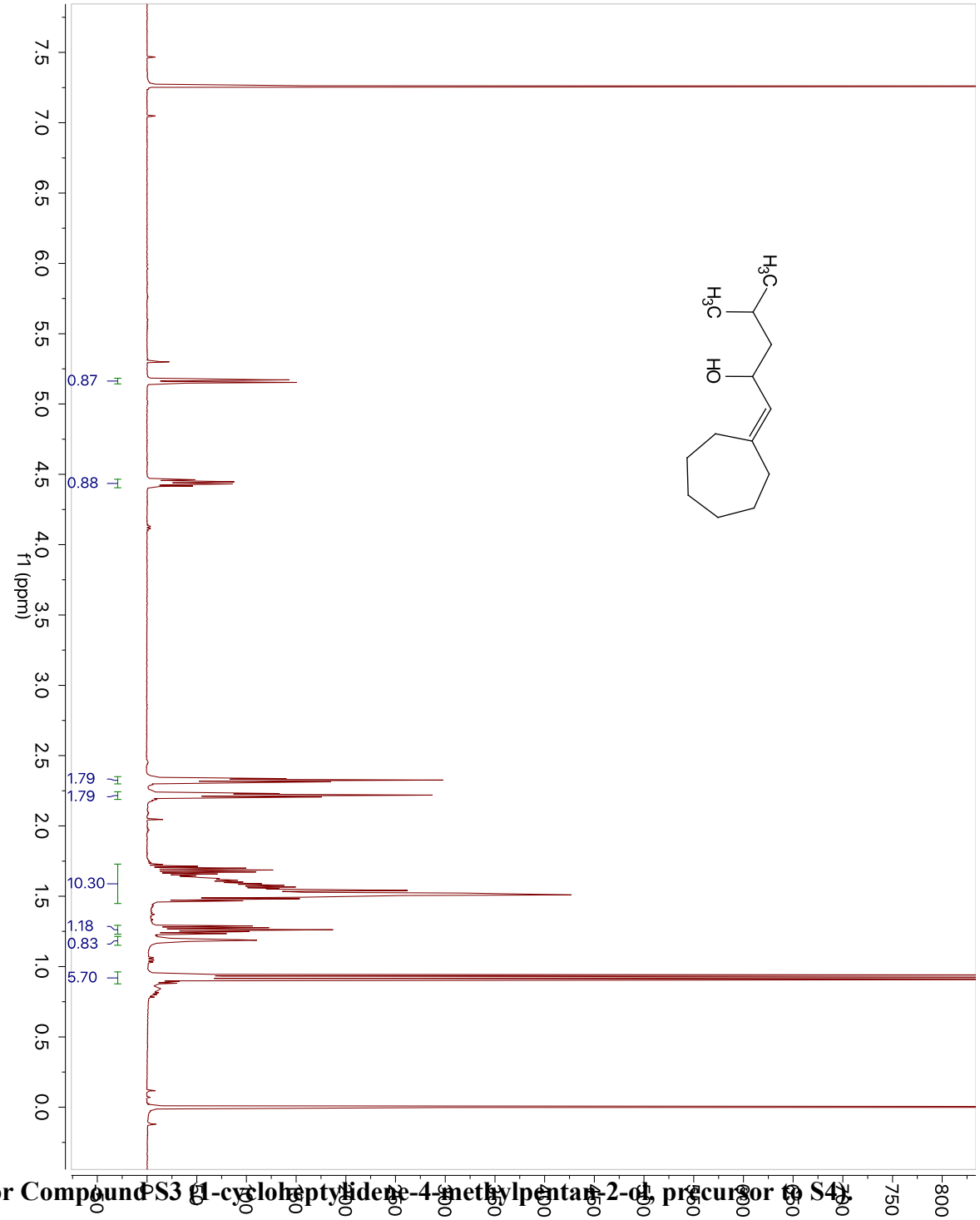
^{1}H NMR for Compound S2 (1-cyclopentyl-4-methylpentan-2-ol, precursor to 8).



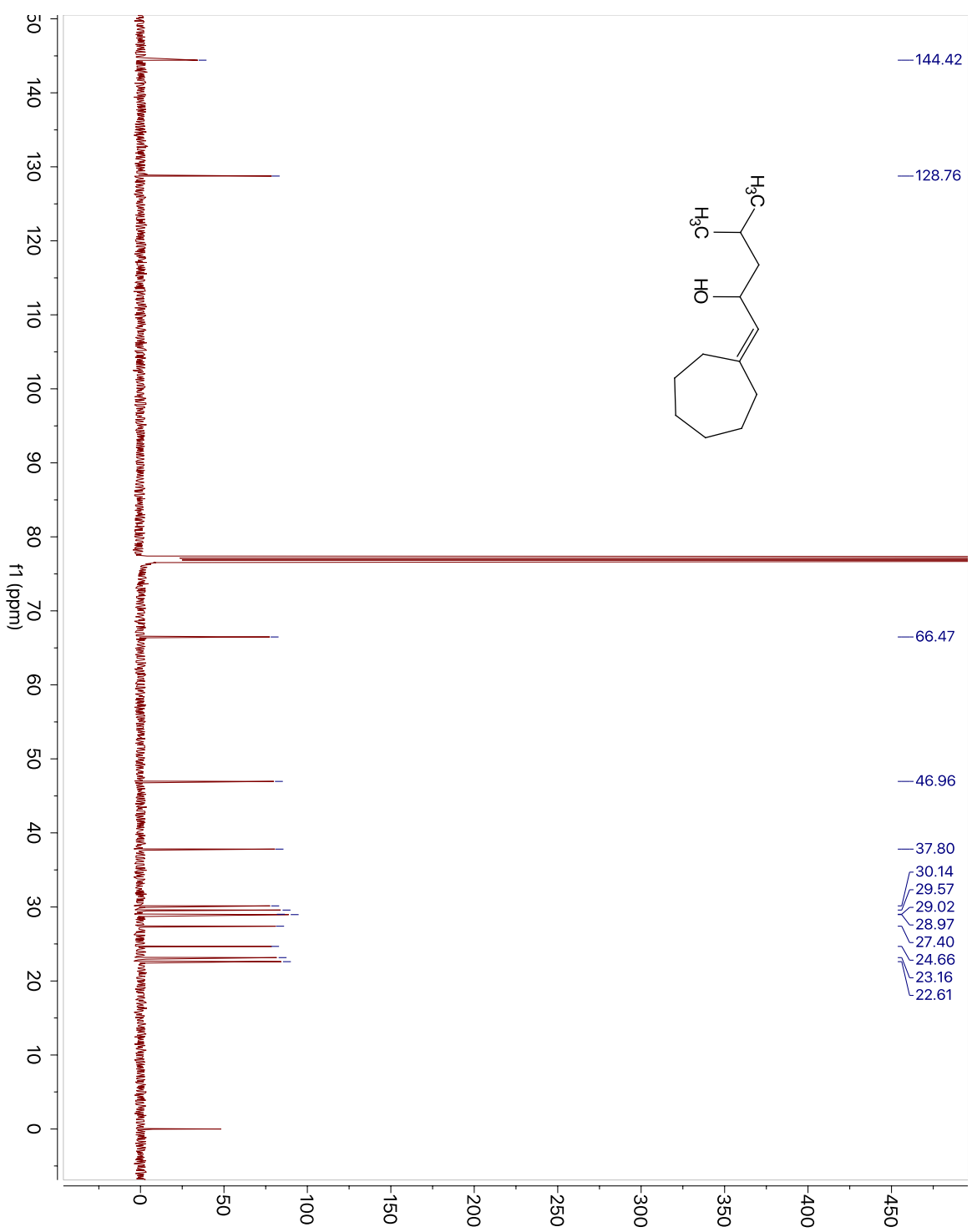
^{13}C NMR for Compound S2 (1-cyclopentyl-4-methylpentan-2-ol, precursor to 8).



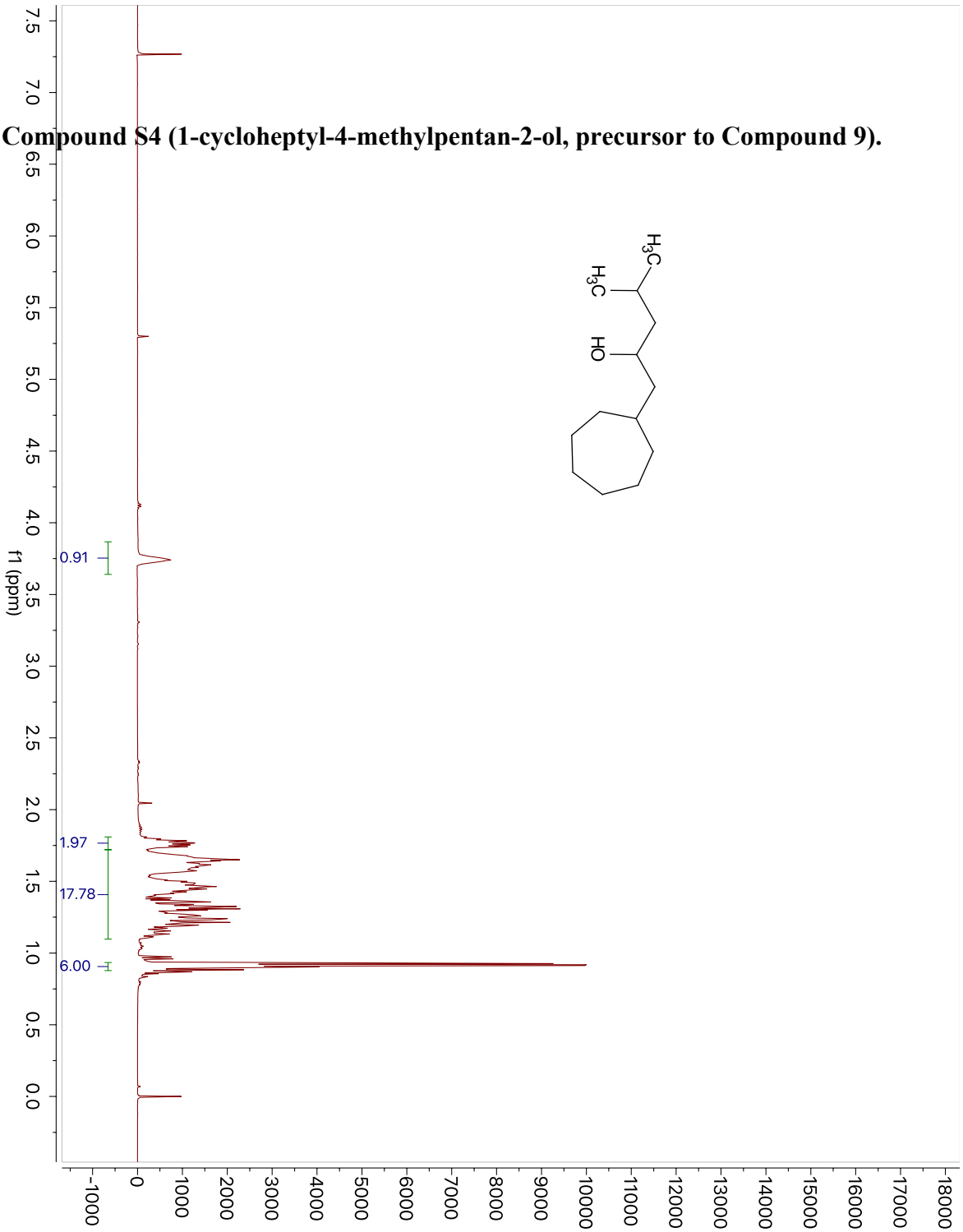
^{1}H NMR for Compound S3 (1-cycloheptylidene-4-methylpentan-2-ol, precursor to S4)



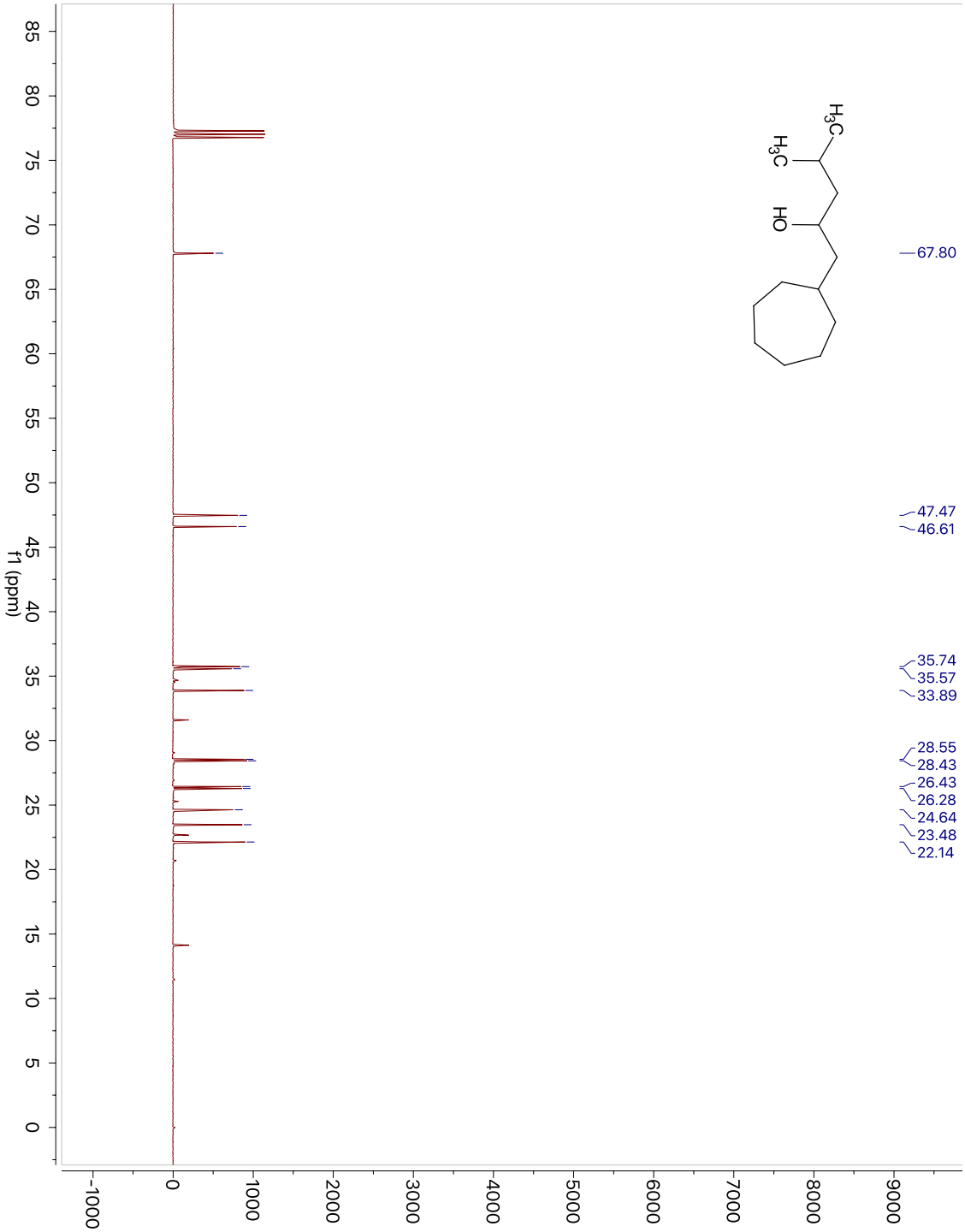
^{13}C NMR for Compound S3 (1-cycloheptylidene-4-methylpentan-2-ol, precursor to S4).


144.42
128.76
66.47
46.96
37.80
30.14
29.57
29.02
28.97
27.40
24.66
23.16
22.61
H3C
H3C
HO
f1 (ppm)

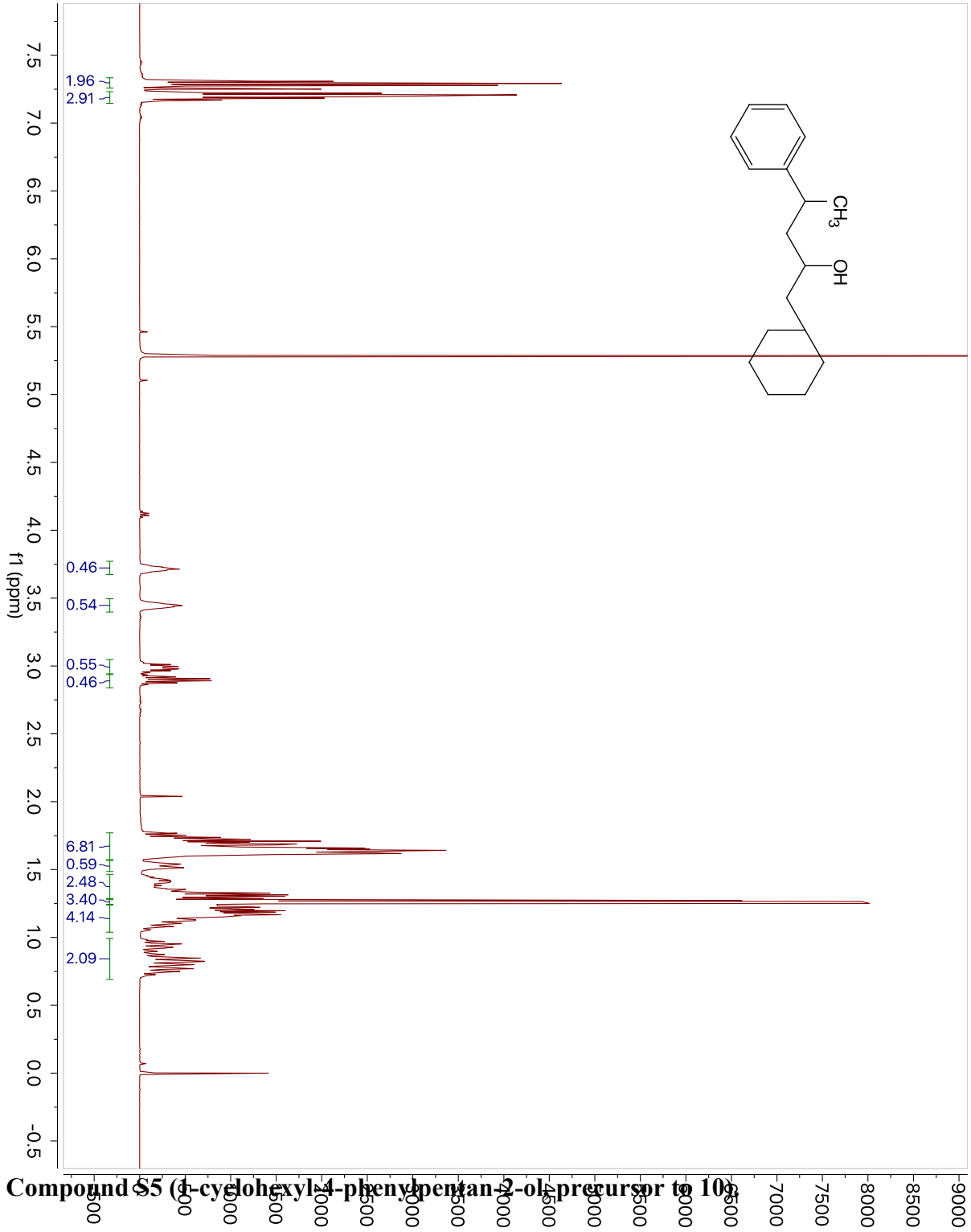
^{1}H NMR for Compound S4 (1-cycloheptyl-4-methylpentan-2-ol, precursor to Compound 9).



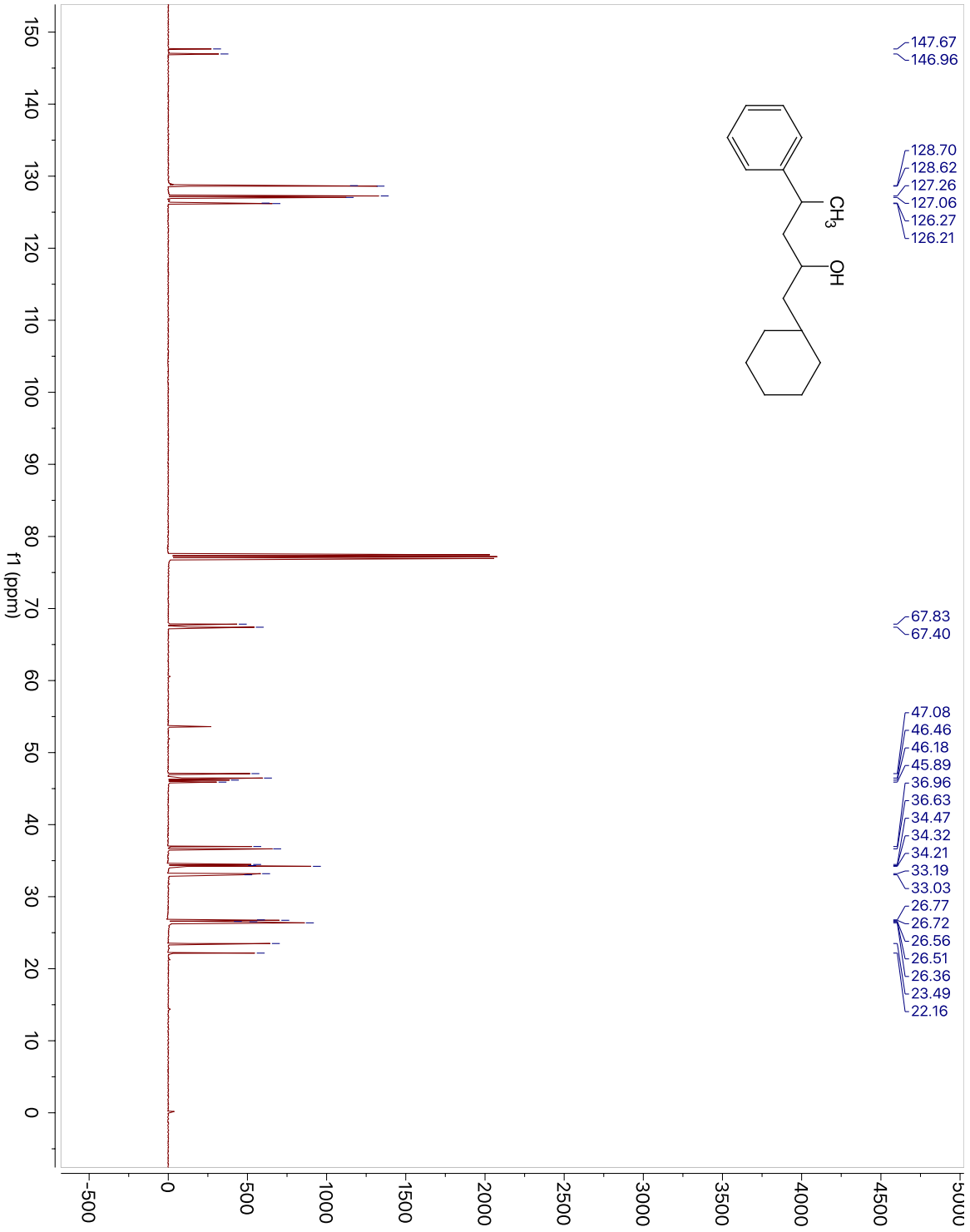
^{13}C NMR for Compound S4 (1-cycloheptyl-4-methylpentan-2-ol, precursor to 9).



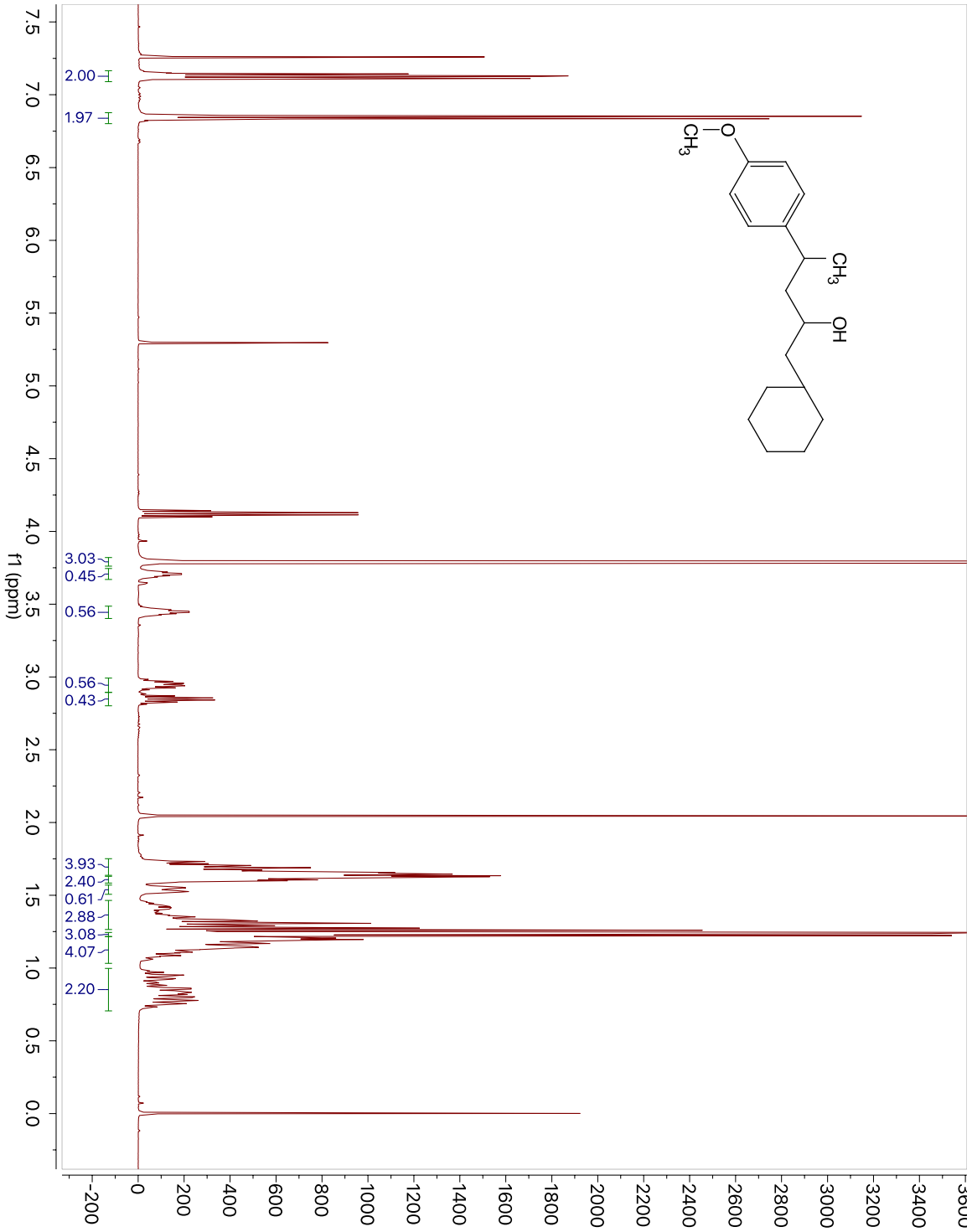
^{1}H NMR for Compound S5 (1-cyclohexyl-4-phenylpentan-2-ol, precursor to 10).



