Supporting Information

Cross-Coupling of Sulfonic Acid Derivatives via Aryl-Radical Transfer (ART) Using TTMSS or Photoredox.

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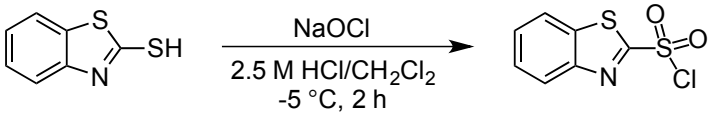
General information. All reactions were performed using oven- or flame-dried glassware under an atmosphere of dry argon with magnetic stirring, unless otherwise noted. Non-aqueous reagents were transferred by syringe under argon. Organic solutions were concentrated using a Buchi rotary evaporator. Methylene chloride, benzene, toluene, tetrahydrofuran, and diethyl ether were dried using a J.C. Meyer solvent purification system. Triethylamine, *N*,*N*-diisopropylethylamine pyridine, acetonitrile and *tert*-butyl acetate were distilled from CaH_2 under argon. Dimethyl sulfoxide and dimethylformamide were distilled from CaH_2 at reduced pressure. All other solvents and commercial reagents were used as provided unless otherwise noted. Flash column chromatography was performed employing 32-63 µm silica gel (Dynamic Adsorbents Inc). Thin-layer chromatography (TLC) was performed on silica gel 60 F_{254} plates (SiliCycle). Preparative TLC was performed using silica gel GF 1000 µm Uniplates (Analtech).

^{1}H and ^{13}C NMR were recorded on Bruker DRX spectrometers in deuterated solvents and at frequencies as noted. Data for ^{1}H NMR are reported as follows: chemical shift (δ, in ppm), multiplicity (s=singlet, br s=broad singlet, d=doublet, t=triplet, q=quartet, hept=heptet, m=multiplet, app=apparent), coupling constant (*J*, in Hz), and integration. Data for ^{13}C NMR are reported in terms of chemical shift. Low-resolution mass spectrometry (LRMS) was performed on a JEOL JMS-LCmate liquid chromatography spectrometer system using APCI+ ionization mode, or a Waters Acquity UPC^2 system using ESI+, ESI–, or APCI+. IR spectra were recorded on a Perkin-Elmer FTIR spectrometer. Data for IR are reported as follows: wavenumber (ν, in cm^{-1}), intensity (s=strong, m=moderate, w=weak).

Synthesis of sulfonyl chloride substrate precursors

Sulfonyl chloride S1:[1]



S1

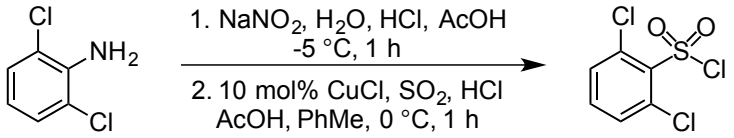
Based on a published procedure,[2] bleach (400 mL, 5.7% NaOCl, 306 mmol, 5.1 equiv) was added from an addition funnel over 1 hour to a suspension of 2-mercaptobenzothiazole (10.0 g, 59.8

1 R. O. Roblin Jr. and J. W. Clapp, *J. Am. Chem. Soc.* 1950, **72**, 4890.

2 J. Bornholdt, J. Felding, R. P. Clausen and J. L. Kristensen, *Chem. - Eur. J.* 2010, **16**, 12474.

mmol, 1.0 equiv) in CH_2Cl_2 (300 mL) and 7.5 M hydrochloric acid (200 mL) at -10 °C in an ice/acetone bath, giving a final aqueous HCl concentration of 2.5 M. The resulting homogeneous solution was stirred for 1 hour below -5 °C. The layers were separated, the aqueous layer was extracted with CH_2Cl_2 (pre-cooled to 0 °C, 2 x 100 mL), and the combined organic layers were washed with brine (pre-cooled to 0 °C, 100 mL), dried over $MgSO_4$, and concentrated below 5 °C. The resulting orange solid was suspended in dry diethyl ether (50 mL) at -78 °C for 1.5 hours, filtered, washed with diethyl ether (pre-cooled to -78 °C, 20 mL), air-dried for 10 minutes, and dried on a vacuum line at 0 °C to provide the sulfonyl chloride as a light peach solid (9.49 g, 68% yield). This compound could be stored under argon at -20 °C for at least 3 months without noticeable decomposition. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.32 (dd, *J* = 7.1, 2.2 Hz, 1H), 8.05 (dd, *J* = 6.9, 2.2 Hz, 1H), 7.70 (m, 2H).

Sulfonyl chloride 24:[3]



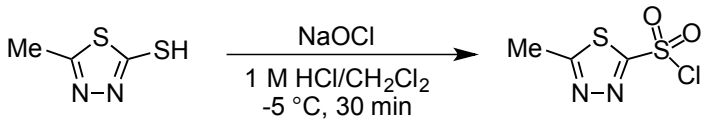
24
54% yield

Based on a published procedure,[4] concentrated hydrochloric acid (100 mL) was added to a solution of 2,6-dichloroaniline (16.2 g, 100 mmol, 1.0 equiv) in acetic acid (20 ml) in an open 250 mL beaker to give a white suspension that was then cooled to below -5 °C in an acetone/ice bath. A solution of sodium nitrite (7.64 g, 111 mmol, 1.1 equiv) in water (18 ml) was added over 15 minutes, and the light orange mixture was stirred below -5 °C. After 1 hour, the suspension was filtered and the clear yellow solution of the resulting diazonium salt was added over 20 minutes from an addition funnel to a suspension of copper(I) chloride (1.00 g, 10.1 mmol, 0.10 equiv) in liquid sulfur dioxide (20 mL), concentrated HCl (3 mL), acetic acid (40 mL), and toluene (40 mL) in an open 600 mL beaker at 0 °C. After 1 hour, the clear green aqueous layer was separated from the clear red organic layer, the latter of which which was diluted with toluene (50 mL), washed with water (2 x 25 mL), dried over $MgSO_4$, and concentrated. The red oily residue was purified by flash chromatography (0 → 2% ethyl acetate/hexanes) to afford the sulfonyl chloride as a light orange solid (13.4 g, 54% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 8.0, 0.9 Hz, 2H), 7.50 (dd, *J* = 9.0, 7.0 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 139.1, 135.7, 134.9, 132.2.

3 H. Meerwein, G. Dittmar, R. Göllner, K. Hafner, F. Mensch and O. Steinfort, *Chem. Ber.* 1957, **90**, 841.

4 K. Wellinga and J. H. H. Eussen, *US Pat.*, 4927452 A, 1990, column 15.

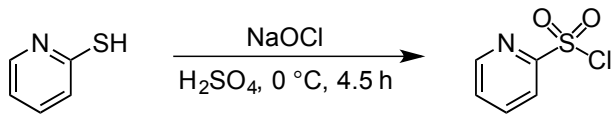
Sulfonyl chloride S2:[5]



S2
86% yield

Based on a published procedure,[2] bleach (85 mL, 8.25% NaOCl, 104 mmol, 3.5 equiv) was added from an addition funnel over 20 minutes to a mixture of CH_2Cl_2 (80 mL) and 2.4 M hydrochloric acid (65 mL) below -5 °C in an acetone/ice bath, giving a final aqueous HCl concentration of 1 M. After 10 minutes at this temperature, a slurry of 5-methyl-1,3,4-thiadiazole-2-thiol (3.95 g, 29.9 mmol, 1.0 equiv) in CH_2Cl_2 (20 mL) was added in 6 portions over 10 minutes. The resulting suspension was stirred for 30 minutes below -5 °C. Excess chlorine was then quenched with 1 M $Na_2S_2O_3$ (11 mL). In a separatory funnel pre-cooled to -20 °C, the layers were separated, the organic layer was washed with saturated $NaHCO_3$ (pre-cooled to 0 °C, 30 mL) and brine (pre-cooled to 0 °C, 30 mL), dried over $MgSO_4$ at -78 °C, and concentrated below -10 °C. The resulting pale green solid was dried on a vacuum line for 30 minutes at -10 °C, suspended in dry diethyl ether (50 mL) at -78 °C for 2 hours, filtered, washed with diethyl ether (pre-cooled to -78 °C, 10 mL), air-dried for 10 minutes, and dried on a vacuum line at -10 °C for 1 hour to provide the sulfonyl chloride as a light green solid (5.13 g, 86% yield). Stored under argon at -20 °C for 1 week, this material was 18% decomposed to 2-chloro-5-methyl-1,3,4-thiadiazole.[2] ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.97 (s, 3H).

Sulfonyl chloride S3:[6]



S3
82% yield

Based on a published procedure,[7] bleach (235 mL, 5.7% NaOCl, 180 mmol, 10 equiv) was added from an addition funnel over 4 hours to a solution of 2-mercaptopyridine (2.00 g, 18.0 mmol, 1.0 equiv) in sulfuric acid (50 mL) at 0 °C. The resulting solution was stirred for 30 minutes at 0 °C, and then poured into water (150 mL). The aqueous layer was extracted with CH_2Cl_2 (3 x 150 mL), and the combined organic layers were washed with brine (50 mL), dried over $MgSO_4$, and

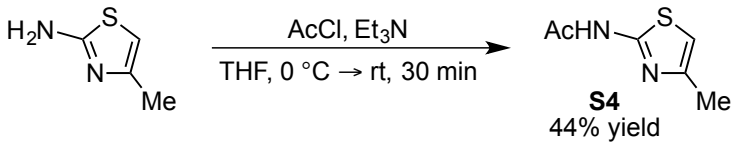
5 E. Vedejs, S. Lin, A. Klapars and J. Wang, *J. Am. Chem. Soc.* 1996, **118**, 9796.

6 B. G. Boggiano, V. Petrow, O. Stephenson and A. M. Wild, *J. Pharm. Pharmacol.* 1961, **13**, 567.

7 A. García-Rubia, B. Urones, R. Gómez Arrayás and J. C. Carretero, *Angew. Chem. Int. Ed.* 2011, **50**, 10927.

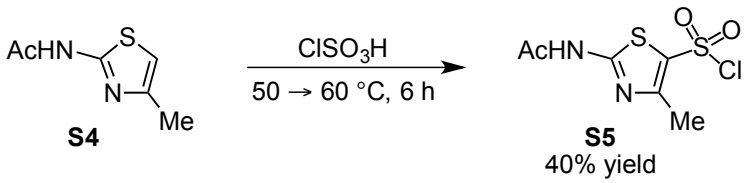
concentrated. The resulting pale yellow oil was dried overnight on a vacuum line at 0 °C to provide the sulfonyl chloride (2.61 g, 82% yield). This compound was used immediately upon characterization. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.84 (d, *J* = 4.2 Hz, 1H), 8.12 (d, *J* = 7.9 Hz, 1H), 8.05 (td, *J* = 7.7, 1.7 Hz, 1H), 7.68 (ddd, *J* = 7.4, 4.6, 1.2 Hz, 1H).

Amide S4:[8]



Based on a published procedure,[8] acetyl chloride (2.2 mL, 31 mmol, 1.0 equiv) was added over 10 minutes to a solution of 2-amino-4-methylthiazole (3.45 g, 30.2 mmol, 1.00 equiv) and triethylamine (4.8 mL, 34 mmol, 1.1 equiv) in tetrahydrofuran (100 mL) at 0 °C. The mixture was warmed to room temperature after 30 minutes, and after 1.5 hours further, filtered and washed with tetrahydrofuran (5 mL). The filtrate was concentrated to provide a pale yellow solid (4.15 g) determined by ^{1}H NMR spectroscopy to be a 10:1 mixture of the desired amide and the starting material. This crude material was recrystallized from ~ 4:1 hexanes/tetrahydrofuran (50 mL) and cooling to 4 °C overnight to provide a light yellow solid (2.74 g) containing a 98:2 mixture of the amide and the starting material. Final purification by flash chromatography (0 → 3% methanol/CH_2Cl_2) afforded the amide as an off-white solid (2.10 g, 44% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.32 (s, 1H), 6.55 (d, *J* = 1.0 Hz, 1H), 2.37 (d, *J* = 1.0 Hz, 3H), 2.22 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.1, 159.2, 146.5, 108.5, 23.3, 17.2.

Sulfonyl chloride S5:[9]

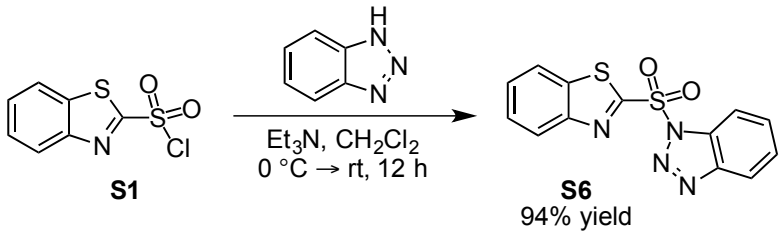


Chlorosulfonic acid (5.6 mL, 84 mmol, 8.2 equiv) was added to amide **S4** (1.61 g, 10.3 mmol, 1.00 equiv) at -10 °C. The resulting solid mass was thawed to room temperature, stirred, heated to 50 °C for 3 hours, and then 60 °C for 3 hours. After cooling to room temperature, the mixture was poured into water. This aqueous solution was extracted with diethyl ether (2 x 35 mL), and the combined organic layers were washed with water (20 mL), dried over $MgSO_4$, and concentrated. The resulting beige solid (1.05 g, 40% yield) was ~ 95% pure by ^{1}H NMR spectroscopy. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.05 (s, 1H), 2.67 (s, 3H), 2.34 (s, 3H).

8 R. A. Coburn and R. A. Glennon, *J. Pharm. Sci.* 1973, **62**, 1785.

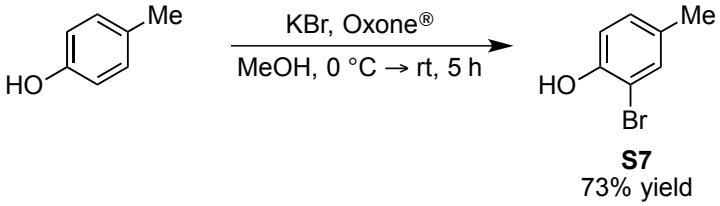
9 H. J. Backer and J. de Jonge, *Rec. Trav. Chim. Pays-Bas* 1943, **62**, 163.

Synthesis of sulfonyl benzotriazole substrate precursor S6:



Based on Katriztky's method,[10] sulfonyl chloride **S1** (8.39 g, 35.9 mmol, 1.00 equiv) was added in small portions to a solution of benzotriazole (4.28g, 35.9 mmol, 1.00 equiv) and triethylamine (5.5 mL, 39 mmol, 1.1 equiv) in CH_2Cl_2 (200 mL) at 0 °C, and the white suspension was stirred for 12 hours while warming slowly to room temperature. The mixture was then washed with water (150 mL), dried over $MgSO_4$, and concentrated to provide a white solid (15.5 g). This residue was purified by flash chromatography (CH_2Cl_2) to afford the title compound as a fluffy white solid (10.73 g, 94% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (d, *J* = 8.4 Hz, 1H), 8.13 (m, 2H), 7.97 (m, 1H), 7.74 (ddd, *J* = 8.3, 7.2, 0.9 Hz, 1H), 7.59 (m, 2H), 7.54 (ddd, *J* = 8.2, 7.2, 0.9 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.9, 152.2, 145.7, 137.5, 132.0, 131.1, 129.0, 128.2, 126.6, 126.2, 122.4, 121.0, 112.7. LRMS (APCI+) for $C_{13}H_8N_4O_2S_2$ $[MH]^+$ m/z calcd 317.02, found 317.10. IR (ATR) ν 1591 (w), 1473 (w), 1462 (w), 1447 (w), 1405 (m), 1390 (w), 1324 (w), 1302 (w), 1276 (w), 1276 (m), 1236 (w), 1228 (w), 1186 (m), 1147 (w), 1122 (w), 1087 (w), 1070 (w), 1021 (w), 1007 (w), 943 (m), 907 (m), 851 (w), 763 (s), 745 (s), 730 (w), 713 (w), 692 (m), 672 (s), 648 (w), 624 (s), 596 (s), 572 (s) 559 (s), 538 (s), 503 (m), 480 (w), 433 (m).

Bromophenol S7:[11]

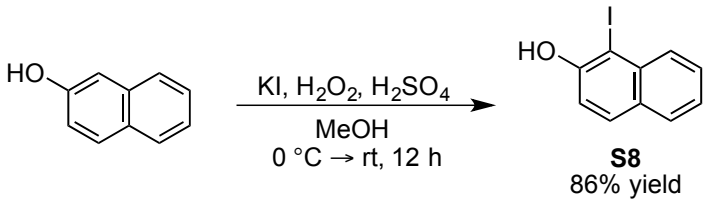


Based on a published procedure,[12] Oxone® (16.89 g, 27.48 mmol, 1.10 equiv) was added in small portions to a solution of *p*-cresol (2.70 g, 25.0 mmol, 1.00 equiv) and potassium bromide (3.27 g, 27.5 mmol, 1.10 equiv) in methanol (125 mL) at 0 °C, and the solution was stirred for 5 hours while warming slowly to room temperature. The mixture was then filtered, washed with ethyl acetate, and the filtrate was concentrated. The residue was purified by flash chromatography (0 → 5% ethyl acetate/hexanes) to provide a yellow oil (4.22 g) in ~ 90% purity as judged by ^{1}H NMR. Distillation (47 °C/3-5 mmHg) afforded the pure title compound as a clear, colorless oil (3.40 g, 73% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.24 (d, *J* = 1.2 Hz, 1H), 6.98 (dd, *J* = 8.2, 1.5 Hz, 1H), 6.89 (d, *J* = 8.3 Hz, 1H), 5.39 (br s, 1H), 2.24 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 150.1,

10 A. R. Katritzky, T. Kurz, S. Zhang, M. Voronkov and P. J. Steel, *Heterocycles* 2001, **55**, 1703.

132.2, 131.5, 129.9, 115.9, 109.9, 20.3. LRMS (APCI+) for $C_7H_7{}^{79}BrO$ $[MH]^+$ m/z calcd 186.98, found 187.18.

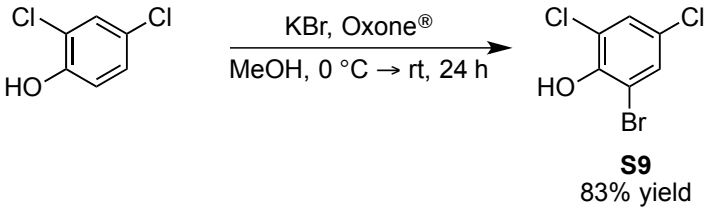
Iodophenol S8:[13]



S8
86% yield

Sulfuric acid (1.60 mL, 30.0 mmol, 1.20 equiv) was added to a solution of 2-naphthol (3.61 g, 25.0 mmol, 1.00 equiv) and potassium iodide (4.19 g, 25.2 mmol, 1.01 equiv) in methanol (250 mL) at 0 °C. A precipitate formed, and hydrogen peroxide (5.65 mL, 30% aqueous solution, 49.8 mmol, 1.99 equiv) was added. After 12 hours of warming slowly to room temperature, the mixture was filtered, and the filtrate was concentrated. The residue was dissolved in CH_2Cl_2 (300 mL), washed with 25% sat. aq. $Na_2S_2O_3$ (250 mL) and water (200 mL), dried over Na_2SO_4, and concentrated to provide a solid (6.58 g). This material was purified by flash chromatography (5 → 10% ethyl acetate/hexanes) to provide an orange solid (6.14 g) that was recrystallized from hexanes (50 mL), cooling to -20 °C for 2 days, to afford the title compound as a light peach solid (5.84 g, 86% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.5 Hz, 1H), 7.74 (d, *J* = 9.1 Hz, 2H), 7.54 (ddd, *J* = 8.4, 6.9, 1.3 Hz, 1H), 7.38 (ddd, *J* = 8.1, 6.8, 1.1 Hz, 1H), 7.25 (d, *J* = 8.8 Hz, 1H, overlaps with $CHCl_3$ signal), 5.75 (s, 1H).

Bromophenol S9:[14]



S9
83% yield

Oxone® (17.03 g, 27.70 mmol, 1.10 equiv) was added in small portions to a solution of 2,4-dichlorophenol (4.11 g, 25.2 mmol, 1.00 equiv) and potassium bromide (3.30 g, 27.7 mmol, 1.10 equiv) in methanol (125 mL) at 0 °C, and the solution was stirred for 24 hours while warming slowly to room temperature. The mixture was then filtered, washed with ethyl acetate (50 mL), and the filtrate was concentrated. The solid orange residue (7.1 g) was purified by flash

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11 J. H. Espenson , Z. Zhu and T. H. Zauche, *J. Org. Chem.* 1999, **64**, 1191.

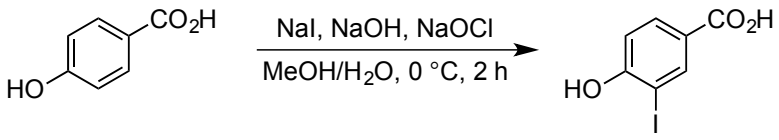
12 N. Narender, P. Srinivasu, M. Ramakrishna Prasad, S. J. Kulkarni and K. V. Raghavan, *Synth. Commun.* **2002**, *32*, 2313.

13 J. Iskra, S. Stavber and M. Zupan, *Synthesis* 2004, **2004**, 1869.

14 L. Xu, Y. Wang, X. Wen, C. Ding, G. Zhang and X. Liang, *Synlett* 2011, **2011**, 2265.

chromatography (10 → 25% CH_2Cl_2/hexanes) to provide an orange solid (6.1 g) that was recrystallized from hexanes (50 mL) to afford the title compound as yellow needles (2.22 g, 36%). A second recrystallization of the concentrated filtrate from hexanes (15 mL) yielded a second crop of spectroscopically identical material as orange needles (2.86 g, 47%), for a total yield of 83%. ^{1}H NMR (400 MHz, CDCl3) δ 7.41 (m, 1H), 7.31 (m, 1H), 5.82 (s, 1H). ^{13}C NMR (101 MHz, CDCl3) δ 147.9, 131.1, 128.8, 126.0, 121.3, 110.5.

Iodophenol S10:[15]

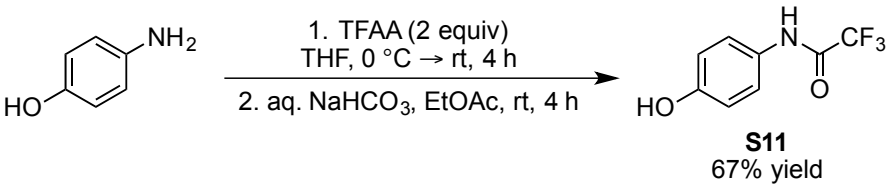


S10
58% yield

Bleach (62 mL, 8.25% NaOCl, 75 mmol, 1.0 equiv) was added from an addition funnel over 1 hour to a mixture of *p*-hydroxybenzoic acid (10.36 g, 75.01 mmol, 1.0 equiv), sodium iodide (11.24 g, 74.99 mmol, 1.0 equiv), and sodium hydroxide (6.00 g, 150 mmol, 2.0 equiv) in methanol (150 mL) and water (65 mL) at 0 °C. After 2 hours, the reaction was quenched with a solution of half-saturated $Na_2S_2O_3$ and stirred for 15 hours. The solution pH was then adjusted to 4 by adding ~ 20 mL of concentrated HCl, forming a yellow precipitate. The mixture was filtered and the filtrate was concentrated to a volume of ~ 125 mL (mostly water). This solution was diluted with water (100 mL), extracted with ethyl acetate (4 x 100 mL), and the combined organic extracts were dried over Na_2SO_4 and concentrated. The resulting white solid (18.83 g) was ~ 90% pure as judged by ^{1}H NMR and was recrystallized from ~ 4:1 toluene/hexanes (300 mL) to afford a white solid (14.54 g) of greater purity, though a detectable byproduct persisted. Another recrystallization from toluene (175 mL) was effected by cooling slowly on the hot plate used to boil the solution while stirring overnight under argon. The last recrystallization was repeated once more to provide the title compound as a coarse white solid (11.58 g, 58% yield). ^{1}H NMR (400 MHz, d_6-DMSO) δ 12.71 (br s, 1H), 11.17 (br s, 1H), 8.20 (d, *J* = 1.1 Hz, 1H), 7.79 (dd, *J* = 8.4, 1.2 Hz, 1H), 6.93 (d, *J* = 8.5 Hz, 1H). ^{13}C NMR (101 MHz, d_6-DMSO) δ 165.9, 160.7, 140.4, 131.3, 123.4, 114.5, 84.2. LRMS (APCI+) for $C_7H_5IO_3$ $[MH]^+$ m/z calcd 264.94, found 265.18.

15 D. P. Walker, D. W. Piotrowski, E. J. Jacobsen, B A. Acker and V. E. Groppi, *US Pat.*, 232853 A1, 2003, pp. 39.

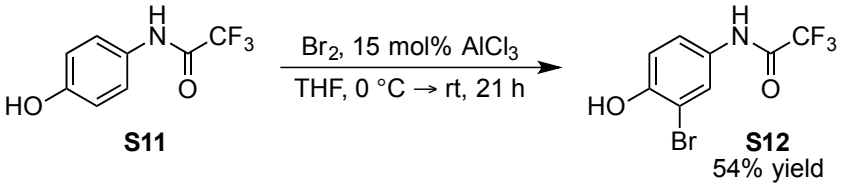
Phenol S11:[16]



S11
67% yield

Trifluoroacetic anhydride (11.4 mL, 82.0 mmol, 2.05 equiv) was added over 30 minutes to a solution of 4-aminophenol (4.36 g, 40.0 mmol, 1.00 equiv) in tetrahydrofuran (80 mL) at 0 °C, and the solution was stirred for 3.5 hours further while warming slowly to room temperature. The mixture was then concentrated, diluted with ethyl acetate (150 mL), washed with sat. aq. $NaHCO_3$ (3 x 75 mL), water (3 x 50 mL), and brine (25 mL), dried over $MgSO_4$, and concentrated. ^{1}H NMR analysis revealed a 1.7:1.0 mixture of the bis(trifluoroacetylated) intermediate and the desired phenol. This mixture was therefore dissolved in ethyl acetate (100 mL) and sat. aq. $NaHCO_3$ (75 ml) and stirred vigorously for 4 hours, at which point TLC analysis (15% ethyl acetate/hexanes) gave a single spot. The layers were separated and the organic layer was washed with water (50 mL) and brine (25 mL), dried over $MgSO_4$, and concentrated to provide a light pink-purple solid that was recrystallized from ~ 6:1 hexanes/ethyl acetate (350 mL) to afford the phenol as a light tan-purple solid (5.53 g, 67% yield). ^{1}H NMR (500 MHz, d_6-DMSO) δ 10.98 (s, 1H), 9.49 (s, 1H), 7.44 (d, J = 8.7 Hz, 2H), 6.78 (d, J = 8.8 Hz, 2H). ^{13}C NMR (126 MHz, d_6-DMSO) δ 155.2, 154.1 (q, $^2J_{CF}$ = 36.4 Hz), 127.7, 122.9, 116.0 (q, $^1J_{CF}$ = 288.6 Hz), 115.3.

Bromophenol S12:



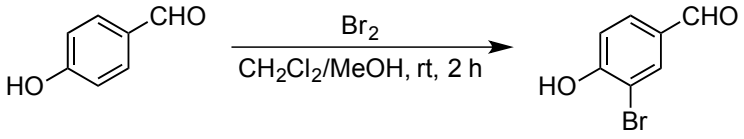
S11 **S12**
54% yield

Bromine (0.85 mL, 16.6 mmol, 1.1 equiv) was added over 1 hour to a solution of phenol **S11** (3.08 g, 15.0 mmol, 1.00 equiv) and aluminum chloride (303 mg, 2.27 mmol, 0.15 equiv) in tetrahydrofuran (90 mL) at 0 °C, and the solution was stirred for 20 hours further while warming slowly to room temperature. The reaction was then quenched with sat. aq. $Na_2S_2O_3$ (5 mL), concentrated, diluted with water (75 mL), and extracted with ethyl acetate (2 x 75 mL). The combined organic extracts were washed with brine (30 mL), dried over $MgSO_4$, and concentrated. The residue was purified by flash chromatography (20 → 25% ethyl acetate/hexanes) to provide the desired product contaminated with 4-bromo-1-butanol, derived from tetrahydrofuran ring-opening. Recrystallization from ~ 10:1 CH_2Cl_2/hexanes (75 mL) afforded the pure bromophenol as a light cream solid (2.31 g, 54% yield). ^{1}H NMR (500 MHz, d_6-DMSO) δ 11.11 (s, 1H), 10.33 (s, 1H), 7.83 (d, J = 2.5 Hz, 1H), 7.46 (dd, J = 8.8, 2.5 Hz,

16 T. Agag, C. R. Arza, F. H. J. Maurer and H. Ishida, *Macromolecules* 2010, **43**, 2748.

1H), 6.97 (d, *J* = 8.8 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.3 (q, $^2J_{CF}$ = 36.8 Hz), 152.0, 128.7, 125.7, 122.0, 116.2, 115.9 (q, $^1J_{CF}$ = 288.5 Hz), 108.8. LRMS (APCI+) for $C_8H_5{}^{81}BrF_3NO_2$ $[MH]^+$ m/z calcd 285.95, found 286.28. IR (ATR) ν 3286 (m), 1703 (m), 1680 (m), 1609 (w), 1544 (w), 1501 (m), 1429 (w), 1415 (m), 1340 (m), 1279 (m), 1217 (m), 1191 (m), 1153 (s), 1042 (m), 939 (w), 915 (w), 888 (w), 864 (w), 810 (m), 799 (m), 731 (w), 671 (m), 592 (w), 572 (w), 513 (m), 432 (w).

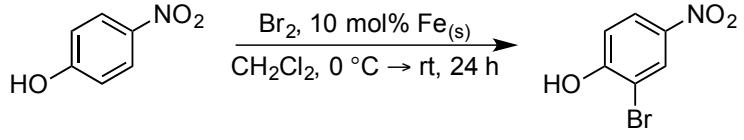
Bromophenol S13:[17]



S13
58% yield

A solution of bromine (1.40 mL, 27.3 mmol, 1.10 equiv) in CH_2Cl_2 (6 mL) was added over 30 minutes to a solution of *p*-hydroxybenzaldehyde (3.05 g, 25.0 mmol, 1.00 equiv) in CH_2Cl_2 (32 mL) and methanol (3 mL), and the solution was stirred for 2 hours further. The mixture was then diluted with CH_2Cl_2 (60 mL), washed with water (3 x 60 mL), dried over Na_2SO_4, and concentrated. The solid pink residue (5.05 g) was purified by flash chromatography (50 → 100% CH_2Cl_2/hexanes) to provide a white solid (3.52 g) that was recrystallized from chloroform (40 mL) to afford the title compound as a white solid (2.92 g, 58% yield). ^{1}H NMR (500 MHz, d_6-DMSO) δ 11.47 (s, 1H), 9.77 (s, 1H), 8.02 (d, *J* = 1.9 Hz, 1H), 7.74 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.10 (d, *J* = 8.4 Hz, 1H). ^{13}C NMR (126 MHz, d_6-DMSO) δ 190.2, 159.7, 135.0, 130.5, 129.6, 116.5, 110.0.

Bromophenol S14:[18]



S14
87% yield

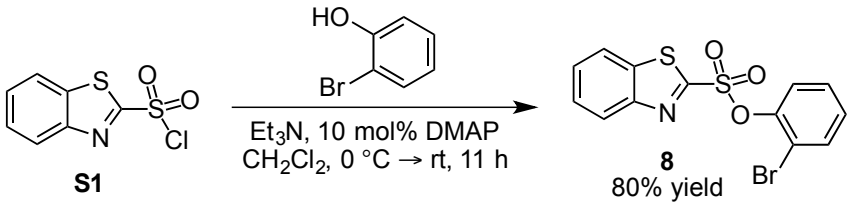
Using a published procedure,[19] bromine (1.35 mL, 26.3 mmol, 1.06 equiv) was added dropwise to a solution of *p*-nitrophenol (3.46 g, 24.9 mmol, 1.00 equiv) in CH_2Cl_2 (50 mL) at 0 °C, and after stirring for 1 hour, iron powder (142.5 mg, 2.551 mmol, 0.10 equiv) was added. The solution was stirred for 24 hours further while warming slowly to room temperature. The reaction was then quenched with 50% sat. $Na_2S_2O_3$ (50 mL), the aqueous layer was extracted with CH_2Cl_2 (25 mL), and the combined organic layers were dried over $MgSO_4$ and concentrated. The brown solid residue (5.5 g) was purified by flash chromatography (30 → 100% CH_2Cl_2/hexanes) to provide a white solid (4.69 g, 87% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, *J* = 2.6 Hz, 1H),

17 A. H. Lewin, J. Szewczyk, J. W. Wilson and F. I. Carroll, *Tetrahedron* 2005, **61**, 7144.

8.17 (dd, *J* = 9.0, 2.6 Hz, 1H), 7.13 (d, *J* = 9.0 Hz, 1H), 6.19 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.9, 141.9, 128.4, 125.4, 116.1, 110.2.

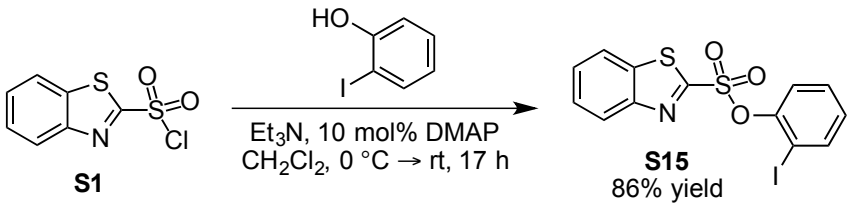
Synthesis of (2-haloaryl)sulfonic acid derivative substrates

Bromide 8:



Sulfonyl chloride **S1** (2.34 g, 10.0 mmol, 1.0 equiv) was added in small portions over 5 minutes to a solution of 2-bromophenol (1.27 mL, 12.0 mmol, 1.2 equiv), triethylamine (3.5 mL, 25 mmol, 2.5 equiv), and 4-dimethylaminopyridine (122 mg, 1.00 mmol, 0.10 equiv) in CH_2Cl_2 (50 mL) at 0 °C, and the solution was stirred for 11 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (50 mL), washed with 1 M HCl (3 x 40 mL) and brine (20 mL), dried over $MgSO_4$, and concentrated. The residue was purified by flash chromatography (25 → 30% CH_2Cl_2/hexanes) and recrystallized from ~ 1:1 hexanes/ethyl acetate (125 mL) to provide the bromide as white prisms (2.96 g, 80% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 (dd, *J* = 7.4, 1.5 Hz, 1H), 8.01 (dd, *J* = 7.3, 1.6 Hz, 1H), 7.65 (m, 2H), 7.55 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.47 (dd, *J* = 8.2, 1.4 Hz, 1H), 7.36 (td, *J* = 8.0, 1.5 Hz, 1H), 7.19 (td, *J* = 7.8, 1.5 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.4, 152.3, 147.3, 137.3, 134.2, 129.00, 128.98, 128.7, 128.1, 126.1, 124.3, 122.3, 116.4. LRMS (APCI+) for $C_{13}H_8{}^{81}BrNO_3S_2$ $[MH]^+$ m/z calcd 371.92, found 372.32. IR (ATR) ν 1463 (m), 1393 (s), 1319 (w), 1200 (m), 1174 (s), 1123 (w), 1089 (w), 1027 (m), 861 (s), 784 (s), 763 (s), 746 (m), 711 (w), 696 (w), 653 (w) 622 (s), 546 (s), 429 (m).

Iodide S15:



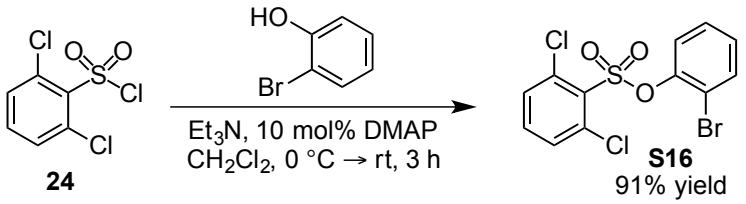
Sulfonyl chloride **S1** (2.34 g, 10.0 mmol, 1.0 equiv) was added in small portions over 5 minutes to a solution of 2-iodophenol (2.67 g, 12.1 mmol, 1.2 equiv), triethylamine (3.5 mL, 25 mmol, 2.5 equiv), and 4-dimethylaminopyridine (125 mg, 1.02 mmol, 0.10 equiv) in CH_2Cl_2 (50 mL) at 0 °C, and the clear yellow solution was stirred for 17 hours while warming slowly to room

18 T. Oberhauser, *J. Org. Chem.* 1997, **62**, 4504.

19 J.-M. Bernardon and P. Nedoncelle, *US Pat.*, 6316009 B1, 2001, column 38.

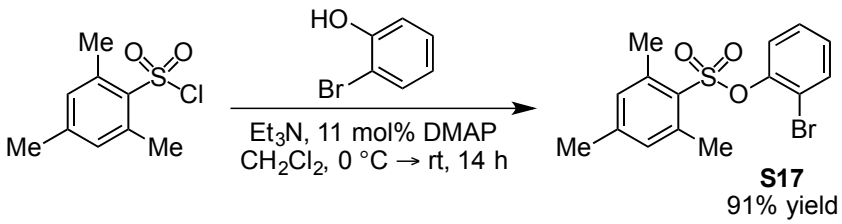
temperature. The mixture was then diluted with CH_2Cl_2 (100 mL), washed with 1 M HCl (3 x 40 mL) and brine (20 mL), dried over $MgSO_4$, and concentrated. The residue was purified by flash chromatography (2 → 15% ethyl acetate/hexanes, with ~ 20% CH_2Cl_2 added near the end to dissolve the solids) and recrystallized from ~ 2:1 hexanes/ethyl acetate (150 mL) to provide the iodide as white needles (3.57 g, 86% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 (d, *J* = 7.7 Hz, 1H), 8.02 (d, *J* = 7.5 Hz, 1H), 7.78 (d, *J* = 7.6 Hz, 1H), 7.65 (m, 2H), 7.46 (d, *J* = 7.8 Hz, 1H), 7.39 (t, *J* = 7.4 Hz, 1H), 7.04 (t, *J* = 7.2 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.5, 152.3, 150.5, 140.4, 137.4, 130.0, 129.2, 128.7, 128.1, 126.1, 123.4, 122.3, 89.7. LRMS (APCI+) for $C_{13}H_8INO_3S_2$ $[MH]^+$ m/z calcd 417.91, found 418.24. IR (ATR) ν 1468 (w), 1456 (w), 1389 (s), 1319 (w), 1196 (m), 1168 (m), 1088 (w), 1020 (w), 860 (s), 783 (s), 762 (s), 743 (m), 707 (w), 694 (w), 622 (s), 546 (s), 428 (m).

Bromide S16:



Triethylamine (1.60 mL, 11.5 mmol, 1.15 equiv) was added dropwise to a solution of 2-bromophenol (1.06 mL, 10.0 mmol, 1.00 equiv) and sulfonyl chloride **24** (2.46 g, 10.0 mmol, 1.00 equiv) in CH_2Cl_2 (50 mL) at 0 °C, followed by 4-dimethylaminopyridine (125 mg, 1.02 mmol, 0.10 equiv), and the solution was stirred for 3 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (50 mL), washed with 1 M HCl (3 x 30 mL) and brine (20 mL), dried over $MgSO_4$, and concentrated. The cream-colored solid was recrystallized from hexanes (100 mL) and a minimum of benzene (20 mL) to provide the bromide as colorless plates (3.50 g, 91% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.53 (m, 2H), 7.45 (dd, *J* = 9.1, 6.9 Hz, 1H), 7.29 (ddd, *J* = 8.8, 7.4, 1.6 Hz, 1H), 7.17 (m, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 147.2, 136.7, 134.3, 134.1, 133.4, 131.7, 128.8, 128.6, 124.0, 116.4. LRMS (APCI+) for $C_{12}H_7{}^{81}Br^{35}Cl_2O_3S$ $[MH_3O]^+$ m/z calcd 408.88, found 401.15. IR (ATR) ν 1579 (w), 1460 (w), 1425 (w), 1380 (m), 1259 (w), 1203 (m), 1172 (m), 1153 (w), 1114 (m), 1087 (w), 1040 (w), 1022 (w), 991 (w), 855 (s), 771 (s), 751 (s), 720 (w), 698 (s), 641 (w), 587 (s), 554 (s), 440 (m).

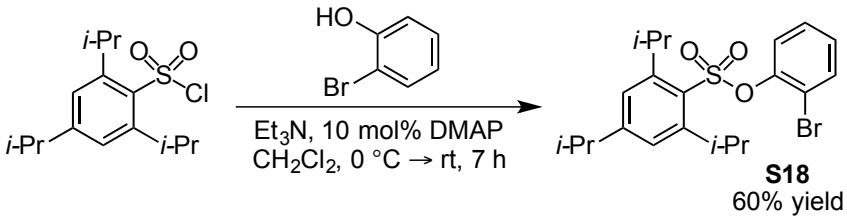
Bromide S17:



S17
91% yield

2-Mesitylenesulfonyl chloride (1.10 g, 5.03 mmol, 1.0 equiv) was added in small portions over 5 minutes to a solution of 2-bromophenol (0.56 mL, 5.30 mmol, 1.05 equiv), triethylamine (1.75 mL, 12.6 mmol, 2.5 equiv), and 4-dimethylaminopyridine (65 mg, 0.53 mmol, 0.11 equiv) in CH_2Cl_2 (25 mL) at 0 °C, and the solution was stirred for 14 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (25 mL), washed with 1 M HCl (3 x 20 mL) and brine (15 mL), dried over $MgSO_4$, and concentrated. The residue was purified by flash chromatography (5 → 50% CH_2Cl_2/hexanes) and recrystallized from hexanes (15 mL) to provide the bromide as white prisms (1.63 g, 91% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.23 (m, 1H), 7.11 (td, *J* = 7.7, 1.5 Hz, 1H), 7.06 (dd, *J* = 8.2, 1.5 Hz, 1H), 7.00 (s, 2H), 2.60 (s, 6H), 2.34 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 147.2, 144.2, 140.7, 134.1, 132.0, 131.8, 128.5, 128.1, 123.9, 117.0, 23.1, 21.3. LRMS (APCI+) for $C_{15}H_{15}{}^{81}BrO_3S$ $[MH]^+$ m/z calcd 357.00, found 357.38. IR (ATR) ν 1602 (w), 1468 (m), 1442 (m), 1362 (s), 1201 (m), 1168 (s), 1044 (m), 1034 (m), 850 (s), 771 (s), 732 (s), 701 (s), 664 (s), 647 (s), 571 (s), 535 (s), 456 (w), 439 (w).

Iodide S18:

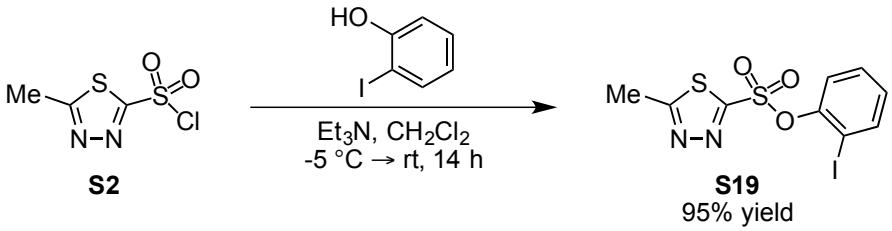


S18
60% yield

2,4,6-Triisopropylbenzenesulfonyl chloride (1.82 g, 6.01 mmol, 1.01 equiv) was added to a solution of 2-bromophenol (0.63 mL, 5.97 mmol, 1.00 equiv), triethylamine (0.98 mL, 7.0 mmol, 2.5 equiv), and 4-dimethylaminopyridine (75 mg, 0.61 mmol, 0.10 equiv) in CH_2Cl_2 (40 mL) at 0 °C, and the solution was stirred for 7 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (20 mL), washed with 1 M HCl (3 x 20 mL) and brine (15 mL), dried over $MgSO_4$, and concentrated. The resulting pale yellow oil solidified in the freezer (-20 °C) overnight, and was recrystallized from hexanes (20 mL) to provide the bromide as a white solid (1.57 g, 60% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.62 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.23 (s, 2H), 7.21 (m, 1H), 7.11 (td, *J* = 7.8, 1.5 Hz, 1H), 6.96 (dd, *J* = 8.1, 1.5 Hz, 1H), 4.11 (hept, *J* = 6.7 Hz, 2H), 2.95 (hept, *J* = 6.9 Hz, 1H), 1.29 (d, *J* = 6.9 Hz, 6H), 1.23 (d, *J* = 6.8 Hz, 12H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 154.5, 151.2, 147.5, 134.2, 131.1, 128.4, 128.1, 124.1, 123.6, 117.4, 34.4, 30.1, 24.8, 23.7. LRMS (APCI+) for $C_{21}H_{27}{}^{81}BrO_3S$ $[MH]^+$ m/z calcd 441.09, found 441.46. IR (ATR)

ν 2961 (w), 2932 (w), 2865 (w), 1727 (w), 1600 (w), 1568 (w), 1468 (m), 1441 (m), 1425 (m), 1383 (m), 1355 (m), 1260 (w), 1202 (m), 1171 (m), 1106 (w), 1061 (w), 1042 (m), 939 (w), 884 (w), 850 (s), 766 (s), 730 (s), 708 (s), 659 (s), 609 (w), 579 (w), 553 (s), 524 (w), 509 (w), 446 (w).

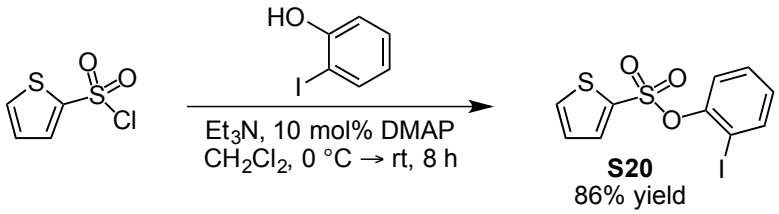
Iodide S19:



S2 **S19**
95% yield

Sulfonyl chloride **S2** (1.62 g, 82% pure by ^{1}H NMR, 6.69 mmol, 1.1 equiv) was added in small portions over 5 minutes to a solution of 2-iodophenol (1.33 g, 6.05 mmol, 1.00 equiv) and triethylamine (1.00 mL, 7.18 mmol, 1.20 equiv) in CH_2Cl_2 (40 mL) at -5 °C in an ice/acetone bath, and the solution was stirred for 14 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (20 mL), washed with 1 M HCl (3 x 25 mL) and brine (20 mL), dried over $MgSO_4$, and concentrated. The residual white solid was purified by flash chromatography (50 → 100% CH_2Cl_2/hexanes) and recrystallized from ~ 2:1 hexanes/ethyl acetate (75 mL) to provide the iodide as white needles (2.19 g, 95% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.82 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.50 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.41 (m, 1H), 7.06 (td, *J* = 7.7, 1.5 Hz, 1H), 2.93 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.7, 163.3, 150.2, 140.5, 130.2, 129.4, 123.3, 89.6, 16.3. LRMS (APCI+) for $C_9H_7IN_2O_3S_2$ $[MH]^+$ m/z calcd 382.90, found 383.27. IR (ATR) ν 1460 (m), 1427 (w), 1397 (s), 1206 (s), 1165 (s), 1116 (w), 1092 (m), 1042 (w), 1024 (w), 945 (w), 874 (s), 864 (s), 768 (s), 744 (m), 703 (m), 659 (m), 638 (s), 618 (m), 573 (s), 565 (s), 518 (m), 506 (m), 444 (m), 403 (w).

Iodide S20:

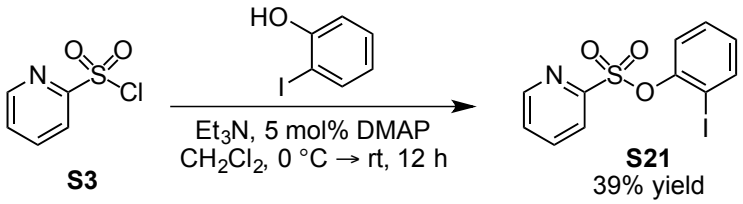


S20
86% yield

Triethylamine (1.15 mL, 8.25 mmol, 1.38 equiv) was added dropwise to a solution of 2-iodophenol (1.32 g, 6.00 mmol, 1.00 equiv) and thiophene-2-sulfonyl chloride (1.28 g, 7.01 mmol, 1.17 equiv) in CH_2Cl_2 (40 mL) at 0 °C, followed by 4-dimethylaminopyridine (75 mg, 0.61 mmol, 0.10 equiv), and the solution was stirred for 8 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (20 mL), washed with 1 M HCl (3 x 20 mL), dried over $MgSO_4$, and concentrated to leave a light brown oil that solidified on standing. This solid was carefully recrystallized from > 10:1 hexanes/ethyl acetate (35 mL) to afford the

iodide as white needles (1.90 g, 86% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.77 (m, 1H), 7.75 (dd, *J* = 5.0, 1.3 Hz, 1H), 7.69 (dd, *J* = 3.8, 1.3 Hz, 1H), 7.36 (m, 2H), 7.14 (dd, *J* = 4.9, 3.9 Hz, 1H), 7.01 (m, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 150.2, 140.3, 136.0, 135.2, 135.2, 129.7, 128.8, 127.9, 123.4, 90.2. LRMS (APCI+) for $C_{10}H_7IO_3S_2$ $[MH]^+$ m/z calcd 366.90, found 366.32. IR (ATR) ν 1570 (w), 1503 (w), 1460 (m), 1438 (m), 1400 (m), 1368 (m), 1235 (w), 1194 (m), 1168 (s), 1098 (m), 1040 (w), 1015 (s), 942 (w), 872 (m), 851 (m), 771 (m), 731 (s), 702 (m), 667 (m), 642 (w), 612 (w), 584 (s), 571 (s), 544 (s), 502 (w), 484 (w), 449 (w), 429 (w).