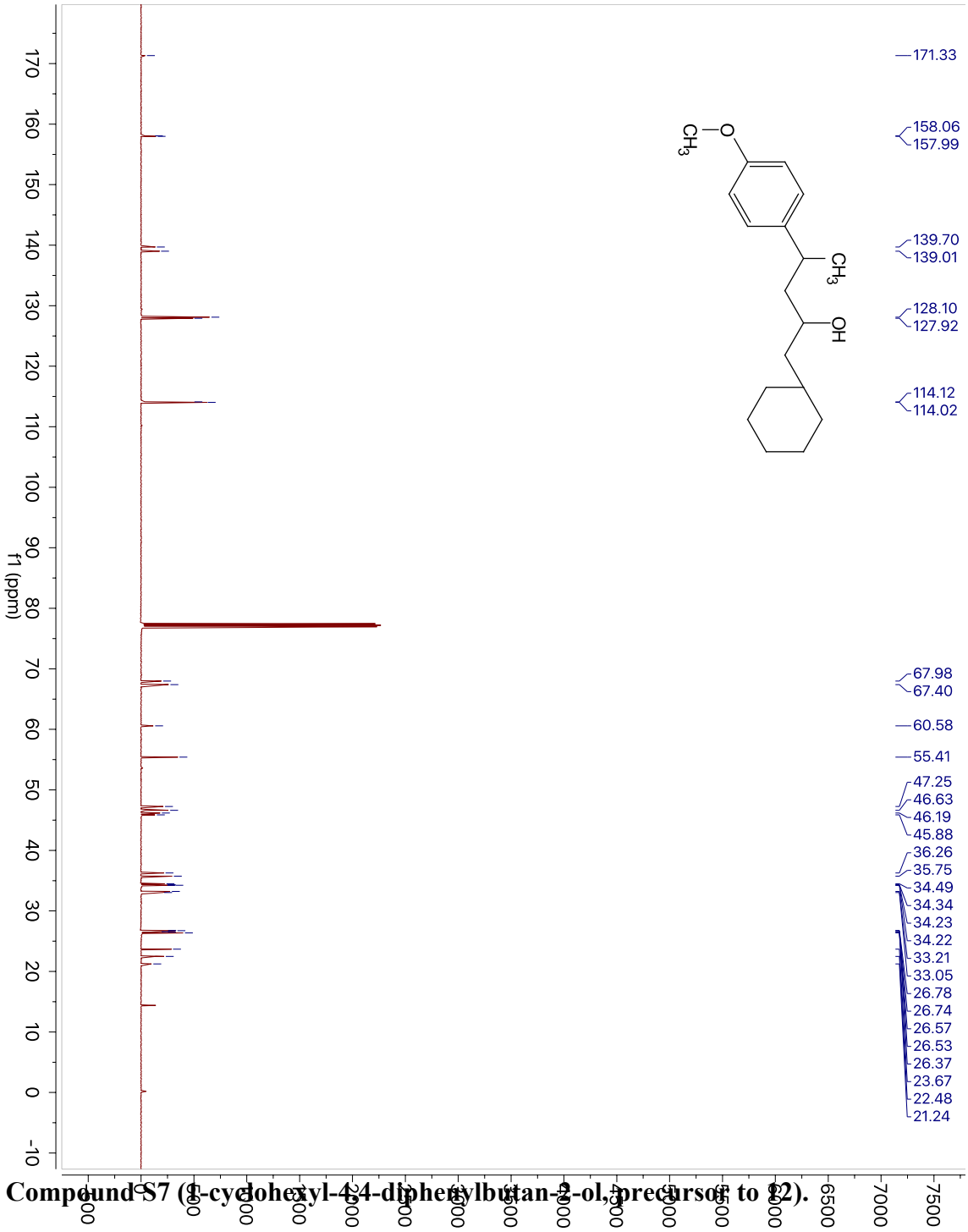
^{13}C NMR for Compound S5 (1-cyclohexyl-4-phenylpentan-2-ol, precursor to 10a)



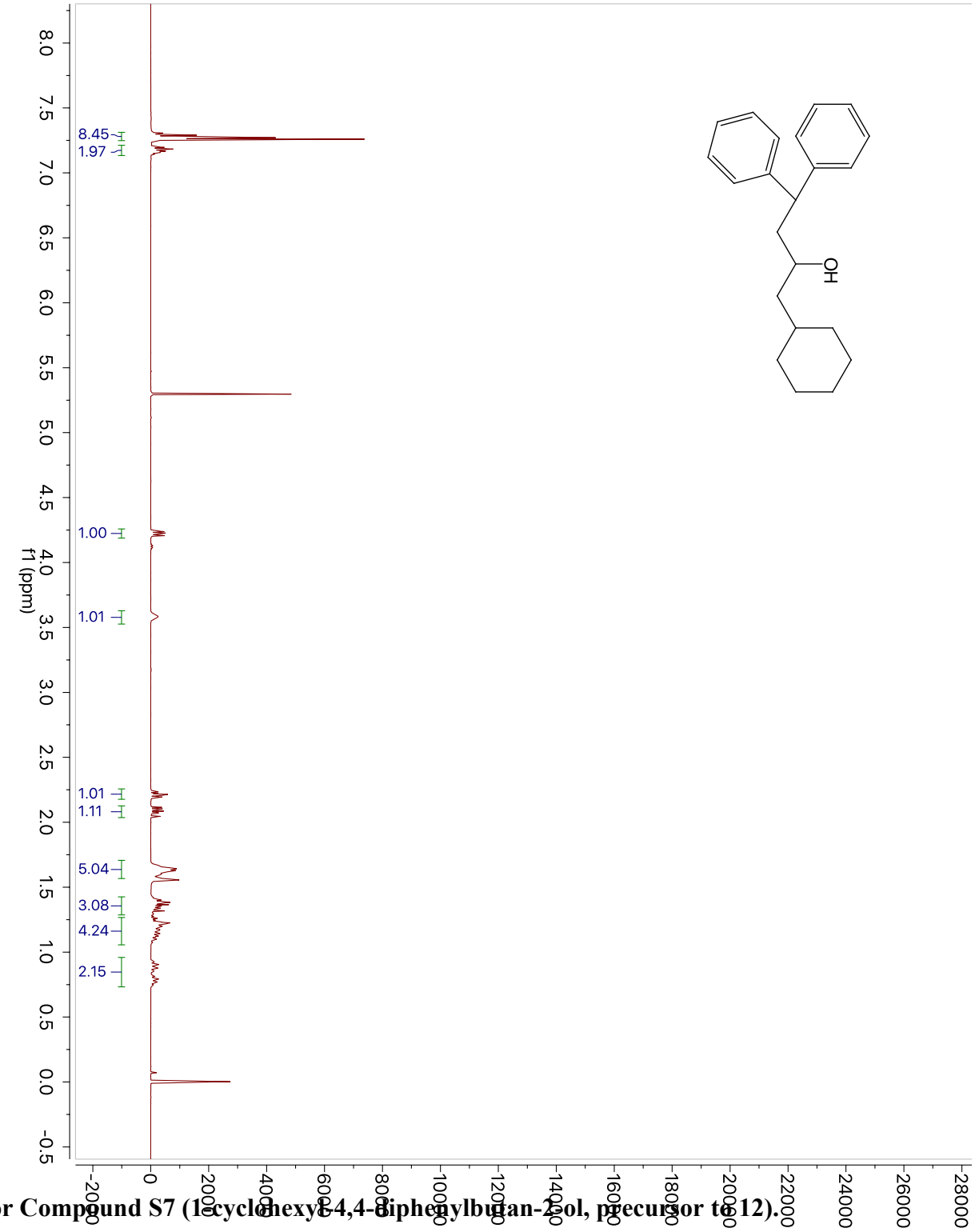
^{1}H NMR for Compound S6 (1-cyclohexyl-4-(4-methoxyphenyl)pentan-2-ol, precursor to 11).



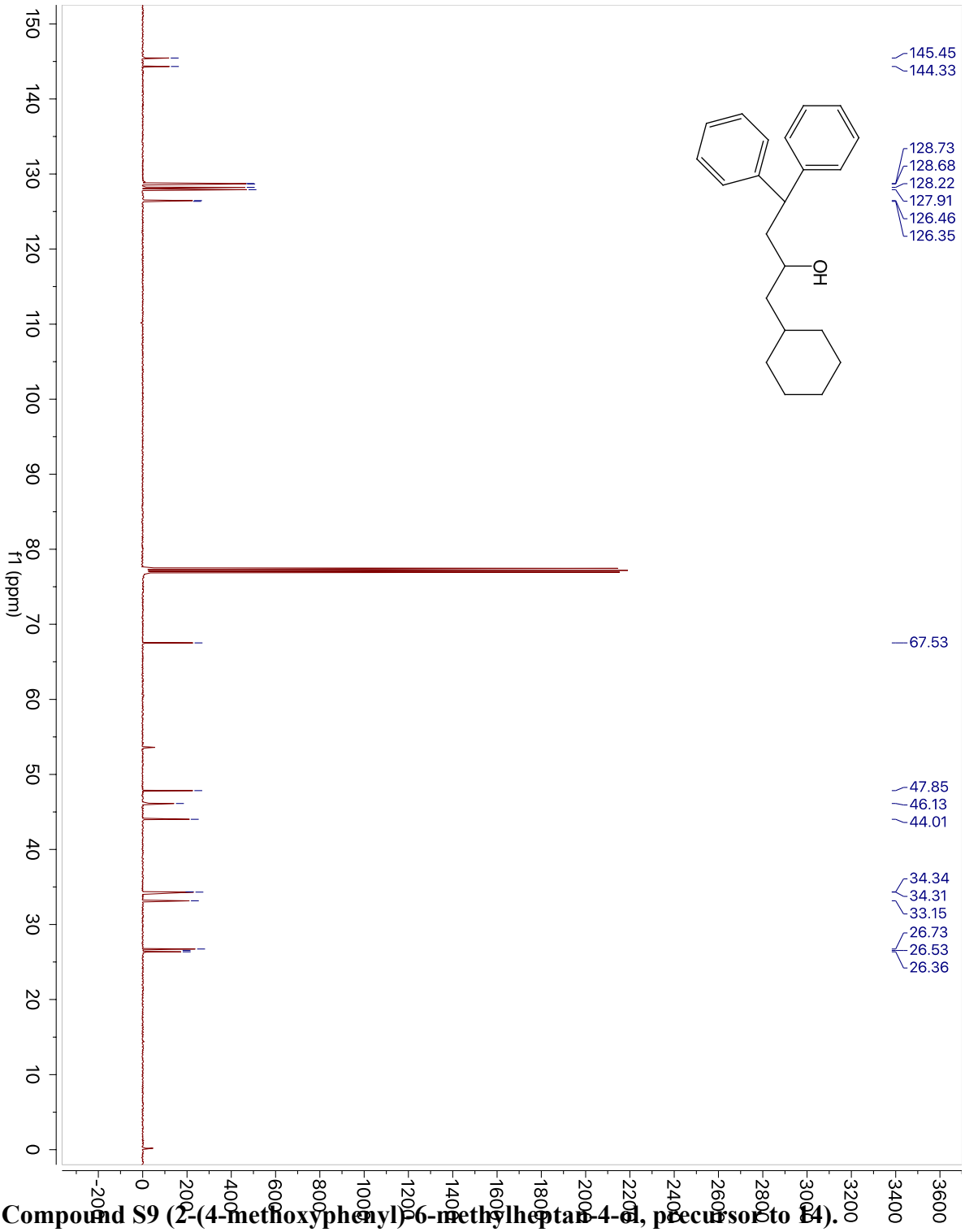
^{13}C NMR for Compound S6 (1-cyclohexyl-4-(4-methoxyphenyl)pentan-2-ol, precursor to 11).



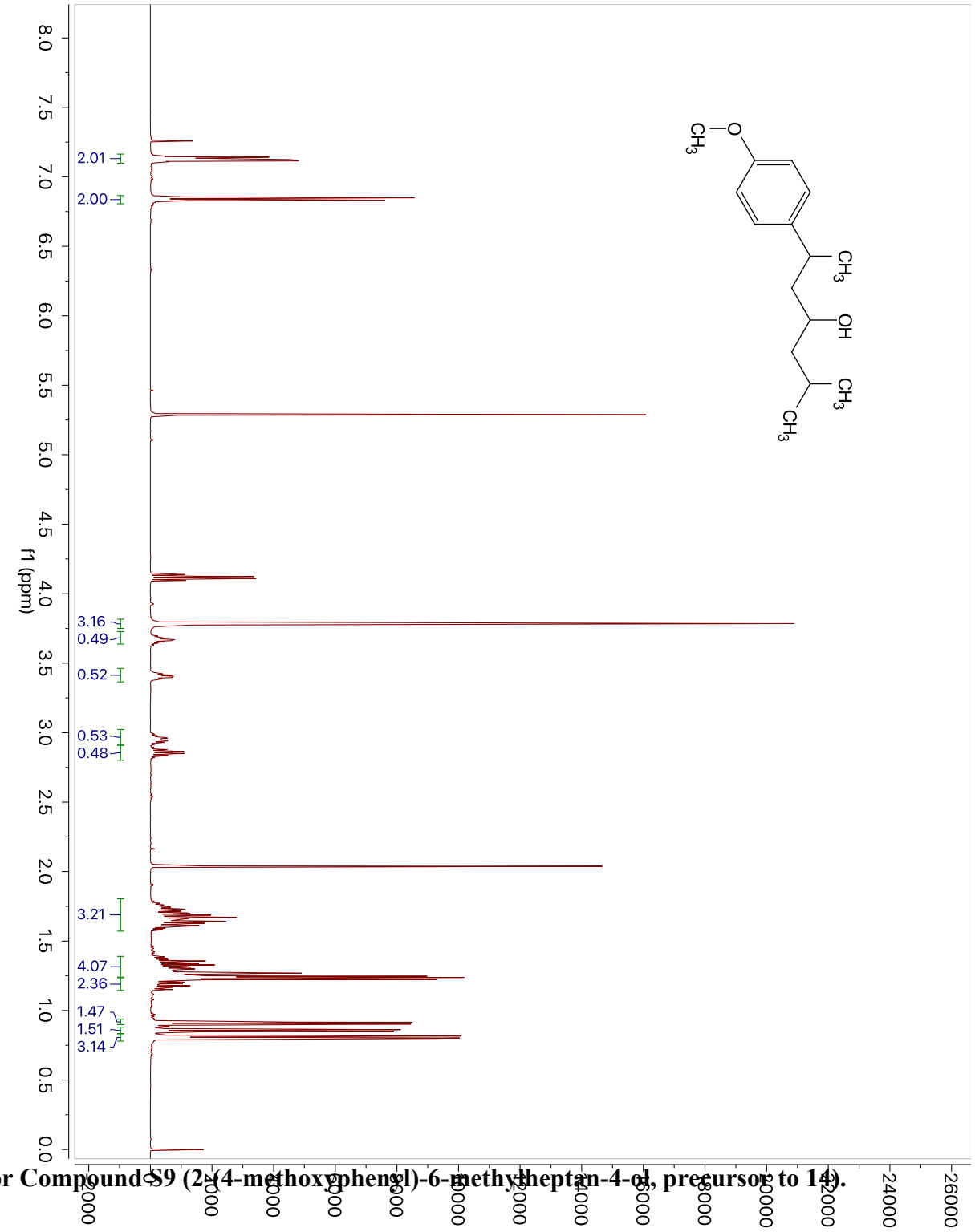
^{1}H NMR for Compound S7 (1-cyclohexyl-4,4-diphenylbutan-2-ol, precursor to 22).



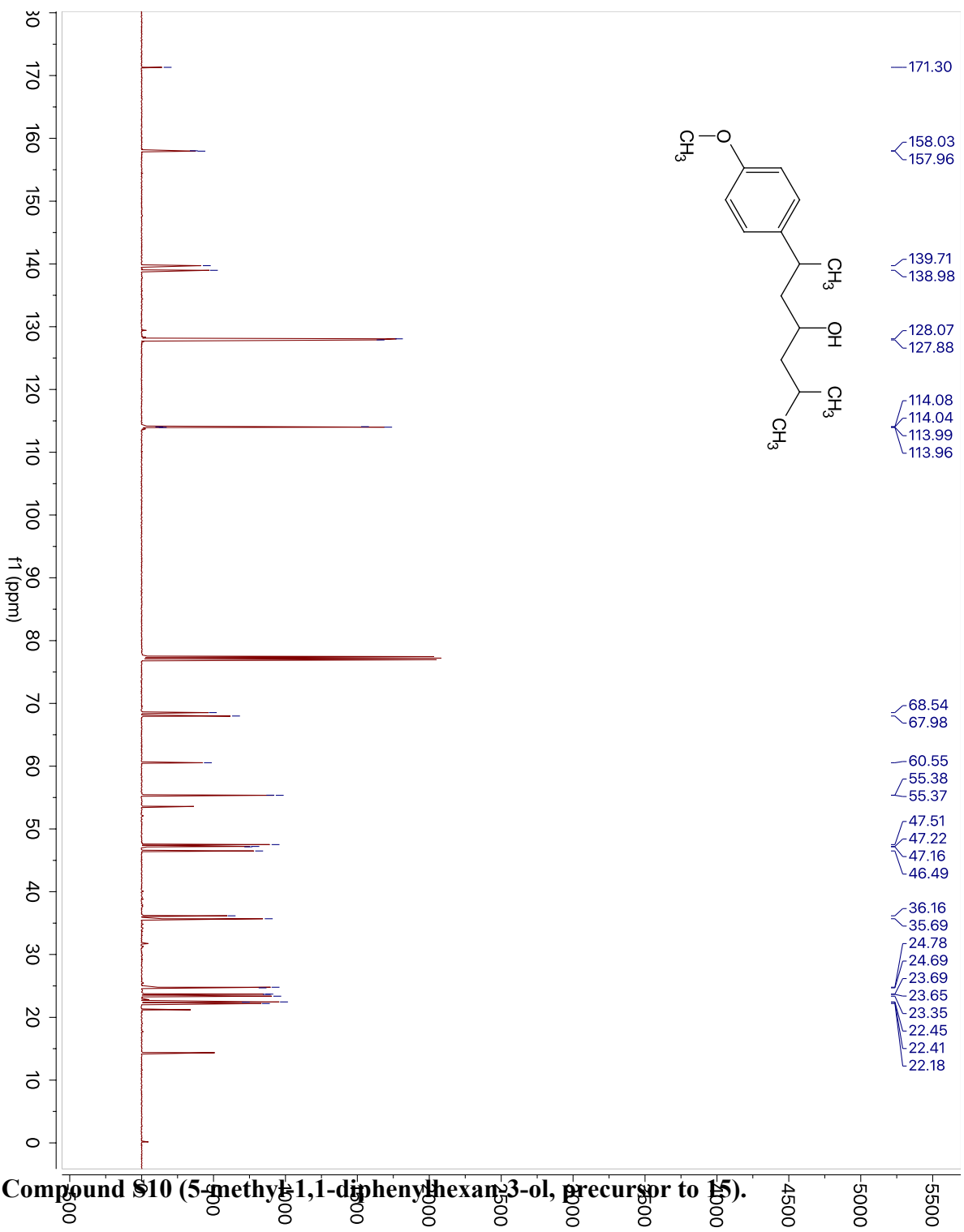
^{13}C NMR for Compound S7 (1-cyclohexyl-4,4-diphenylbutan-2-ol, precursor to 12).



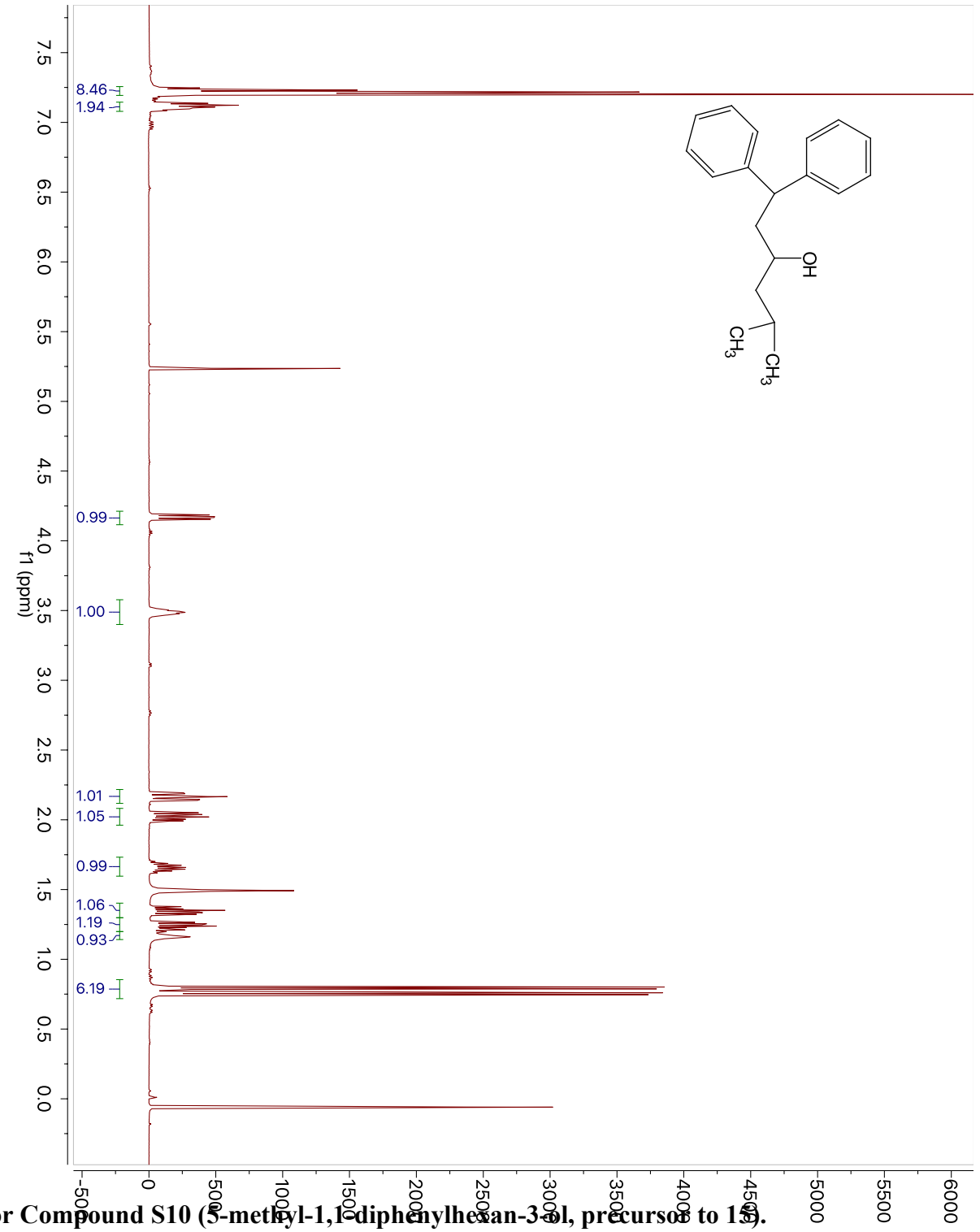
^{1}H NMR for Compound S9 (2-(4-methoxyphenyl)-6-methylheptan-4-ol, precursor to 14).



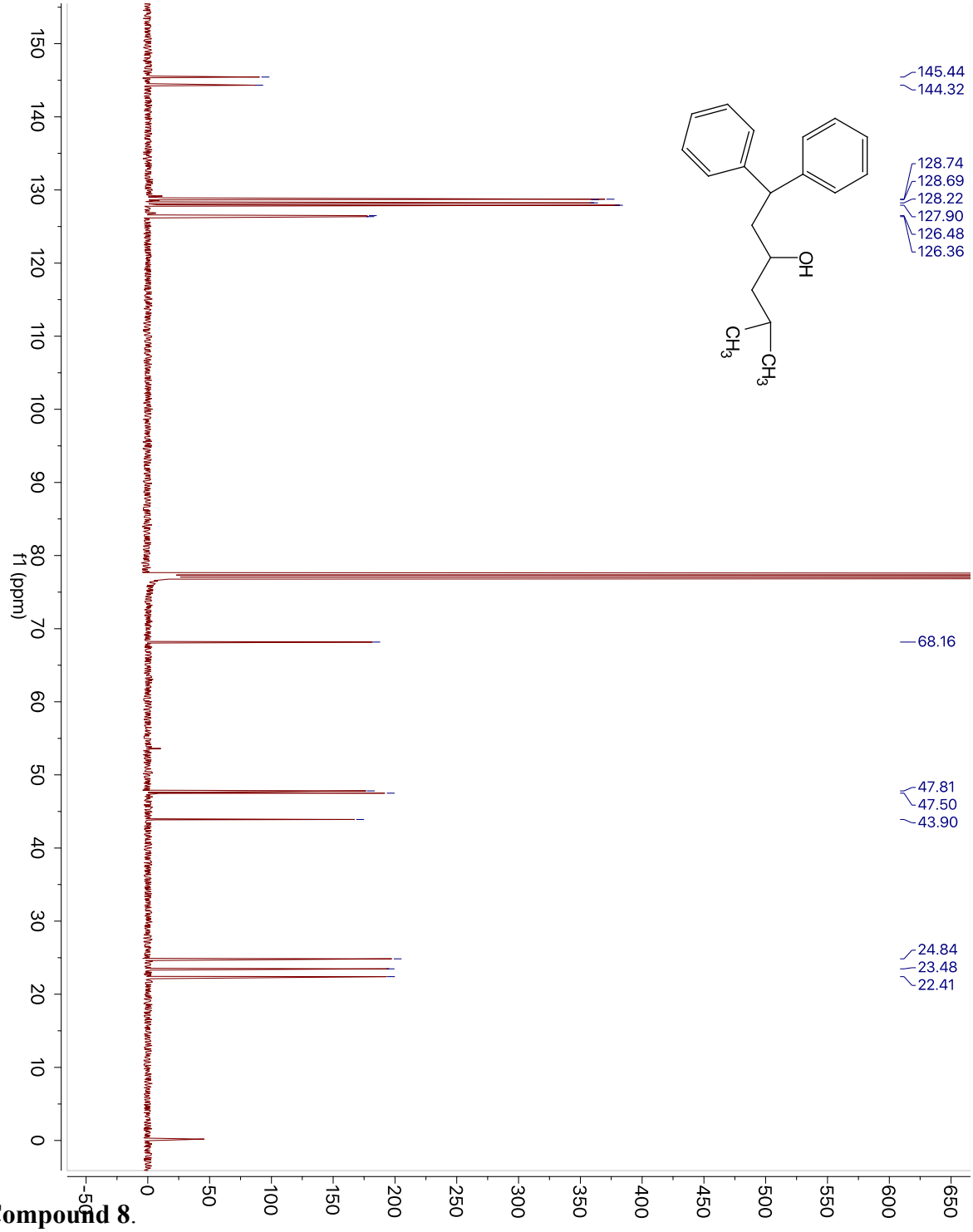
^{13}C NMR for Compound S9 (2-(4-methoxyphenyl)-6-methylheptan-4-ol, precursor to 14).



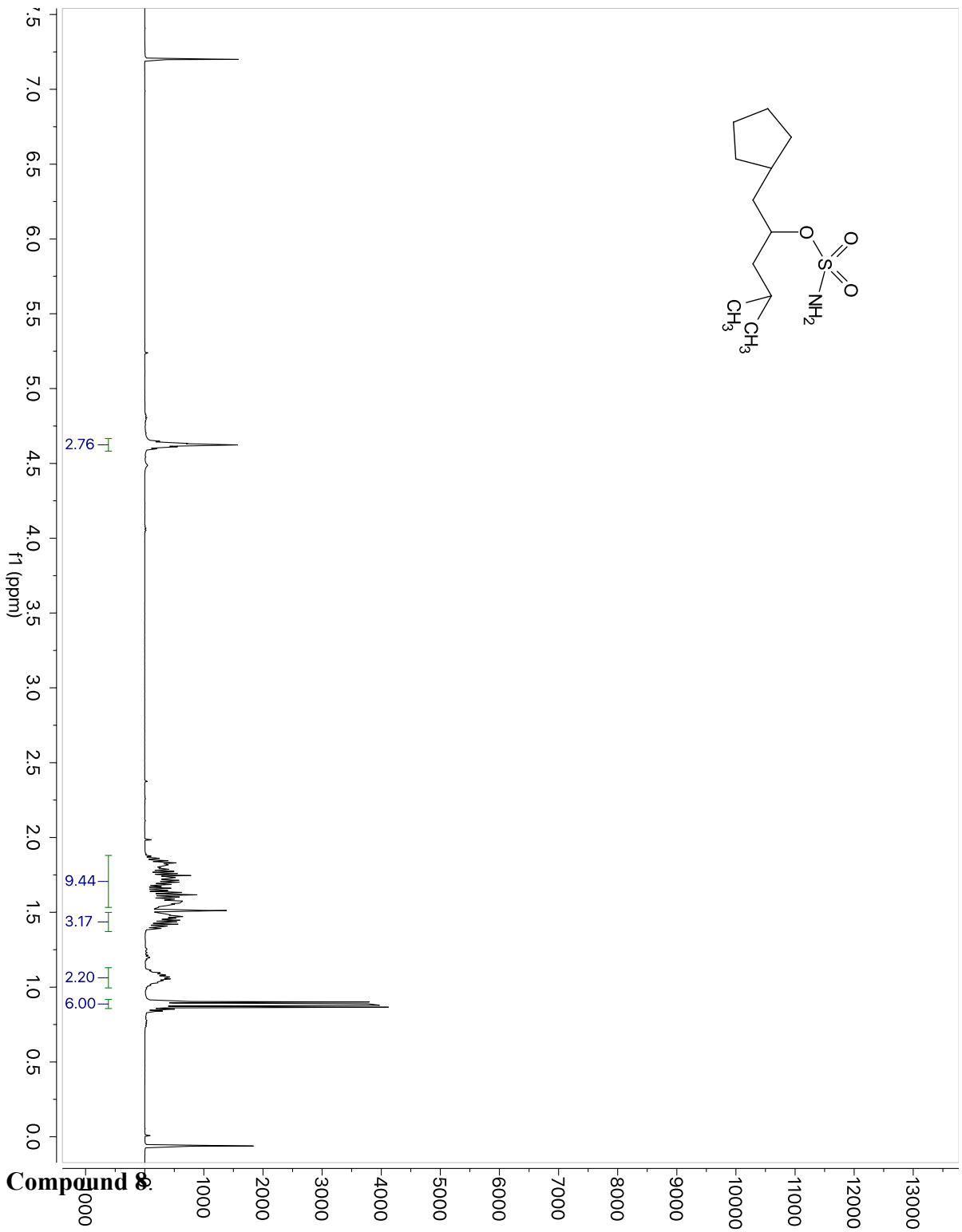
^{1}H NMR for Compound S10 (5-methyl-1,1-diphenylhexan-3-ol, precursor to 15).