Iodide S21:

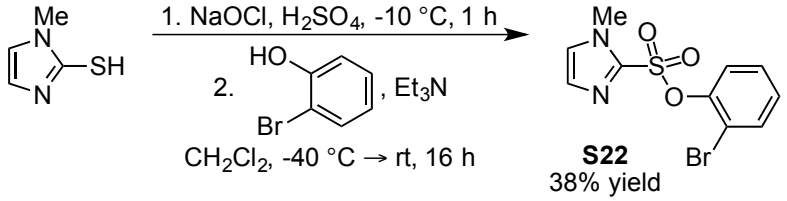


S3

S21
39% yield

A solution of sulfonyl chloride **S3** (2.10 g, 11.8 mmol, 1.18 equiv) in CH_2Cl_2 (25 mL) was added dropwise over 15 minutes to a solution of 2-iodophenol (2.20 g, 10.0 mmol, 1.0 equiv), triethylamine (4.2 mL, 30 mmol, 3.0 equiv), and 4-dimethylaminopyridine (61.7 mg, 0.505 mmol, 0.051 equiv) in CH_2Cl_2 (25 mL) at 0 °C, and the solution was stirred for 12 hours while warming slowly to room temperature. The mixture was then diluted with ethyl acetate (200 mL), concentrated to about three quarters of the initial volume, washed with 1 M HCl (2 x 50 mL), saturated $NaHCO_3$ (50 mL), and brine (50 mL), dried over $MgSO_4$, and concentrated. The residue was purified by flash chromatography (20 → 35% CH_2Cl_2/hexanes) to afford a white solid (2.49 g) that was crystallized by slow evaporation over 2 days of its solution in CH_2Cl_2/hexanes (50 mL) to a volume of about 20 mL to provide the iodide as a white solid (1.41 g, 39% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.77 (dd, *J* = 4.6, 0.7 Hz, 1H), 8.10 (d, *J* = 7.9 Hz, 1H), 7.98 (td, *J* = 7.8, 1.7 Hz, 1H), 7.77 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.63 (ddd, *J* = 7.6, 4.7, 1.0 Hz, 1H), 7.45 (dd, *J* = 8.2, 1.4 Hz, 1H), 7.36 (m, 1H), 7.00 (td, *J* = 7.8, 1.4 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 154.2, 150.64, 150.60, 140.1, 138.5, 129.8, 128.7, 128.4, 124.4, 123.4, 89.9. LRMS (APCI+) for $C_{11}H_8INO_3S$ $[MH]^+$ m/z calcd 361.93, found 362.26. IR (ATR) ν 1561 (w), 1461 (m), 1432 (m), 1393 (s), 1254 (w), 1200 (m), 1176 (s), 1135 (m), 1094 (w), 1041 (m), 940 (w), 863 (s), 788 (m), 770 (s), 746 (s), 723 (m), 697 (m), 653 (m), 594 (s), 558 (s), 490 (m), 459 (m), 428 (s).

Bromide S22:

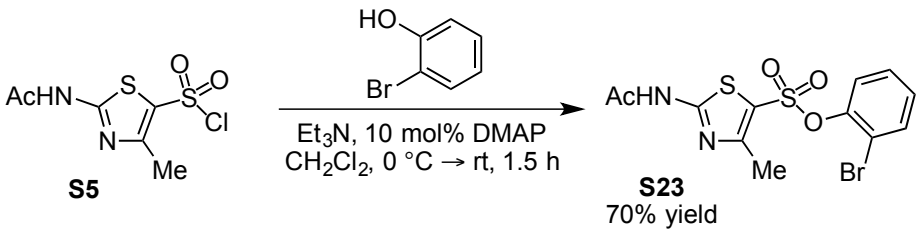


Based on a published procedure,[20] bleach (85 mL, 8.25% NaOCl, 104 mmol, 10 equiv) was added from an addition funnel over 30 minutes to a solution of 2-mercapto-1-methylimidazole (1.15 g, 10.1 mmol, 1.0 equiv) in sulfuric acid (50 mL) at -10 °C in an ice/acetone bath. The resulting solution was stirred for 30 minutes at -10 °C. The mixture was diluted with ice water (50 mL), the aqueous layer was extracted with CH_2Cl_2 (pre-cooled to -20 °C, 3 x 50 mL), and the combined organic layers were dried over $MgSO_4$ in a flask pre-cooled to -78 °C, quickly vacuum filtered, and concentrated at -10 °C. The sulfonyl chloride was obtained as a white solid and used immediately, without characterization, due to its instability above 0 °C.

The sulfonyl chloride was dissolved in CH_2Cl_2 (pre-cooled to -20 °C, 15 mL) and transferred by cannula to a solution of 2-bromophenol (1.10 mL, 10.4 mmol, 1.0 equiv) and triethylamine (1.50 mL, 10.8 mmol, 1.1 equiv) in CH_2Cl_2 (25 mL) at -40 °C. The clear yellow solution was stirred for 16 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (35 mL), washed with 1 M HCl (3 x 35 mL) and brine (20 mL), dried over $MgSO_4$, and concentrated. The resulting yellow oil was shown by ^{1}H NMR to contain a 1.7:1.0 mixture of 2-bromophenol and the desired sulfonate. This mixture was purified by flash chromatography (30% CH_2Cl_2/hexanes → CH_2Cl_2 → 5% methanol/CH_2Cl_2) to afford recovered 2-bromophenol which could be distilled for reuse, followed by the desired product, which was recrystallized from ~ 2:1 hexanes/ethyl acetate (25 mL) to provide the bromide as white needles (1.21 g, 38% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.41 (dd, *J* = 8.2, 1.4 Hz, 1H), 7.34 (td, *J* = 8.0, 1.5 Hz, 1H), 7.16 (m, 2H), 7.12 (s, 1H), 3.98 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 147.0, 138.2, 133.9, 130.3, 129.0, 128.8, 127.0, 124.7, 115.8, 35.8. LRMS (APCI+) for $C_{10}H_9{}^{81}BrN_2O_3S$ $[MH]^+$ m/z calcd 318.96, found 319.33. IR (ATR) ν 1501 (w), 1468 (m), 1384 (s), 1329 (m), 1280 (m), 1208 (m), 1186 (s), 1153 (s), 1130 (m), 1042 (m), 866 (s), 852 (s), 793 (m), 770 (s), 740 (s), 703 (m), 689 (m), 652 (w), 619 (s), 606 (s), 539 (s), 506 (m), 473 (m), 447 (m), 433 (w).

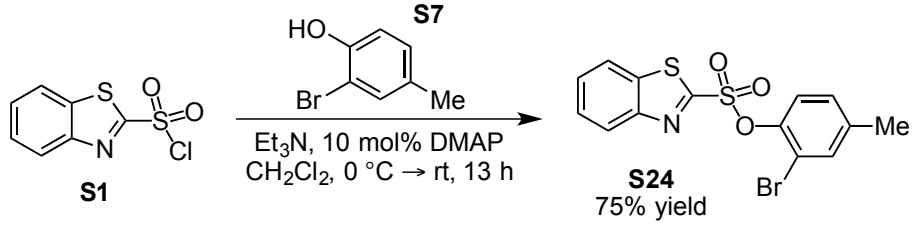
20 J. Mun, A. A. Jabbar, N. S. Devi, S. Yin, Y. Wang, C. Tan, D. Culver, J. P. Snyder, E. G. Van Meir and M. M. Goodman, *J. Med. Chem.* 2012, **55**, 6738.

Bromide S23:



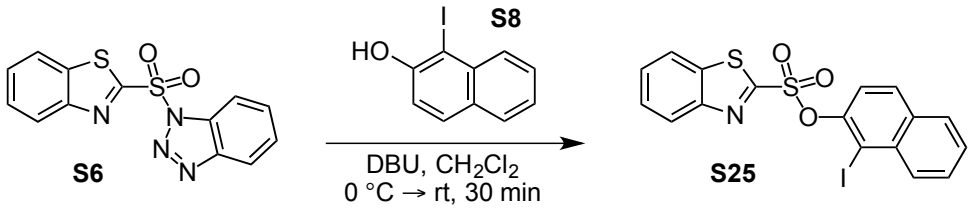
Triethylamine (0.69 mL, 5.0 mmol, 1.2 equiv) was added dropwise to a solution of 2-bromophenol (0.46 mL, 4.4 mmol, 1.1 equiv) and sulfonyl chloride **S5** (1.05 g, 4.12 mmol, 1.00 equiv) in CH_2Cl_2 (50 mL) at 0 °C, followed by 4-dimethylaminopyridine (51 mg, 0.42 mmol, 0.10 equiv), and the solution was stirred for 1.5 hours while warming to room temperature. The mixture was then diluted with CH_2Cl_2 (40 mL), washed with 1 M HCl (3 x 20 mL) and brine (15 mL), dried over $MgSO_4$, and concentrated. The white solid was recrystallized from ~ 2:1 hexanes/ethyl acetate (50 mL), cooling to -20 °C for 2 days to provide the bromide as off-white prisms (1.12g, 70% yield). ^{1}H NMR (400 MHz, d_6-DMSO) δ 12.79 (s, 1H), 7.66 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.44 (ddd, *J* = 8.2, 7.3, 1.6 Hz, 1H), 7.34 (dd, *J* = 8.2, 1.6 Hz, 1H), 7.27 (ddd, *J* = 8.0, 7.4, 1.6 Hz, 1H), 2.29 (s, 3H), 2.15 (s, 3H). ^{13}C NMR (126 MHz, d_6-DMSO) δ 170.0, 161.6, 157.3, 146.0, 133.9, 129.4, 129.3, 124.3, 115.7, 115.3, 22.4, 16.4. LRMS (APCI+) for $C_{12}H_{12}{}^{81}BrN_2O_4S_2$ $[MH]^+$ m/z calcd 392.94, found 393.20.

Bromide S24:



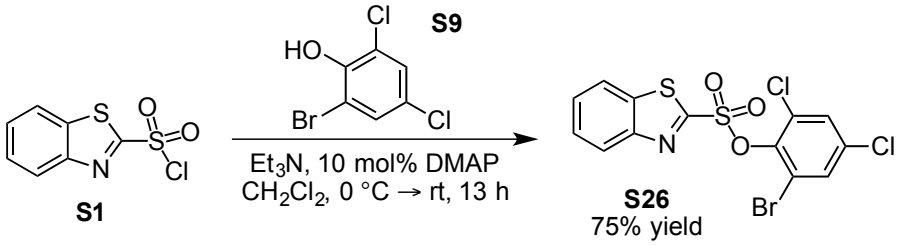
Sulfonyl chloride **S1** (1.31 g, 5.61 mmol, 1.13 equiv) was added in small portions to a solution of 2-bromophenol **S24** (929 mg, 4.97 mmol, 1.00 equiv), triethylamine (0.85 mL, 6.1 mmol, 1.2 equiv), and 4-dimethylaminopyridine (62.0 mg, 0.507 mmol, 0.10 equiv) in CH_2Cl_2 (50 mL) at 0 °C, and the resulting cloudy white solution was stirred for 13 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (25 mL), washed with 1 M HCl (3 x 20 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography (35% CH_2Cl_2/hexanes) and recrystallized from ~ 5:1 hexanes/ethyl acetate (50 mL) to provide the bromide as white crystals (1.44 g, 75% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (m, 1H), 8.01 (m, 1H), 7.64 (m, 2H), 7.35 (d, *J* = 1.2 Hz, 1H), 7.31 (d, *J* = 8.4 Hz, 1H), 7.13 (dd, *J* = 8.3, 1.3 Hz, 1H), 2.32 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.4, 152.3, 145.0, 139.4, 137.3, 134.4, 129.6, 128.7, 128.0, 126.0, 123.8, 122.3, 115.9, 20.8. LRMS (APCI+) for $C_{14}H_{10}{}^{81}BrNO_3S_2$ $[MH]^+$ m/z calcd 385.93, found 385.53.

Iodide S25:



1,8-Diazabicyclo[5.4.0]undec-7-ene (0.82 mL, 5.5 mmol, 1.1 equiv) was added to a solution of naphthol **S8** (1.42 g, 5.26 mmol, 1.05 equiv) in CH_2Cl_2 (15 mL) at 0 °C, followed by a solution of sulfonyl benzotriazole **S6** (1.58 g, 4.99 mmol, 1.00 equiv) in CH_2Cl_2 (30 mL). After stirring for 30 minutes at room temperature, sat. aq. NH_4Cl (10 mL) was added, the CH_2Cl_2 was evaporated, and 1 M HCl (90 mL) was added. The resulting solution was extracted with ethyl acetate (75 mL), the aqueous layer was basified with solid Na_2CO_3 (10.6 g, 100 mmol) and extracted with CH_2Cl_2 (50 mL), and the combined organic layers were dried over Na_2SO_4 and concentrated. The residue was filtered through a plug of silica, washing with CH_2Cl_2 (1.2 L), and the filtrate was concentrated to provide a mixture of the desired product and unreacted naphthol, which could not be removed by chromatography. Therefore, this mixture was dissolved in CH_2Cl_2 (100 mL) and treated with triethylamine (0.14 mL, 1.00 mmol) and *n*-decanoyl chloride (0.16 mL, 0.78 mmol). After 15 minutes at room temperature, the solution was washed with 1 M HCl (2 x 25 mL) and sat. aq. $NaHCO_3$ (25 mL), dried over Na_2SO_4, and concentrated. The residue (2.15 g) was purified by flash chromatography (20 → 100% CH_2Cl_2/hexanes) and recrystallized from ~ 4:1 ethyl acetate/CH_2Cl_2 (50 mL), cooling to -20 °C for 2 days to afford an off-white solid (1.52 g, 65% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (m, 1H), 8.10 (dd, *J* = 8.3, 1.0 Hz, 1H), 8.00 (m, 1H), 7.86 (d, *J* = 8.9 Hz, 1H), 7.81 (dd, *J* = 8.2, 1.3 Hz, 1H), 7.60 (m, 5H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.6, 152.3, 149.2, 137.4, 135.4, 132.9, 132.6, 130.8, 128.8, 128.7, 128.5, 128.0, 127.4, 126.1, 122.3, 121.1, 95.1 LRMS (APCI+) for $C_{17}H_{10}INO_3S_2$ $[MH]^+$ m/z calcd 467.92, found 468.11.

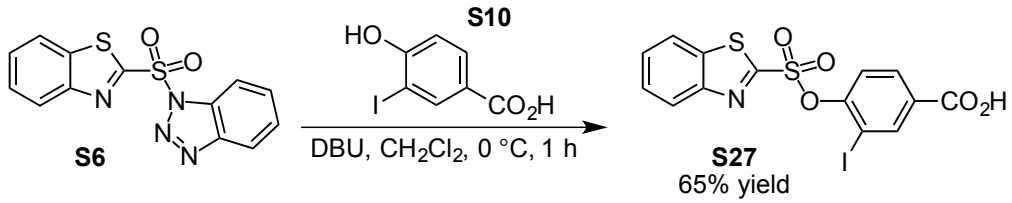
Bromide S26:



Sulfonyl chloride **S1** (1.31 g, 5.61 mmol, 1.12 equiv) was added in small portions to a solution of 2-bromophenol **S9** (1.21 g, 5.00 mmol, 1.00 equiv), triethylamine (0.85 mL, 6.1 mmol, 1.2 equiv), and 4-dimethylaminopyridine (63.2 mg, 0.517 mmol, 0.10 equiv) in CH_2Cl_2 (50 mL) at 0 °C, and the resulting cloudy green solution was stirred for 13 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (25 mL), washed with 1 M HCl (3 x 20 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography (35% CH_2Cl_2/hexanes) and recrystallized from ~ 5:1 hexanes/ethyl acetate (50

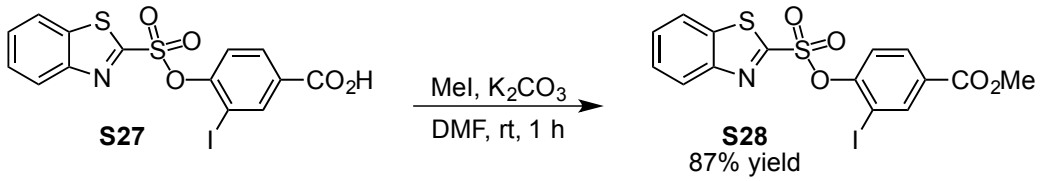
mL) to provide the bromide as white needles (1.64 g, 75% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29 (m, 1H), 8.04 (m, 1H), 7.67 (m, 2H), 7.52 (d, *J* = 2.4 Hz, 1H), 7.41 (d, *J* = 2.4 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.7, 152.0, 143.5, 137.4, 134.1, 132.4, 130.6, 130.1, 128.9, 128.2, 126.2, 122.4, 119.2. LRMS (APCI+) for $C_{13}H_6{}^{81}Br^{35}Cl_2NO_3S_2$ $[MH]^+$ m/z calcd 439.84, found 439.56.

Iodide S27:



1,8-Diazabicyclo[5.4.0]undec-7-ene (3.2 mL, 21 mmol, 2.1 equiv) was added to a solution of 2-iodophenol **S10** (2.65 g, 10.0 mmol, 1.00 equiv) in CH_2Cl_2 (150 mL) at 0 °C, stirred for 15 minutes, and sulfonyl benzotriazole **S6** (3.19 g, 10.1 mmol, 1.01 equiv). After stirring for 1 hour further, the mixture was diluted with CH_2Cl_2 (100 mL), washed with 1 M HCl (6 x 100 mL), dried over Na_2SO_4, and concentrated. The resulting white solid (4.63 g) was purified by flash chromatography (5% methanol/CH_2Cl_2), and recrystallized from 4:1 ethyl acetate/hexanes (125 mL), cooling to -20 °C for 2 days to afford a white solid (2.99 g, 65% yield). ^{1}H NMR (500 MHz, d_6-DMSO) δ 13.48 (br s, 1H), 8.38 (m, 1H), 8.32 (m, 2H), 8.02 (dd, *J* = 8.5, 2.0 Hz, 1H), 7.77 (m, 2H), 7.50 (d, *J* = 8.5 Hz, 1H). ^{13}C NMR (126 MHz, d_6-DMSO) δ 165.0, 159.8, 152.7, 151.7, 140.7, 136.9, 131.7, 131.2, 128.9, 128.4, 125.5, 123.6, 123.1, 91.5. LRMS (ESI–) for $C_{14}H_8INO_5S_2$ $[M–H]^-$ m/z calcd 459.88, found 460.10.

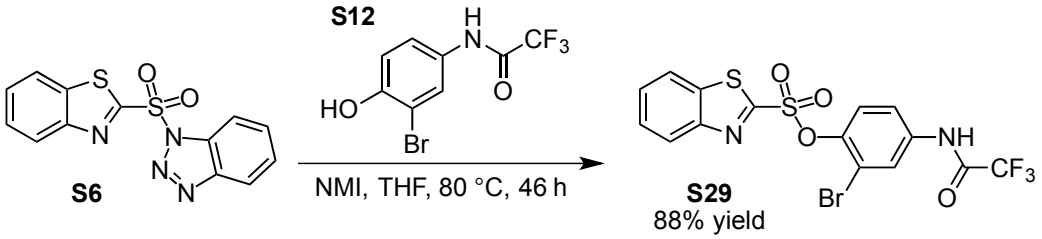
Iodide S28:



Iodomethane (0.28 mL, 4.5 mmol, 1.6 equiv) was added to a solution of acid **S27** (1.33 g, 2.88 mmol, 1.00 equiv) and potassium carbonate (830 mg, 6.01 mmol, 2.08 equiv) in dimethylformamide (25 mL) at room temperature. After stirring for 1 hour, the mixture was diluted with ethyl acetate (100 mL), washed with 1 M HCl (2 x 75 mL), the combined aqueous layers were extracted with ethyl acetate (50 mL), and the combined organic layers were washed with sat. aq. $NaHCO_3$ (25 mL) and brine (25 mL), dried over Na_2SO_4, and concentrated. The resulting yellow solid (1.52 g) was purified by flash chromatography (25% → 100 CH_2Cl_2/hexanes), and recrystallized from ~ 3:1 ethyl acetate/hexanes (50 mL), cooling to -20 °C overnight to afford a white solid (1.19 g, 87% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.45 (d, *J* = 2.0 Hz, 1H), 8.25 (dd, *J* = 8.3, 1.2 Hz, 1H), 8.07 (dd, *J* = 8.5, 2.1 Hz, 1H), 8.03 (m, 1H), 7.66 (pd, *J* = 7.2, 1.4 Hz, 2H), 7.57 (d, *J* = 8.6 Hz, 1H), 3.93 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.7, 160.0,

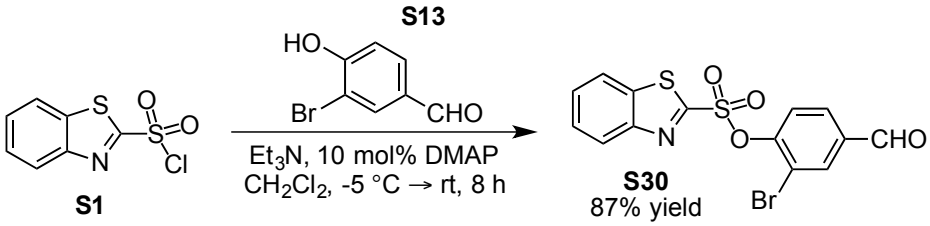
153.5, 152.3, 141.6, 137.3, 131.3, 130.7, 128.9, 128.2, 126.1, 123.1, 122.3, 89.5, 52.8. LRMS (APCI+) for $C_{15}H_{10}INO_5S_2$ $[MH]^+$ m/z calcd 475.91, found 476.03.

Bromide S29:



A solution of sulfonyl benzotriazole **S6** (944 mg, 2.98 mmol, 1.14 equiv), 2-bromophenol **S12** (741 mg, 2.61 mmol, 1.00 equiv), and *N*-methylimidazole (0.26 mL, 3.26 mmol, 1.25 equiv) in tetrahydrofuran (30 mL) was heated to 80 °C and stirred for 46 hours. The mixture was then concentrated and the residue was purified by flash chromatography (10 → 25% ethyl acetate/hexanes) and was recrystallized from ~ 4:1 hexanes/ethyl acetate (60 mL) to provide the bromide as a white solid (1.14 g, 88% yield). ^{1}H NMR (500 MHz, d_6-DMSO) δ 11.53 (s, 1H), 8.37 (m, 1H), 8.33 (m, 1H), 8.04 (d, J = 2.5 Hz, 1H), 7.76 (m, 3H), 7.50 (d, J = 9.0 Hz, 1H). ^{13}C NMR (101 MHz, d_6-DMSO) δ 159.6, 154.8 (q, $^2J_{CF}$ = 37.5 Hz), 151.7, 143.2, 136.88, 136.86, 128.9, 128.4, 125.6, 125.4, 124.6, 123.6, 121.8, 115.7, 115.5 (q, $^1J_{CF}$ = 289 Hz). LRMS (APCI+) for $C_{15}H_8{}^{81}BrF_3N_2O_4$ $[MH]^+$ m/z calcd 482.91, found 482.88. IR (ATR) ν 3296 (w), 3097 (w), 1707 (m), 1594 (w), 1532 (m), 1486 (m), 1474 (m), 1404 (m), 1330 (m), 1318 (m), 1269 (m), 1242 (w), 1181 (s), 1173 (w), 1150 (w), 1084 (m), 1042 (m), 1024 (m), 956 (w), 917 (w), 901 (w), 891 (w), 851 (s), 832 (m), 765 (s), 731 (m), 713 (w), 696 (m), 671 (s), 625 (s), 603 (m), 576 (m), 550 (s), 518 (w), 492 (w), 448 (w), 438 (w), 424 (w), 403 (w).

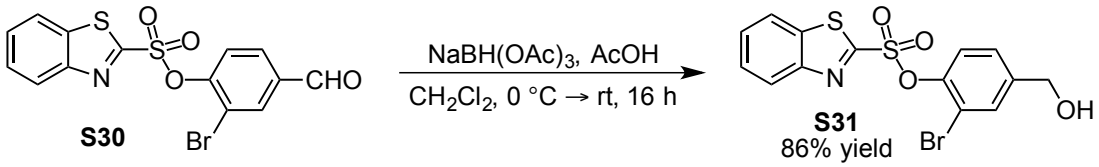
Bromide S30:



Sulfonyl chloride **S1** (2.58 g, 11.0 mmol, 1.10 equiv) was added in small portions to a solution of 2-bromophenol **S13** (2.02 g, 10.0 mmol, 1.00 equiv), triethylamine (1.7 mL, 12 mmol, 1.2 equiv), and 4-dimethylaminopyridine (125.6 mg, 1.028 mmol, 0.10 equiv) in CH_2Cl_2 (100 mL) at -5 °C in an acetone/ice bath, and the solution was stirred for 8 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (50 mL), washed with 1 M HCl (3 x 20 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography (50 → 75% CH_2Cl_2/hexanes) and recrystallized from ~ 3:1 hexanes/ethyl acetate (75 mL) to provide the bromide as a cream solid (3.47 g, 87% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.96 (s,

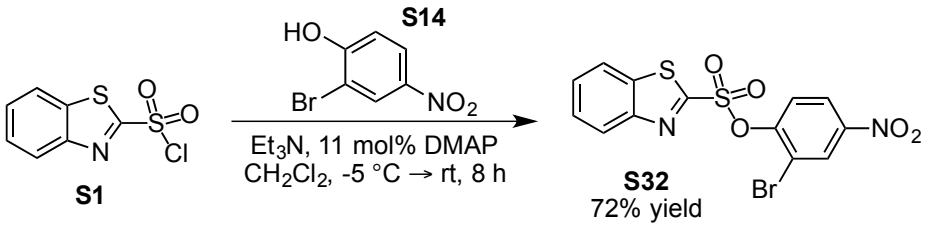
1H), 8.24 (dd, *J* = 6.8, 2.3 Hz, 1H), 8.07 (d, *J* = 1.8 Hz, 1H), 8.04 (dd, *J* = 6.7, 2.3 Hz, 1H), 7.90 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.72 (d, *J* = 8.4 Hz, 1H), 7.67 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 189.3, 159.8, 152.2, 151.2, 137.2, 136.2, 134.9, 130.3, 129.0, 128.2, 126.1, 124.9, 122.4, 117.6. LRMS (APCI+) for $C_{14}H_8{}^{81}BrNO_4S_2$ $[MH]^+$ m/z calcd 399.91, found 399.49.

Bromide S31:



Sodium triacetoxyborohydride (3.20 g, 15.1 mmol, 3.01 equiv) was added in small portions to a solution of aldehyde **S30** (2.00 g, 5.02 mmol, 1.00 equiv) in CH_2Cl_2 (60 mL) at 0 °C, followed by acetic acid (0.87 mL, 15.2 mmol, 3.0 equiv). The mixture was stirred for 16 hours while warming slowly to room temperature, and the reaction was quenched with 1 M NaOH (50 mL). CH_2Cl_2 (50 mL) was added, the layers were separated, the aqueous layer was extracted with CH_2Cl_2 (25 mL), and the combined organic extracts were washed with sat. aq. NH_4Cl (25 mL) and brine (25 mL), dried over Na_2SO_4, and concentrated. The residue (2.03 g) was purified by flash chromatography (0 → 5% methanol/CH_2Cl_2) and recrystallized from ~ 3:1 hexanes/ethyl acetate (50 mL) to provide an off-white solid (1.72 g, 86% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.21 (d, *J* = 7.6 Hz, 1H), 8.01 (m, 1H), 7.65 (m, 2H), 7.55 (s, 1H), 7.39 (d, *J* = 8.4 Hz, 1H), 7.30 (d, *J* = 8.4 Hz, 1H), 4.65 (d, *J* = 5.6 Hz, 2H), 2.38 (t, *J* = 5.8 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.2, 152.1, 146.1, 142.3, 137.2, 132.0, 128.8, 128.1, 127.0, 125.9, 124.1, 122.3, 116.3, 63.6. LRMS (ESI+) for $C_{14}H_{10}{}^{81}BrNO_4S_2$ $[MNa]^+$ m/z calcd 423.91, found 424.02.

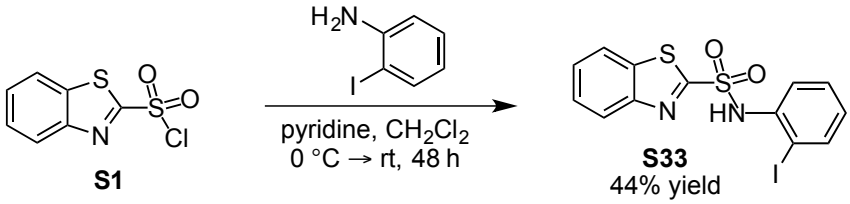
Bromide S32:



Sulfonyl chloride **S1** (1.31 g, 5.61 mmol, 1.12 equiv) was added in small portions to a solution of 2-bromophenol **S14** (1.09 g, 5.00 mmol, 1.00 equiv), triethylamine (0.85 mL, 6.1 mmol, 1.2 equiv), and 4-dimethylaminopyridine (65.0 mg, 0.532 mmol, 0.11 equiv) in CH_2Cl_2 (50 mL) at -5 °C in an acetone/ice bath, and the solution was stirred for 8 hours while warming slowly to room temperature. The mixture was then diluted with CH_2Cl_2 (25 mL), washed with 1 M HCl (3 x 20 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography (50% CH_2Cl_2/hexanes) and recrystallized from ~ 3:1 hexanes/ethyl acetate (50 mL) to provide the bromide as light green needles (1.49 g, 72% yield). ^{1}H NMR (400 MHz, $CDCl_3$)

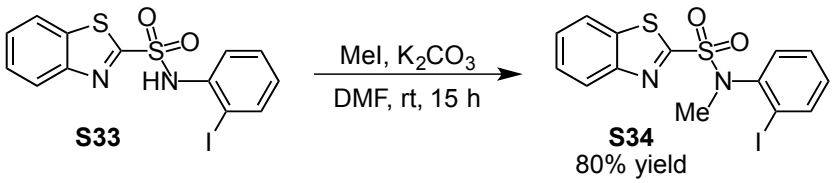
δ 8.44 (d, *J* = 2.6 Hz, 1H), 8.25 (ddd, *J* = 9.4, 8.1, 2.8 Hz, 2H), 8.05 (dd, *J* = 6.6, 2.6 Hz, 1H), 7.76 (d, *J* = 9.0 Hz, 1H), 7.69 (pd, *J* = 7.2, 3.6 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.5, 152.2, 151.6, 146.6, 137.2, 129.4, 129.1, 128.4, 126.1, 124.7, 124.3, 122.4, 117.3. LRMS (APCI+) for $C_{13}H_7{}^{81}BrN_2O_5S_2$ $[MH]^+$ m/z calcd 416.90, found 416.48.

Iodide S33:



Sulfonyl chloride **S1** (1.17 g, 5.01 mmol, 1.00 equiv) was added in small portions to a solution of 2-iodoaniline (1.31, 5.98 mmol, 1.19 equiv) and pyridine (0.57 mL, 7.0 mmol, 1.4 equiv) in CH_2Cl_2 (40 mL) at 0 °C, and the solution was stirred for 23 hours while warming slowly to room temperature. ^{1}H NMR analysis of an aliquot showed 10-15% unreacted sulfonyl chloride remained, so more pyridine (0.50 mL, 6.2 mmol, 1.2 equiv) was added. After stirring for 25 hours further, the reaction was complete and the mixture was diluted with CH_2Cl_2 (50 mL), washed with 1 M HCl (3 x 25 mL) and brine (15 mL), dried over $MgSO_4$, and concentrated to provide a red solid (2.20 g). This residue was purified by flash chromatography (50 → 75% CH_2Cl_2/hexanes) and recrystallized from ~ 2:1 hexanes/ethyl acetate (150 mL) to afford the iodide as off-white needles (1.83 g, 44% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16 (d, *J* = 8.2 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.76 (dd, *J* = 8.1, 0.9 Hz, 1H), 7.69 (d, *J* = 7.9 Hz, 1H), 7.59 (t, *J* = 7.3 Hz, 1H), 7.55 (dd, *J* = 11.3, 3.9 Hz, 1H), 7.36 (m, 1H), 7.23 (s, 1H), 6.90 (m, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.1, 152.4, 139.5, 137.0, 136.6, 129.8, 128.0, 128.0, 127.7, 125.7, 123.7, 122.2, 92.9. LRMS (APCI+) for $C_{13}H_9IN_2O_2S_2$ $[MH]^+$ m/z calcd 416.92, found 416.74. IR 3031 (w), 2819 (w), 2754 (w), 1575 (w), 1555 (w), 1468 (s), 1442 (m), 1419 (m), 1351 (s), 1318 (m), 1277 (w), 1222 (w), 1168 (s), 1158 (s), 1091 (m), 1051 (w), 1032 (m), 1022 (m), 930 (m), 902 (w), 856 (m), 758 (s), 725 (m), 710 (s), 645 (m), 619 (s), 601 (m), 559 (s), 544 (s), 511 (m), 492 (m), 463 (m), 427 (m), 411 (w).

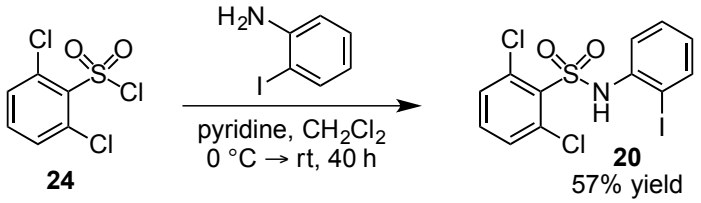
Iodide S34:



Iodomethane (0.48 mL, 7.7 mmol, 2.0 equiv) was added dropwise to a mixture of iodide **S33** (1.60 g, 3.83 mmol, 1.00 equiv) and potassium carbonate (1.60 g, 11.6 mmol, 3.02 equiv) in dimethylformamide (25 mL) and the solution was stirred for 15 hours. The mixture was then diluted with ethyl acetate (50 mL), washed with 1 M HCl (20 mL), the aqueous layer was

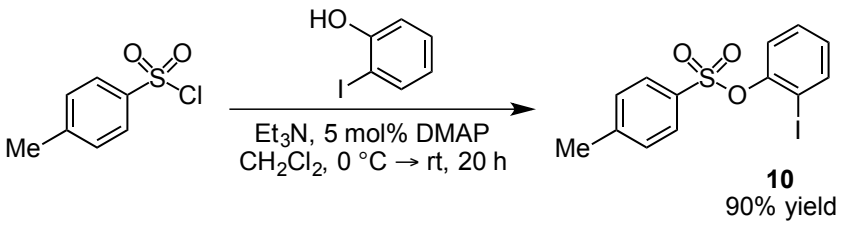
extracted with ethyl acetate (2 x 20 mL), and the combined organic layers were washed with brine (15 mL), dried over $MgSO_4$, and concentrated. The residue was purified by flash chromatography (10% ethyl acetate/hexanes) and recrystallized from ~ 4:1 hexanes/ethyl acetate (75 mL) to afford the iodide as light brown needles (1.79 g, 80% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.26 (d, *J* = 8.3 Hz, 1H), 7.99 (d, *J* = 7.9 Hz, 1H), 7.92 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.64 (m, 1H), 7.59 (m, 1H), 7.31 (td, *J* = 7.9, 1.4 Hz, 1H), 7.26 (m, 1H), 7.06 (td, *J* = 7.9, 1.7 Hz, 1H), 3.48 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.7, 152.7, 143.0, 140.6, 136.7, 130.6, 129.7, 129.7, 127.8, 127.6, 125.5, 122.3, 101.1, 40.0. LRMS (APCI+) for $C_{14}H_{12}IN_2O_2S_2$ $[MH]^+$ m/z calcd 430.94, found 430.72. IR (ATR) ν 1465 (m), 1423 (w), 1362 (s), 1315 (w), 1282 (w), 1241 (w), 1190 (m), 1155 (m), 1126 (w), 1078 (m), 1021 (m), 898 (m), 854 (w), 782 (m), 760 (m), 728 (w), 713 (m), 691 (w) 642 (w), 616 (s), 604 (m), 562 (m), 582 (m), 544 (s), 469 (w), 430 (w), 406 (w).

Iodide 20:



Sulfonyl chloride **24** (1.26 g, 5.13 mmol, 1.00 equiv) was added to a solution of 2-iodoaniline (1.11, 5.07 mmol, 0.99 equiv) and pyridine (0.81 mL, 10 mmol, 2.0 equiv) in CH_2Cl_2 (35 mL) at 0 °C, and the solution was stirred for 15 hours while warming slowly to room temperature. ^{1}H NMR analysis of an aliquot showed low sulfonyl chloride conversion, so more 2-iodoaniline (0.55 g, 2.5 mmol, 0.49 equiv) and pyridine (2.5 mL, 31 mmol, 6.1 equiv) were added. After stirring for 25 hours further, the reaction was complete, so the mixture was concentrated and dissolved in ethyl acetate (100 mL), then washed with 1 M HCl (3 x 50 mL), sat. aq. $NaHCO_3$ (50 mL), and brine (15 mL), dried over Na_2SO_4, and concentrated. This residue was purified by flash chromatography (15 → 35% CH_2Cl_2/hexanes) and recrystallized from ~ 4:1 hexanes/ethyl acetate (50 mL) to afford a white solid (1.25 g, 57% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.62 (br s, 1H), 7.53 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.44 (m, 2H), 7.33 (dd, *J* = 8.8, 7.3 Hz, 1H), 7.25 (m, 1H), 6.79 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 139.8, 137.2, 135.8, 134.5, 133.3, 131.8, 129.7, 126.3, 119.3, 89.3. LRMS (ESI+) for $C_{12}H_8{}^{35}Cl_2INO_2S$ $[MNa]^+$ m/z calcd 449.86, found 450.02.

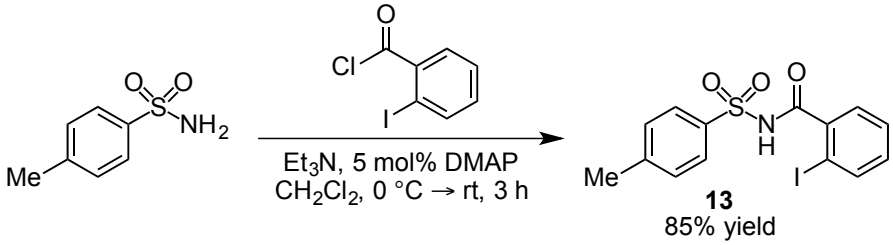
Iodide 10:[21]



10
90% yield

4-Toluenesulfonyl chloride (4.21 g, 22.1 mmol, 1.10 equiv) was added to a solution of 2-iodophenol (4.40 g, 20.0 mmol, 1.00 equiv), triethylamine (5.6 mL, 40 mmol, 2.0 equiv) and 4-dimethylaminopyridine (123 mg, 1.01 mmol, 0.050 equiv) in CH_2Cl_2 (100 mL) at 0 °C, and the solution was stirred for 20 hours while warming slowly to room temperature The mixture was then concentrated to half its original volume, diluted with ethyl acetate (400 mL), washed with 1 M HCl (2 x 100 mL) and brine (50 mL), dried over $MgSO_4$, and concentrated. The resulting light orange solid (7.95 g) was purified by flash chromatography (2 → 10% ethyl acetate/hexanes), and recrystallized from hexanes (175 mL), cooling to -20 °C for 2 weeks to afford a white solid (6.75 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 8.4 Hz, 2H), 7.74 (d, *J* = 7.3 Hz, 1H), 7.32 (m, 4H), 6.96 (m, 1H), 2.44 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.1, 145.8, 140.2, 132.9, 129.9, 129.6, 128.9, 128.4, 123.1, 90.3, 21.9. LRMS (APCI+) for $C_{13}H_{11}IO_3S$ $[MH]^+$ m/z calcd 374.96, found 375.10.

Iodide 13:



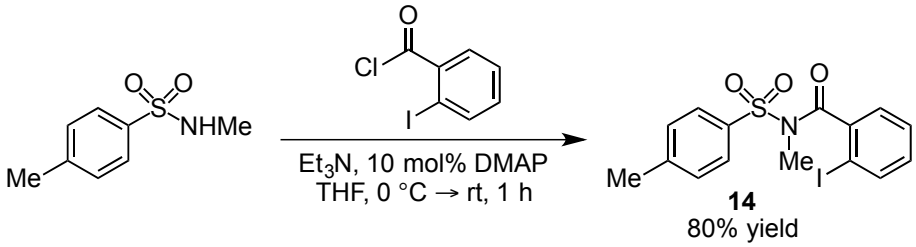
13
85% yield

2-Iodobenzoyl chloride[23] (2.66 g, 9.98 mmol, 1.00 equiv) was added to a solution of 4-toluenesulfonamide (1.71 g, 10.0 mmol, 1.00 equiv), triethylamine (3.5 mL, 25 mmol, 2.5 equiv) and 4-dimethylaminopyridine (60 mg, 0.49 mmol, 0.049 equiv) in CH_2Cl_2 (75 mL) at 0 °C, and the resulting solution was stirred for 3 hours while warming slowly to room temperature. The resulting mixture was washed with 1 M HCl (3 x 40 mL) and brine (25 mL), dried over Na_2SO_4, and concentrated. The white solid residue (4.08 g) was purified by flash chromatography (50% ethyl acetate/hexanes) and recrystallized from ~ 3:1 hexanes/ethyl acetate (75 mL), cooling to -20 °C for 2 days to afford a white solid (3.42 g, 85% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.89 (s, 1H), 8.01 (d, *J* = 8.4 Hz, 2H), 7.80 (dd, *J* = 8.0, 1.0 Hz, 1H), 7.36 (m, 4H), 7.10 (ddd, *J* = 7.9, 7.1, 2.0 Hz, 1H), 2.45 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.8, 145.5, 140.4, 138.6, 135.1, 132.6,

21 C.-G. Dong and Q.-S. K. Hu, *Org. Lett.* 2006, **8**, 5057.

129.7, 128.92, 128.89, 128.4, 91.7 21.9. LRMS (APCI+) for $C_{14}H_{12}INO_3S$ $[MH]^+$ m/z calcd 401.97, found 402.12.

Iodide 14:[22]



14
80% yield

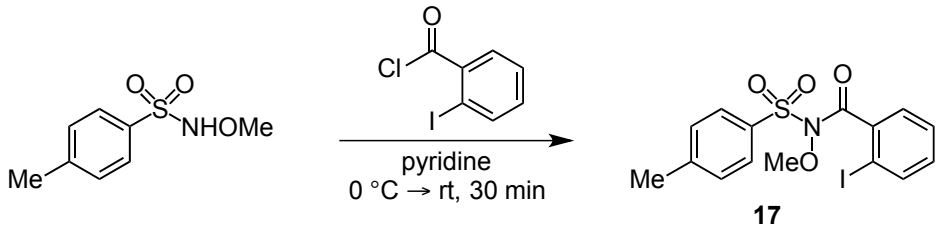
Triethylamine (3.0 mL, 22 mmol, 1.2 equiv) was added dropwise to a solution of crude, freshly prepared 2-iodobenzoyl chloride[23] (18 mmol, 1.0 equiv), *N*-methyl-4-toluenesulfonamide[24] (3.24 g, 17.5 mmol, 1.0 equiv), and 4-dimethylaminopyridine (215 mg, 1.76 mmol, 0.10 equiv) in tetrahydrofuran (50 mL) at 0 °C. The resulting white suspension was stirred for 1 hour, then poured into 0.2 M HCl (250 mL), and extracted with ethyl acetate (2 x 150 mL). The combined organic extracts were then washed with brine (50 mL), dried over Na_2SO_4, and concentrated. The residue was purified by flash chromatography (15% ethyl acetate/hexanes), recrystallized from ~ 2:1 CH_2Cl_2/hexanes (200 mL), and evaporated slowly over 7 days to a volume of 150 mL to give white prisms. The recrystallization was repeated on 75% of the previous scale to afford the pure iodide (5.79 g, 80% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.4 Hz, 2H), 7.76 (dd, *J* = 8.0, 0.7 Hz, 1H), 7.38 (td, *J* = 7.6, 1.0 Hz, 1H), 7.32 (d, *J* = 8.1 Hz, 2H), 7.19 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.10 (td, *J* = 7.8, 1.6 Hz, 1H), 3.27 (s, 3H), 2.43 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.6, 145.3, 141.3, 139.3, 135.2, 131.2, 129.6, 128.8, 128.1, 127.5, 91.7, 34.4, 21.8. LRMS (APCI+) for $C_{15}H_{14}INO_3S$ $[MH]^+$ m/z calcd 415.98, found 415.57.

22 W. B. Motherwell and A. M. K. Pennell, *J. Chem. Soc. Chem. Commun.* 1991, **1991**, 877.

23 D. P. Phillion, D. S. Braccolino, M. J. Graneto, W. G. Phillips, K. A. Van Sant, D. M. Walker and S. C. Wong, *US Pat.*, 5,498,630, 1996, column 60.

24 J. Aymamí Bofarull, F. C. Nicolas Chevalier, M. Soler López, M. T. Luque Garrofé and M. Martinell Pedemonte, *World Pat.*, 080722 A2, 2009, pp. 29.

Iodide 17:

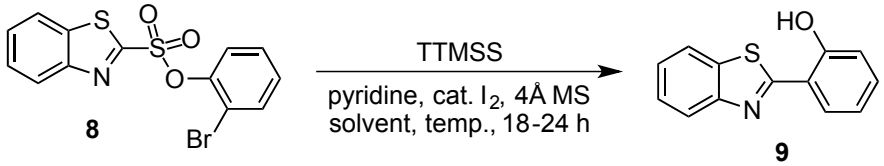


17
80% yield

2-Iodobenzoyl chloride[23] (1.99 g, 7.47 mmol, 1.42 equiv) was added to a solution of *N*-methoxy-4-toluenesulfonamide[25] (1.06 g, 5.27 mmol, 1.00 equiv) in pyridine (8 mL) at 0 °C. The resulting white suspension was stirred for 30 minutes at room temperature, diluted with ethyl acetate (100 mL), washed with 1 M HCl (2 x 50 mL), 5% Na_2CO_3 (2 x 50 mL), and brine (25 mL), dried over Na_2SO_4, and concentrated. The 2-iodobenzoic acid byproduct was difficult to remove by extraction or chromatography, so the mixture was dissolved in methanol (100 mL) and treated with acetyl chloride (1.2 mL, 17 mmol) and stirred for 24 hours at room temperature to convert the carboxylic acid to its methyl ester. The solution was then concentrated and the residue was purified by flash chromatography (20 → 100% CH_2Cl_2/hexanes) and recrystallized from ~ 4:1 hexanes/ethyl acetate (50 mL), cooling to -20 °C for 2 days to afford a white solid (1.91 g, 84% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.1 Hz, 2H), 7.77 (d, *J* = 7.9 Hz, 1H), 7.37 (m, 3H), 7.21 (d, *J* = 7.4 Hz, 1H), 7.12 (t, *J* = 7.6 Hz, 1H), 3.85 (s, 3H), 2.44 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.9, 146.1, 140.2, 139.2, 133.2, 131.4, 129.7, 129.4, 127.6, 127.6, 91.4, 66.4, 21.8. LRMS (APCI+) for $C_{15}H_{14}INO_4S$ $[MH]^+$ m/z calcd 431.98, found 432.21.

Synthesis of biaryls

Optimization of TTMSS-mediated protocol using bromide 8:



8 **9**

A crystal of iodine (< 0.1 equiv) was added to a solution of bromide **8** (29.5 mg, 0.0797 mmol, 1.00 equiv), pyridine (39 µL, 0.48 mmol, 6.1 equiv), and tris(trimethylsilyl)silane in the indicated solvent (0.01 M unless otherwise indicated) containing 4Å mol sieves. A needle open to the air was put through the septum. After 18-24 hours, the suspension was filtered through a plug of silica, washed with ethyl acetate (50 mL), and concentrated. Benzyl ether (10.0 µL) was added to the residue, and the yield was determined by ^{1}H NMR spectroscopy.