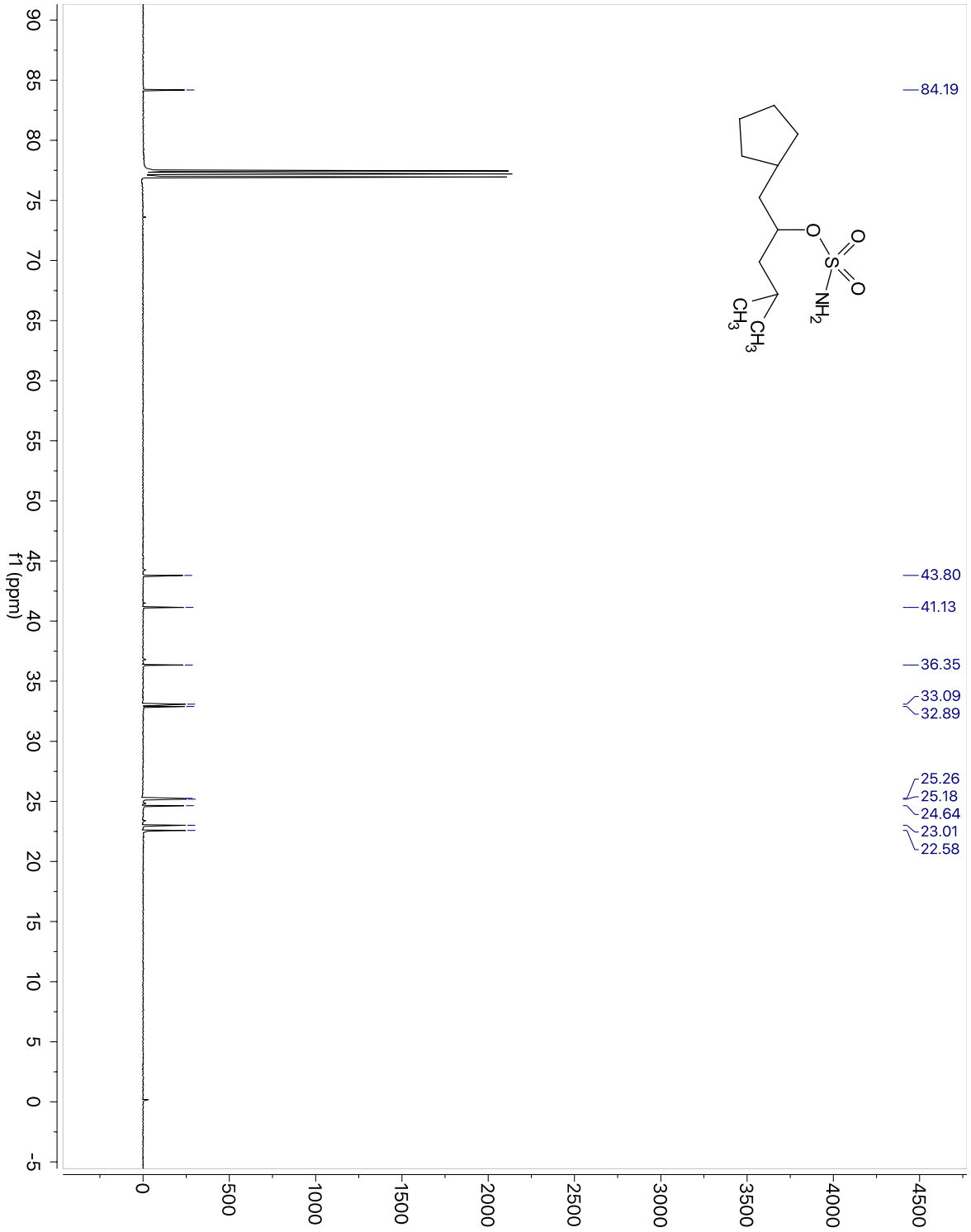
^{13}C NMR for Compound S10 (5-methyl-1,1-diphenylhexan-3-ol, precursor to 15).



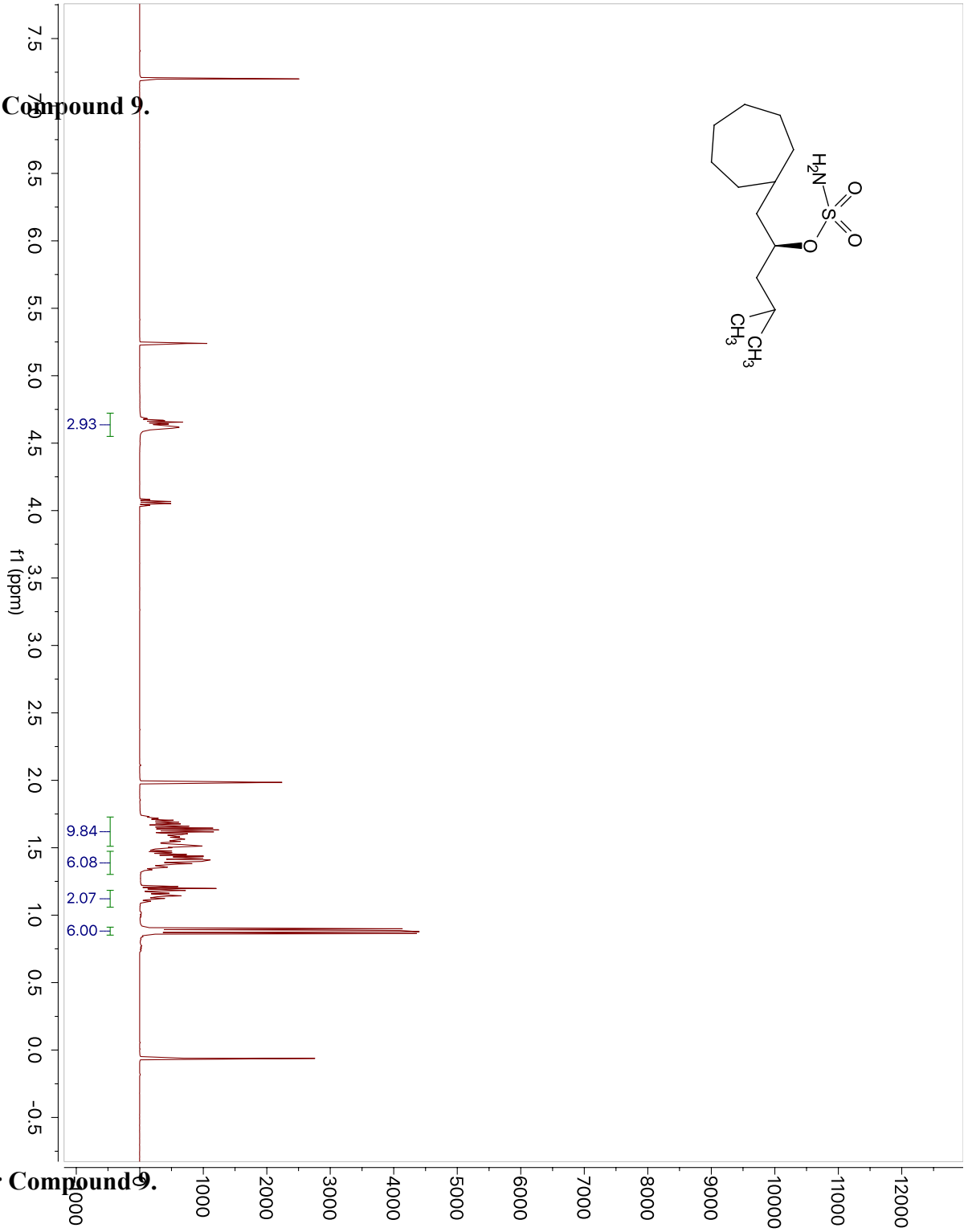
^{1}H NMR for Compound 8.



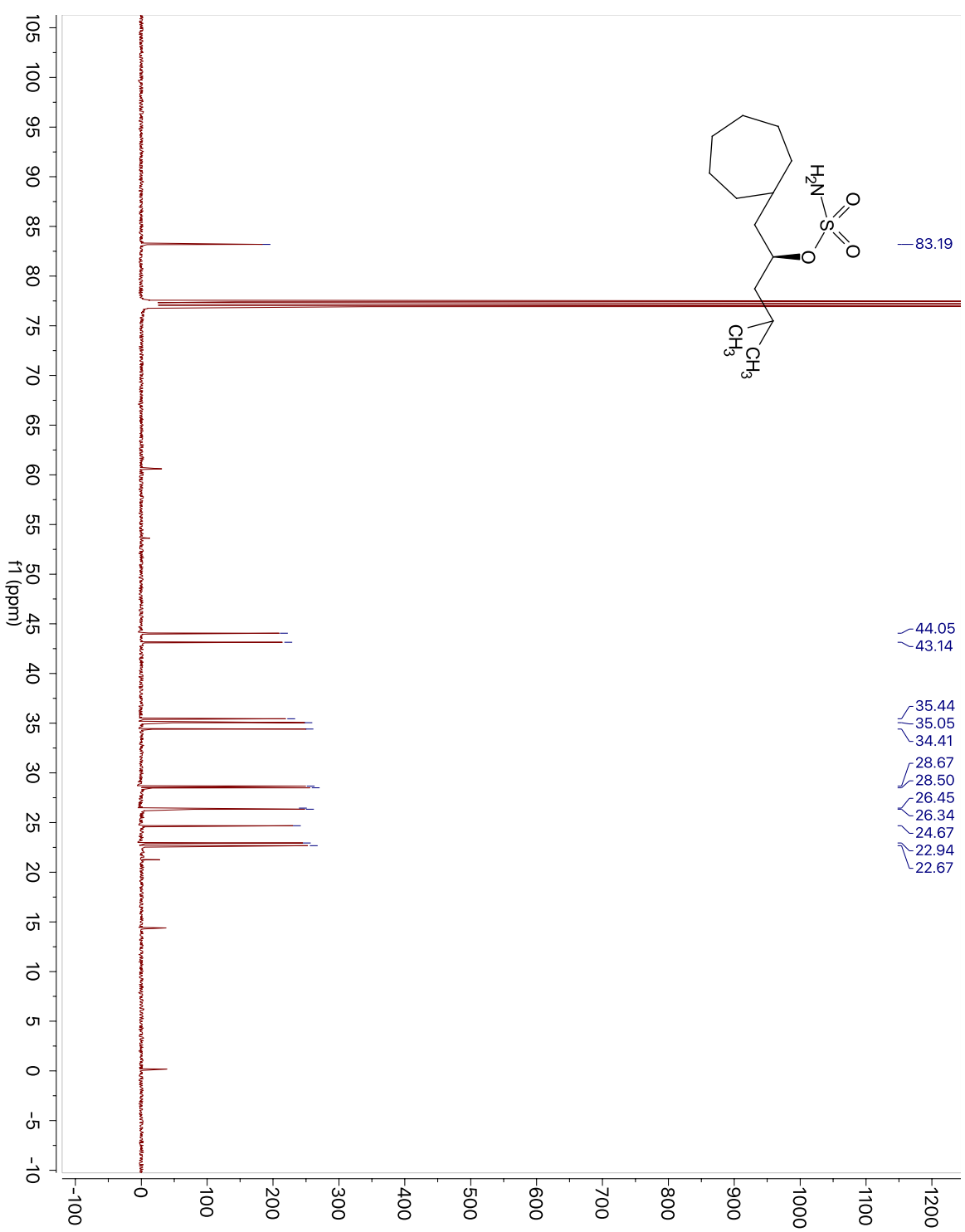
^{13}C NMR for Compound 8.


84.19
43.80
41.13
36.35
33.09
32.89
25.26
25.18
24.64
23.01
22.58
f1 (ppm)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
0
500
1000
1500
2000
2500
3000
3500
4000
4500
O
O
S
O
NH2
O
CH3
CH3

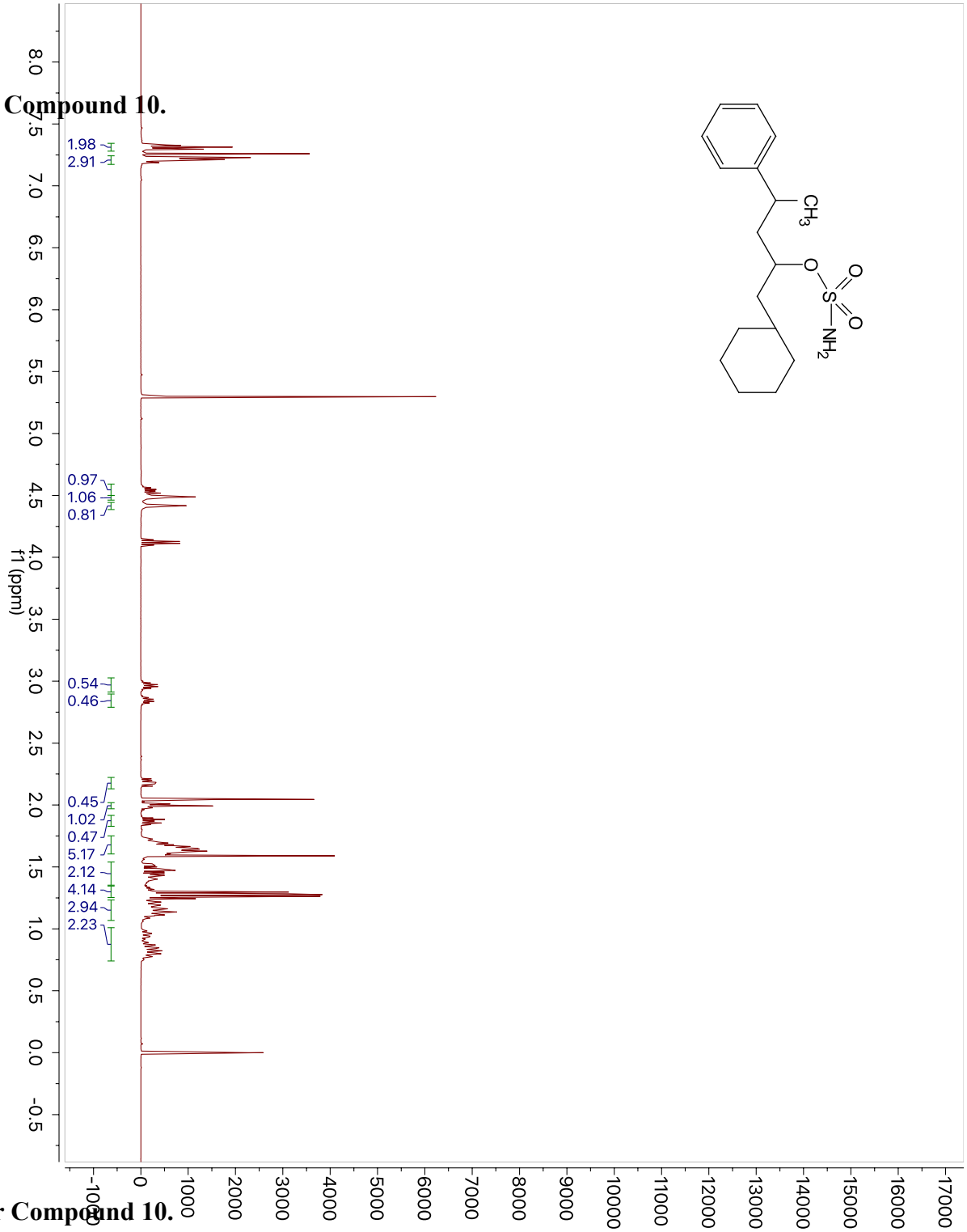
^{1}H NMR for Compound 9.



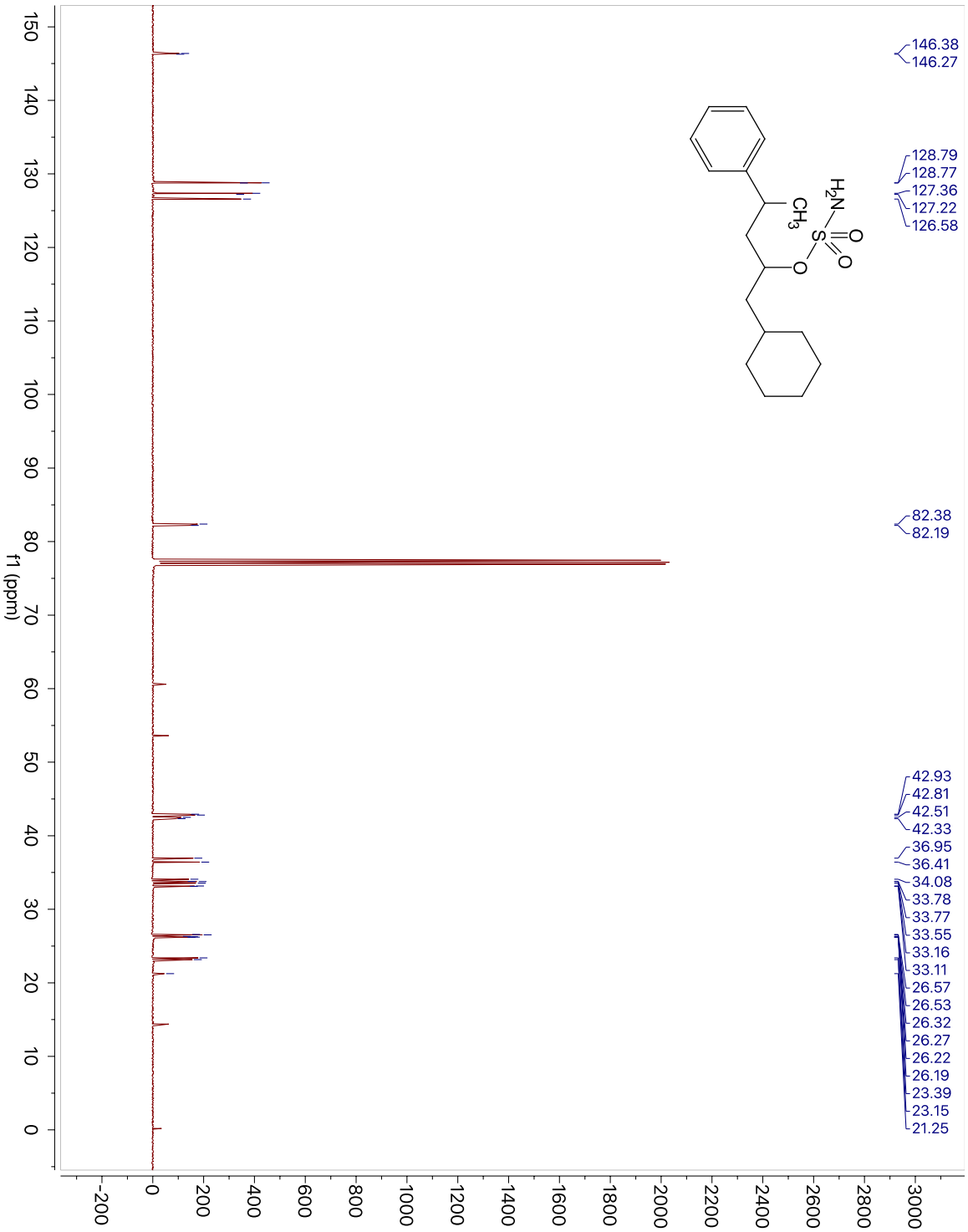
^{13}C NMR for Compound 9.


83.19
44.05
43.14
35.44
35.05
34.41
28.67
28.50
26.45
26.34
24.67
22.94
22.67
f1 (ppm)

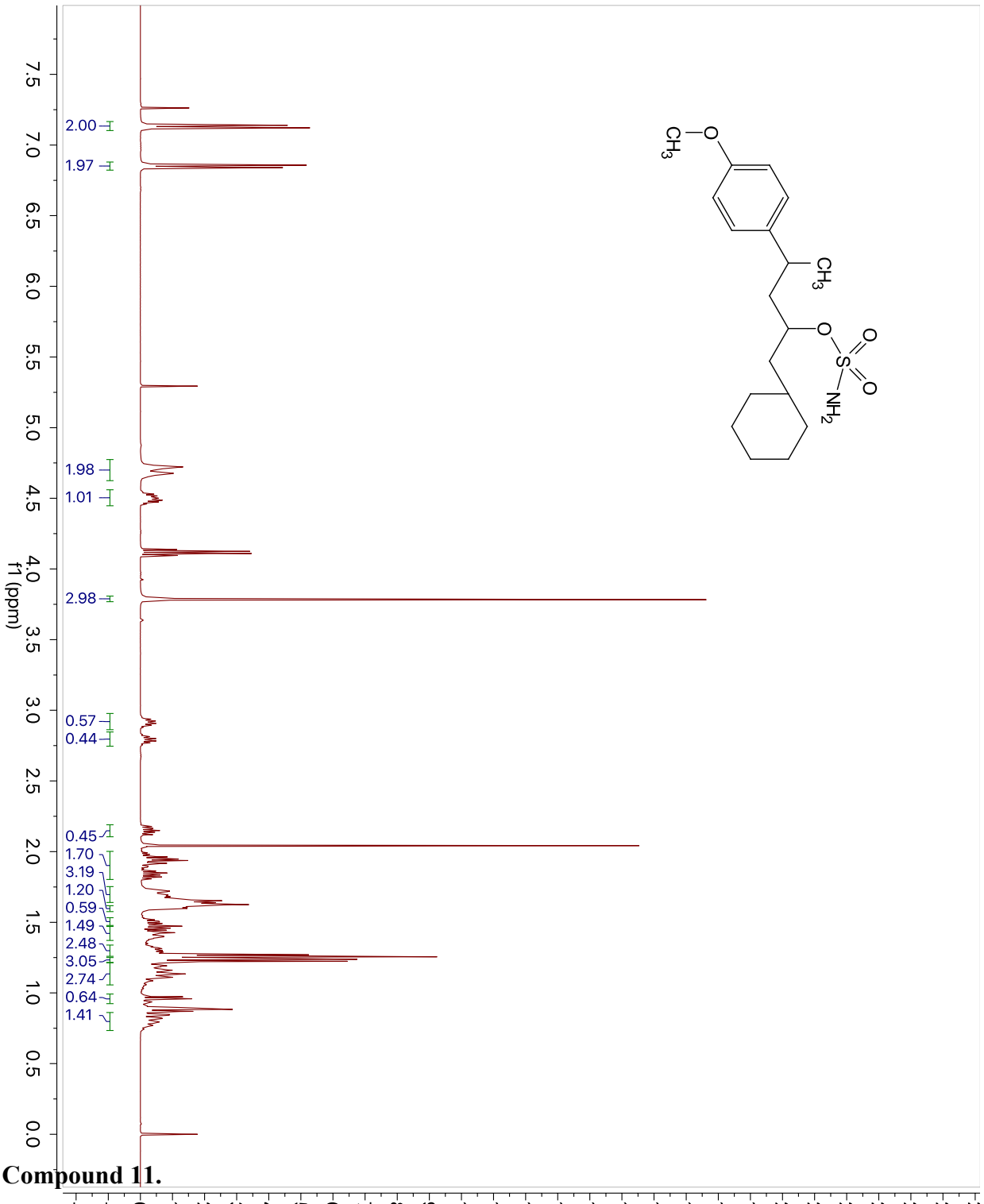
[1]H NMR for Compound 10.



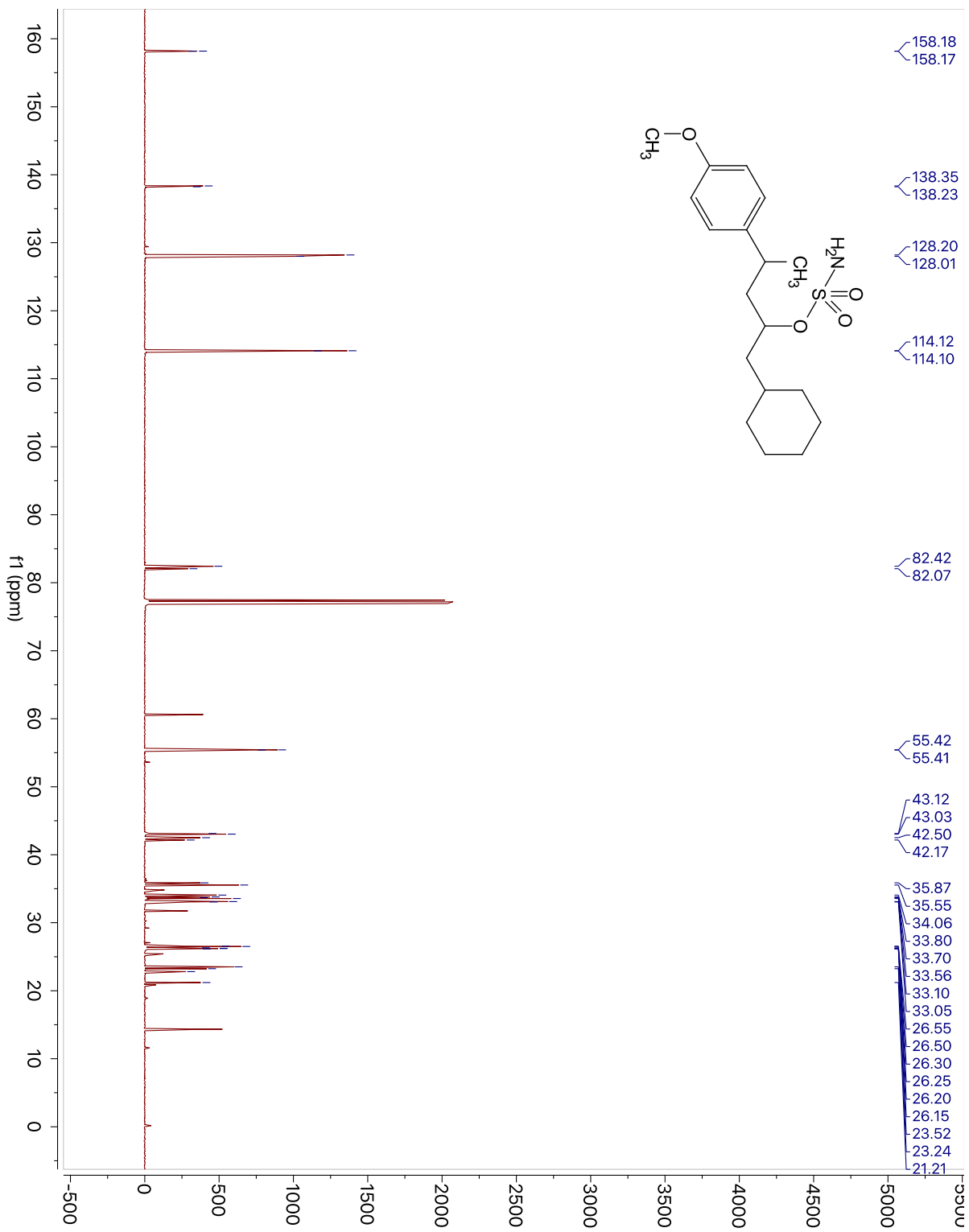
[13]C NMR for Compound 10.



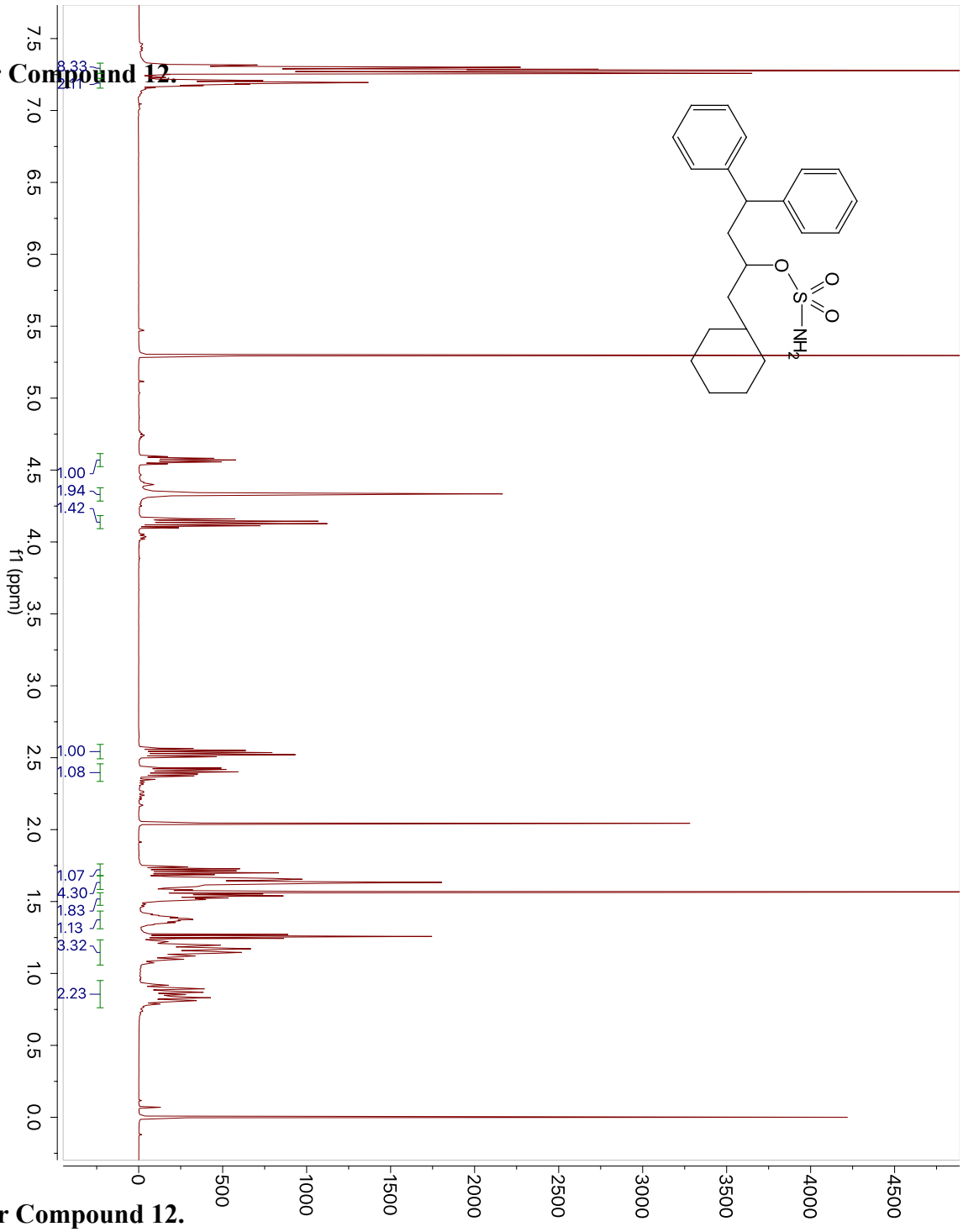
[1]H NMR for Compound 11.