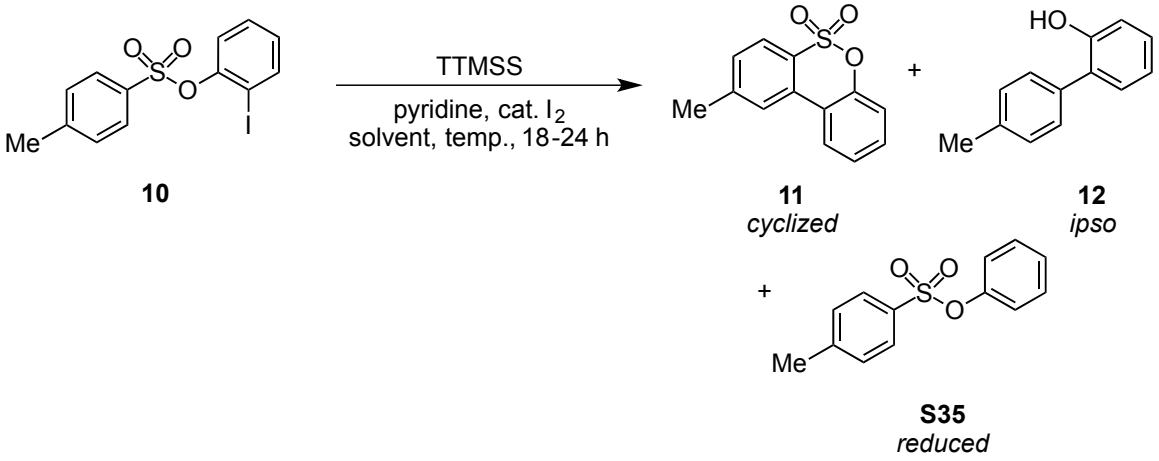
25 T. Tabuchi, T. Yamamoto and M. Nakayama, *Eur. Pat.*, 1174028 A1, 2002, pp. 55.

Table S1. Optimization of TTMSS-mediated aryl radical transfer.

entry	Deviation from standard conditions	% yield
1	none	81[a]
2	1.5 equiv TTMSS	70
3	argon atmosphere	15
4	O_2 atmosphere	50
5	0.1 M	18
6	Na_2CO_3 base	0
7	0 °C	55
8	50 °C	28
9	AcOH solvent	69
10	iodide substrate	84[a]

[a] Isolated yield.

Solvent screen of TTMSS-mediated protocol using iodide S35:

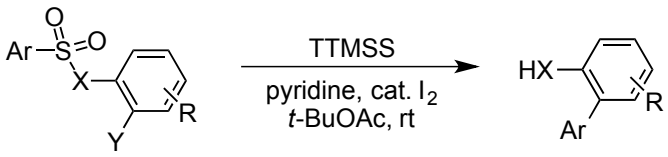


This study was conducted before bromide **8** was identified as a model substrate, but the sum of cyclized and ipso products should nonetheless reflect the efficiency of the intended ART reaction. A crystal of iodine (< 0.1 equiv) was added to a solution of iodide **S35** (18.7 mg, 0.0500 mmol, 1.00 equiv), pyridine (20 µL, 0.25 mmol, 4.9 equiv), and tris(trimethylsilyl)silane in the indicated solvent (0.01 M unless otherwise indicated). A needle open to the air was put through the septum. After 21-24 hours, the suspension was filtered through a plug of silica, washed with ethyl acetate (50 mL), and concentrated. Benzyl ether (10.0 µL) was added to the residue, and the yield was determined by ^{1}H NMR spectroscopy.

Table S2. Solvent screen for TTMSS-mediated aryl radical generation.

entry	solvent	% cyclized (**11**)	% ipso (**12**)	% reduced (**S35**)	% SM
1	*t*-BuOAc	86	8	6	0
2	CyH	13	2	20	66
3	*t*-BuOH	72	11	8	9
4	MeCN	4	1	0	95
5	AcMe	14	2	20	84
6	CH_2Cl_2	15	3	0	82
7	THF	11	0	34	55
8	EtOAc	67	10	9	14
9	DMSO	< 1	0	0	99

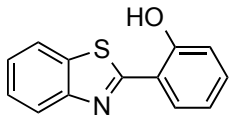
Substrate scope of TTMSS-mediated protocol



General protocol

A crystal of iodine (< 0.1 equiv) was added to a solution of the bromide or iodide substrate (0.20 mmol, 1.0 equiv), pyridine, and tris(trimethylsilyl)silane in *tert*-butyl acetate (20 mL). A needle open to the air was put through the septum. Within 5 minutes, a white precipitate typically formed. After the indicated time, the suspension was filtered through a plug of silica, washed with ethyl acetate (100 mL), concentrated, and the residue was purified by flash chromatography and then by any further methods described, typically by recrystallization. The final purification is necessary to remove silane-derived byproducts, which typically elute throughout much of a chromatographic separation.

We have been unable to scale this procedure up reliably, as reactions containing much more than about 0.25 mmol of substrate typically result in low conversions, and further addition of TTMSS does not restore reactivity. We are continuing to resolve this issue.



Biaryl 9 (Table 1, entry 10):[26] Prepared from iodide substrate **S15** using pyridine (6.0 equiv), tris(trimethylsilyl)silane (2.0 equiv), and 4Å mol sieves[27] for 20 hours. Purified by flash chromatography (0 → 2% ethyl acetate/hexanes) and recrystallized from hexanes (0.5 mL), cooling to -20

26 T. Itoh and T. Mase, *Org. Lett.* 2007, **9**, 3687.

27 Other substrates did not benefit from this additive.

°C overnight to provide the biaryl as white needles (38.4 mg, 84% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 12.50 (s, 1H), 7.99 (d, *J* = 8.2 Hz, 1H), 7.91 (d, *J* = 7.9 Hz, 1H), 7.70 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.51 (m, 1H), 7.40 (ddd, *J* = 15.5, 8.3, 1.3 Hz, 2H), 7.11 (dd, *J* = 8.3, 0.7 Hz, 1H), 6.96 (m, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.6, 158.1, 152.1, 132.9, 132.8, 128.6, 126.9, 125.7, 122.4, 121.7, 119.7, 118.1, 117.0. LRMS (APCI+) for $C_{13}H_9NOS$ $[MH]^+$ m/z calcd 228.05, found 228.29.

Table 1, entry 1 & Table 2, entry 4: Using bromide substrate **8**, a slightly lower yield was obtained (36.8 mg, 81% yield).

Table 2, entry 1:[28] Prepared from bromide substrate **S16** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 24 hours. Purified by flash chromatography (5 → 10% ethyl acetate/hexanes) and recrystallized from hexanes (0.5 mL), cooling to -20 °C overnight to provide the biaryl as a white solid (42.0 mg, 88% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 (d, *J* = 8.1 Hz, 2H), 7.35 (m, 1H), 7.28 (dd, *J* = 17.5, 9.1 Hz, 1H), 7.11 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.04 (td, *J* = 7.5, 1.0 Hz, 1H), 6.99 (dd, *J* = 8.2, 0.7 Hz, 1H), 4.58 (s, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.6, 136.3, 134.9, 130.8, 130.4, 130.1, 128.5, 123.9, 121.0, 116.1. LRMS (APCI+) for $C_{12}H_8{}^{35}Cl_2O$ $[MH]^+$ m/z calcd 239.00, found 239 .37.

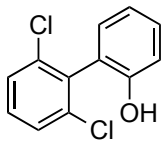
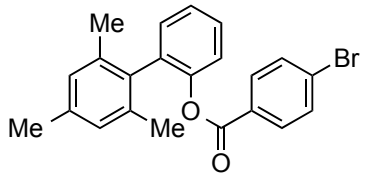


Table 2, entry 2 [*O*-(4-bromobenzoate)]: Prepared from bromide substrate **S17** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 15 hours. Purified by flash chromatography (2.5% ethyl acetate/hexanes). To isolate from the closely eluting unreacted substrate, this material was dissolved in chloroform (2 mL) and treated with triethylamine (35 µL, 0.25 mmol, 1.25 equiv) and 4-bromobenzoyl chloride (48 mg, 0.22 mmol, 1.1 equiv) at 50 °C for 5 hours. The mixture was then diluted with ethyl acetate (10 mL), washed with 1 M HCl (2 x 5 mL), dried over Na_2SO_4 and concentrated. The residue was purified by flash chromatography (0 → 1% ethyl acetate/hexanes) to provide the title compound as a colorless solid (60.0 mg, 76% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (m, 2H), 7.49 (m, 2H), 7.43 (m, 1H), 7.33(m, 2H), 7.23 (m, 1H), 6.84 (s, 2H), 2.24 (s, 3H), 2.02 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.2, 148.6, 137.1, 136.5, 134.0, 133.6, 131.8, 131.4, 131.4, 128.6, 128.5, 128.4, 128.1, 126.5, 122.7, 21.2, 20.4. LRMS (APCI+) for $C_{22}H_{19}{}^{81}BrO_2$ $[MH]^+$ m/z calcd 397.06, found 397.07.



28 J. L. Gross, M. J. Williams, G. P. Stack, H. Gao and D. Zhou, *World Pat.*, 044812 A1, 2005, pp. 97.

Table 2, entry 3 [*O*-(4-bromobenzoate)]: Prepared from bromide substrate **S18** using pyridine (12.1 equiv) and tris(trimethylsilyl)silane (4.0 equiv) for 72 hours. Purified by flash chromatography (0 → 2% ethyl acetate/hexanes). To isolate from the closely eluting unreacted substrate, this material was dissolved in chloroform (2 mL) and treated with triethylamine (150 µL, 1.1 mmol, 5.4 equiv) and 4-bromobenzoyl chloride (224 mg, 1.02 mmol, 5.1 equiv) between 50 °C and 60 °C for 41 hours. The mixture was then diluted with CH_2Cl_2 (15 mL), washed with 1 M HCl (3 x 5 mL), dried over $MgSO_4$ and concentrated. The residue was purified by flash chromatography (0 → 10% CH_2Cl_2/hexanes) and recrystallized from hexanes (1 mL), cooling to to -20 °C overnight to provide the title compound as a white solid (78.5 mg, 82% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 (m, 6H), 7.32 (td, *J* = 7.2, 1.6 Hz, 1H), 7.28 (dd, *J* = 7.4, 1.3 Hz, 1H), 7.00 (s, 2H), 2.89 (hept, *J* = 6.9 Hz, 1H), 2.56 (hept, *J* = 6.8 Hz, 2H), 1.25 (d, *J* = 6.9 Hz, 6H), 1.04 (app t, *J* = 6.3 Hz, 12H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.9, 148.8, 148.7, 147.1, 133.4, 131.8, 131.7, 131.6, 131.4, 128.9, 128.4, 128.3, 125.9, 122.6, 120.6, 34.5, 30.7, 25.1, 24.3, 23.1. LRMS (APCI+) for $C_{28}H_{31}{}^{81}BrO_2$ $[MH]^+$ m/z calcd 481.16, found 480.96. IR (ATR) ν 2959 (m), 2927 (w), 2864 (w), 1732 (s), 1590 (m), 1571 (w), 1491 (w), 1462 (m), 1399 (w), 1382 (w), 1362 (w), 1268 (s), 1238 (m), 1176 (s), 1105 (w), 1071 (s), 1010 (m), 938 (w), 876 (m), 846 (m), 752 (s), 710 (w), 680 (m), 652 (w), 626 (w), 524 (w), 495 (w), 468 (m), 426 (w).

Table 2, entry 5:[29] Prepared from iodide substrate **S19** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 24 hours. Purified by flash chromatography (2.5 → 20% ethyl acetate/hexanes) and recrystallized from ~ 1:1 hexanes/ethyl acetate (1 mL), cooling to -20 °C overnight to provide the biaryl as a white solid (30.7 mg, 80% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.41 (s, 1H), 7.46 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.37 (m, 1H), 7.11 (d, *J* = 8.3 Hz, 1H), 6.94 (t, *J* = 7.5 Hz, 1H), 2.83 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.7, 163.2, 157.3, 132.7, 129.8, 120.0, 118.2, 114.3, 15.8. LRMS (APCI+) for $C_9H_8N_2OS$ $[MH]^+$ m/z calcd 193.04, found 193.34.

Table 2, entry 6 [*O*-(4-bromobenzoate)]: Prepared from iodide substrate **S20** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 24 hours. Purified by flash chromatography (2.5 → 10% ethyl acetate/hexanes). To isolate from the closely eluting unreacted substrate, this material was dissolved in chloroform (2 mL) and treated with triethylamine (35 µL, 0.25 mmol, 1.25 equiv) and 4-bromobenzoyl chloride (48 mg, 0.22 mmol, 1.1 equiv) for 30 minutes. The mixture was then diluted with ethyl acetate (10 mL), washed with 1 M HCl (2 x 5 mL), dried over Na_2SO_4 and concentrated. The residue was purified by flash chromatography (0 → 2% ethyl acetate/hexanes) and recrystallized from ~ 5:1 hexanes/ethyl acetate (1 mL), cooling to to -20 °C for 3 days to provide the title compound as a white solid (50.8 mg, 71% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.06 (m, 2H), 7.70 (dd, *J* = 7.7, 1.8 Hz, 1H), 7.65 (m, 2H), 7.37 (td, *J* = 7.7, 1.8 Hz, 1H), 7.32 (td, *J* = 7.5, 1.5 Hz, 1H), 7.30 (dd, *J* = 3.7, 1.2 Hz, 1H), 7.26 (dd, *J* = 5.1, 1.2 Hz, 1H), 7.24 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.01 (dd, *J* = 5.1, 3.6 Hz,

29 L. D. Arnold, J. W. Coe, T. Kaneko and M. P. Moyer, *US Pat.*, 6130217 A, 2000, column 108.

1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.4, 147.1, 138.2, 132.1, 132.0, 129.9, 129.1, 128.6, 128.5, 127.6, 127.3, 126.7, 126.3, 126.2, 123.6. LRMS (APCI+) for $C_{17}H_{11}{}^{81}BrO_2S$ $[MH]^+$ m/z calcd 358.97, found 359.01.

Table 2, entry 7:[30] Prepared from iodide substrate **S21** using pyridine (9.3 equiv) and tris(trimethylsilyl)silane (3.0 equiv) for 24 hours. Purified by flash chromatography (2 → 4% ethyl acetate/hexanes) and recrystallized from hexanes (0.5 mL), cooling to -20 °C overnight to provide the biaryl as a light yellow solid (18.3 mg, 53% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 14.35 (s, 1H), 8.52 (ddd, *J* = 5.0, 1.8, 0.9 Hz, 1H), 7.92 (d, *J* = 8.4 Hz, 1H), 7.84 (m, 1H), 7.80 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.31 (ddd, *J* = 8.6, 7.2, 1.6 Hz, 1H), 7.24 (m, 1H), 7.03 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.91 (m, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.2, 158.1, 146.0, 137.9, 131.7, 126.2, 121.6, 119.2, 119.0, 118.9, 118.8. LRMS (APCI+) for $C_{11}H_9NO$ $[MH]^+$ m/z calcd 172.08, found 171.98.

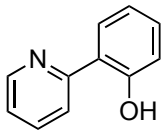


Table 3, entry 1: Prepared from bromide substrate **S24** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 15 hours. Purified by flash chromatography (0 → 2.5% ethyl acetate/hexanes) and recrystallized from hexanes (1 mL) to provide the biaryl as a white solid (37.1 mg, 77% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 12.28 (s, 1H), 7.96 (m, 1H), 7.88 (m, 1H), 7.48 (ddd, *J* = 8.3, 7.2, 1.2 Hz, 1H), 7.46 (m, 1H), 7.38 (ddd, *J* = 8.2, 7.2, 1.2 Hz, 1H), 7.18 (dd, *J* = 8.4, 2.1 Hz, 1H), 7.00 (d, *J* = 8.4 Hz, 1H), 2.34 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.5, 156.0, 152.1, 133.9, 132.8, 128.8, 128.5, 126.8, 125.56, 122.3, 121.6, 117.8, 116.5, 20.6. LRMS (ESI+) for $C_{14}H_{11}NOS$ $[MH]^+$ m/z calcd 242.06, found 242.16.

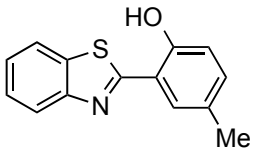


Table 3, entry 2: Prepared from iodide substrate **S25** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 12 hours. Purified by flash chromatography (0 → 1% ethyl acetate/hexanes) and recrystallized from ~ 5:1 hexanes/ethyl acetate (2 mL), cooling to -20 °C for 3 days to provide the biaryl as a bright yellow solid (41.6 mg, 75% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 14.18 (s, 1H), 8.76 (d, *J* = 8.6 Hz, 1H), 8.03 (d, *J* = 8.1 Hz, 1H), 7.92 (d, *J* = 7.5 Hz, 1H), 7.82 (m, 2H), 7.61 (ddd, *J* = 8.5, 6.8, 1.5 Hz, 1H), 7.52 (ddd, *J* = 8.3, 7.2, 1.2 Hz, 1H), 7.40 (m, 2H), 7.30 (d, *J* = 8.9 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 159.2, 149.7, 133.9, 133.0, 131.3, 129.6, 128.7, 128.3, 126.9, 125.5, 123.7, 122.7, 121.8, 121.2, 120.0, 109.7. LRMS (ESI+) for $C_{17}H_{11}NOS$ $[MH]^+$ m/z calcd 278.06, found 278.05.

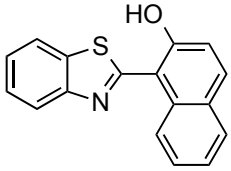
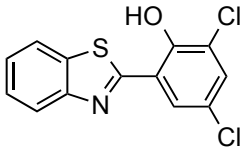


Table 3, entry 3: Prepared from bromide substrate **S26** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 24 hours. Purified by flash chromatography (0 → 1% ethyl acetate/hexanes) and recrystallized from ~ 1:1 hexanes/ethyl acetate (2 mL), cooling to -20 °C for 3 hours to provide the biaryl as a light yellow solid (52.8 mg, 89% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 13.27 (s, 1H), 7.97 (d, *J* = 7.9 Hz, 1H), 7.91 (d, *J* = 7.3 Hz, 1H), 7.53 (m, 2H), 7.45 (m, 1H), 7.42 (d, *J* = 2.5 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.3, 152.9,



30 K. Ohe, T. Yokoi, K. Miki, F. Nishino and S. Uemura, *J. Am. Chem. Soc.* 2002, **124**, 526.

151.3, 132.8, 132.4, 127.3, 126.5, 126.1, 124.0, 123.7, 122.6, 121.8, 118.3. LRMS (ESI+) for $C_{13}H_7{}^{35}Cl_2NOS$ $[MH]^+$ m/z calcd 295.97, found 296.08.

Table 3, entry 4: Prepared from iodide substrate **S28** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 12 hours. Purified by flash chromatography (1 → 5% ethyl acetate/hexanes) and recrystallized from ~ 1:1 hexanes/ethyl acetate (2 mL), cooling to -20 °C for 3 days to provide the biaryl as a white solid (37.9 mg, 66% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 13.08 (s, 1H), 8.39 (d, *J* = 2.1 Hz, 1H), 8.02 (dd, *J* = 8.7, 2.1 Hz, 1H), 7.97 (d, *J* = 7.9 Hz, 1H), 7.90 (d, *J* = 7.6 Hz, 1H), 7.50 (m, 1H), 7.42 (m, Hz, 1H), 7.10 (d, *J* = 8.7 Hz, 1H), 3.93 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.7, 166.2, 161.9, 151.6, 133.9, 132.8, 130.7, 127.0, 126.0, 122.4, 121.8, 118.1, 116.6, 52.2. LRMS (ESI+) for $C_{14}H_{11}NO_2S$ $[MH]^+$ m/z calcd 286.05, found 286.06.

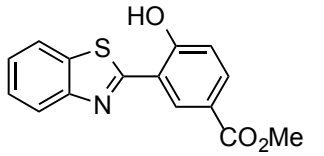


Table 3, entry 5: Prepared from bromide substrate **S29** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 24 hours. Purified by flash chromatography (50 → 85% CH_2Cl_2/hexanes) and recrystallized from ~ 4:1 hexanes/ethyl acetate (0.5 mL), cooling to -20 °C overnight to provide the biaryl as white needles (43.1 mg, 64% yield). ^{1}H NMR (500 MHz, d_6-DMSO) δ 11.57 (s, 1H), 11.28 (s, 1H), 8.58 (d, *J* = 2.1 Hz, 1H), 8.15 (d, *J* = 7.9 Hz, 1H), 8.06 (d, *J* = 8.1 Hz, 1H), 7.73 (dd, *J* = 8.8, 2.1 Hz, 1H), 7.55 (t, *J* = 7.6 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 1H), 7.13 (d, *J* = 8.8 Hz, 1H). ^{13}C NMR (126 MHz, d_6-DMSO) δ 163.8, 154.4 (q, $^2J_{CF}$ = 36.7 Hz), 153.8, 151.4, 134.7, 128.5, 126.5, 125.5, 125.1, 122.2, 122.0, 121.0, 118.6, 117.3, 115.9 (q, $^1J_{CF}$ = 289 Hz). LRMS (APCI+) for $C_{15}H_9F_3N_2O_2S$ $[MH]^+$ m/z calcd 339.04, found 339.41. IR (ATR) ν 3282 (m), 2923 (w), 1693 (s), 1633 (w), 1598 (w), 1556 (m), 1503 (m), 1437 (w), 1391 (w), 1344 (m), 1317 (m), 1288 (w), 1267 (w), 1250 (w), 1226 (w), 1207 (m), 1174 (s), 1150 (s), 1068 (w), 1034 (w), 1000 (m), 933 (m), 901 (m), 860 (m), 829 (m), 807 (w), 770 (s), 755 (m), 726 (m), 694 (s), 635 (m), 571 (w), 521 (w), 504 (m), 456 (w), 427 (w).

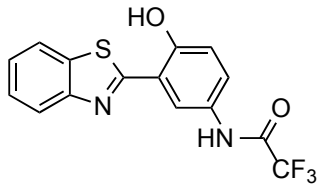


Table 3, entry 6: Prepared from bromide substrate **S30** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 24 hours. Purified by flash chromatography (0 → 5% ethyl acetate/hexanes) and recrystallized from ~ 1:1 hexanes/ethyl acetate (2 mL), cooling to -20 °C for 3 hours to provide the biaryl as a light yellow solid (32.8 mg, 64% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 13.32 (s, 1H), 9.93 (s, 1H), 8.22 (d, *J* = 1.9 Hz, 1H), 8.01 (d, *J* = 8.2 Hz, 1H), 7.94 (dd, *J* = 8.0, 0.7 Hz, 1H), 7.89 (dd, *J* = 8.5, 2.0 Hz, 1H), 7.54 (ddd, *J* = 8.3, 7.2, 1.3 Hz, 1H), 7.46 (ddd, *J* = 8.3, 7.3, 1.2 Hz, 1H), 7.21 (d, *J* = 8.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 190.0, 168.4, 163.2, 151.5, 134.1, 132.7, 130.8, 129.0, 127.2, 126.3, 122.5, 121.9, 118.9, 117.3. LRMS (ESI+) for $C_{14}H_9NO_2S$ $[MH]^+$ m/z calcd 256.04, found 256.10.

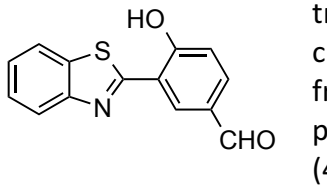
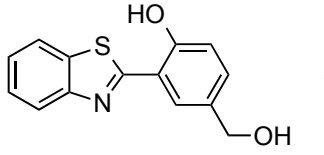


Table 3, entry 7: Prepared from bromide substrate **S31** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 14 hours. Purified by flash chromatography (10 → 20% ethyl acetate/hexanes) and recrystallized from ~ 3:1 hexanes/ethyl acetate (1 mL), cooling to -20 °C overnight to



provide the biaryl as a white solid (30.7 mg, 60% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.51 (s, 1H), 8.02 – 7.94 (m, 1H), 7.90 (ddd, *J* = 8.0, 1.3, 0.7 Hz, 1H), 7.69 (d, *J* = 2.1 Hz, 1H), 7.50 (ddd, *J* = 8.3, 7.2, 1.3 Hz, 1H), 7.41 (ddd, *J* = 8.3, 7.3, 1.2 Hz, 1H), 7.37 (dd, *J* = 8.5, 2.1 Hz, 1H), 7.08 (d, *J* = 8.5 Hz, 1H), 4.68 (d, *J* = 5.3 Hz, 2H), 1.75 (t, *J* = 5.7 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.3, 157.7, 151.9, 132.8, 132.2, 132.0, 127.3, 126.9, 125.8, 122.3, 121.7, 118.2, 116.7, 64.9. LRMS (ESI+) for $C_{14}H_{11}NO_2S$ $[MH]^+$ m/z calcd 258.06, found 258.20.

Table 3, entry 10:[31] Prepared on 0.25 mmol scale from iodide substrate **S33** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 48 hours. Purified by flash chromatography (0 → 3% ethyl acetate/hexanes) and recrystallized from hexanes (1 mL) to provide the biaryl as a yellow solid (50.6 mg, 90% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.1 Hz, 1H), 7.86 (d, *J* = 7.9 Hz, 1H), 7.70 (dd, *J* = 7.9, 1.0 Hz, 1H), 7.44 (m, 1H), 7.34 (t, *J* = 7.6 Hz, 1H), 7.21 (m, 1H), 6.78 (d, *J* = 8.1 Hz, 1H), 6.74 (t, *J* = 7.5 Hz, 1H), 6.38 (br s, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.4, 153.9, 146.9, 133.4, 131.7, 130.5, 126.2, 125.0, 122.6, 121.3, 117.0, 116.9, 115.4. LRMS (APCI+) for $C_{13}H_{10}N_2S$ $[MH]^+$ m/z calcd 227.06, found 227.04.

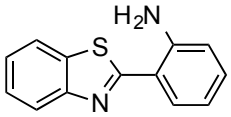
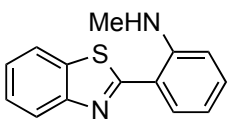
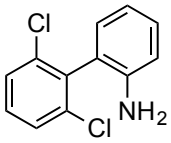


Table 3, entry 11: Prepared on 0.15 mmol scale from iodide substrate **S34** using pyridine (6.2 equiv) and tris(trimethylsilyl)silane (2.1 equiv) for 42 hours. Purified twice by flash chromatography (0 → 2% ethyl acetate/hexanes, then 0 → 0.2% ethyl acetate/hexanes) and recrystallized from hexanes (1 mL), cooling to -20 °C overnight to provide the biaryl as a yellow solid (32.3 mg, 90% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.80 (br s, 1H), 7.96 (d, *J* = 8.1 Hz, 1H), 7.85 (d, *J* = 7.9 Hz, 1H), 7.73 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.44 (m, 1H), 7.34 (m, 2H), 6.78 (d, *J* = 8.4 Hz, 1H), 6.69 (t, *J* = 7.5 Hz, 1H), 3.04 (d, *J* = 5.0 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.8, 153.8, 148.6, 133.3, 132.3, 130.8, 126.1, 124.9, 122.4, 121.3, 115.2, 114.9, 111.0, 29.9. LRMS (APCI+) for $C_{14}H_{12}N_2S$ $[MH]^+$ m/z calcd 241.08, found 241.31. IR (ATR) ν 3277 (w), 2911 (w), 2822 (w), 1611 (m), 1578 (s), 1523 (m), 1498 (s) 1455 (m), 1439 (m), 1420 (m), 1333 (m), 1311 (m), 1288 (w), 1264 (w), 1245 (w), 1214 (s), 1176 (m), 1128 (w), 1114 (w), 1068 (w), 1046 (w), 1013 (w), 954 (m), 837 (w), 797 (w), 748 (s), 736 (s), 727 (s), 692 (s), 661 (w), 632 (w), 549 (m), 516 (m), 492 (w), 457 (w), 427 (w).

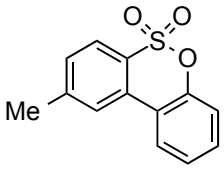


Biaryl 11 (Table 3, entry 12): Prepared from iodide substrate **20** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 18 hours. Purified by flash chromatography (3 → 5% ethyl acetate/hexanes) and then by preparative thin layer chromatography (15% ethyl acetate/hexanes) to provide the biaryl as a yellow syrup (43.2 mg, 91% yield). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 (d, *J* = 8.1 Hz, 2H), 7.25 (m, 2H), 6.99 (dd, *J* = 7.6, 1.5 Hz, 1H), 6.87 (t, *J* = 7.4 Hz, 1H), 6.82 (d, *J* = 8.0 Hz, 1H), 3.46 (br s, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 143.7, 136.7, 136.2, 130.2, 129.7, 129.7, 128.5, 123.0, 118.7, 115.9. LRMS (ESI+) for $C_{12}H_9{}^{35}Cl_2N$ $[MH]^+$ m/z calcd 238.02, found 237.86.

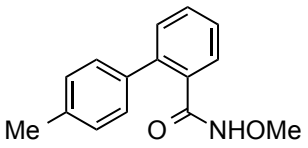


31 N. Park, Y. Heo, M. R. Kumar, Y. Kim, K. H. Song and S. Lee, *Eur. J. Org. Chem.* 2012, **2012**, 1984.

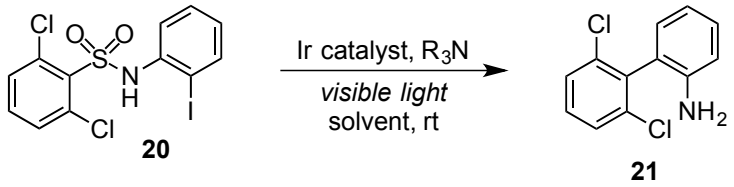
Sultone 11: Prepared from iodide substrate **10** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 16 hours. Purified by flash chromatography (10 → 25% ethyl acetate/hexanes) and recrystallized from hexanes (1 mL), cooling to -20 °C for 3 days to provide the sultone as a white solid (45.5 mg, 92% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.86 (d, *J* = 8.0 Hz, 1H), 7.72 (s, 1H), 7.45 (td, *J* = 7.7, 1.7 Hz, 1H), 7.38 (m, 2H), 7.31 (dd, *J* = 8.1, 1.4 Hz, 1H), 2.52 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.0, 144.8, 131.6, 131.2, 129.9, 129.8, 126.6, 125.4, 125.3, 124.3, 121.8, 120.1, 22.12. LRMS (APCI+) for $C_{13}H_{10}O_3S$ $[MH]^+$ m/z calcd 247.04, found 247.10.



Biaryl 18: Prepared from iodide substrate **17** using pyridine (6.0 equiv) and tris(trimethylsilyl)silane (2.0 equiv) for 18 hours. Purified by flash chromatography (15 → 35% ethyl acetate/hexanes) and then by preparative thin layer chromatography (40 → 50% ethyl acetate/hexanes, 2 elutions for 1 plate) to provide the biaryl as a colorless oil that slowly solidified (43.0 mg, 89% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.82 (s, 1H), 7.66 (d, *J* = 7.5 Hz, 1H), 7.49 (td, *J* = 7.5, 1.5 Hz, 1H), 7.33 (m, 4H), 7.24 (m, 2H), 3.56 (br s, 3H), 2.39 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 167.7, 140.0, 138.0, 136.8, 132.3, 130.8, 130.2, 129.6, 129.3, 128.7, 127.5, 64.00, 21.3. LRMS (ESI+) for $C_{15}H_{15}NO_2$ $[MH]^+$ m/z calcd 242.12, found 242.11.



Optimization of Ir-catalyzed photoredox protocol using iodide 20:



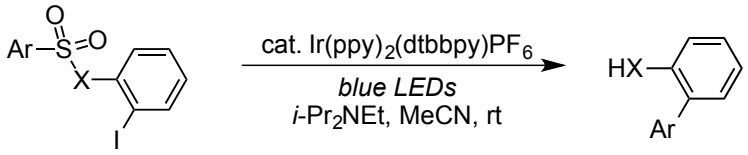
The indicated tertiary amine (0.5 mmol, 10 equiv) and the additive (10 equiv) were added to a solution of iodide **10** (21.5 mg, 0.0502 mmol, 1.00 equiv) and the indicated Ir catalyst, and irradiated until the reaction was complete or until 24 hours had elapsed. The solution was then filtered through a plug of silica, washed with ethyl acetate (50 mL), and concentrated. Mesitylene (10.0 µL) was added to the residue, and the yield was determined by ^{1}H NMR spectroscopy.

Table S3. Optimization of photoredox-catalyzed aryl radical transfer.[a]

entry	catalyst	amine	additive	solvent	conc. (M)	time (h)	yield (%)
1	**22**	*i*-Pr_2NEt	–	MeCN	0.01	24	50
2	**22**	*i*-Pr_2NEt	HCO_2H	MeCN	0.01	24	30
3	**23**	*i*-Pr_2NEt	–	MeCN	0.01	2	85
4	**23**	Et_3N	–	MeCN	0.01	24	74
5	**23**	*n*-Bu_3N	–	MeCN	0.01	6	67
6	**23**	*i*-Pr_2NEt	HCO_2H	MeCN	0.01	24	77
7	**23**	*i*-Pr_2NEt	–	DMSO	0.01	24	27
8	**23**	*i*-Pr_2NEt	–	DMF	0.01	24	25
9	**23**	*i*-Pr_2NEt	–	MeCN	0.03	4	66
10	**23**	*i*-Pr_2NEt	–	MeCN	0.1	4	51
11[b]	**23**	*i*-Pr_2NEt	–	MeCN	0.01	16	90

[a] Substrate **20** was treated with Ir catalyst (0.02 equiv), amine (10 equiv) and, if indicated, HCO_2H (10 equiv). Yields are based on ^1H NMR analysis. [b] Irradiated using a 20 W CFL.

Substrate scope of Ir-catalyzed photoredox protocol



General protocol

N,*N*-diisopropylethylamine (0.35 mL, 2.01 mmol, 10 equiv) was added to a solution of iodide (0.20 mmol, 1.0 equiv) and $Ir(ppy)_2(dtbbpy)PF_6$ (3.7 mg, 0.0040 mmol, 0.020 equiv), and irradiated using a 24 W blue LED strip while cooling with a fan for the indicated time. The solution was then filtered through a plug of silica, washed with ethyl acetate (100 mL), and concentrated. The residue was purified by flash chromatography and then by any further methods described.

Biaryl 21 (Table 5, entry 1): Prepared from iodide substrate **20** (1.07 g, 2.50 mmol, 1.00 equiv) using *N*,*N*-diisopropylethylamine (4.4 mL, 25 mmol, 10 equiv) and $Ir(ppy)_2(dtbbpy)PF_6$ (11.4 mg, 0.0125 mmol, 0.0050 equiv) for 48 hours. Purified by flash chromatography (5 → 10% ethyl acetate/hexanes) to provide the biaryl as a yellow oil (477 mg, 80% yield).

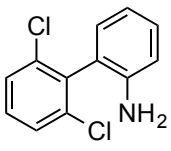


Table 5, entry 2 [*O*-(4-bromobenzoate)]: Prepared from iodide substrate **S20**, stirring for 48 hours. Purified by flash chromatography (2.5 → 10% ethyl acetate/hexanes). To isolate from the closely eluting unreacted substrate, this material was dissolved in chloroform (2 mL) and treated with triethylamine (35 µL, 0.25 mmol, 1.25 equiv) and 4-bromobenzoyl chloride (48 mg, 0.22 mmol, 1.1 equiv) for 30 minutes. The mixture was then diluted with ethyl acetate (10 mL), washed with 1 M HCl (2 x 5 mL), dried over Na_2SO_4 and concentrated. The residue was purified by flash chromatography (0 → 2% ethyl acetate/hexanes) and recrystallized from ~ 5:1 hexanes/ethyl acetate (1 mL), cooling to to -20 °C for 3 days to provide the title compound as a white solid (38.2 mg, 53% yield).

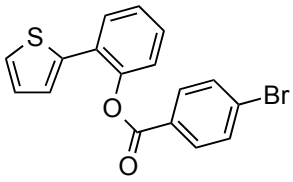


Table 5, entry 3:[30] Prepared from iodide substrate **S21**, stirring for 24 hours. Purified by flash chromatography (2 → 4% ethyl acetate/hexanes) and recrystallized from hexanes (0.5 mL), cooling to -20 °C overnight to provide the biaryl as a light yellow solid (17.0 mg, 50% yield).

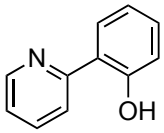
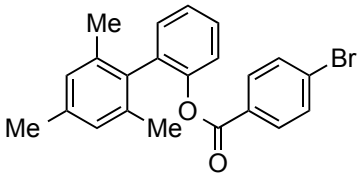
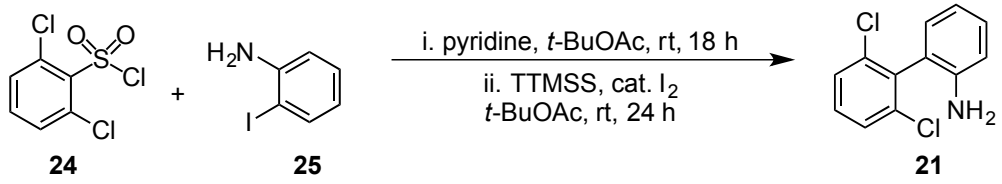


Table 5, entry 4 [*O*-(4-bromobenzoate)]: Prepared from bromide substrate **S17**, stirring for 72 hours. Purified by flash chromatography (2.5% ethyl acetate/hexanes). To isolate from the closely eluting unreacted substrate, this material was dissolved in chloroform (2 mL) and treated with triethylamine (35 µL, 0.25 mmol, 1.25 equiv) and 4-bromobenzoyl chloride (48 mg, 0.22 mmol, 1.1 equiv) at 50 °C for 5 hours. The mixture was then diluted with ethyl acetate (10 mL), washed with 1 M HCl (2 x 5 mL), dried over Na_2SO_4 and concentrated. The residue was purified by flash chromatography (0 → 1% ethyl acetate/hexanes) to provide the title compound as a colorless solid (28.4 mg, 35% yield).



One-pot TTMSS-mediated cross-coupling protocol:

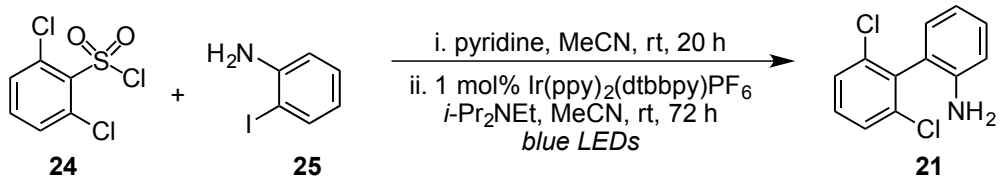


24 **25** **21**

2-Iodoaniline (**25**) (41.8 mg, 0.191 mmol, 1.25 equiv) and pyridine (125 µL, 1.55 mmol, 10.1 equiv) were added to a solution of sulfonyl chloride **24** (0.33 mL, 0.463 M by ^{1}H NMR spectroscopy, 0.153 mmol, 1.00 equiv) in *tert*-butyl acetate. After 18 hours, the sulfonyl chloride was consumed as judged by TLC analysis, and further *tert*-butyl acetate (15 mL), tris(trimethylsilyl)silane (150 µL, 0.486 mmol, 3.18 equiv), and iodine (1 small crystal) were

added. After 24 hours, the suspension was filtered through a plug of silica, washed with ethyl acetate (100 mL), concentrated, and the biaryl **21** was obtained in 49% NMR yield.

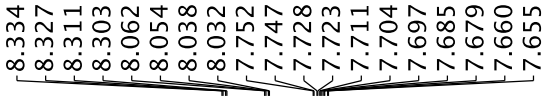
One-pot Ir-catalyzed photoredox cross-coupling protocol:

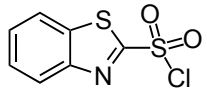


24 **25** **21**

Pyridine (3.0 mL, 37 mmol, 5.0 equiv) was added to a solution of 2-iodoaniline (**25**) (1.64 g, 7.49 mmol, 1.00 equiv) and sulfonyl chloride **24** (2.30 g, 9.37 mmol, 1.25 equiv) in acetonitrile (50 mL). After 20 hours, the aniline was consumed as judged by TLC analysis, and further acetonitrile (700 mL), *N*,*N*-diisopropylethylamine (13 mL, 75 mmol, 10 equiv), and $Ir(ppy)_2(dtbbpy)PF_6$ (68.5 mg, 0.0749 mmol, 0.010 equiv) were added. After 72 hours of irradiation using a 24 W blue LED strip while cooling with a fan, the solution was filtered through a plug of silica, washed with ethyl acetate (500 mL), and concentrated. The residue was purified by flash chromatography (5 → 10% ethyl acetate/hexanes) to provide the biaryl as a yellow oil (1.33 g, 75% yield).

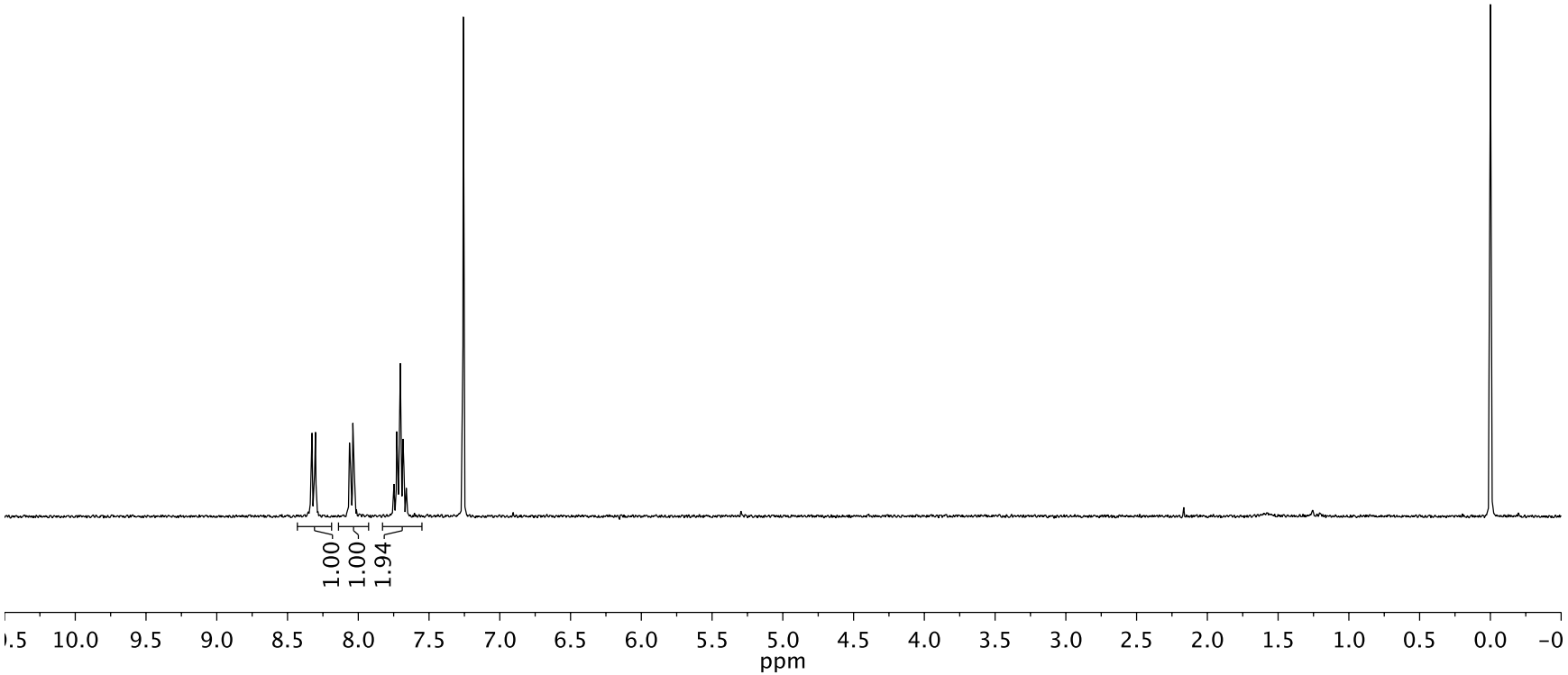
NMR spectra

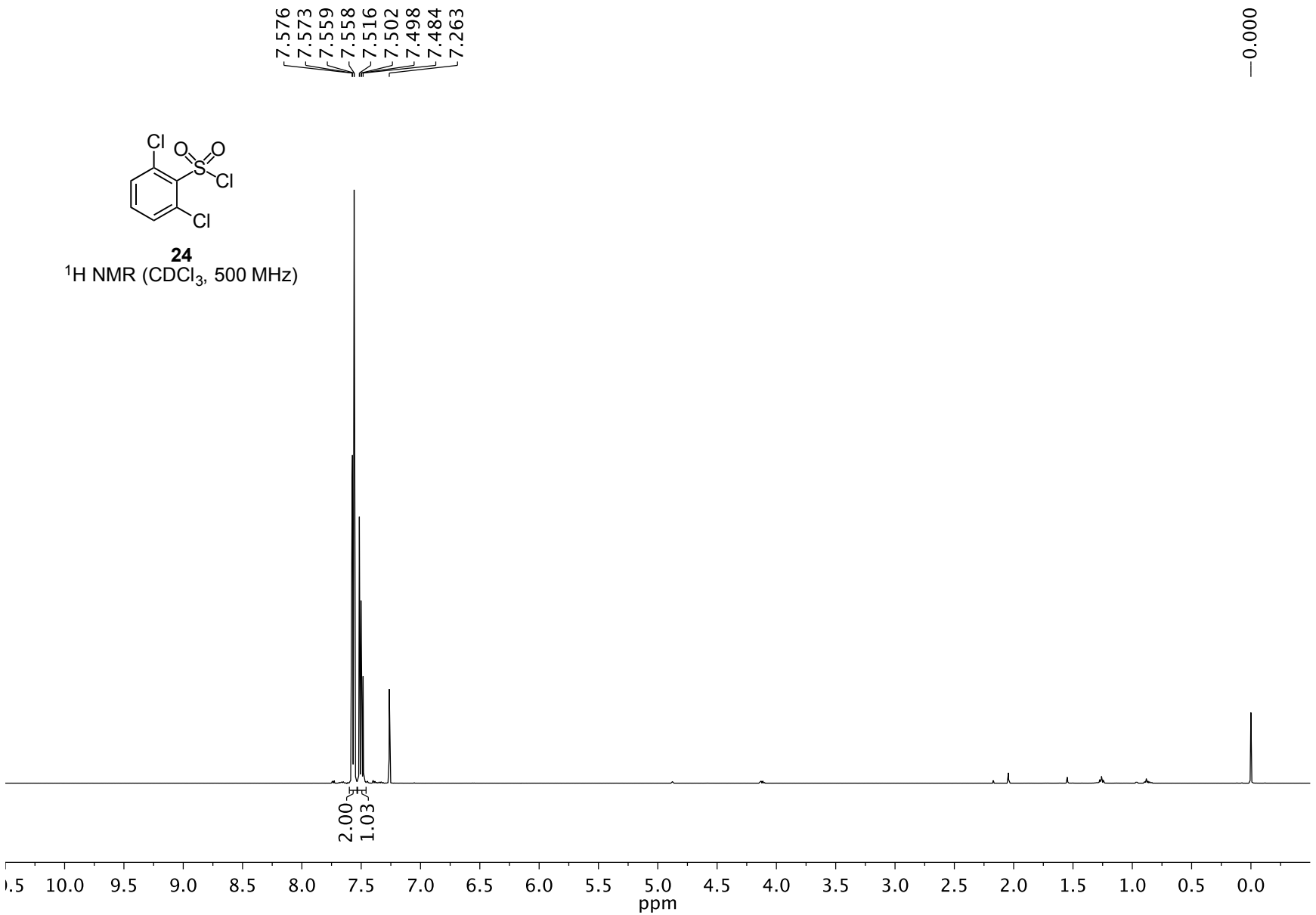




S1

^{1}H NMR ($CDCl_3$, 300 MHz)