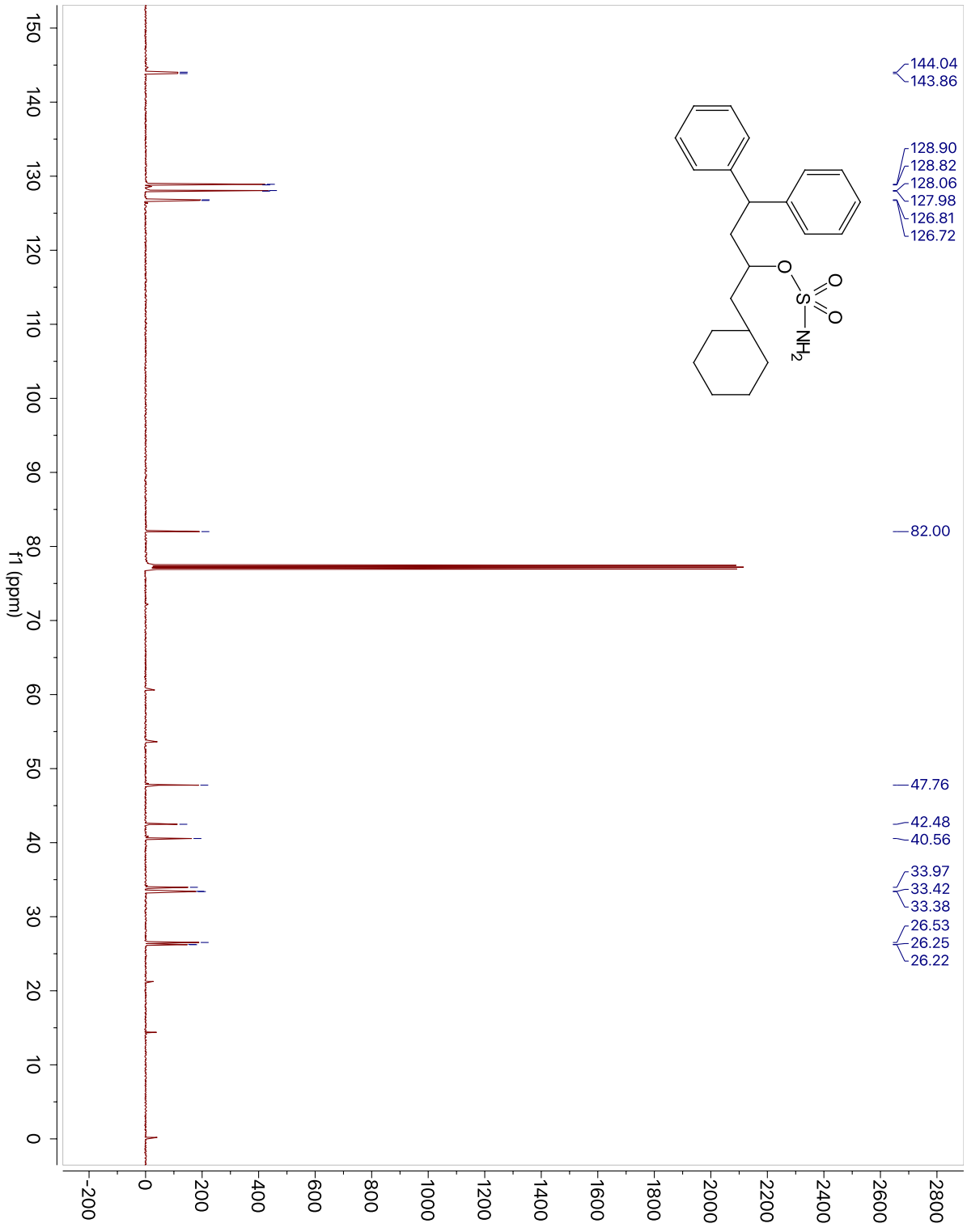
^{13}C NMR for Compound 11.


158.18
158.17
138.35
138.23
128.20
128.01
114.12
114.10
82.42
82.07
55.42
55.41
43.12
43.03
42.50
42.17
35.87
35.55
34.06
33.80
33.70
33.56
33.10
33.05
26.55
26.50
26.30
26.25
26.20
26.15
23.52
23.24
21.21
f1 (ppm)

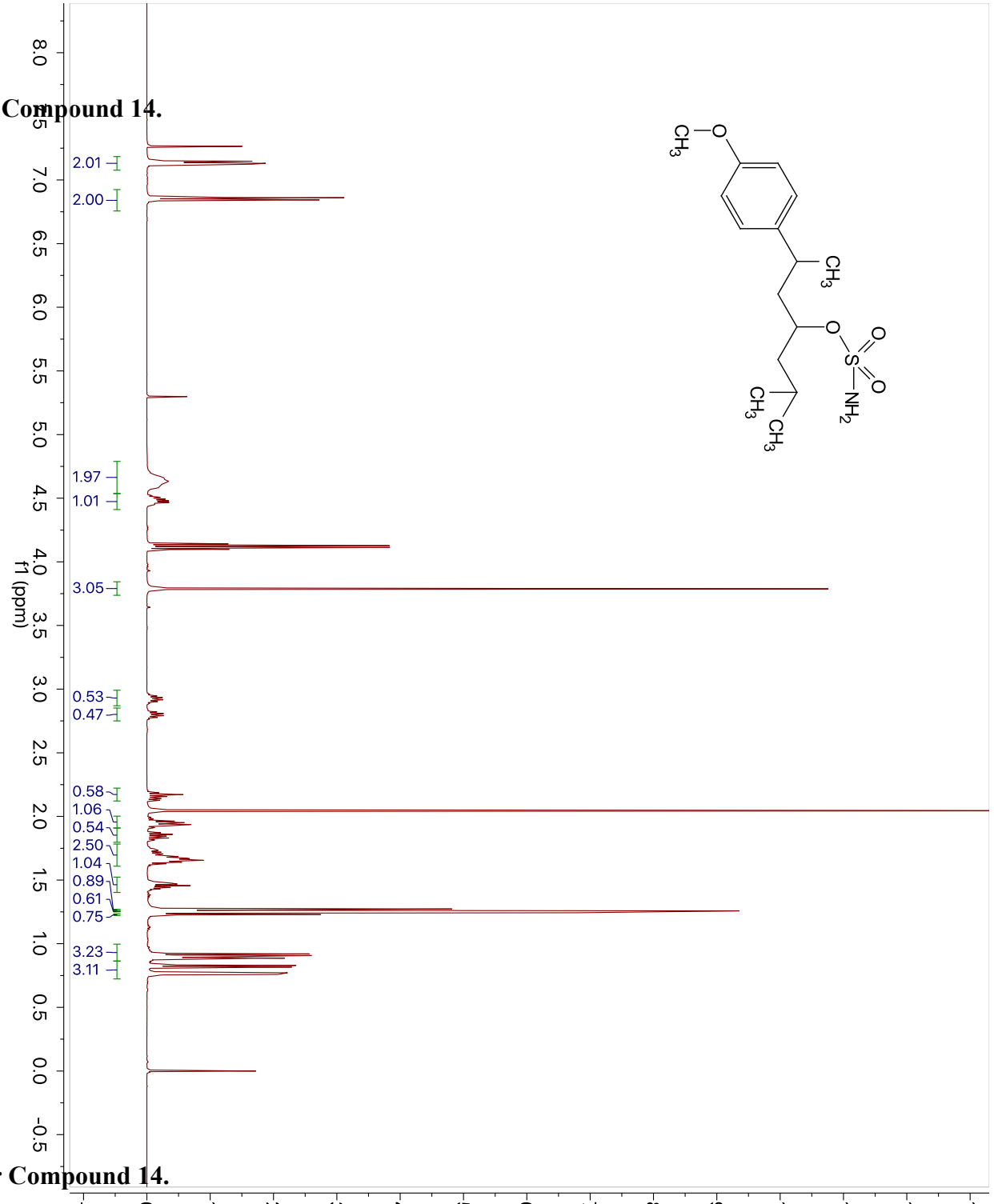
[1]H NMR for Compound 12.



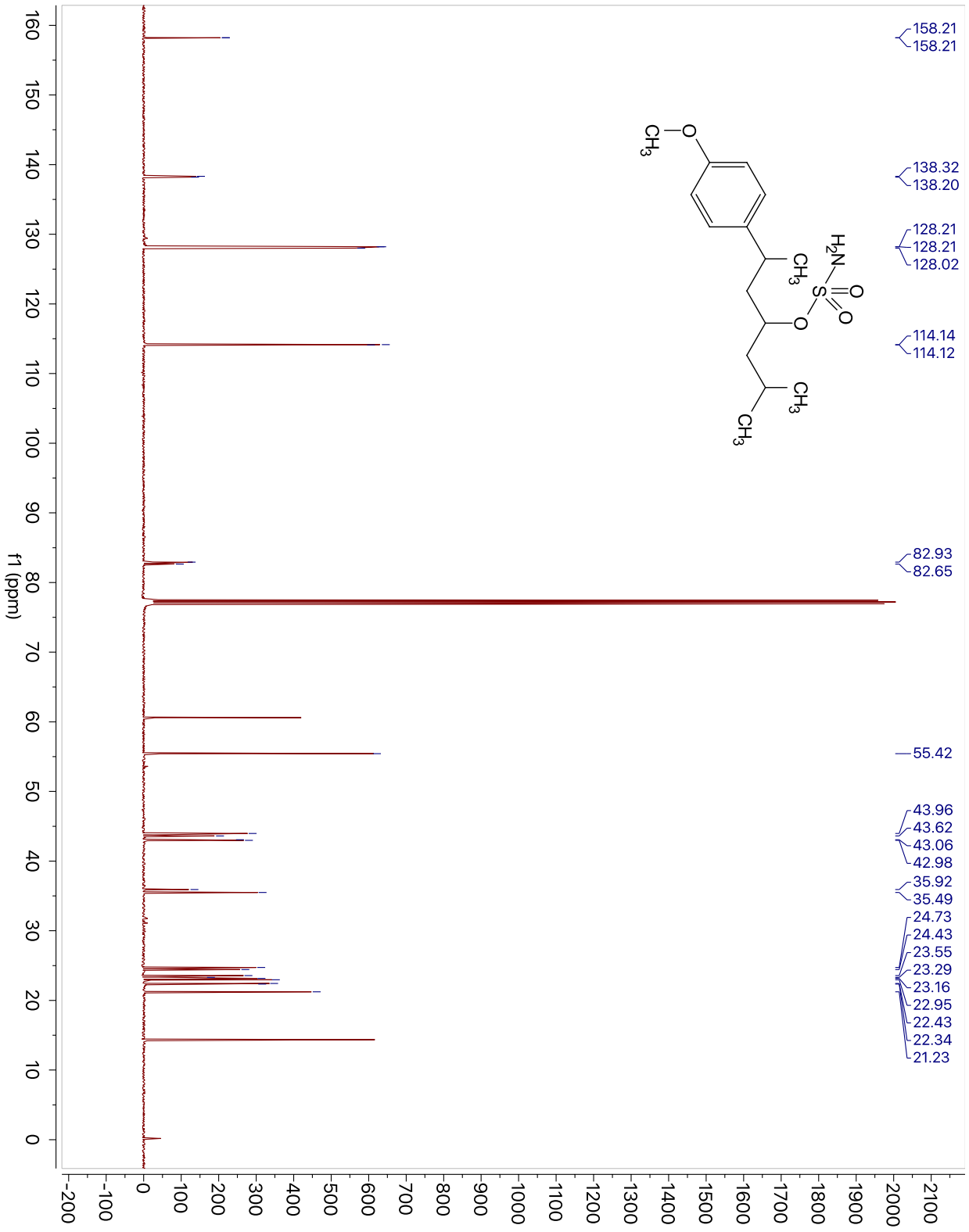
[13]C NMR for Compound 12.


144.04
143.86
128.90
128.82
128.06
127.98
126.81
126.72
82.00
47.76
42.48
40.56
33.97
33.42
33.38
26.53
26.25
26.22
f1 (ppm)

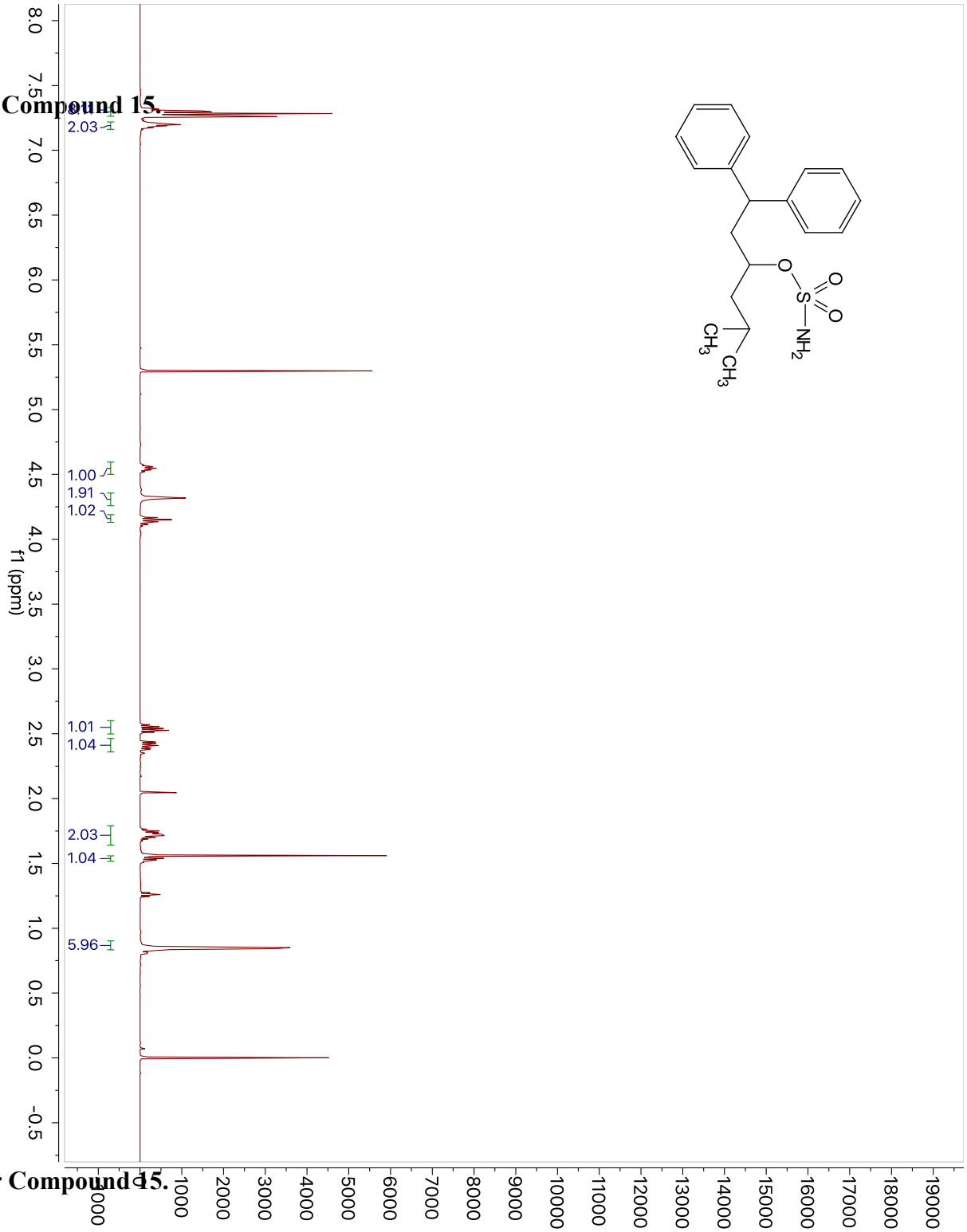
^{1}H NMR for Compound 14.



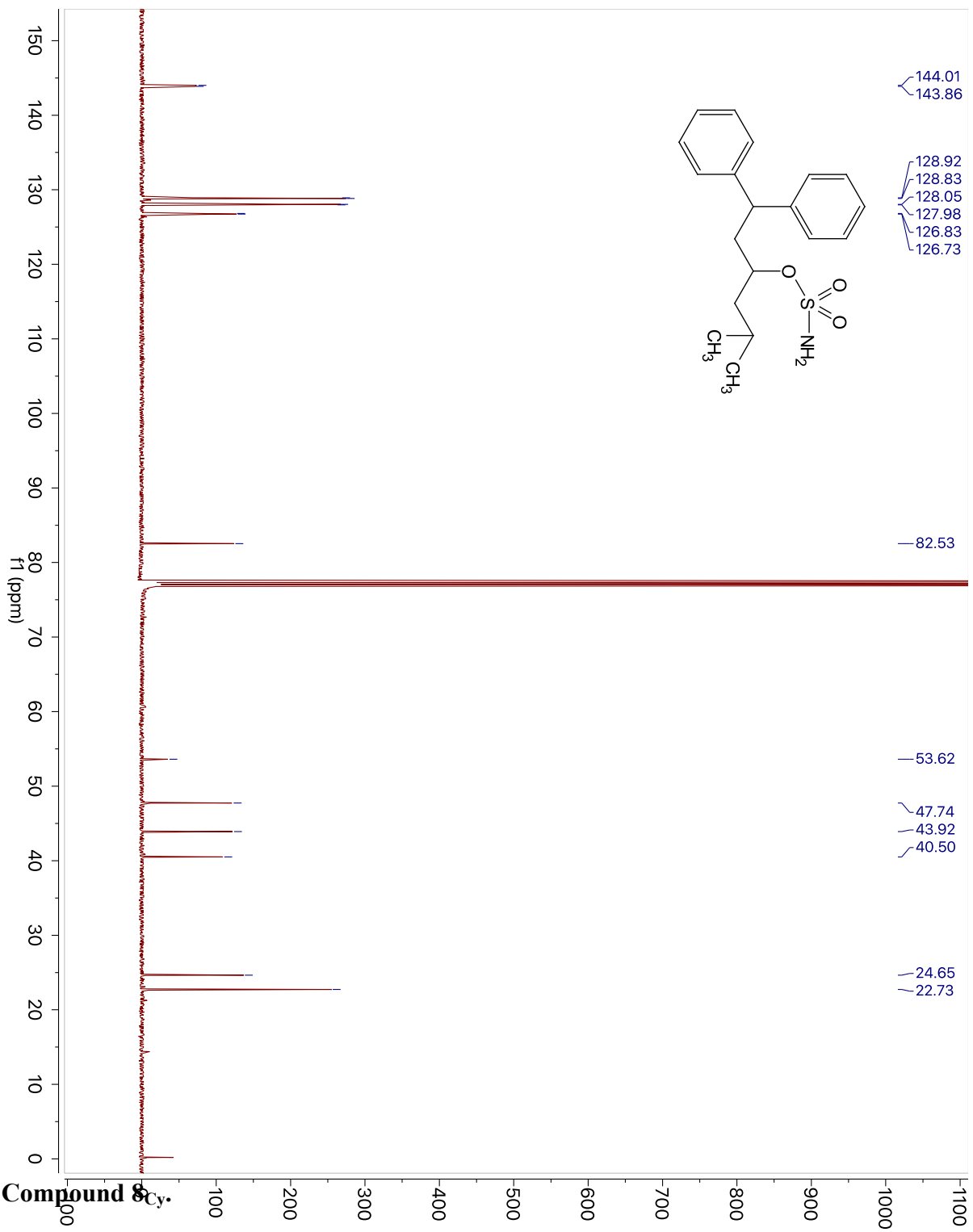
^{13}C NMR for Compound 14.


158.21
158.21
138.32
138.20
128.21
128.21
128.02
114.14
114.12
82.93
82.65
55.42
43.96
43.62
43.06
42.98
35.92
35.49
24.73
24.43
23.55
23.29
23.16
22.95
22.43
22.34
21.23
f1 (ppm)

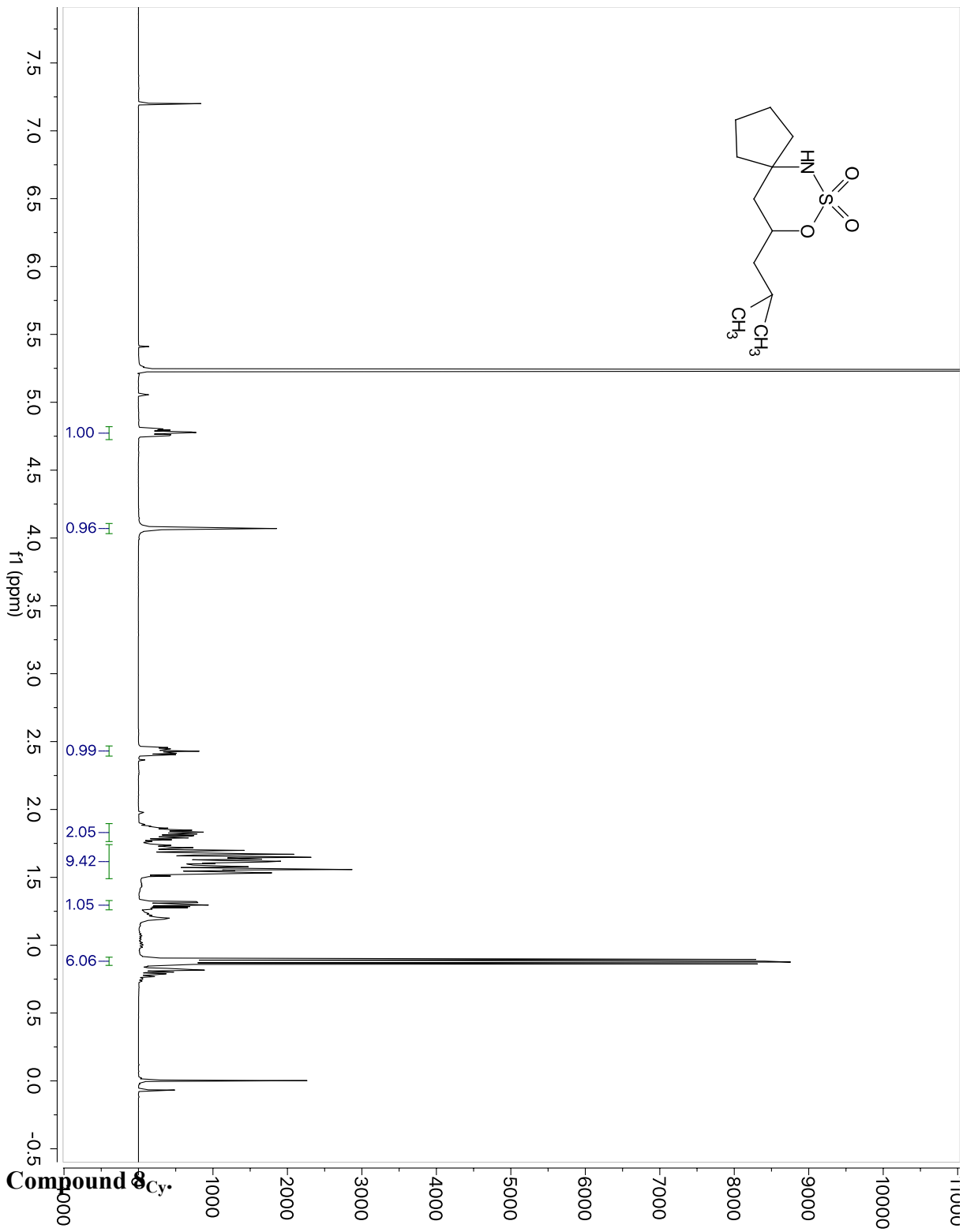
^{1}H NMR for Compound 15.



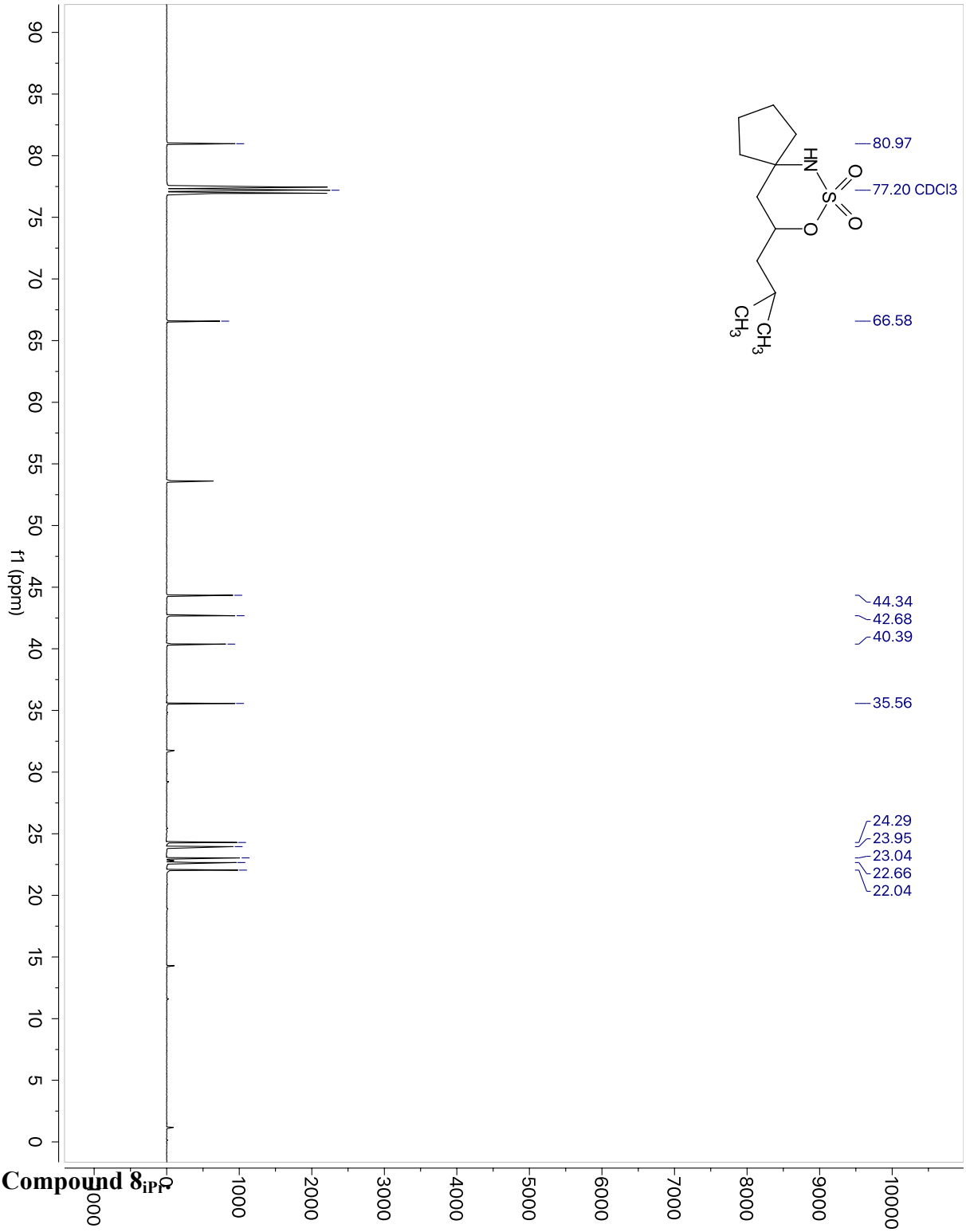
^{13}C NMR for Compound 15.



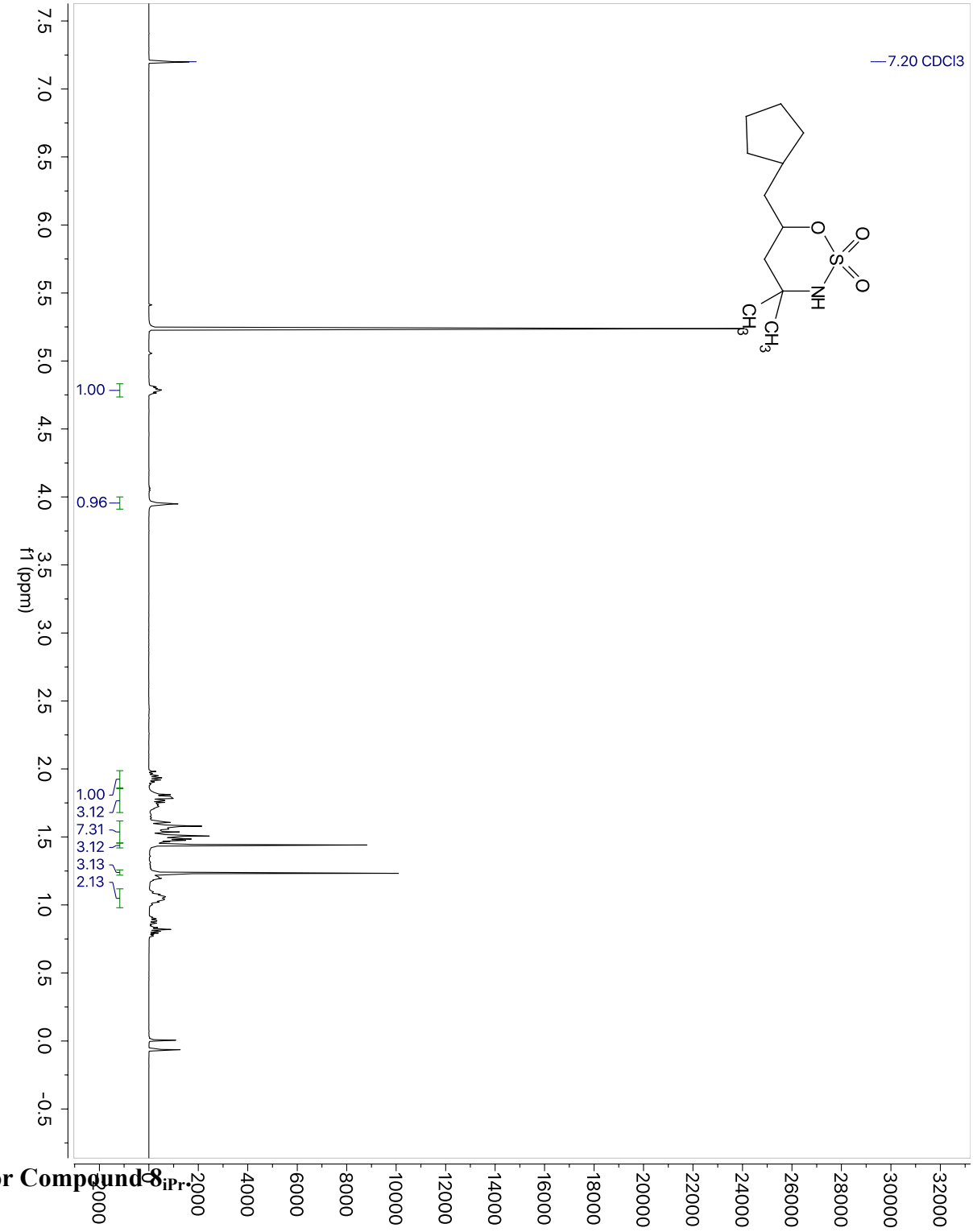
^{1}H NMR for Compound 8$_{Cy}$.