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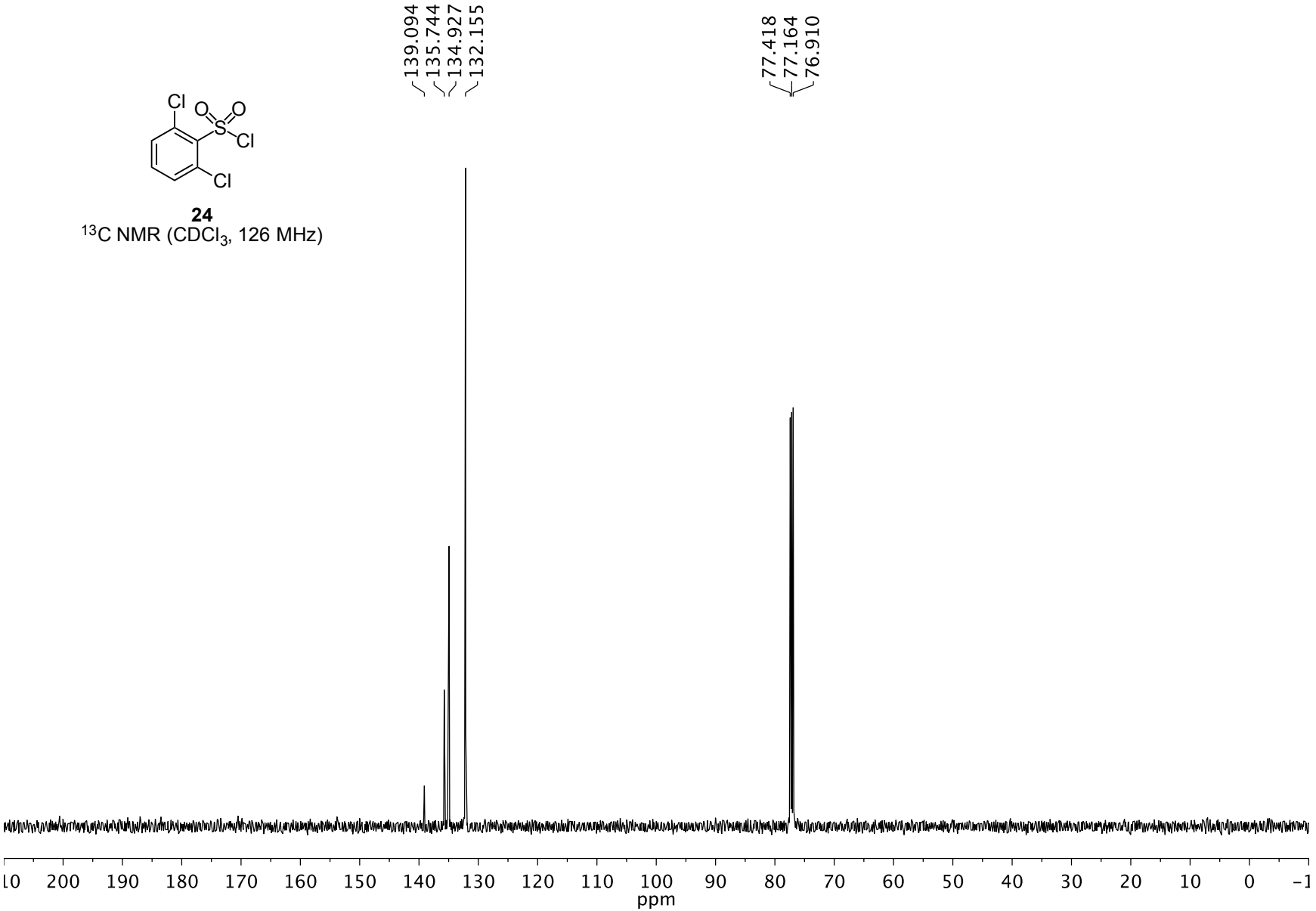
7.573
7.559
7.558
7.516
7.502
7.498
7.484
7.263
0.000
Cl
O
O
S
Cl
Cl
24
1H NMR (CDCl3, 500 MHz)
2.00
1.03
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm


139.094
135.744
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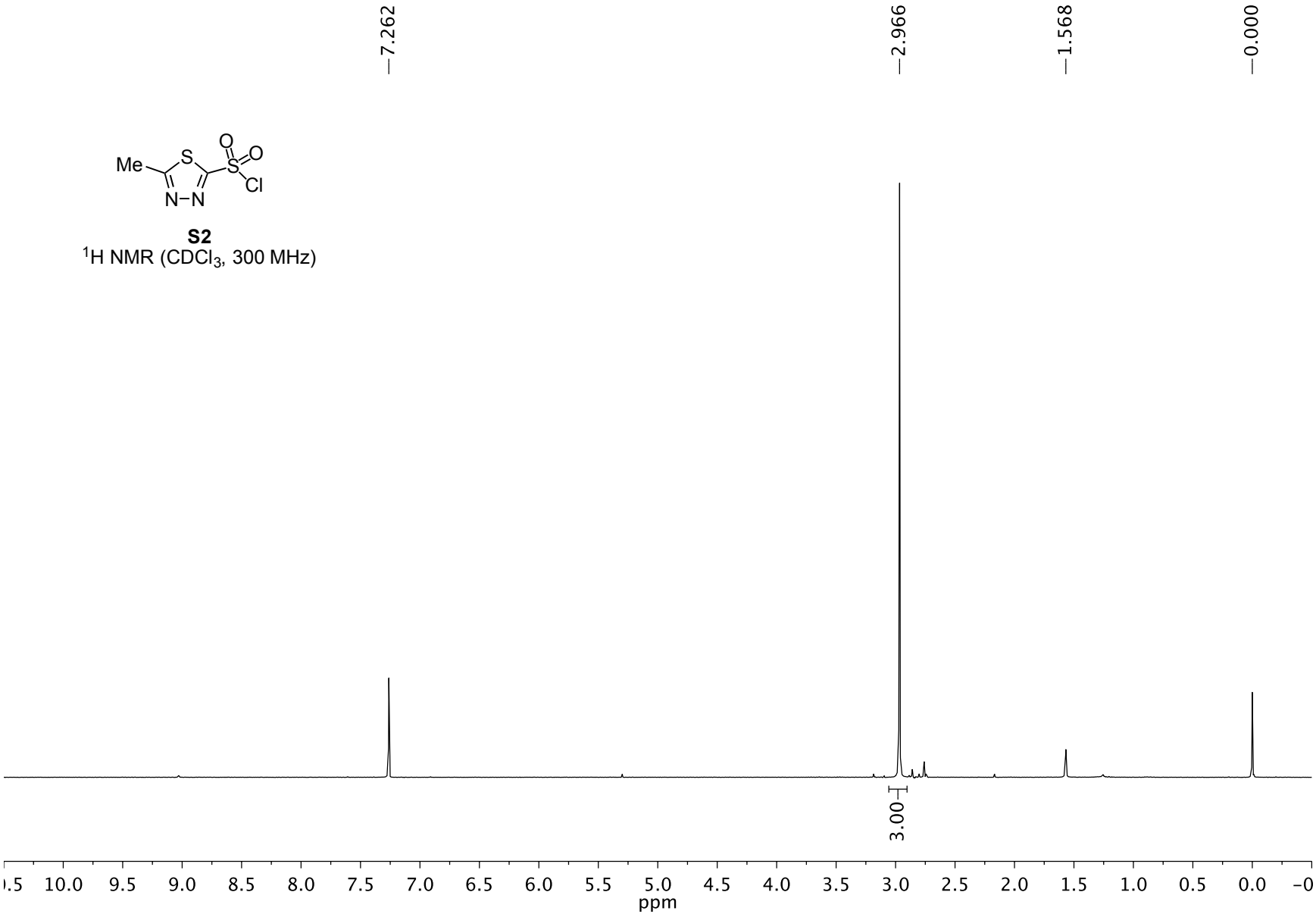
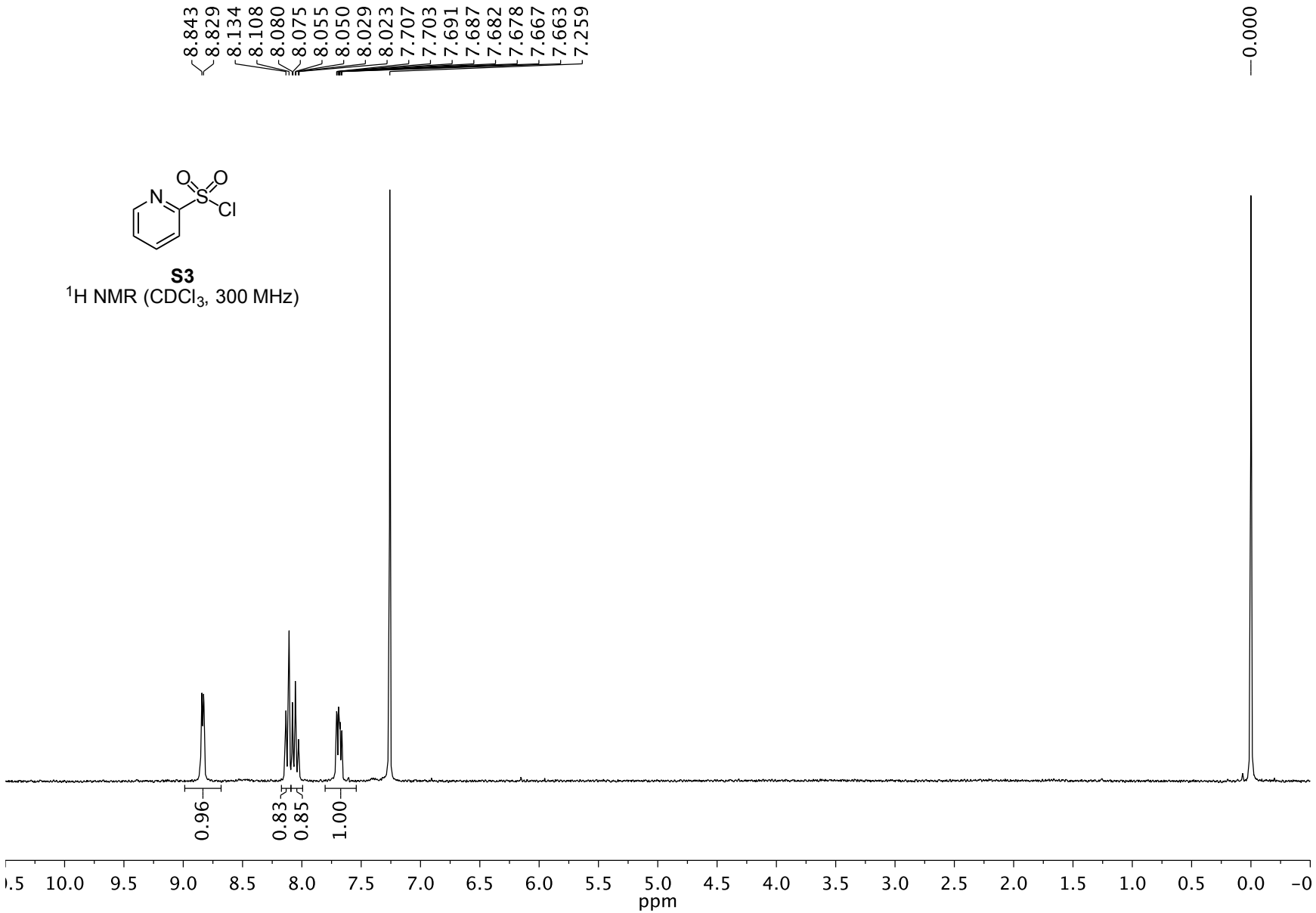
77.418
77.164
76.910
Cl
O
S
O
Cl
Cl
24
13C NMR (CDCl3, 126 MHz)
ppm



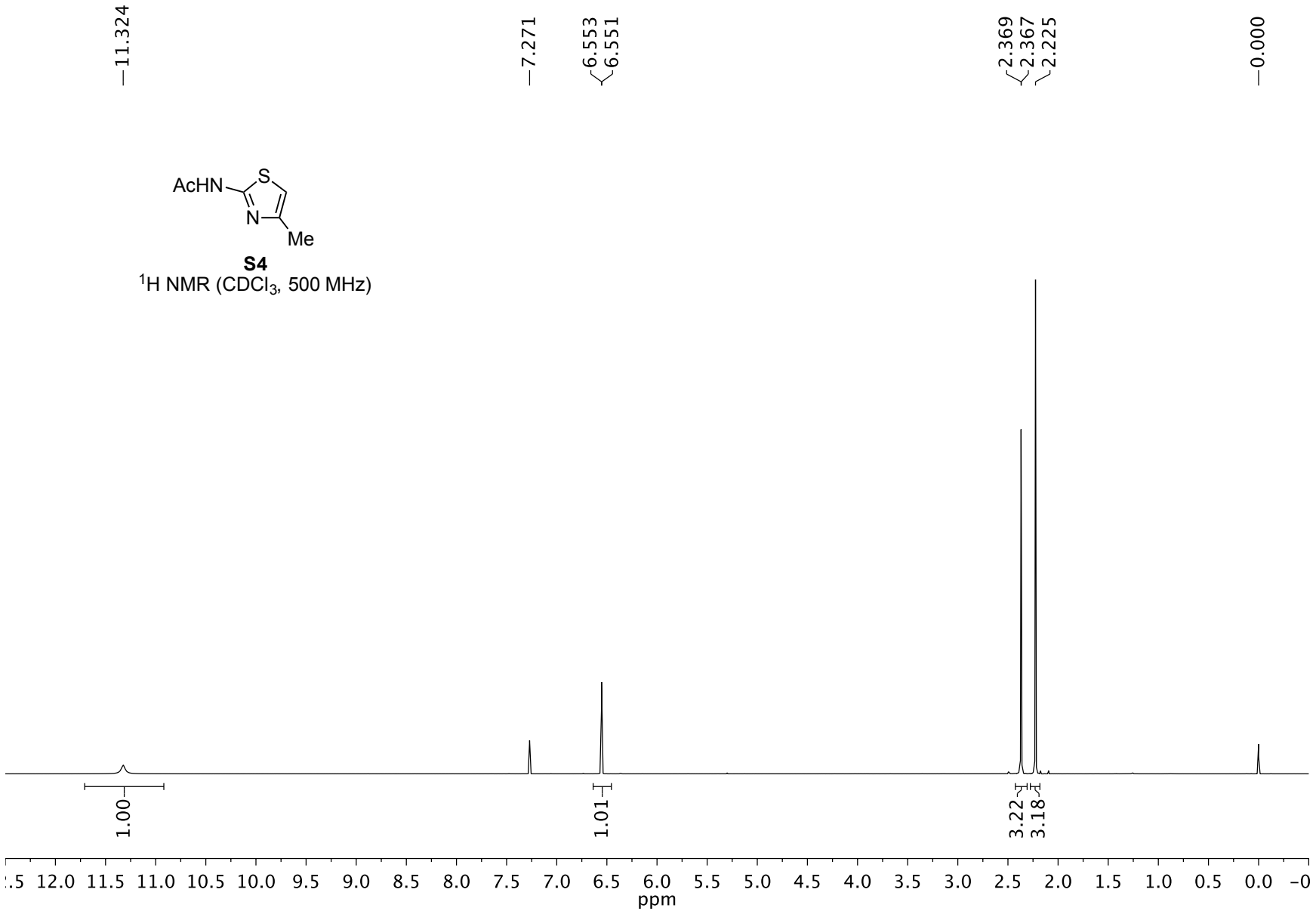
S2

^{1}H NMR ($CDCl_3$, 300 MHz)



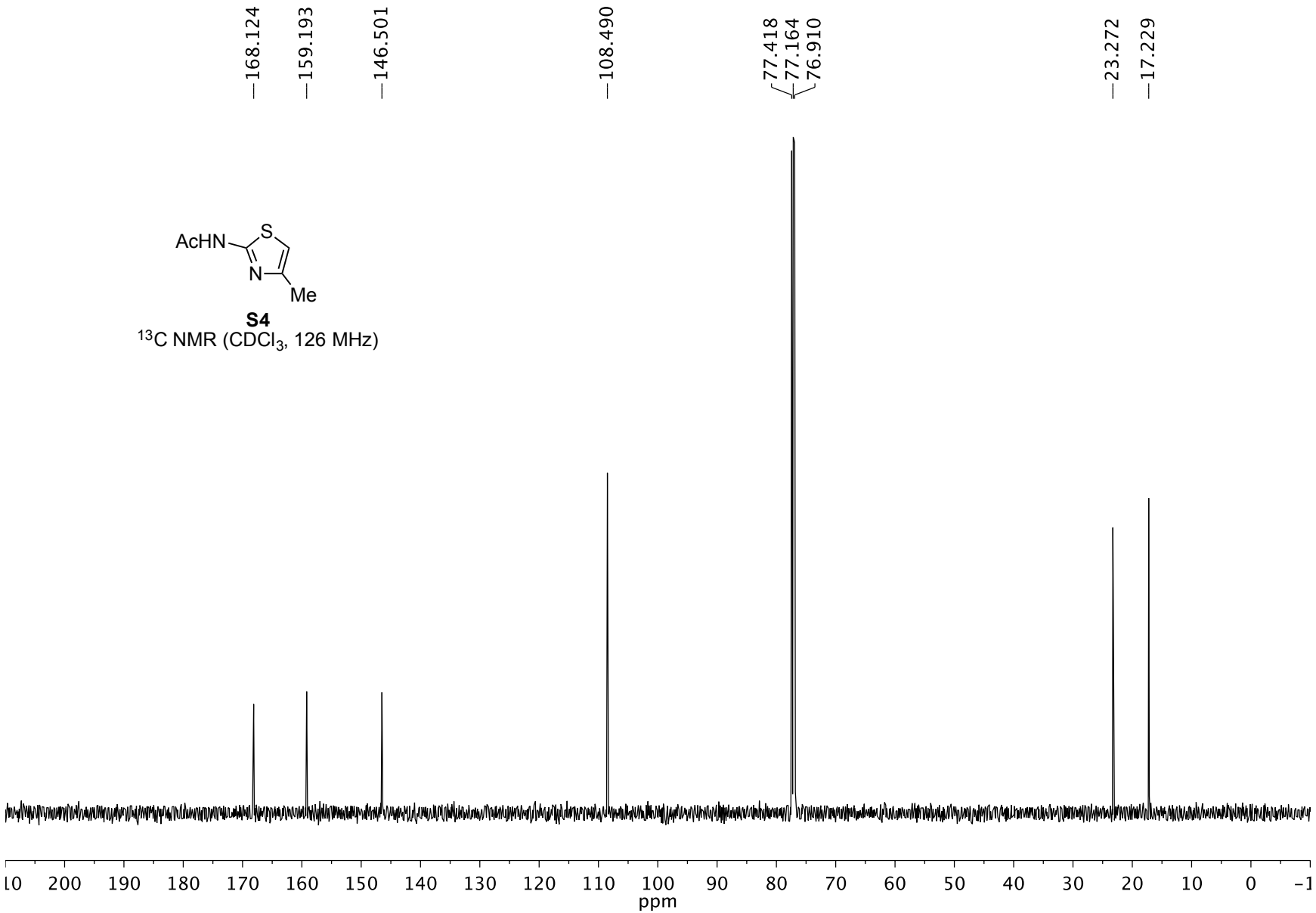
S3

^{1}H NMR ($CDCl_3$, 300 MHz)



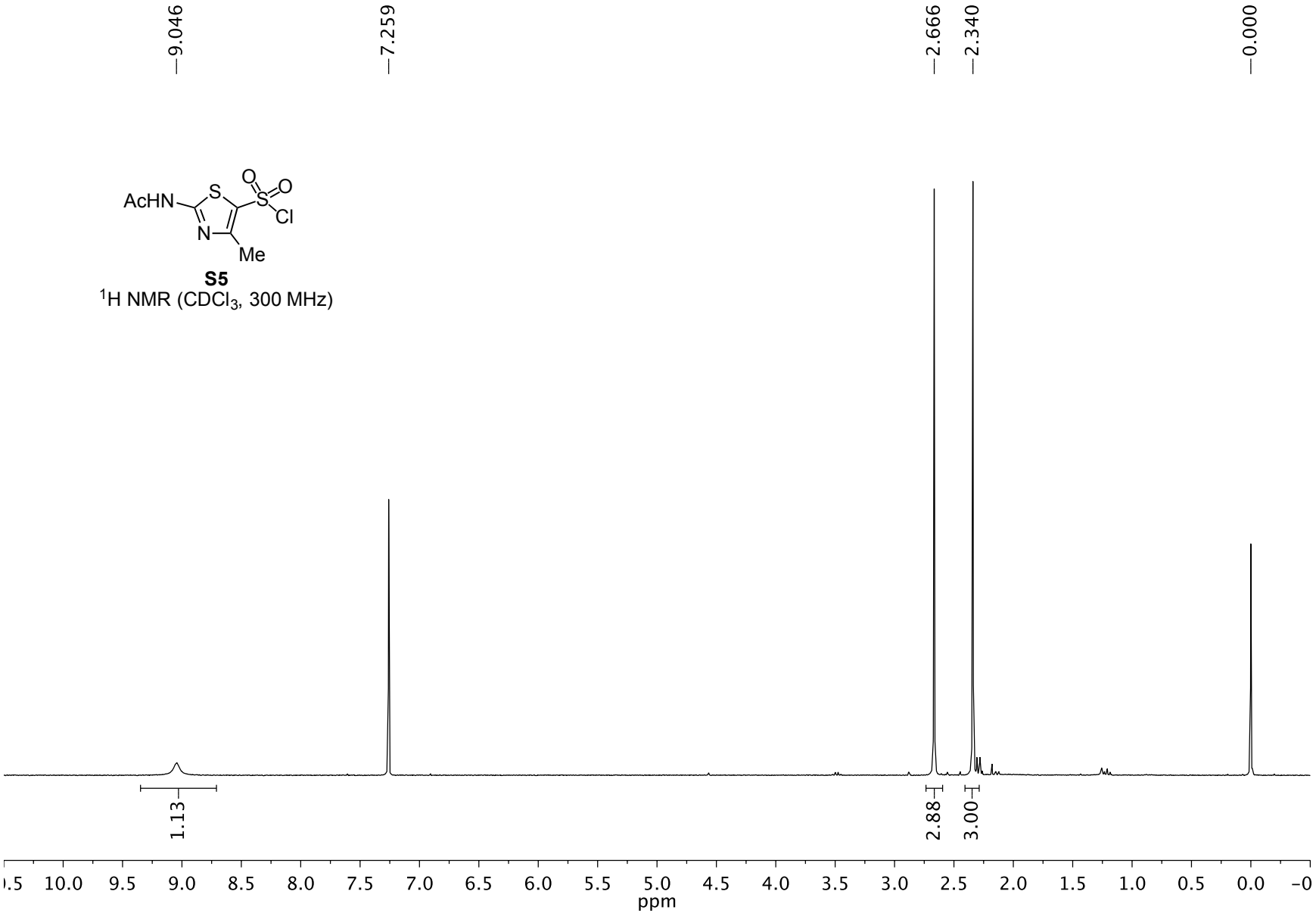
S4

^{1}H NMR ($CDCl_3$, 500 MHz)



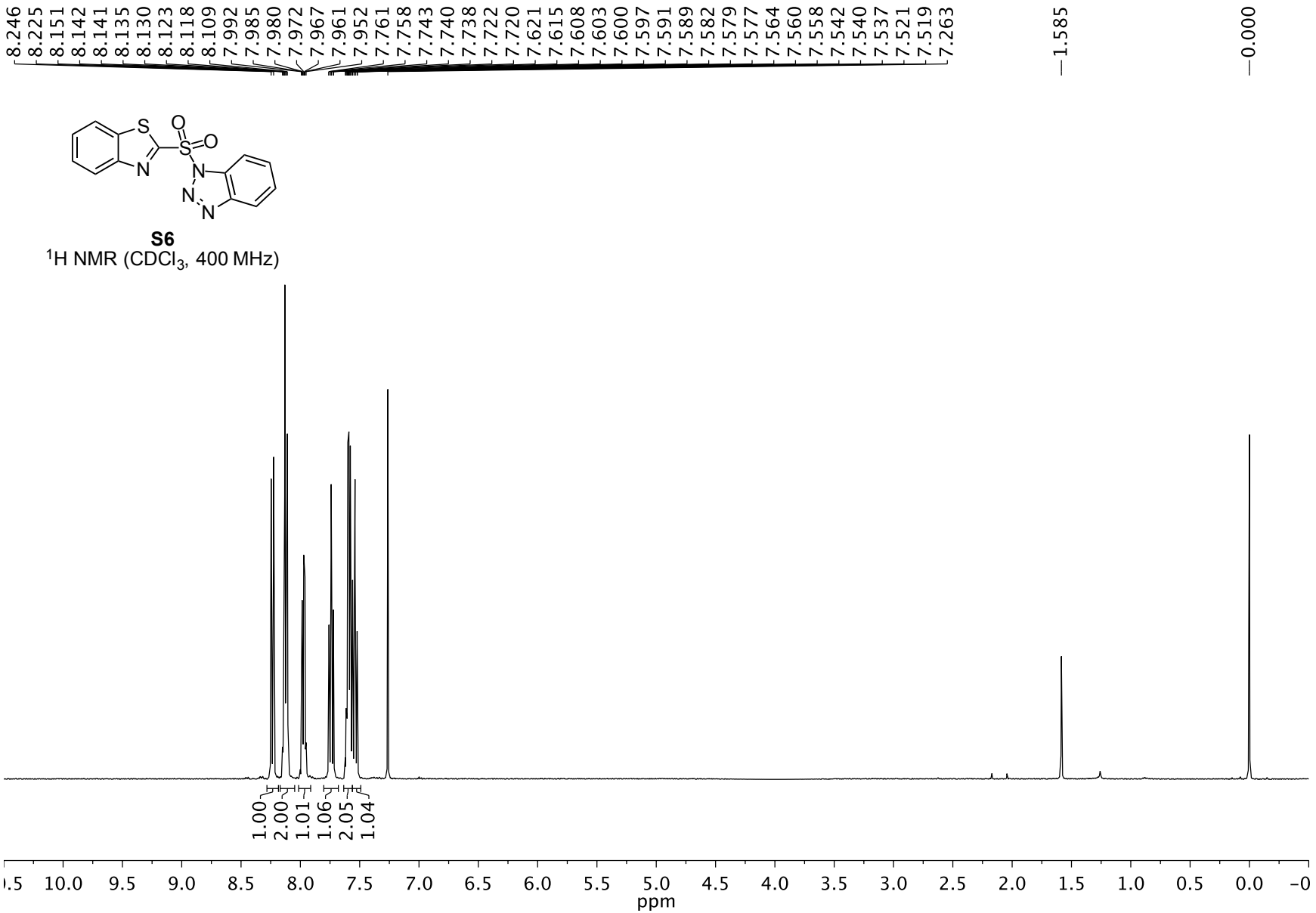
S4

^{13}C NMR ($CDCl_3$, 126 MHz)