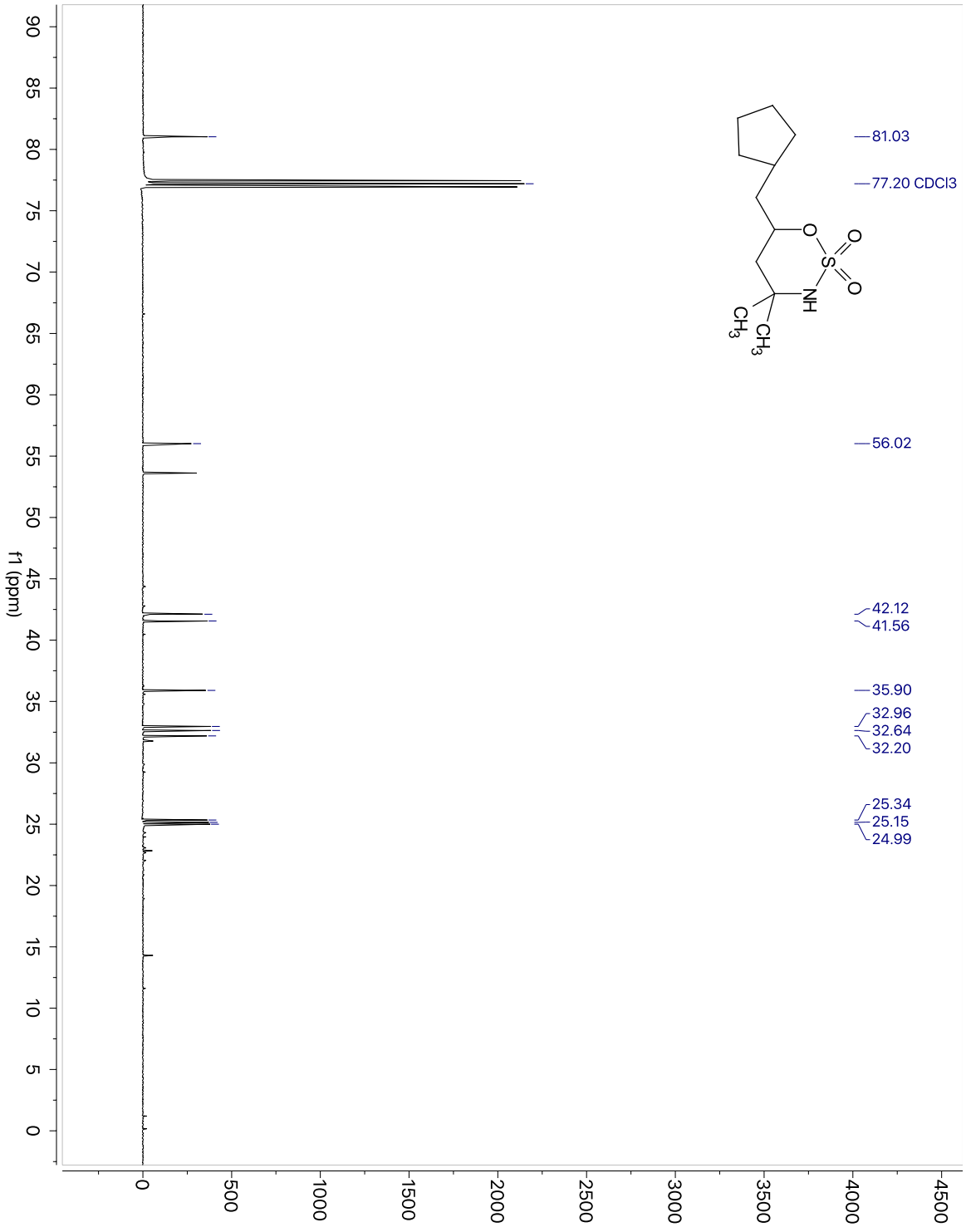
^{13}C NMR for Compound 8$_{Cy}$.



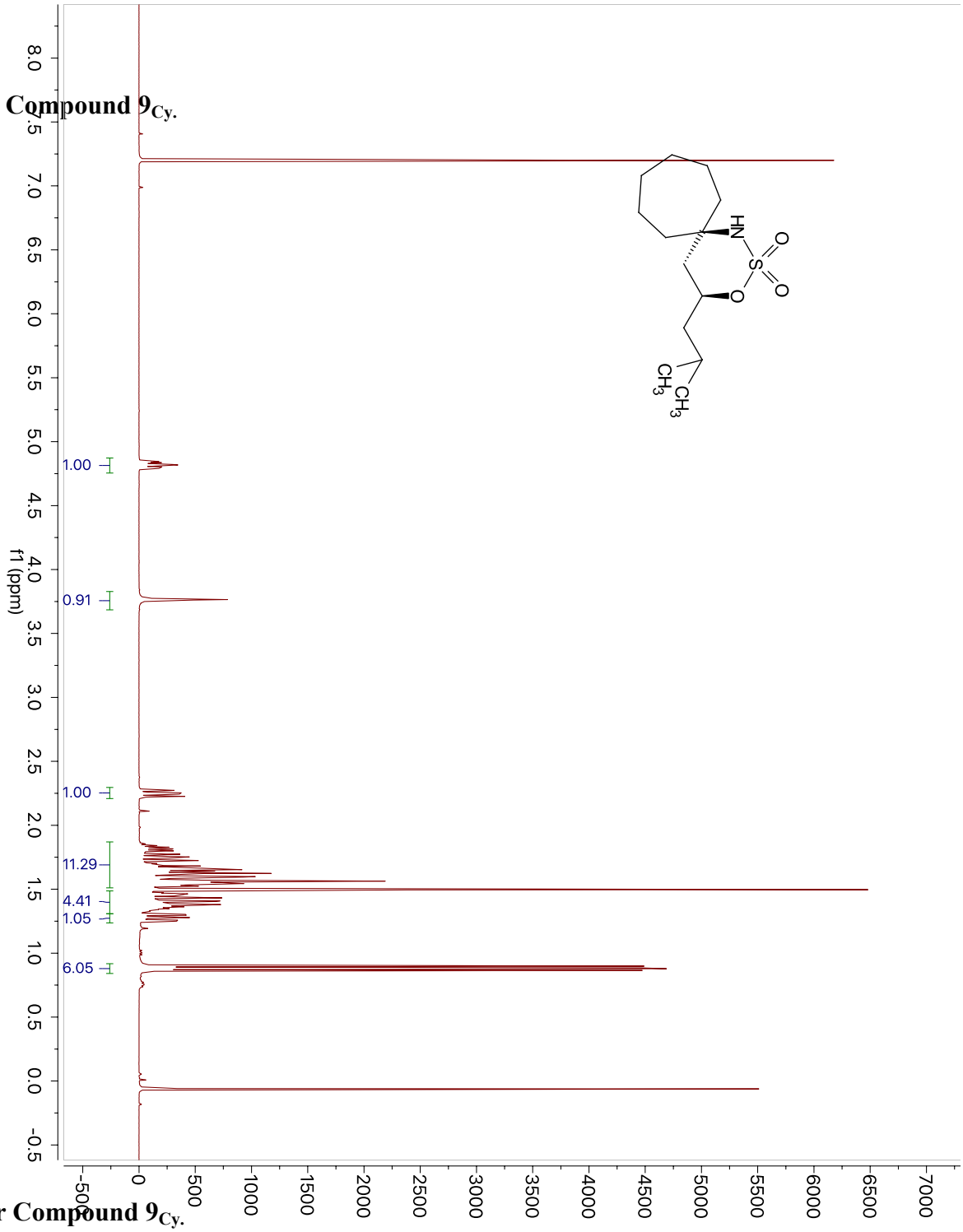
^{1}H NMR for Compound 8$_{iPr}$



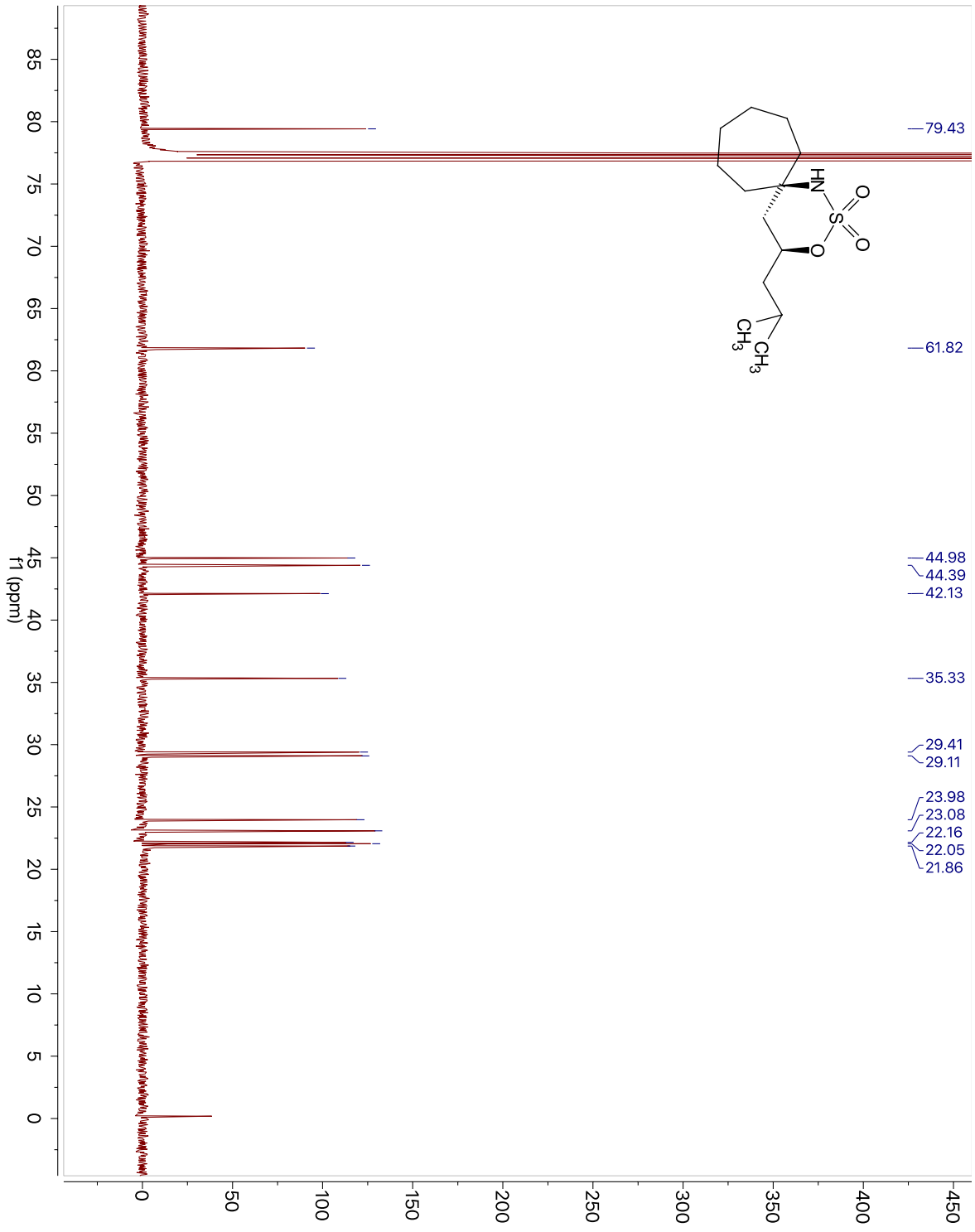
^{13}C NMR for Compound 8$_{iPr}$.


81.03
77.20 CDCl3
56.02
42.12
41.56
35.90
32.96
32.64
32.20
25.34
25.15
24.99
f1 (ppm)
O
S
O
O
NH
CH3
CH3

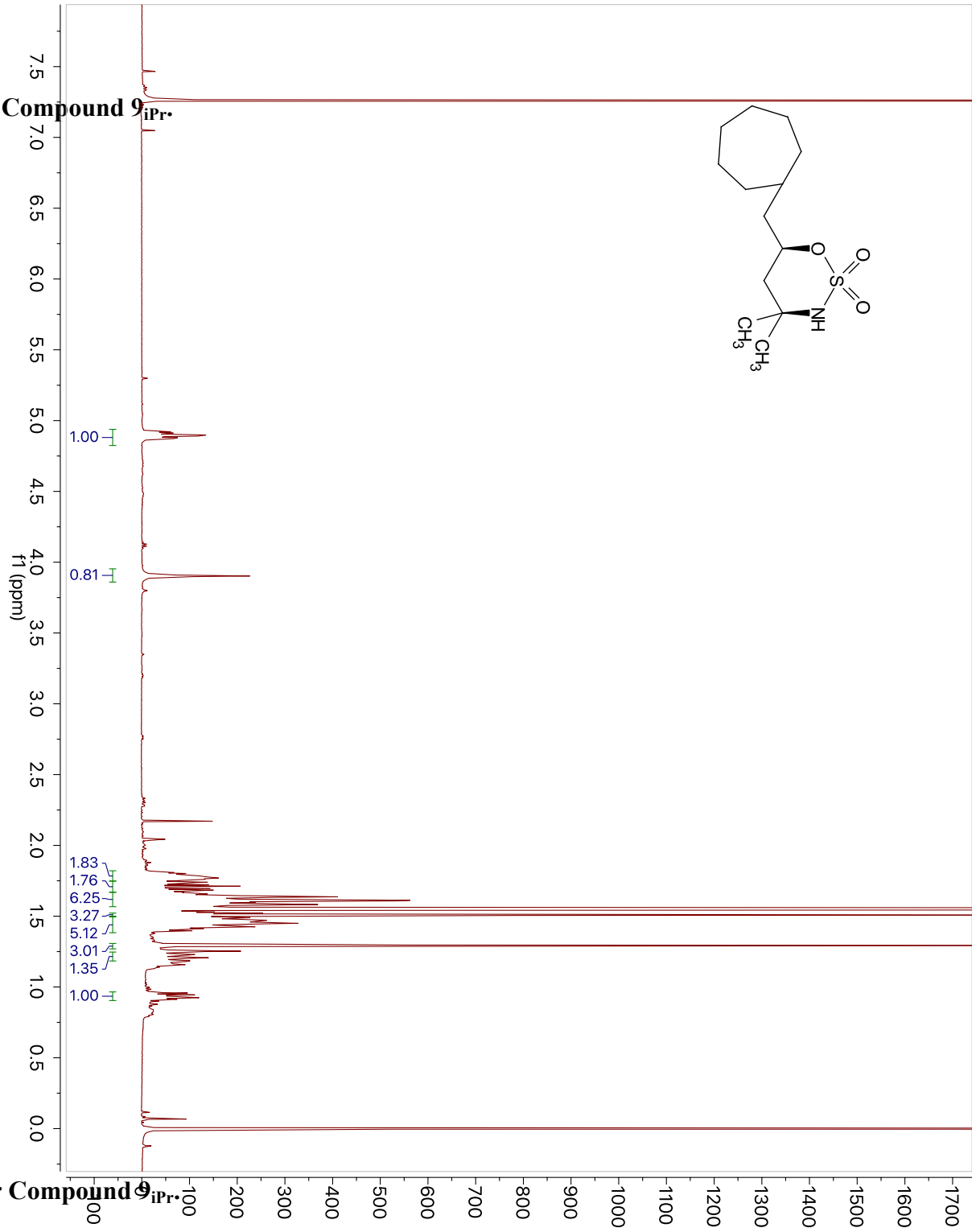
^{1}H NMR for Compound $9_{Cy.}$



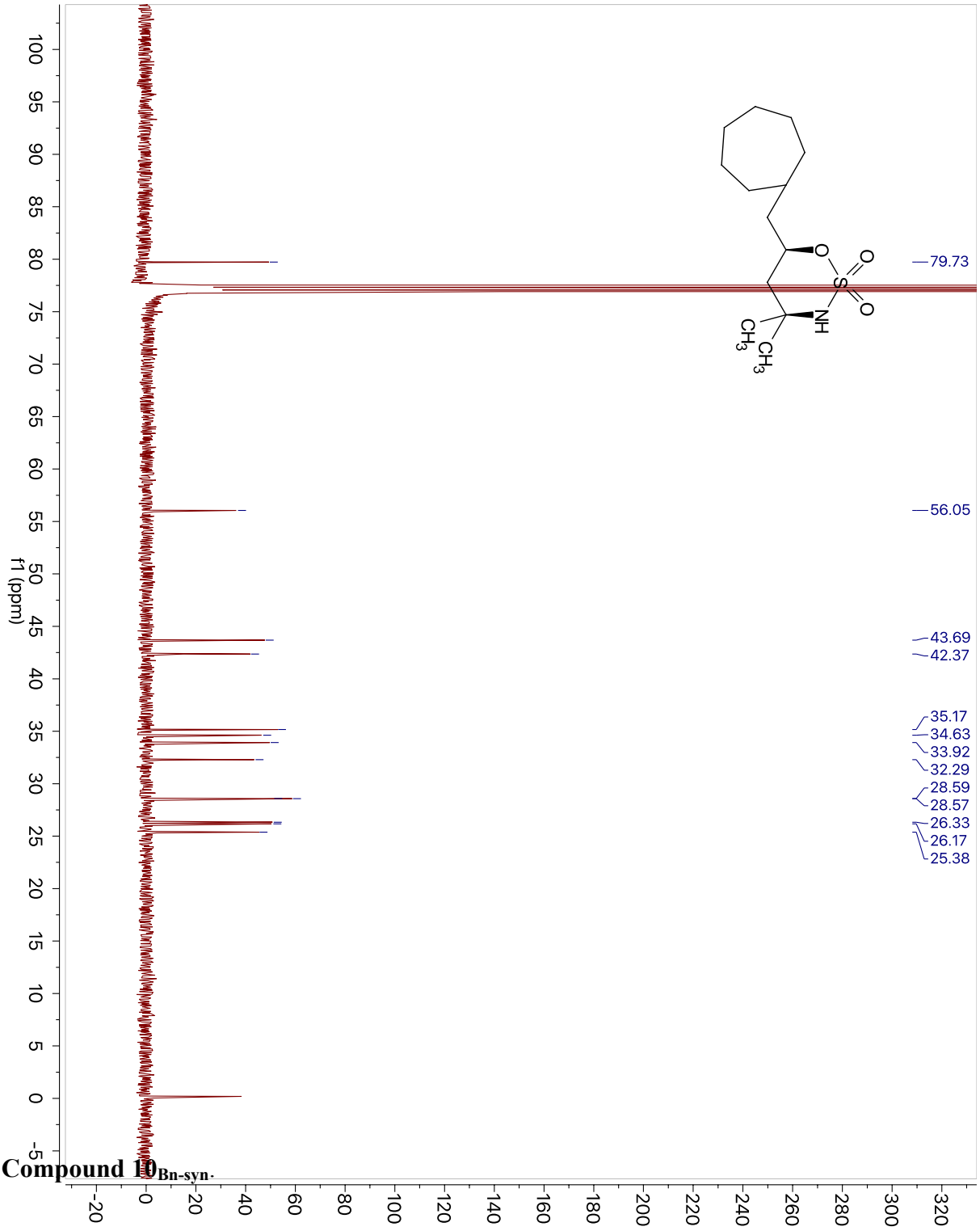
^{13}C NMR for Compound $9_{Cy.}$


79.43
61.82
44.98
44.39
42.13
35.33
29.41
29.11
23.98
23.08
22.16
22.05
21.86
f1 (ppm)

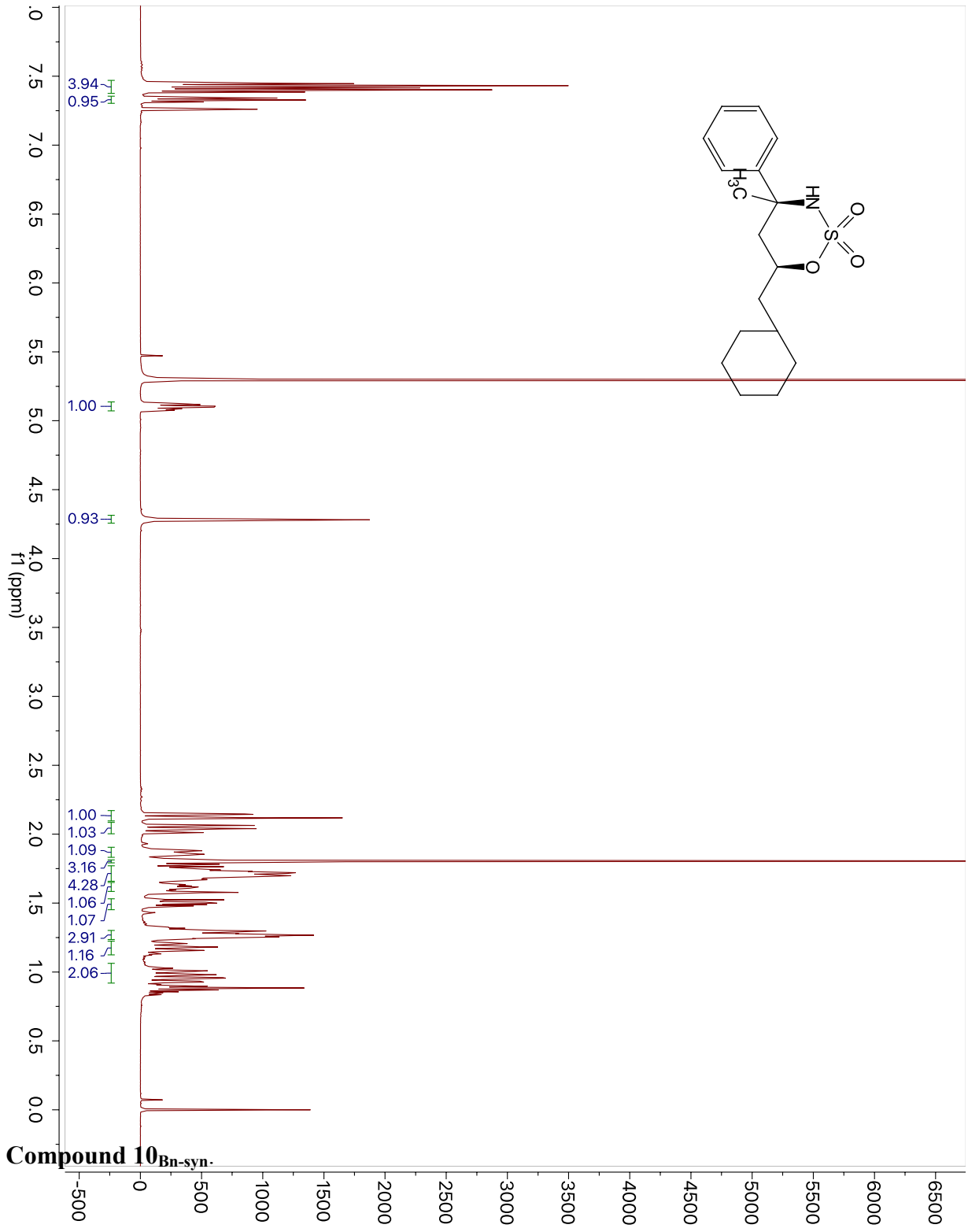
^{1}H NMR for Compound 9_{iPr}.



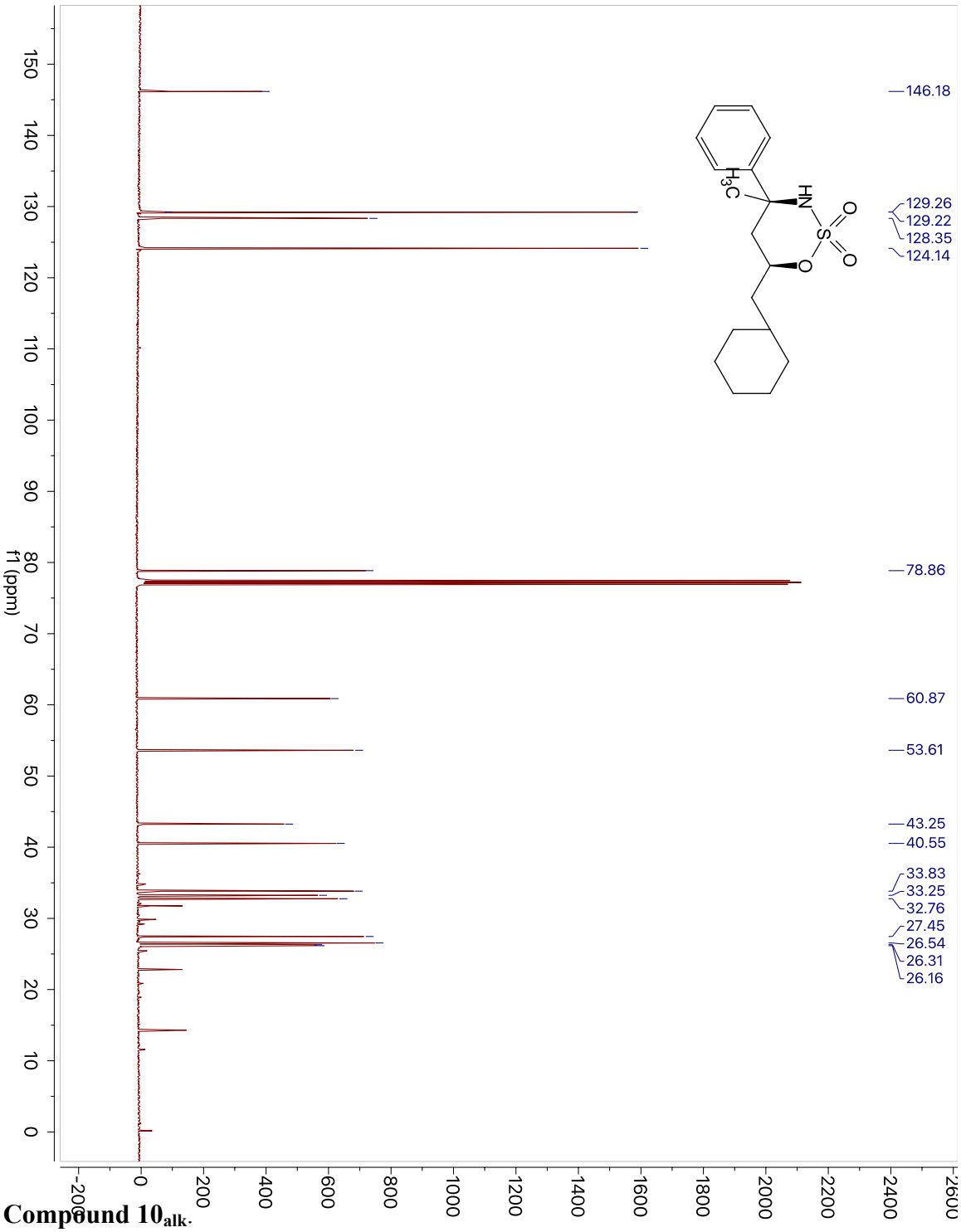
^{13}C NMR for Compound 9_{iPr}.



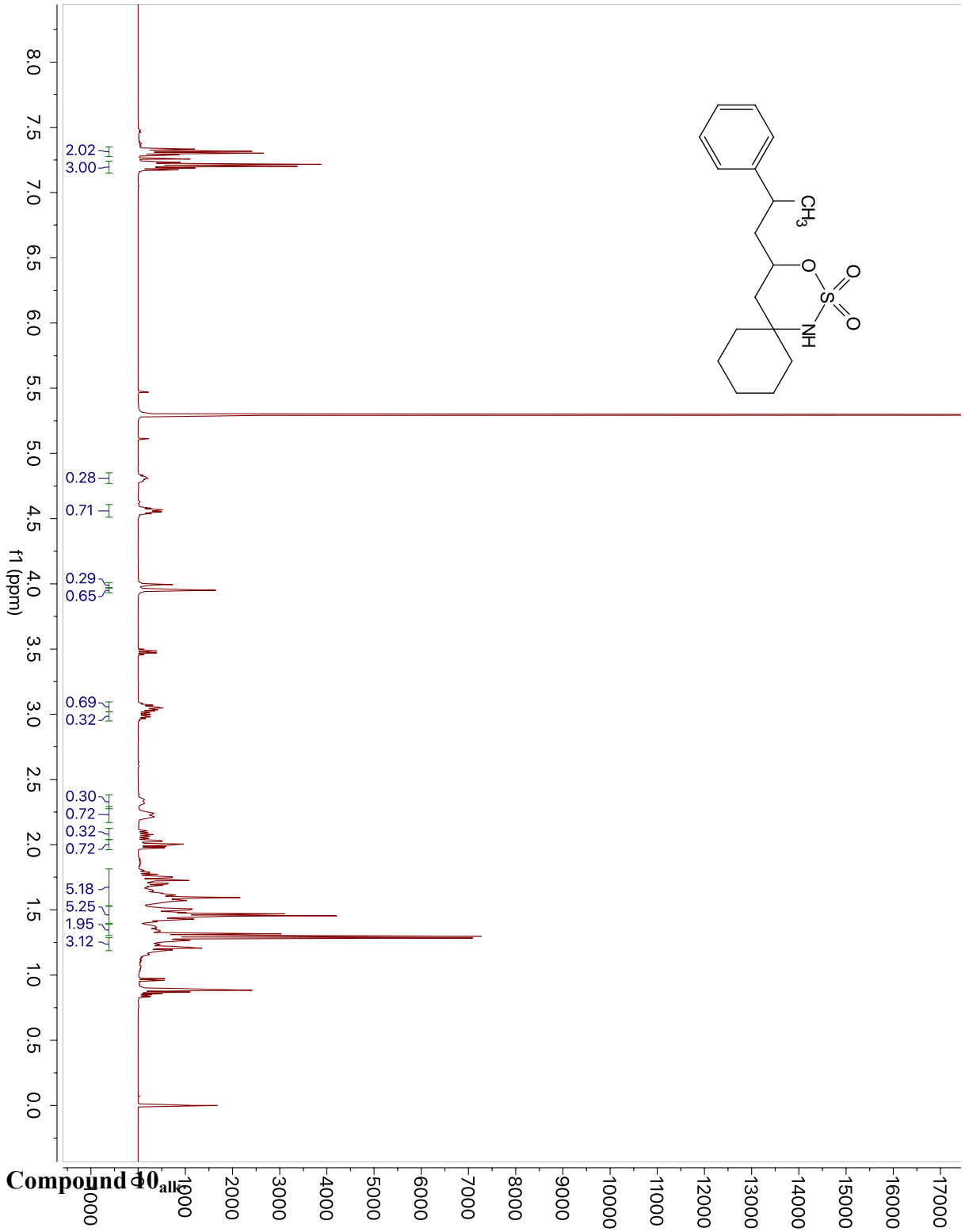
^{1}H NMR for Compound 10$_{Bn\text{-}syn}$.



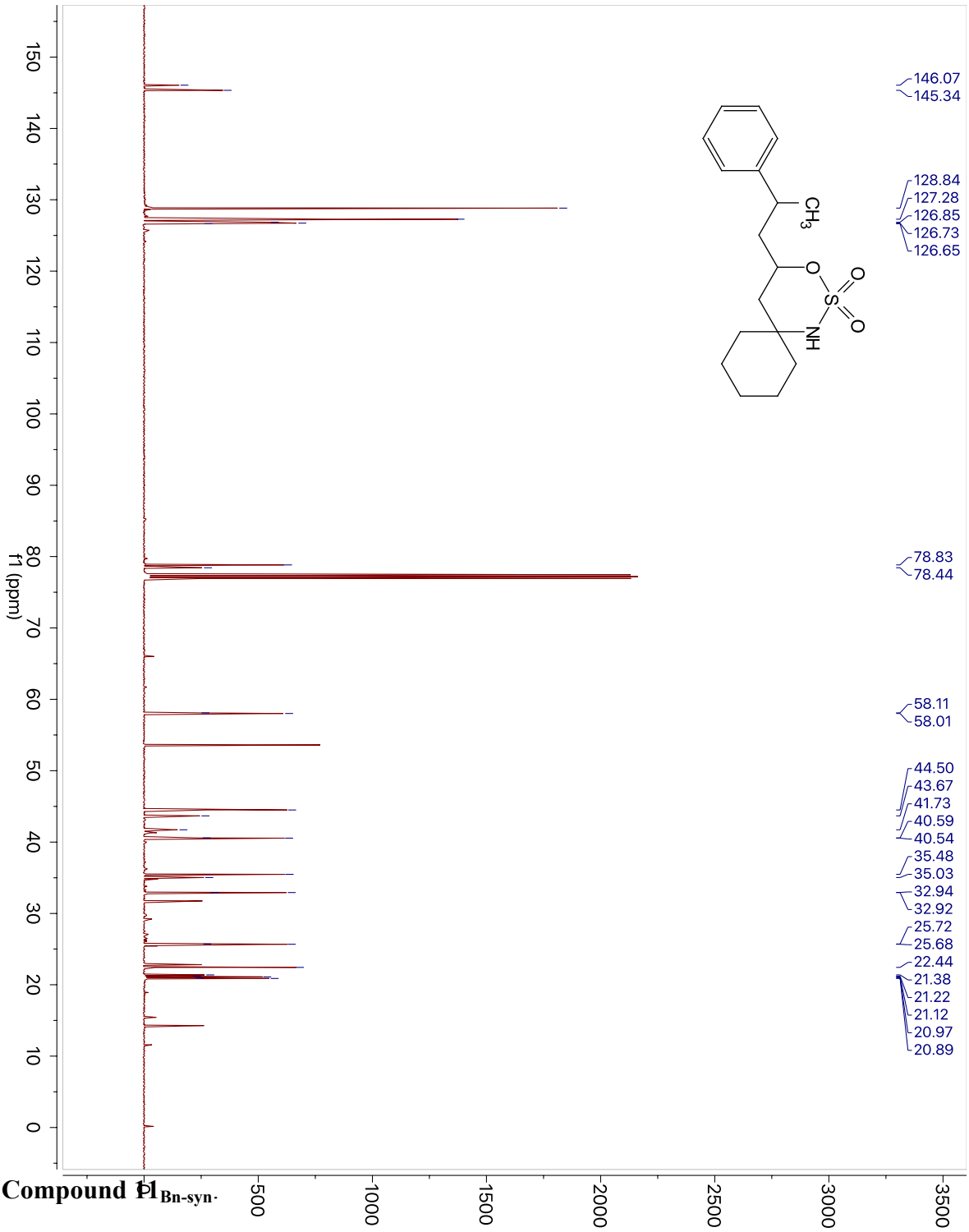
^{13}C NMR for Compound 10$_{Bn\text{-}syn}$.



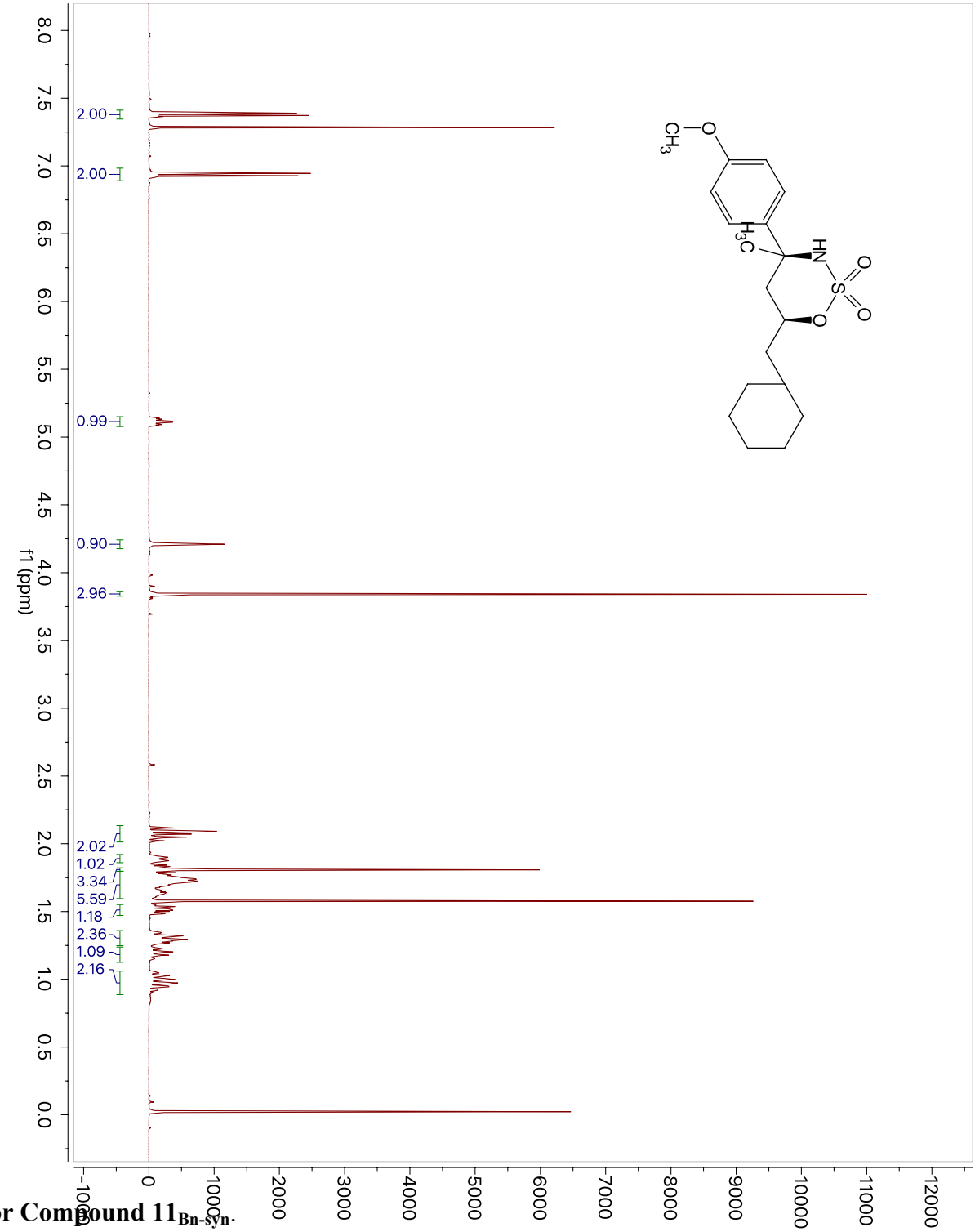
^{1}H NMR for Compound 10_{alk}.



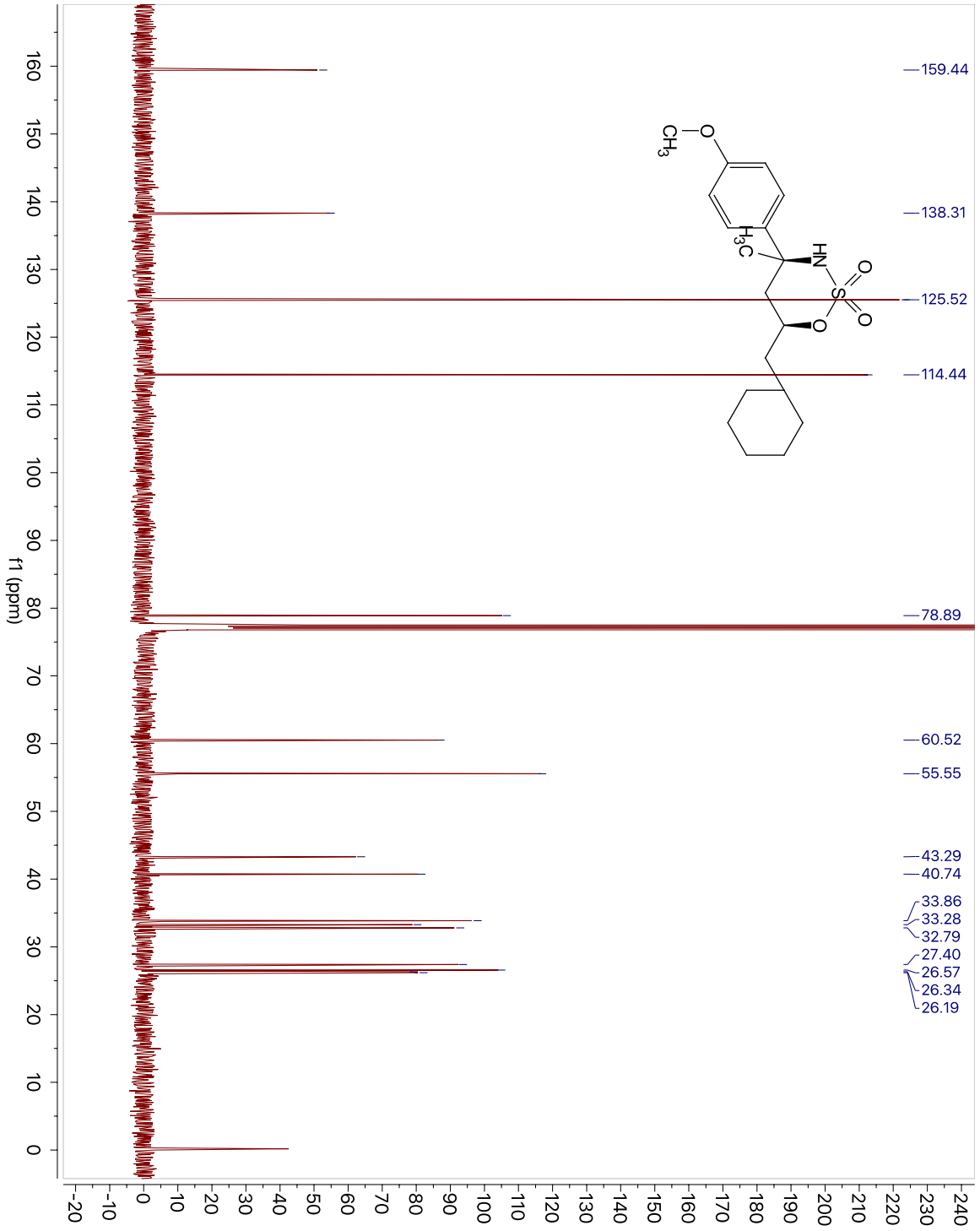
^{13}C NMR for Compound 10$_{alk}$



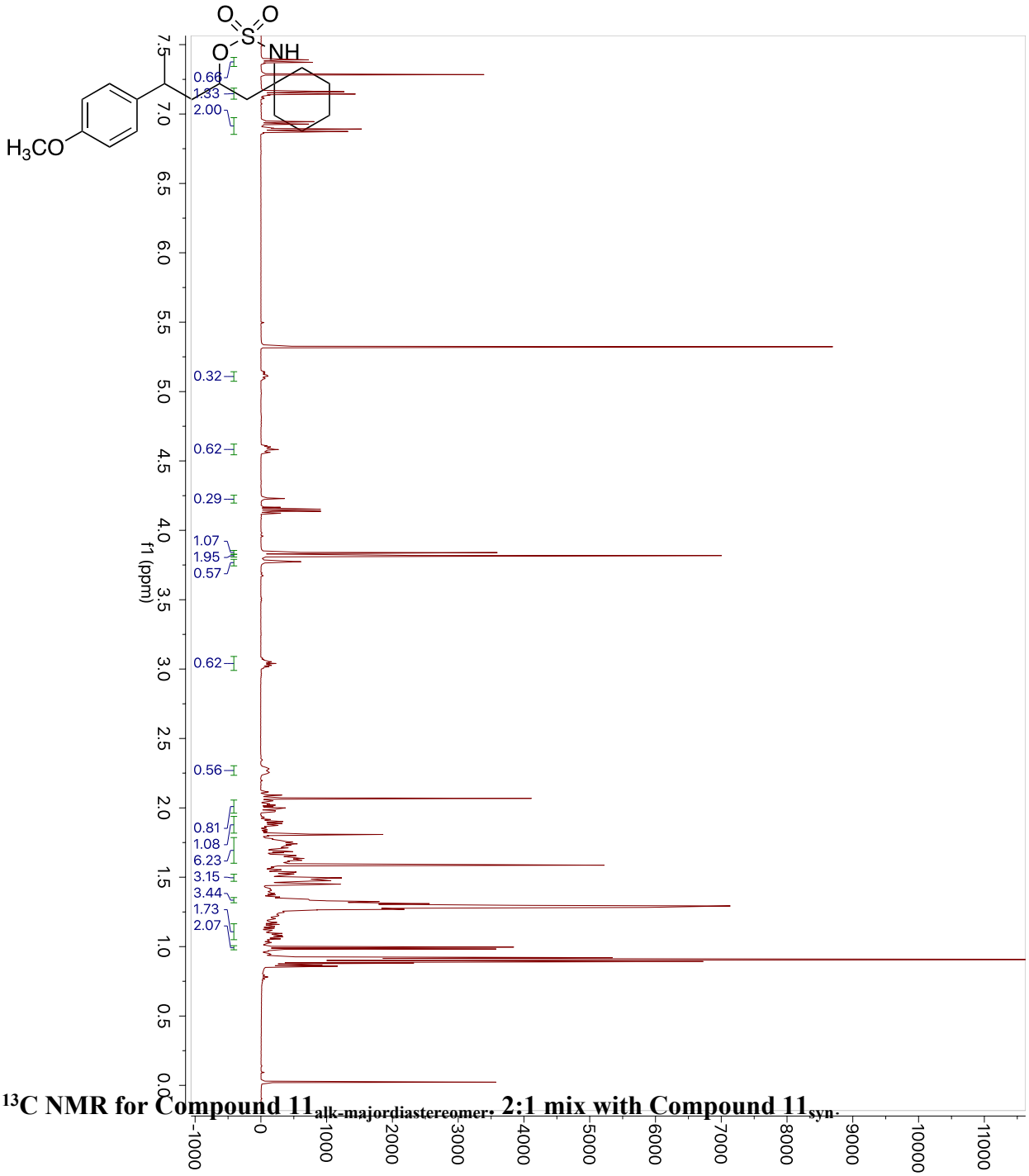
^{1}H NMR for Compound 11$_{Bn\text{-}syn}$.



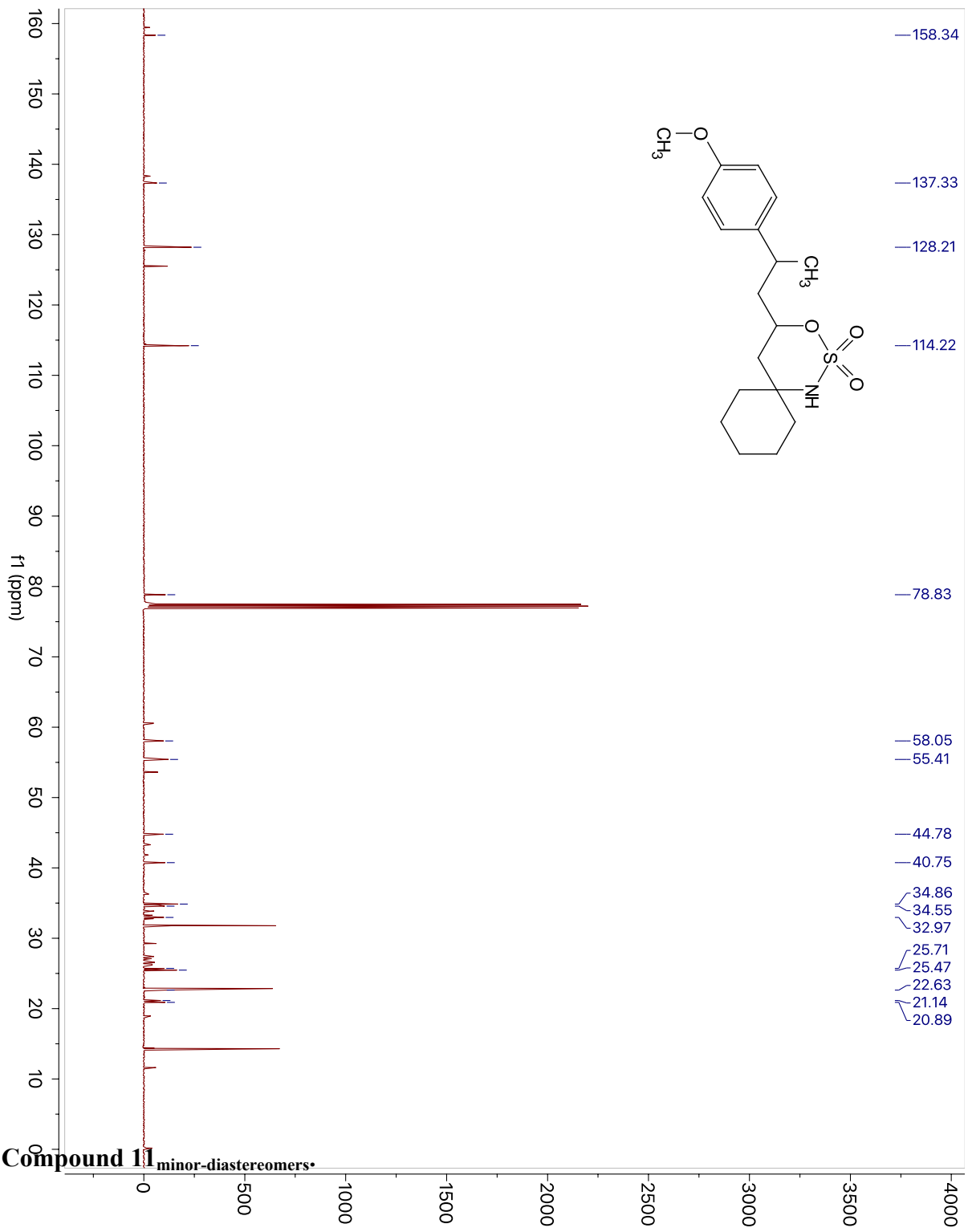
^{13}C NMR for Compound 11$_{Bn\text{-}syn}$.


159.44
138.31
125.52
114.44
78.89
60.52
55.55
43.29
40.74
33.86
33.28
32.79
27.40
26.57
26.34
26.19
f1 (ppm)

^{1}H NMR for Compound 11$_{alk\text{-}majordiastereomer}$. 2:1 mix with Compound 11$_{syn}$.

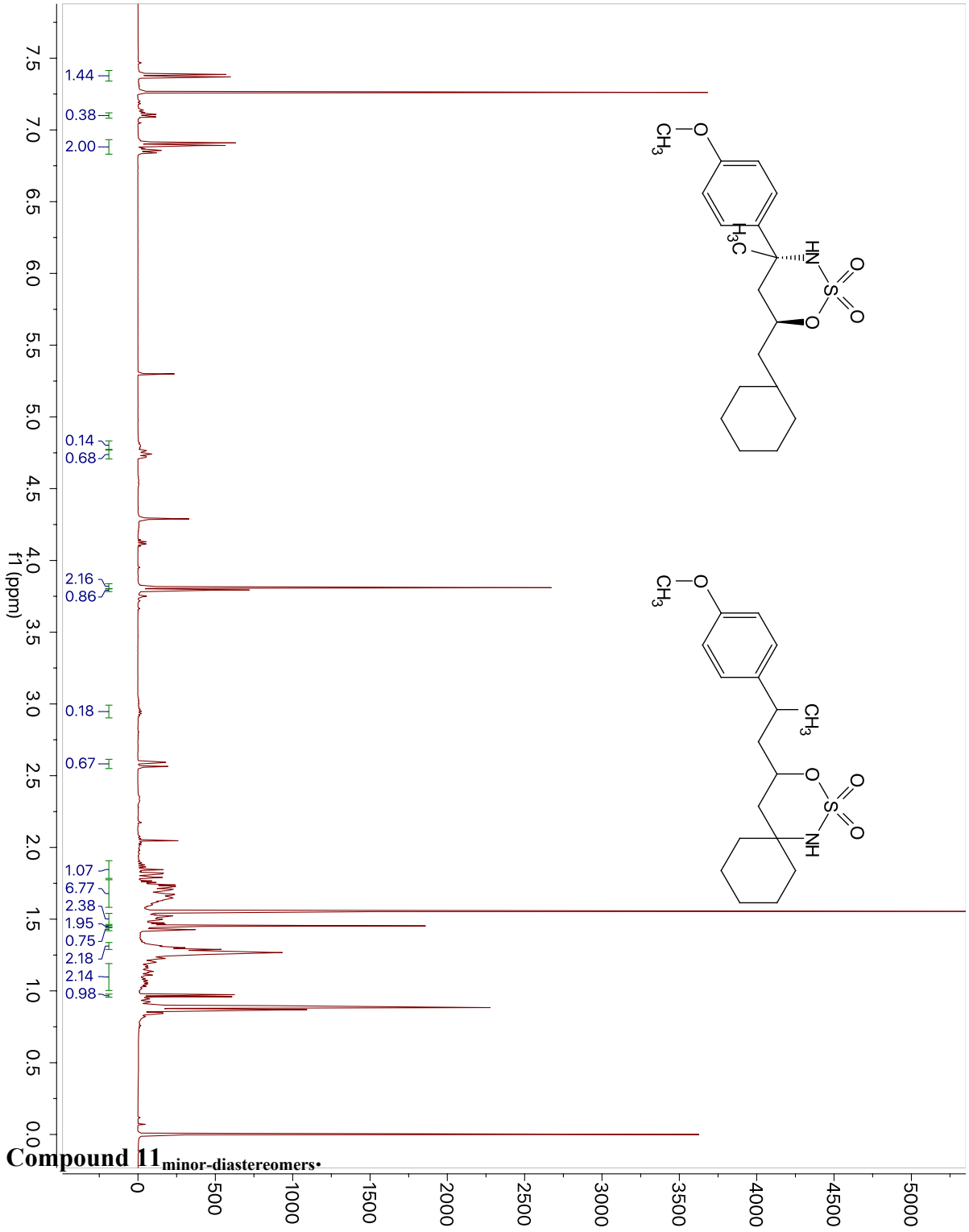


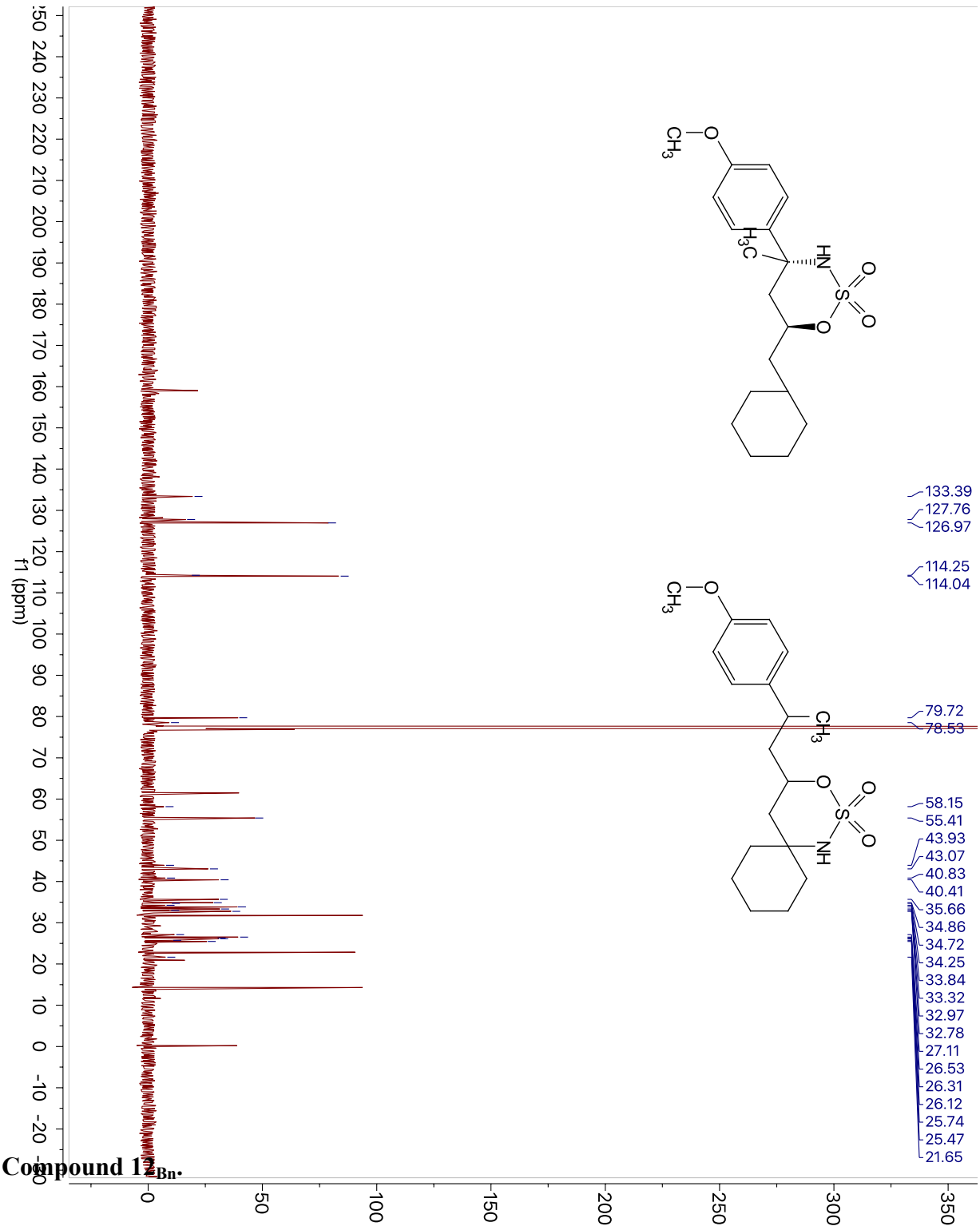
^{13}C NMR for Compound 11$_{alk\text{-}majordiastereomer}$. 2:1 mix with Compound 11$_{syn}$.



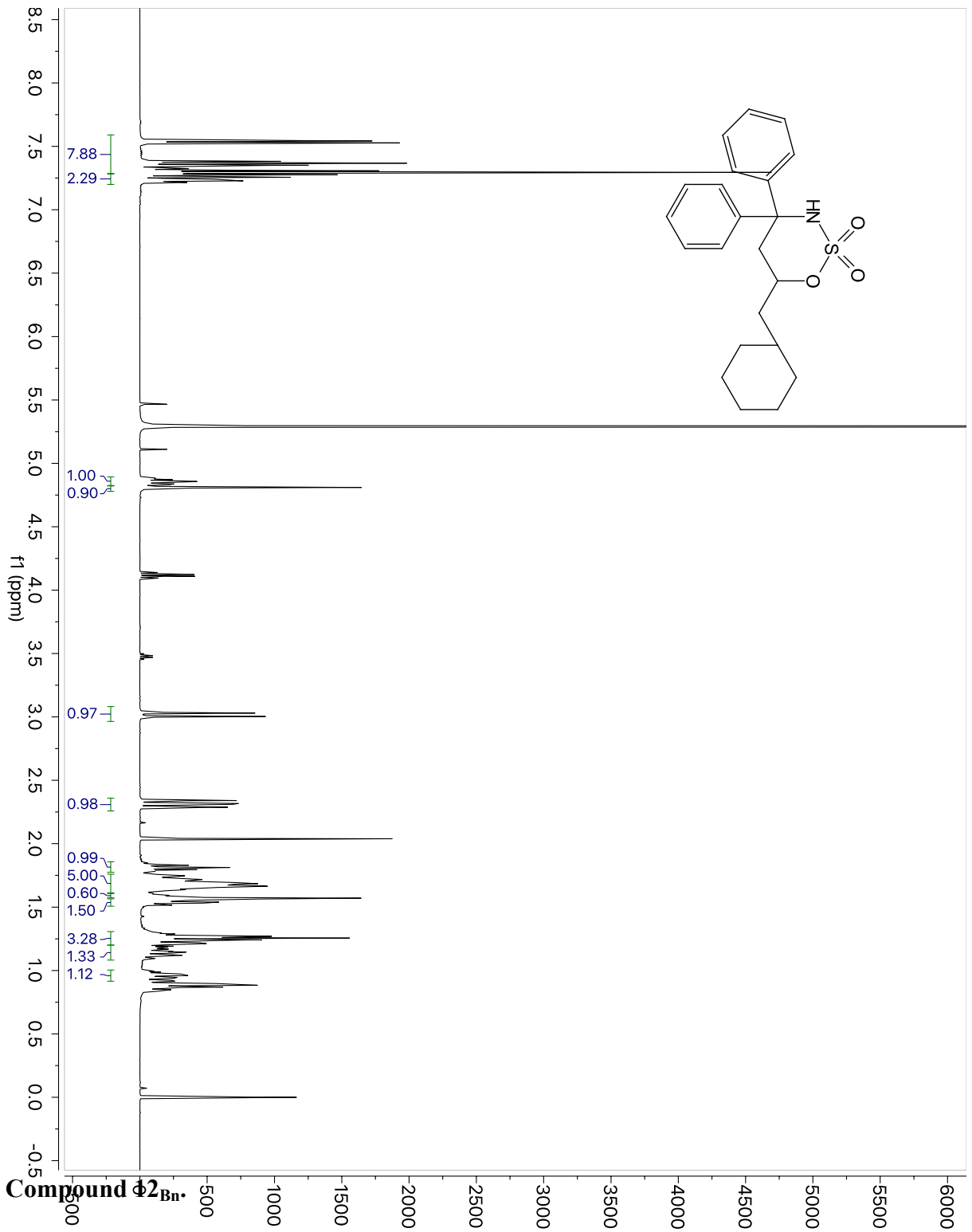
^{1}H NMR for Compound 11$_{\text{minor-diastereomers}}$

^{13}C NMR for Compound 11$_{\text{minor-diastereomers}}$

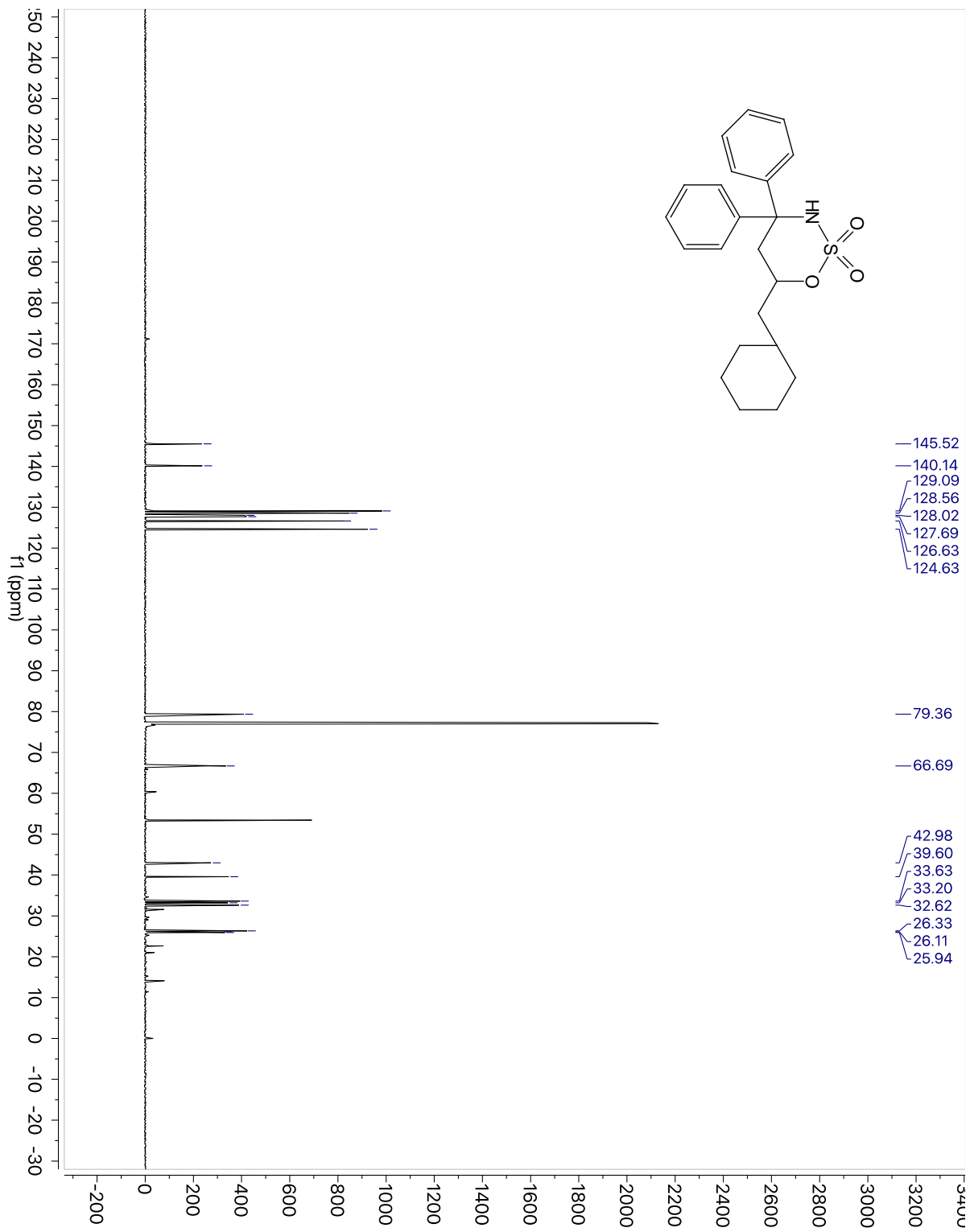




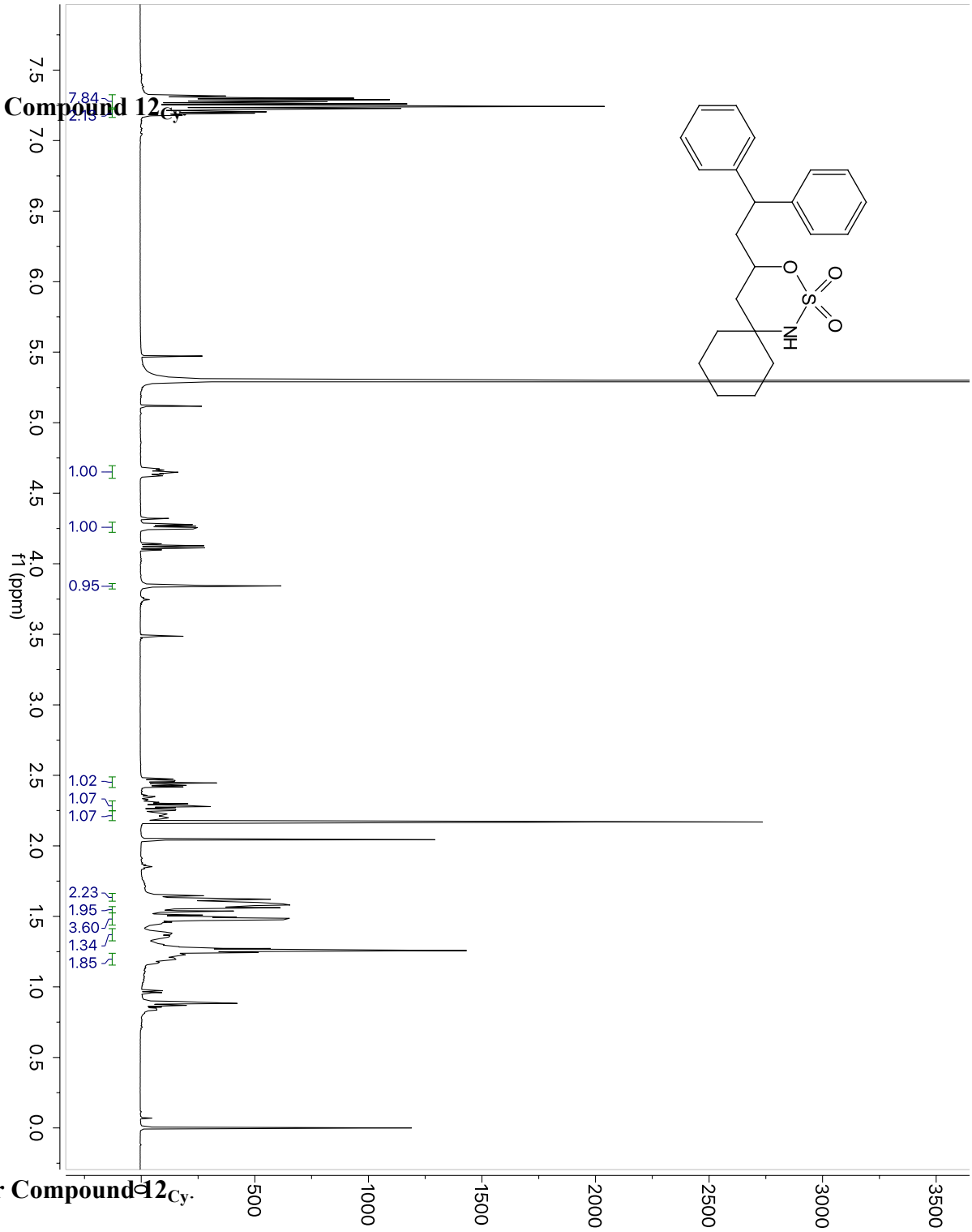
^{1}H NMR for Compound 12$_{Bn}$.



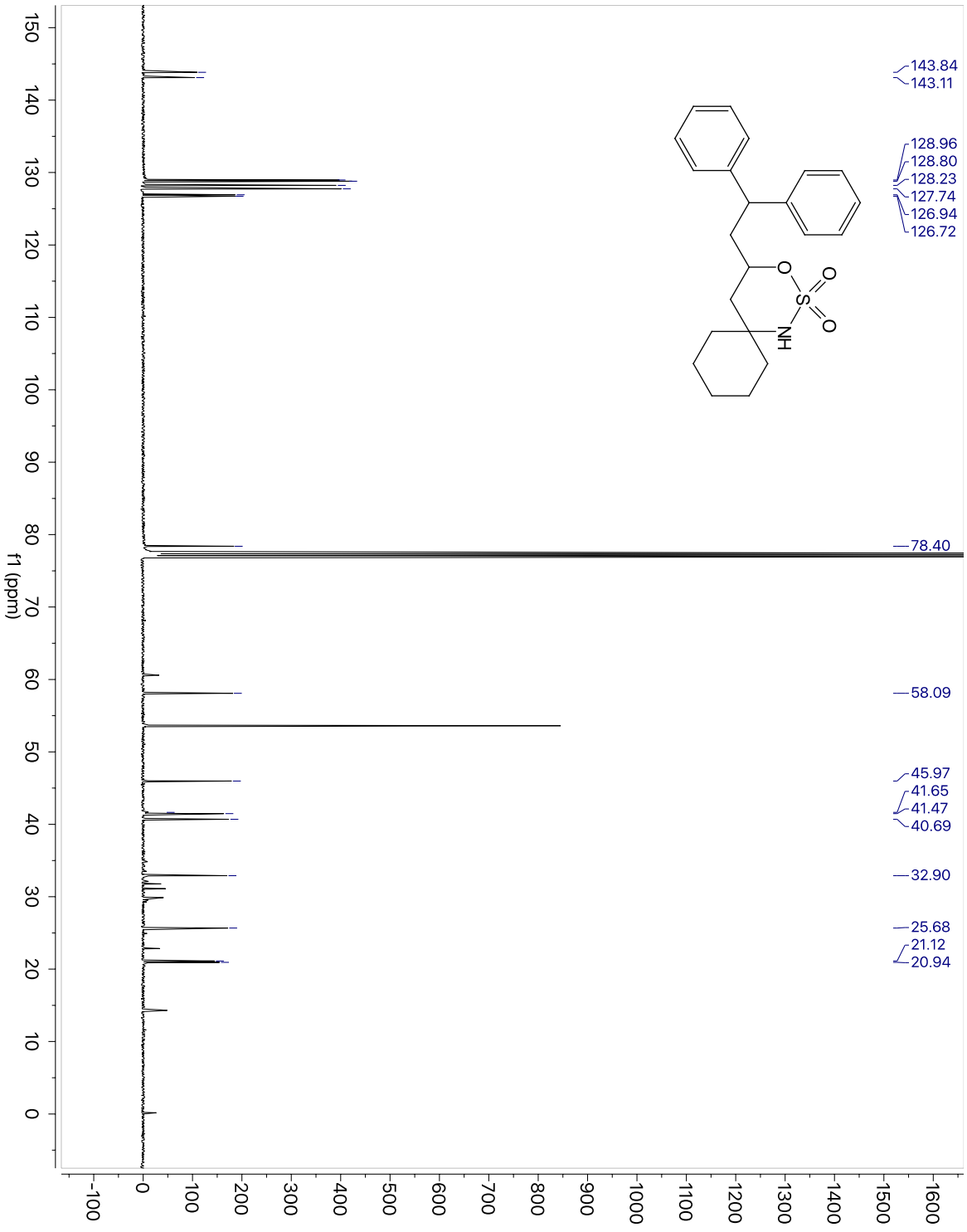
^{13}C NMR for Compound 42$_{Bn}$.


HN
S
O
O
O
145.52
140.14
129.09
128.56
128.02
127.69
126.63
124.63
79.36
66.69
42.98
39.60
33.63
33.20
32.62
26.33
26.11
25.94
f1 (ppm)

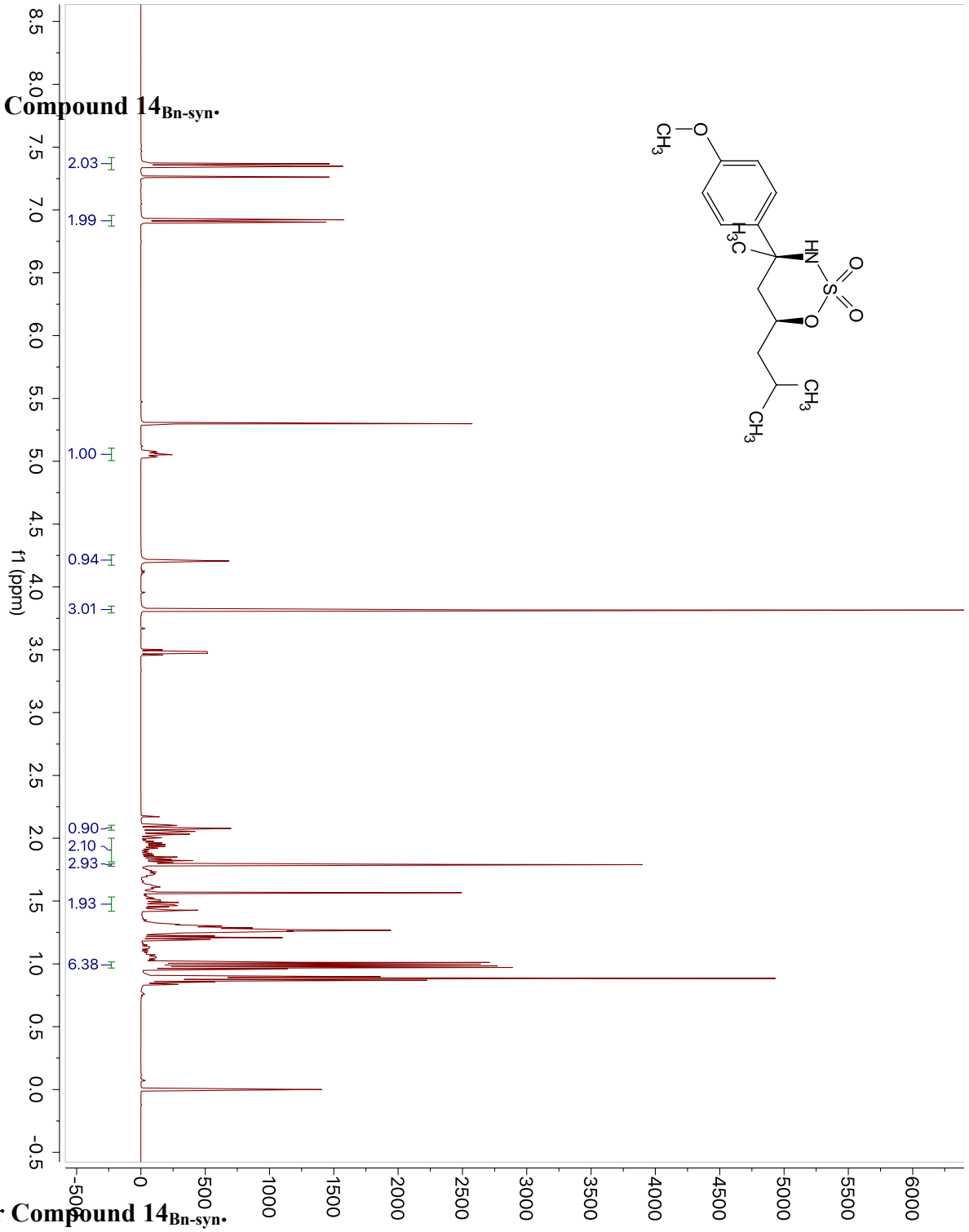
^{1}H NMR for Compound 12$_{Cy}$



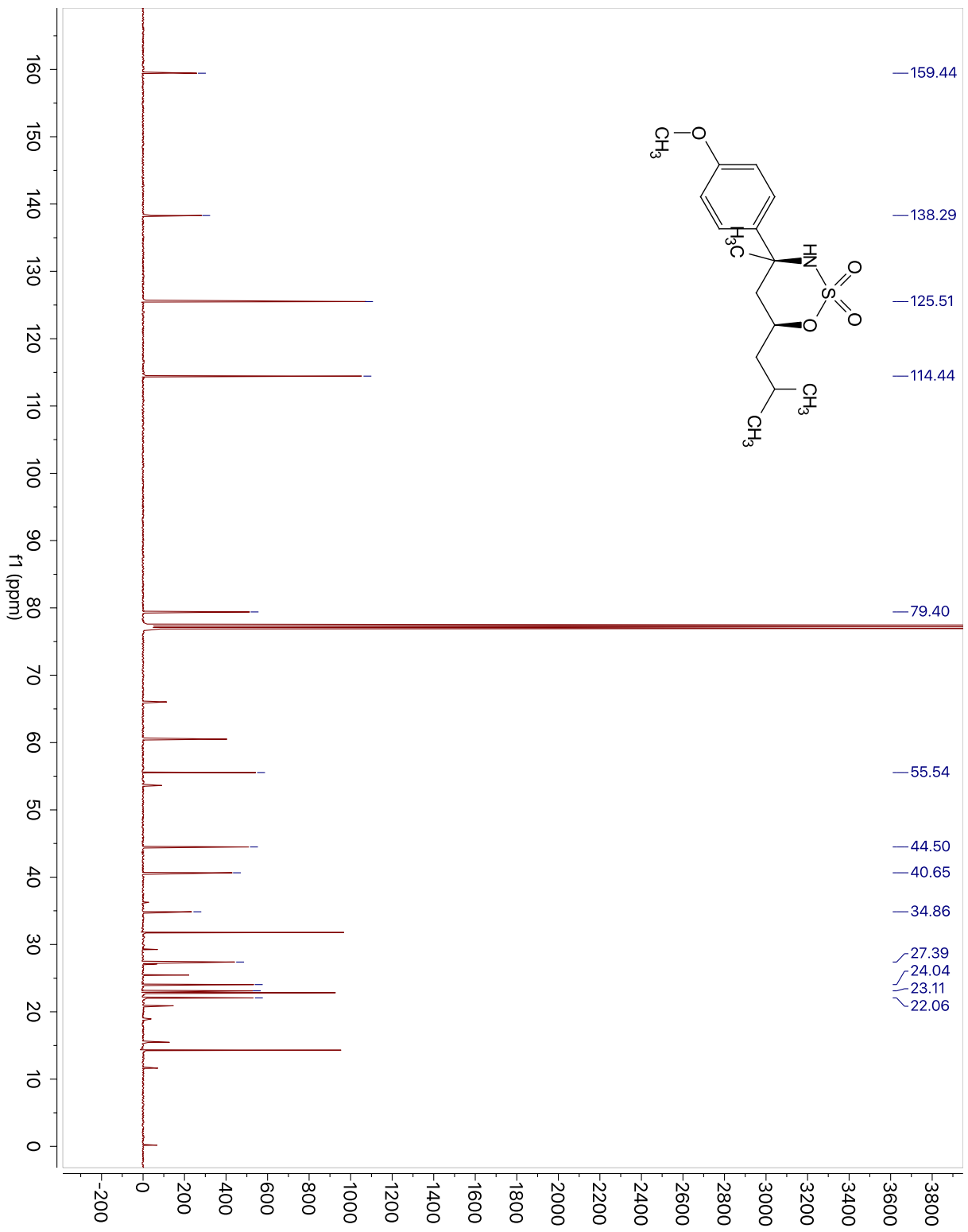
^{13}C NMR for Compound 12$_{Cy}$


143.84
143.11
128.96
128.80
128.23
127.74
126.94
126.72
78.40
58.09
45.97
41.65
41.47
40.69
32.90
25.68
21.12
20.94
O
S
O
O
NH
f1 (ppm)

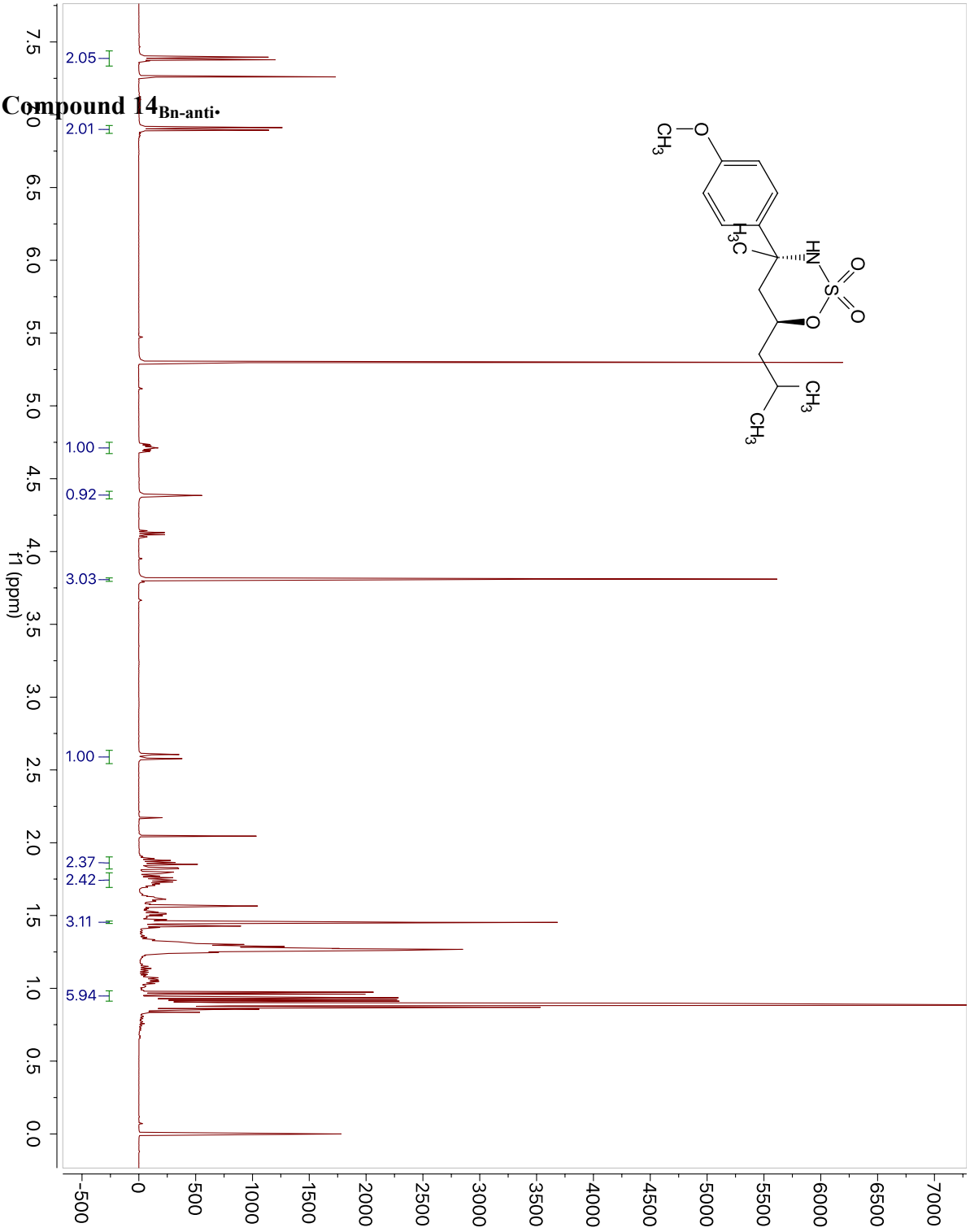
^{1}H NMR for Compound $14_{Bn\text{-}syn}$.

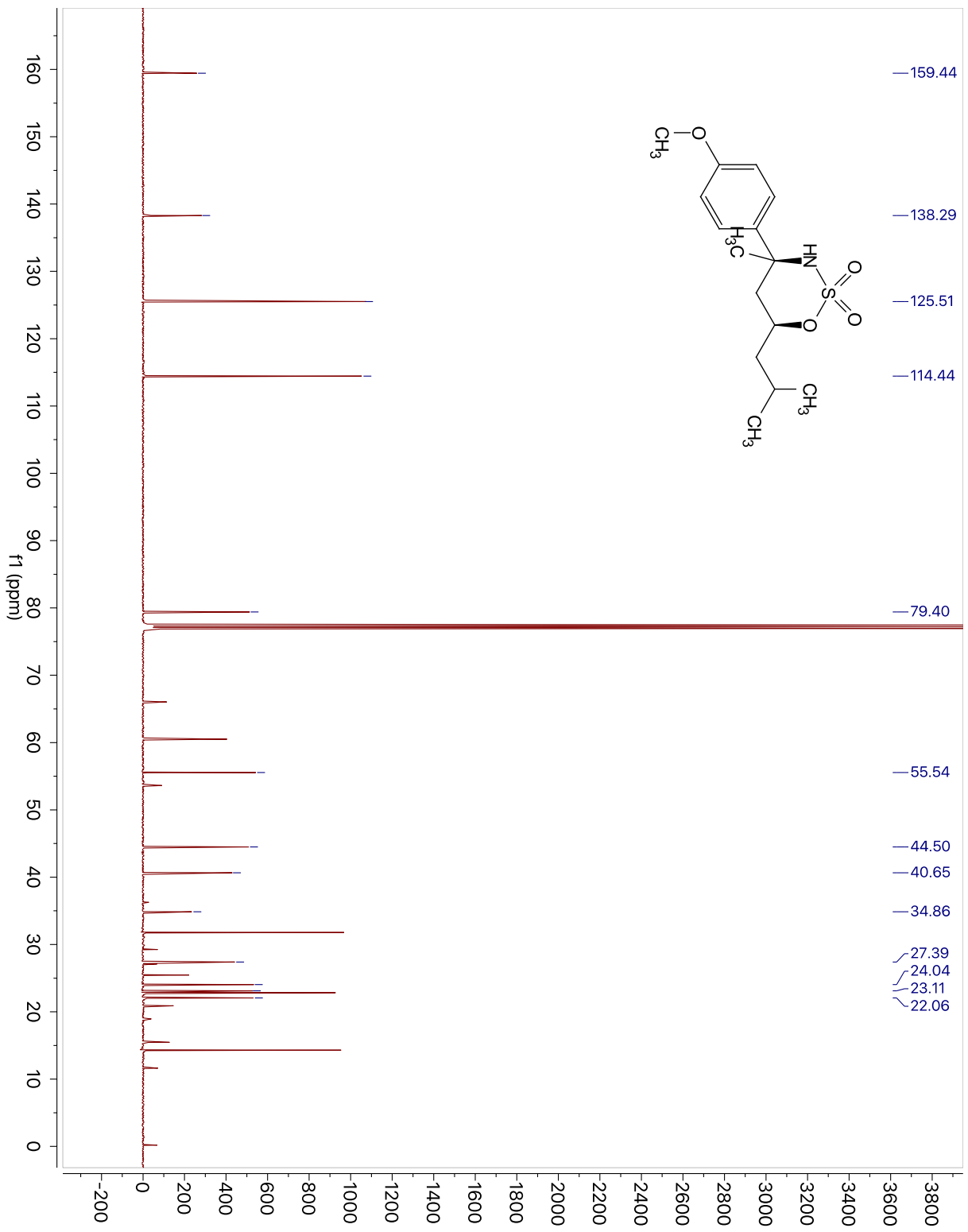


^{13}C NMR for Compound $14_{Bn\text{-}syn}$.

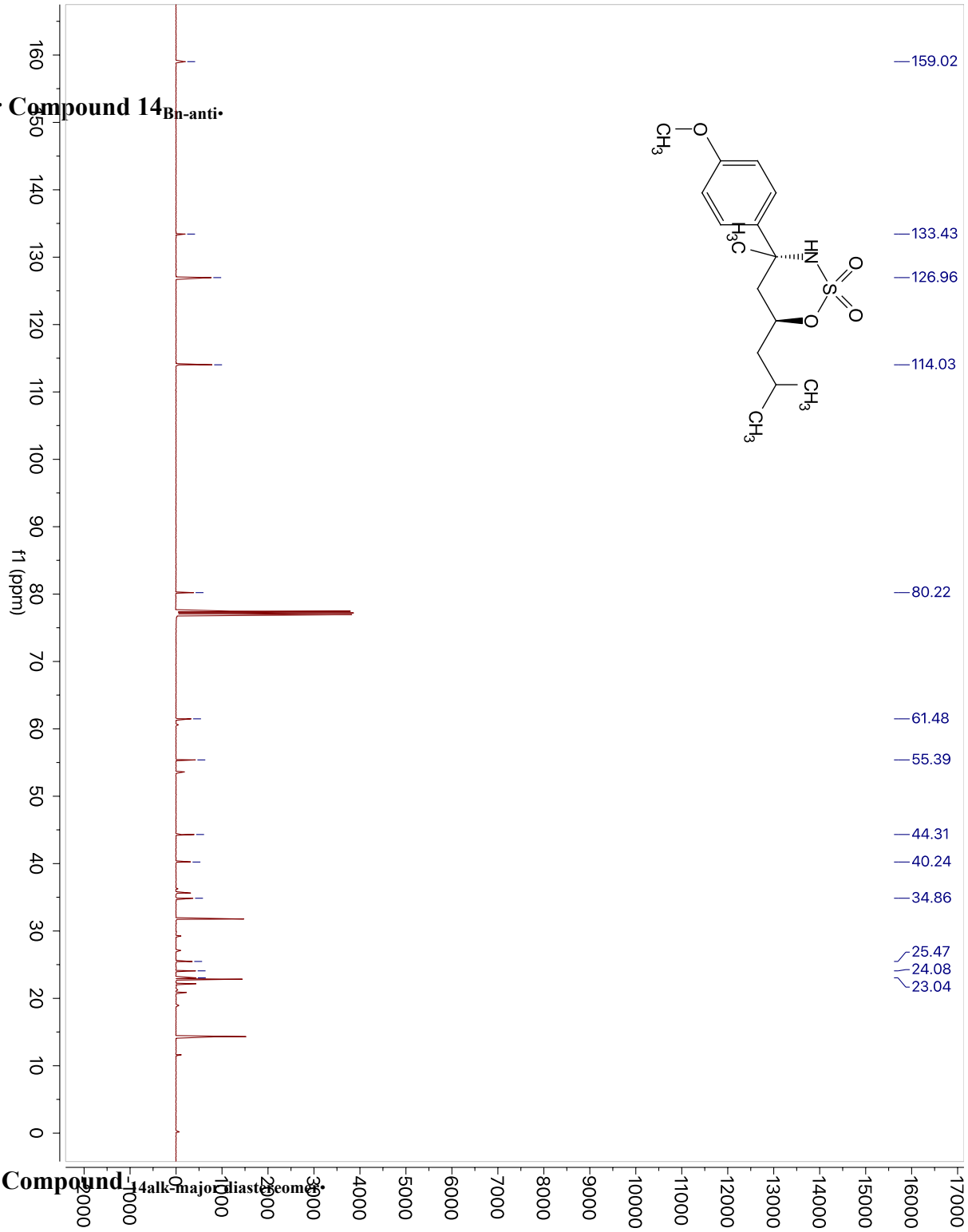

159.44
138.29
125.51
114.44
79.40
55.54
44.50
40.65
34.86
27.39
24.04
23.11
22.06
f1 (ppm)

^{1}H NMR for Compound $14_{Bn\text{-}anti\bullet}$

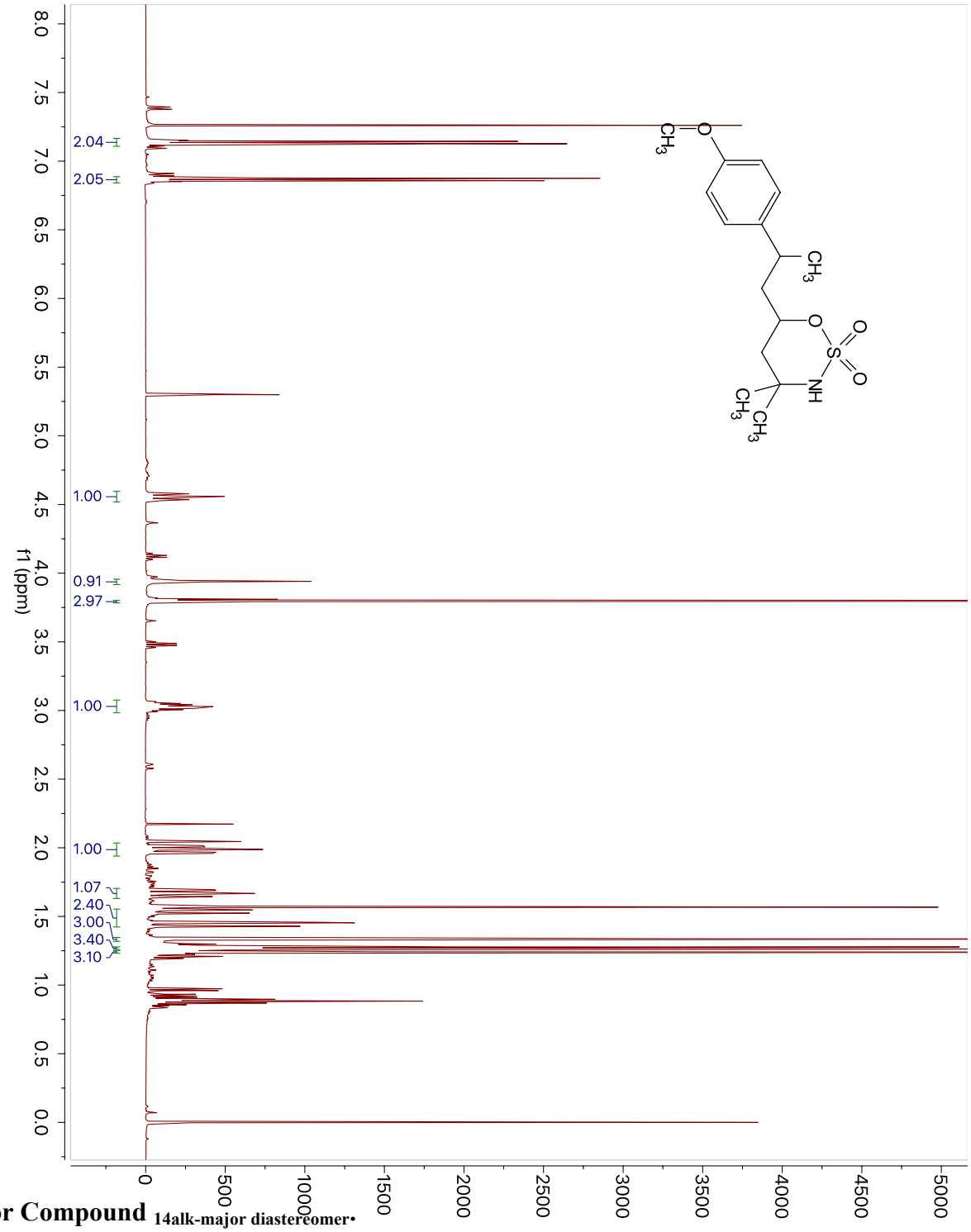



159.44
138.29
125.51
114.44
79.40
55.54
44.50
40.65
34.86
27.39
24.04
23.11
22.06
f1 (ppm)

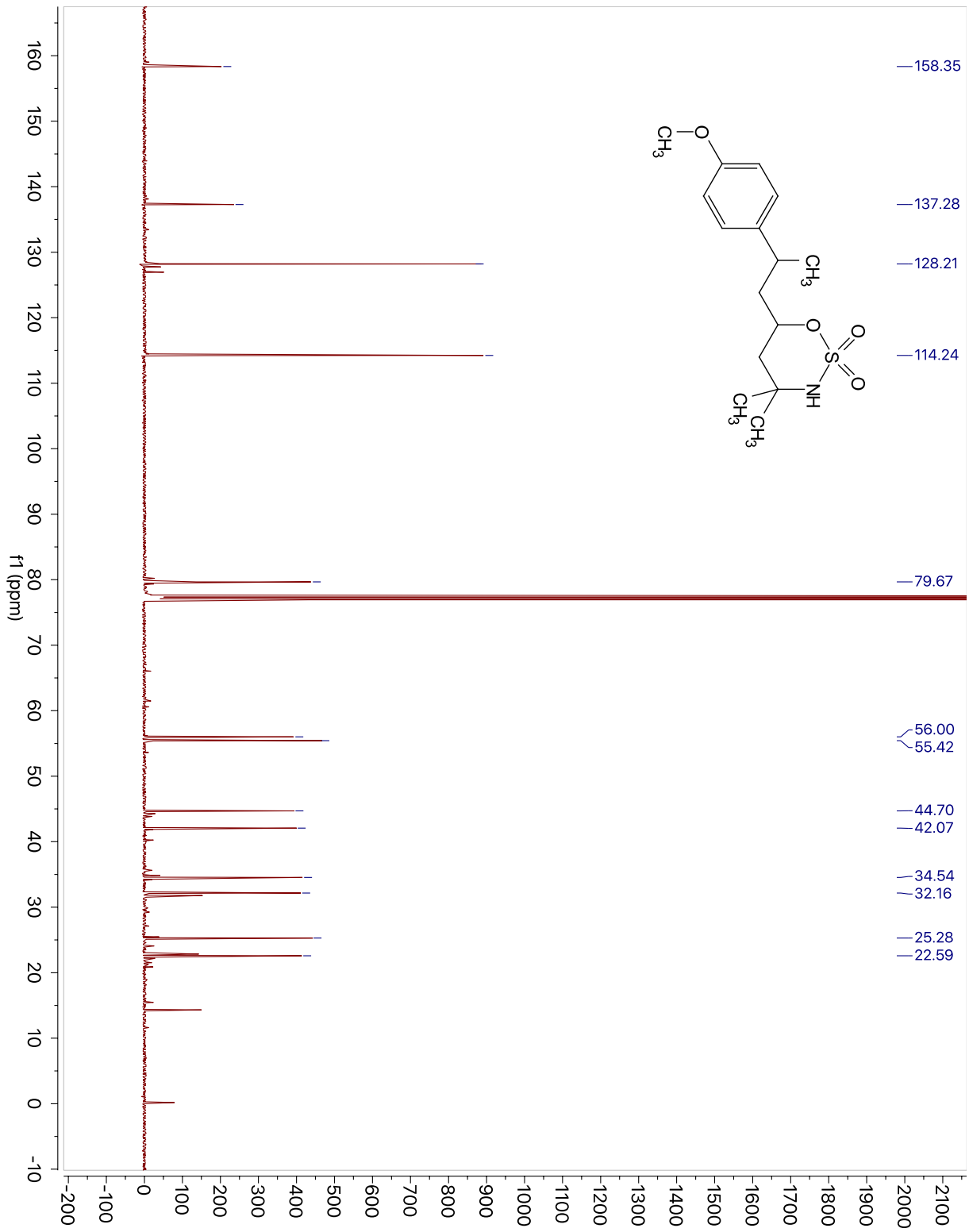
^{13}C NMR for Compound 14$_{Bn\text{-}anti\bullet}$



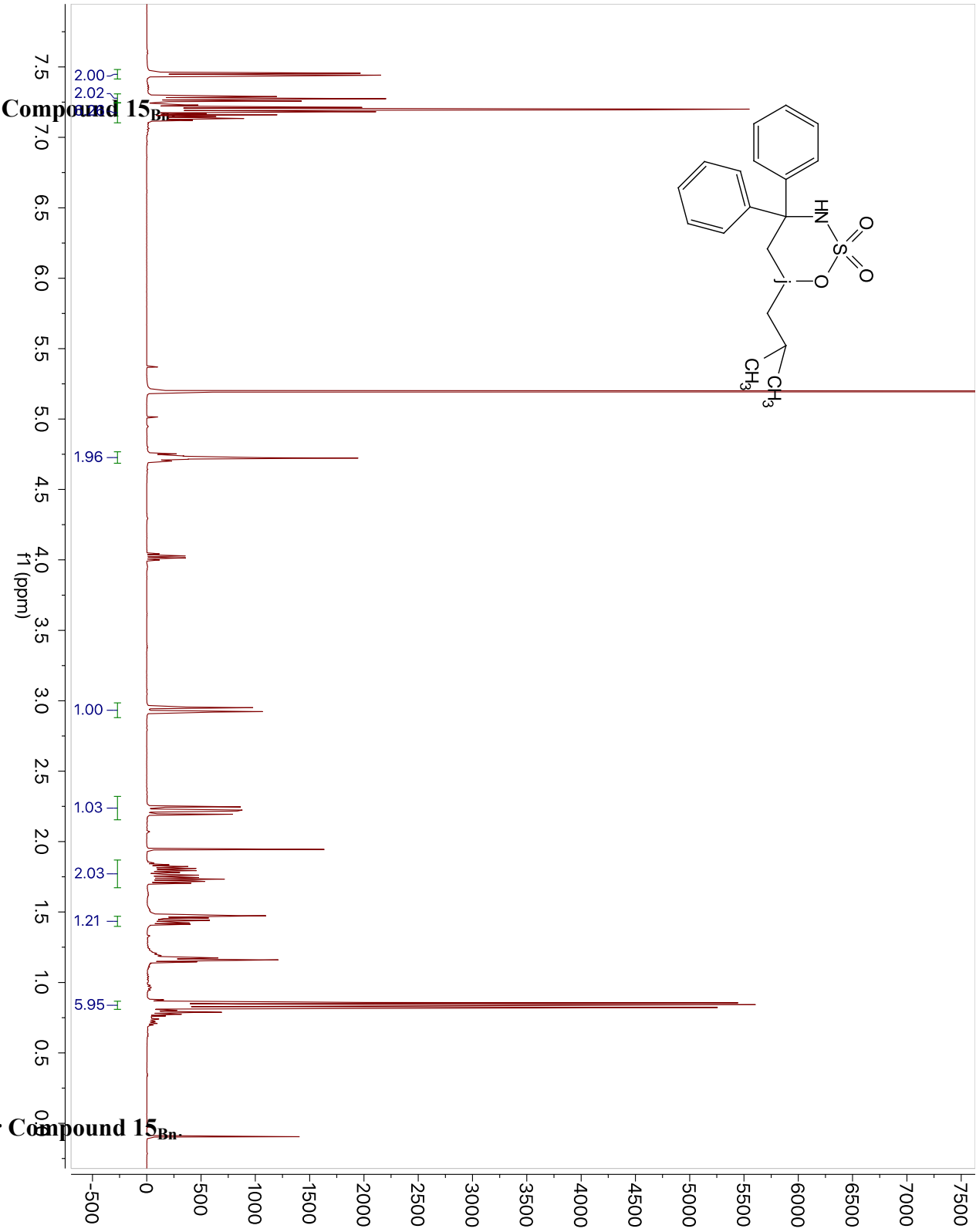
^{1}H NMR for Compound 14alk-major diastereomer•



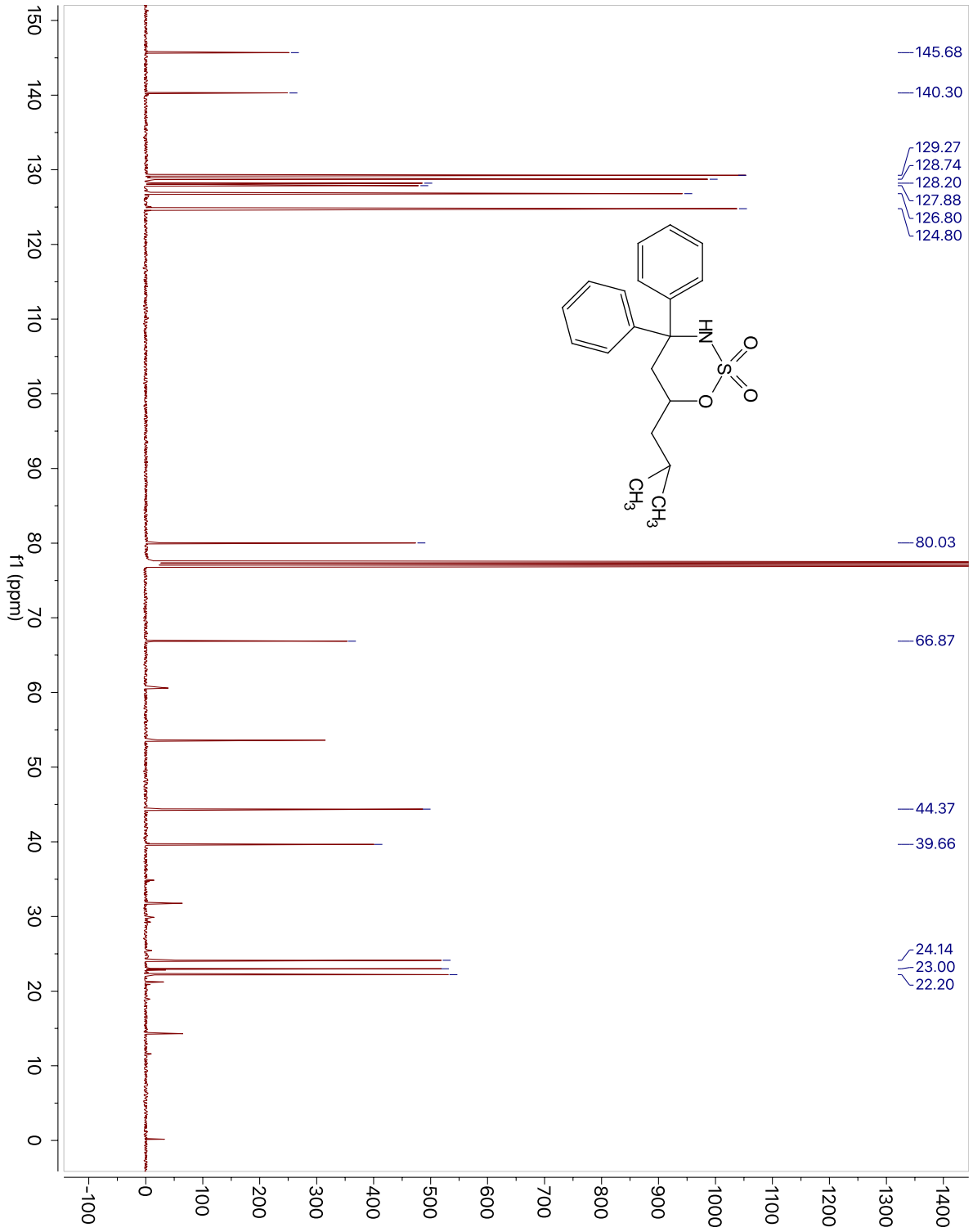
^{13}C NMR for Compound 14alk-major diastereomer•


158.35
137.28
128.21
114.24
79.67
56.00
55.42
44.70
42.07
34.54
32.16
25.28
22.59
f1 (ppm)

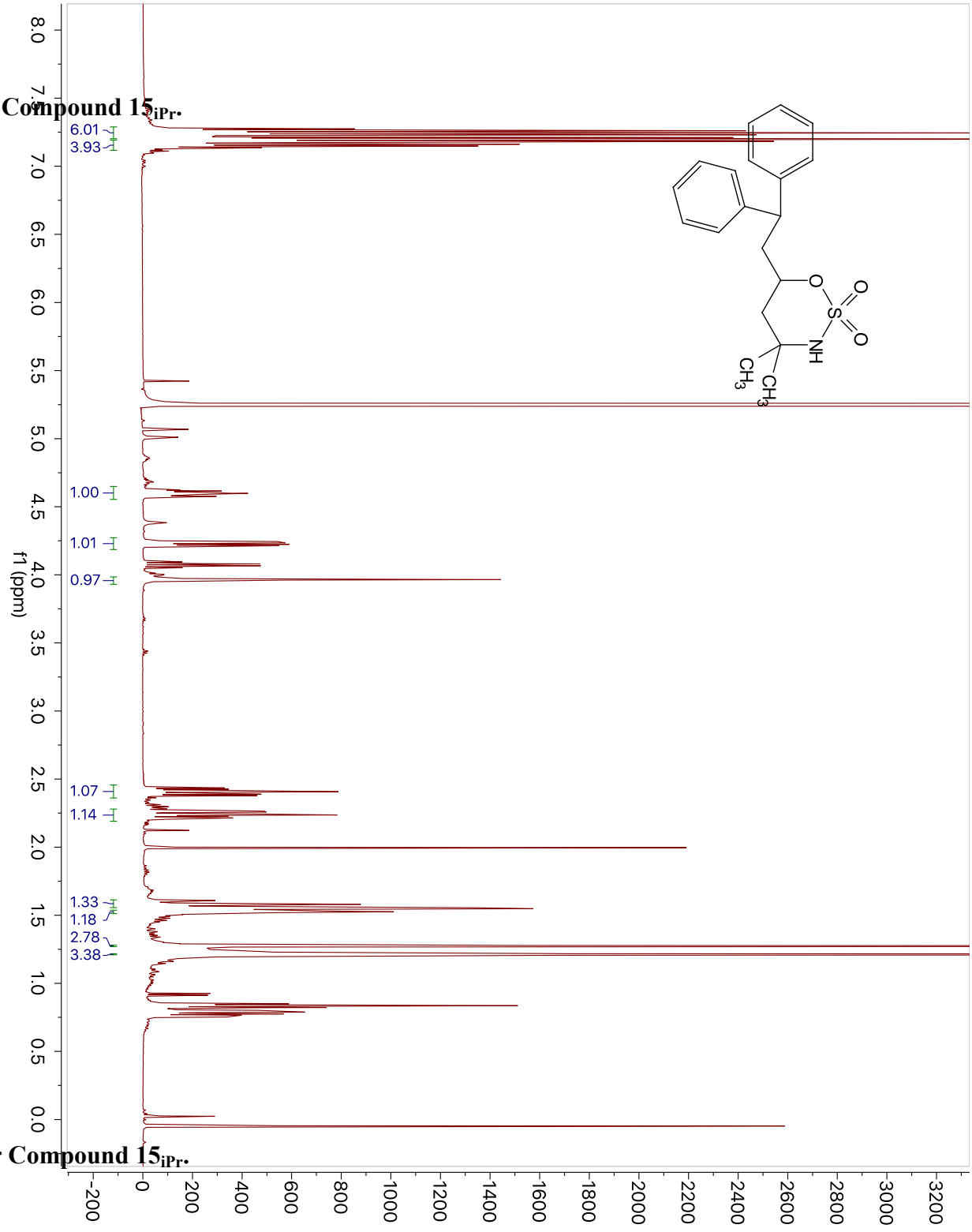
^{1}H NMR for Compound 15_{Bn}



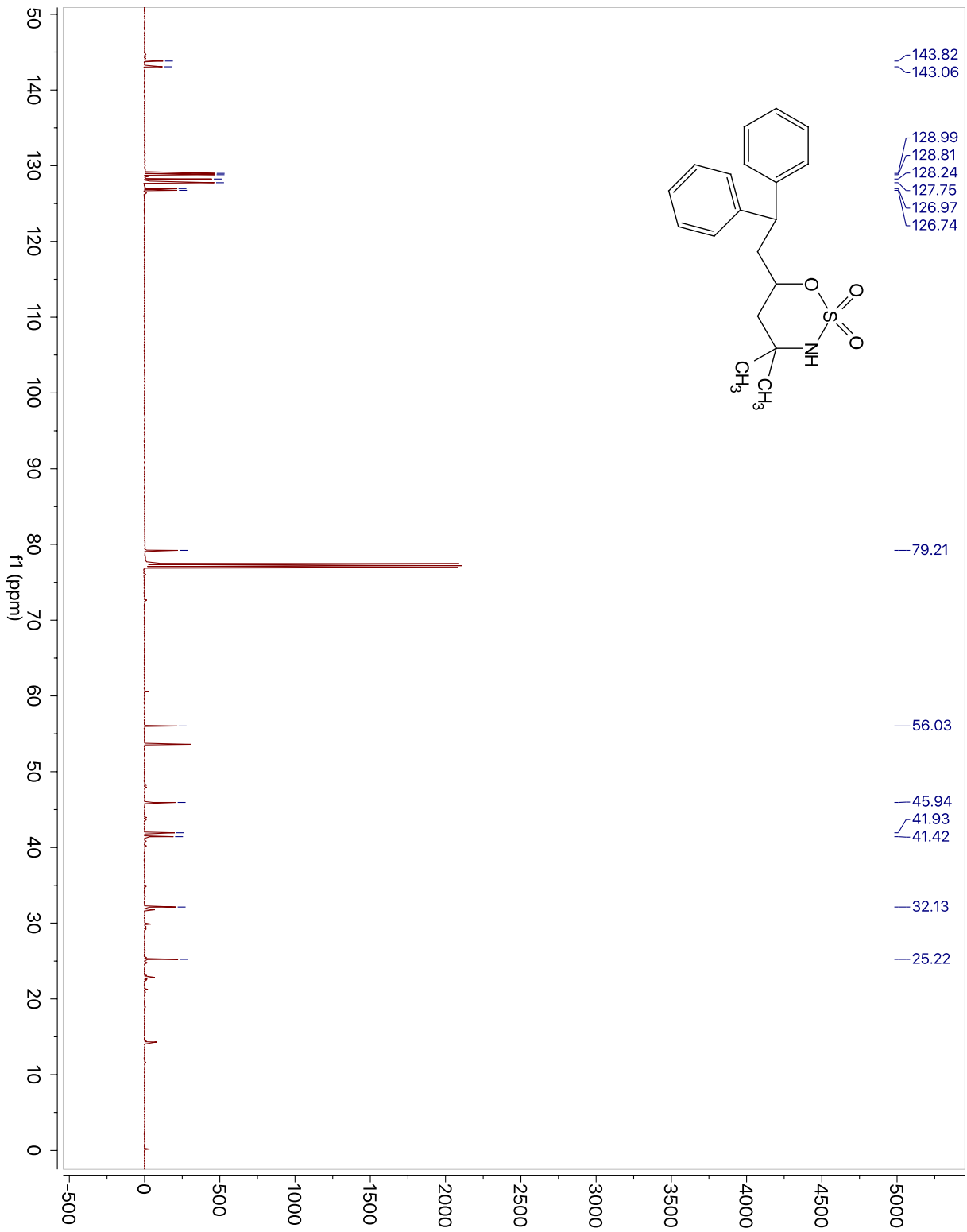
^{13}C NMR for Compound 15_{Bn}


145.68
140.30
129.27
128.74
128.20
127.88
126.80
124.80
80.03
66.87
44.37
39.66
24.14
23.00
22.20
HN
S
O
O
O
CH3
CH3
f1 (ppm)

^{1}H NMR for Compound 15_{iPr}.



^{13}C NMR for Compound 15_{iPr}.


143.82
143.06
128.99
128.81
128.24
127.75
126.97
126.74
79.21
56.03
45.94
41.93
41.42
32.13
25.22
f1 (ppm)