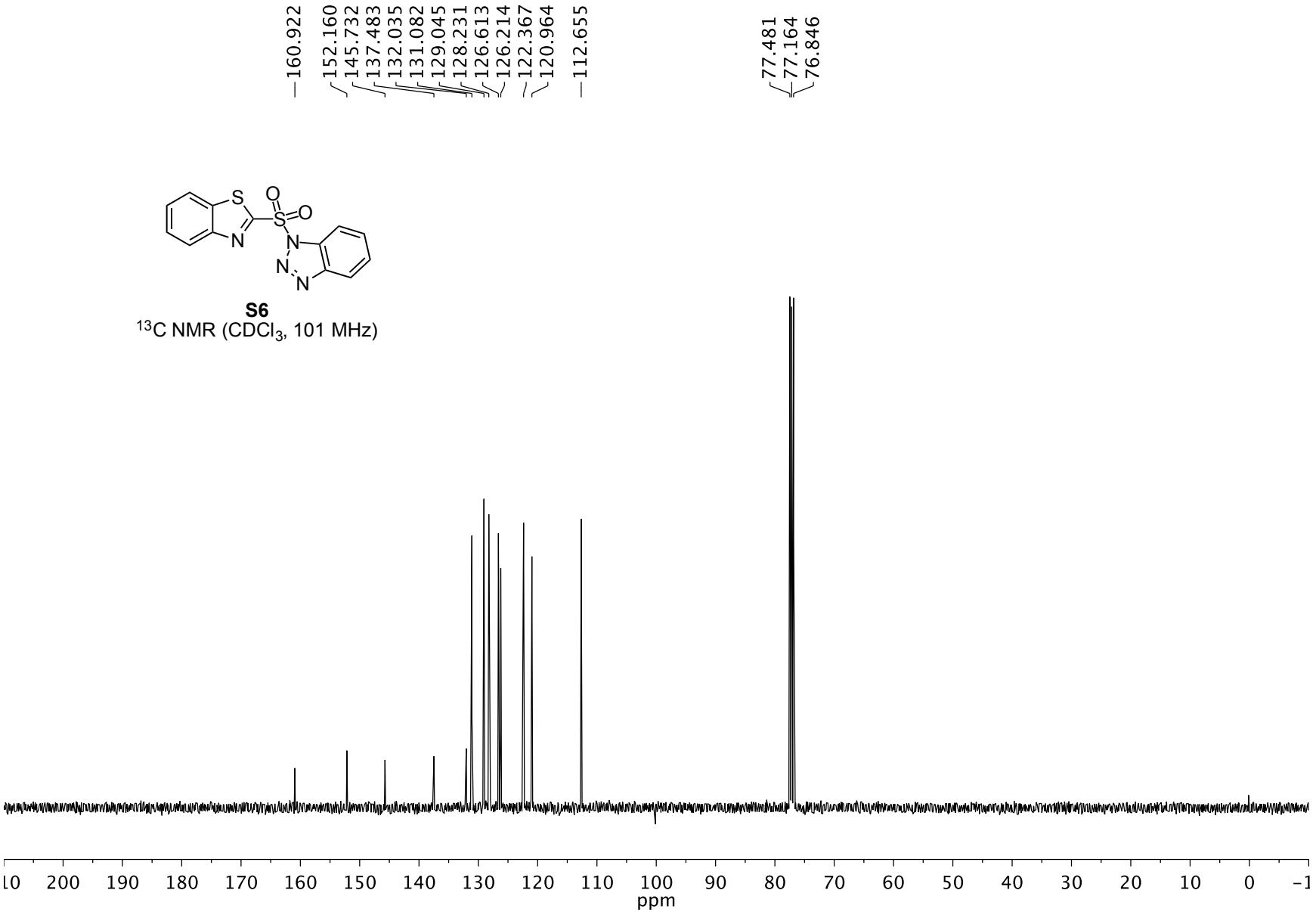
S5

^{1}H NMR ($CDCl_3$, 300 MHz)



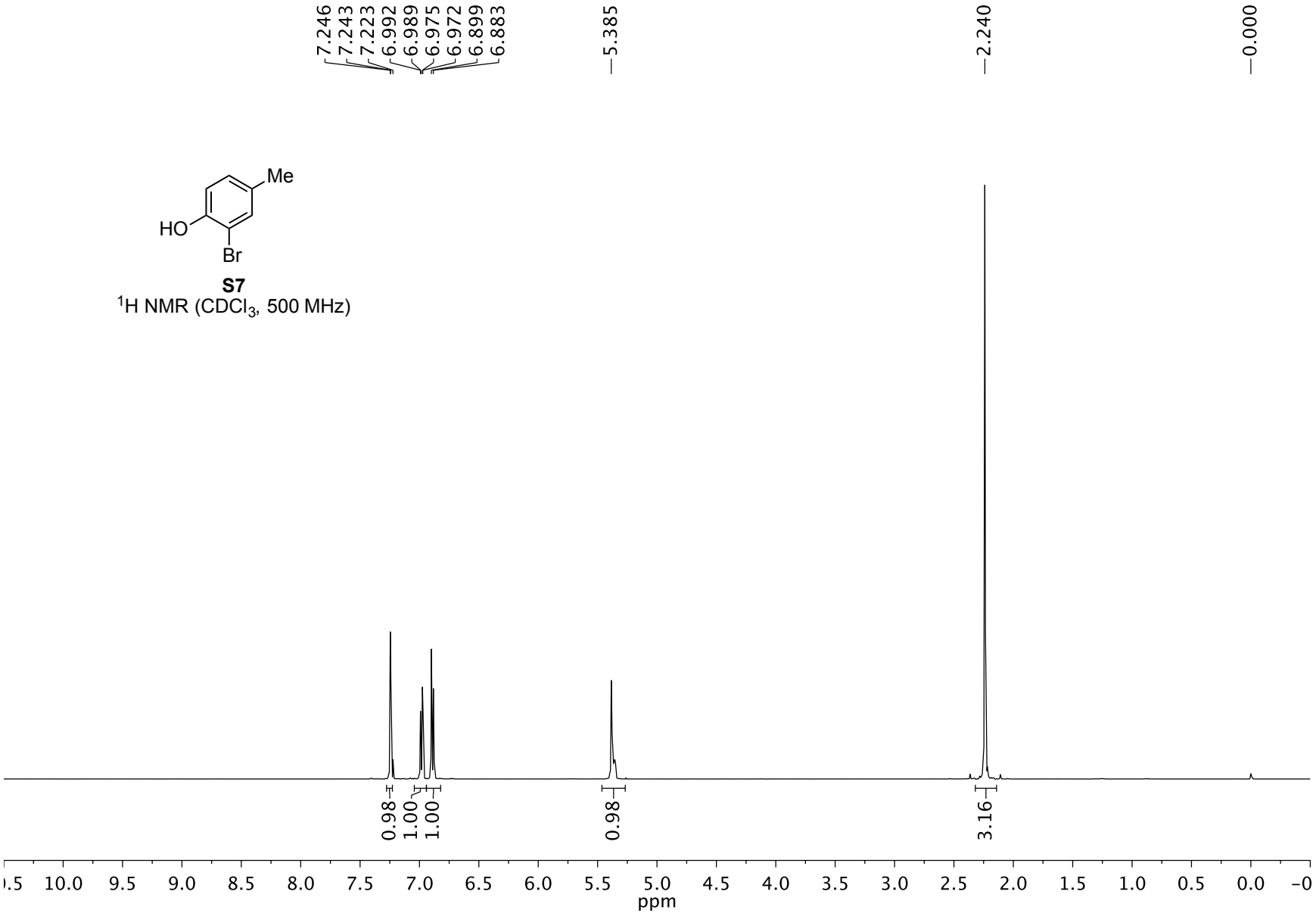
S6

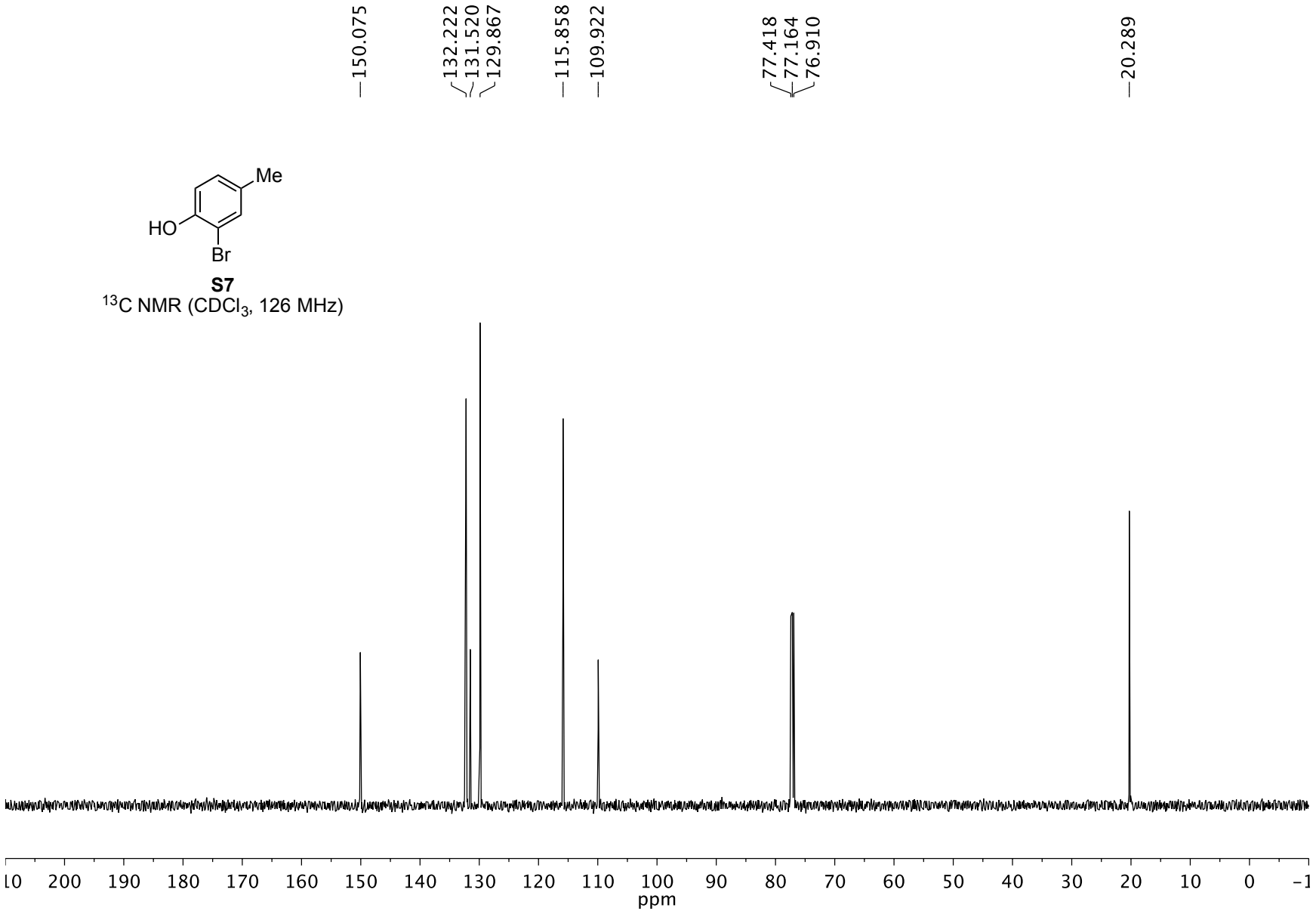
^{1}H NMR ($CDCl_3$, 400 MHz)



S6

^{13}C NMR ($CDCl_3$, 101 MHz)


7.246
7.243
7.223
6.992
6.989
6.975
6.972
6.899
6.883
5.385
2.240
0.000
Me
HO
Br
S7
1H NMR (CDCl3, 500 MHz)
0.98
1.00
1.00
0.98
3.16
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm


150.075
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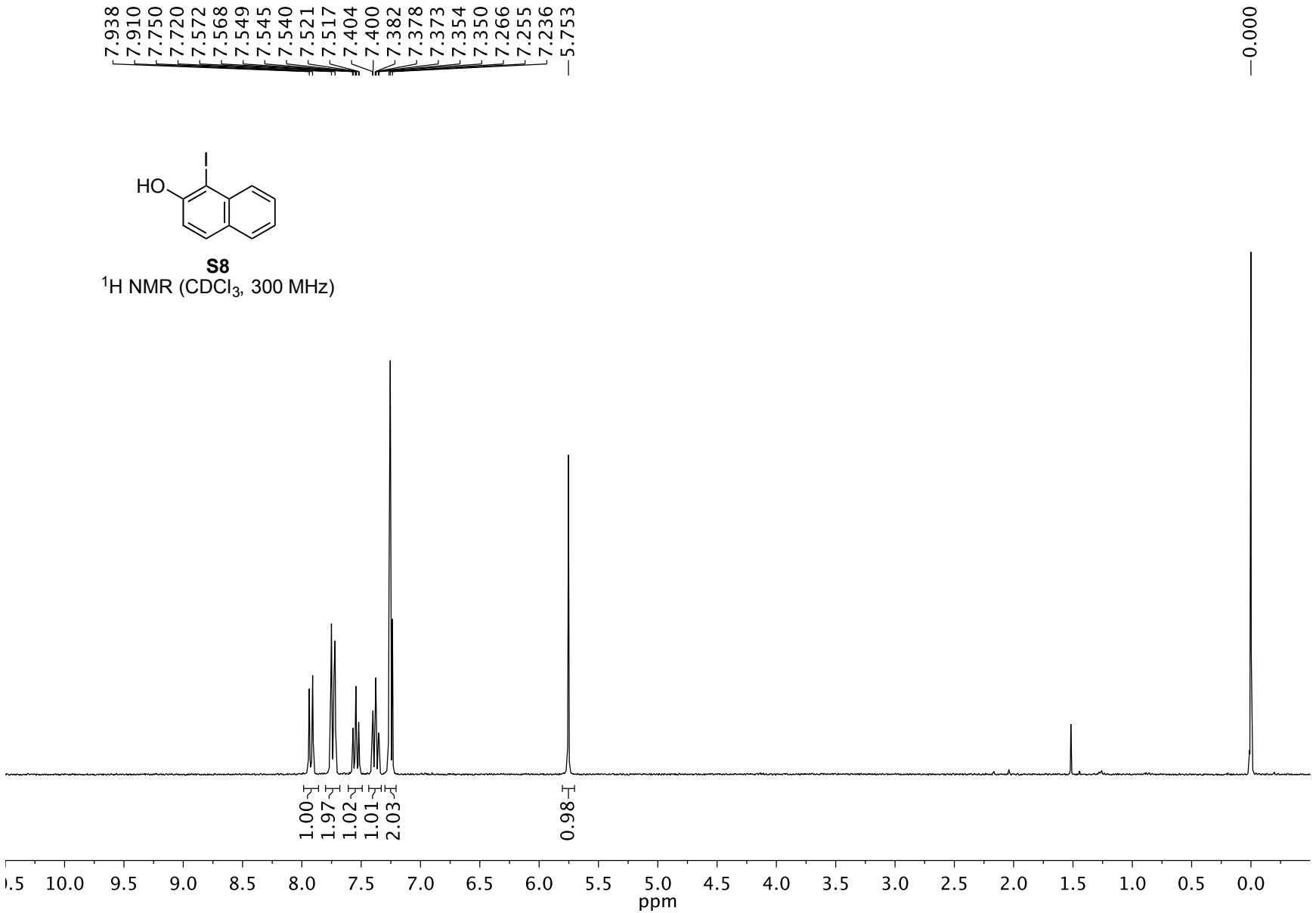
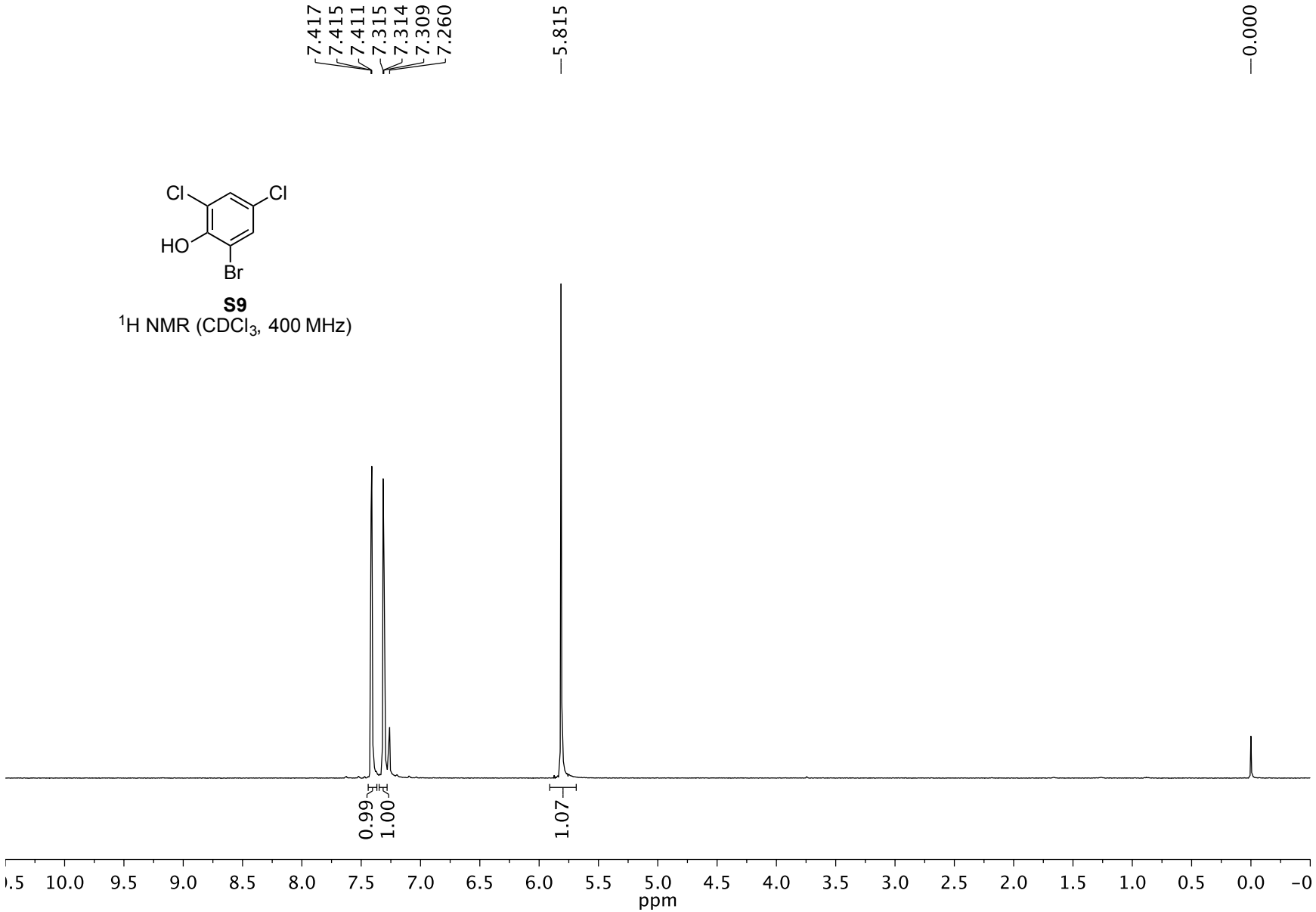
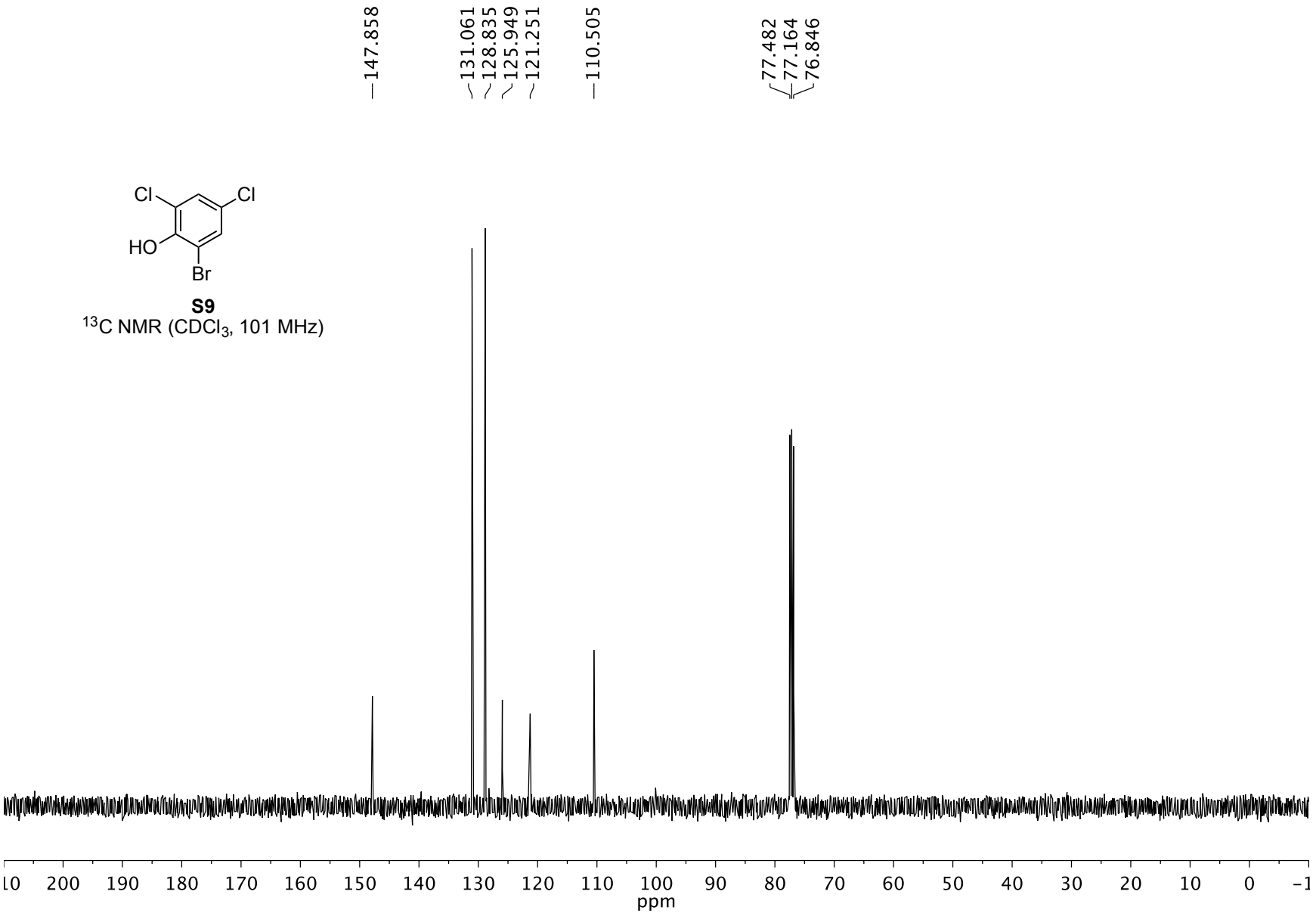
129.867
115.858
109.922
77.418
77.164
76.910
20.289
Me
HO
Br
S7
13C NMR (CDCl3, 126 MHz)
ppm



S8

^{1}H NMR ($CDCl_3$, 300 MHz)


7.417
7.415
7.411
7.315
7.314
7.309
7.260
5.815
0.000
Cl
Cl
HO
Br
S9
1H NMR (CDCl3, 400 MHz)
0.99
1.00
1.07
ppm


147.858
131.061
128.835
125.949
121.251
110.505
77.482
77.164
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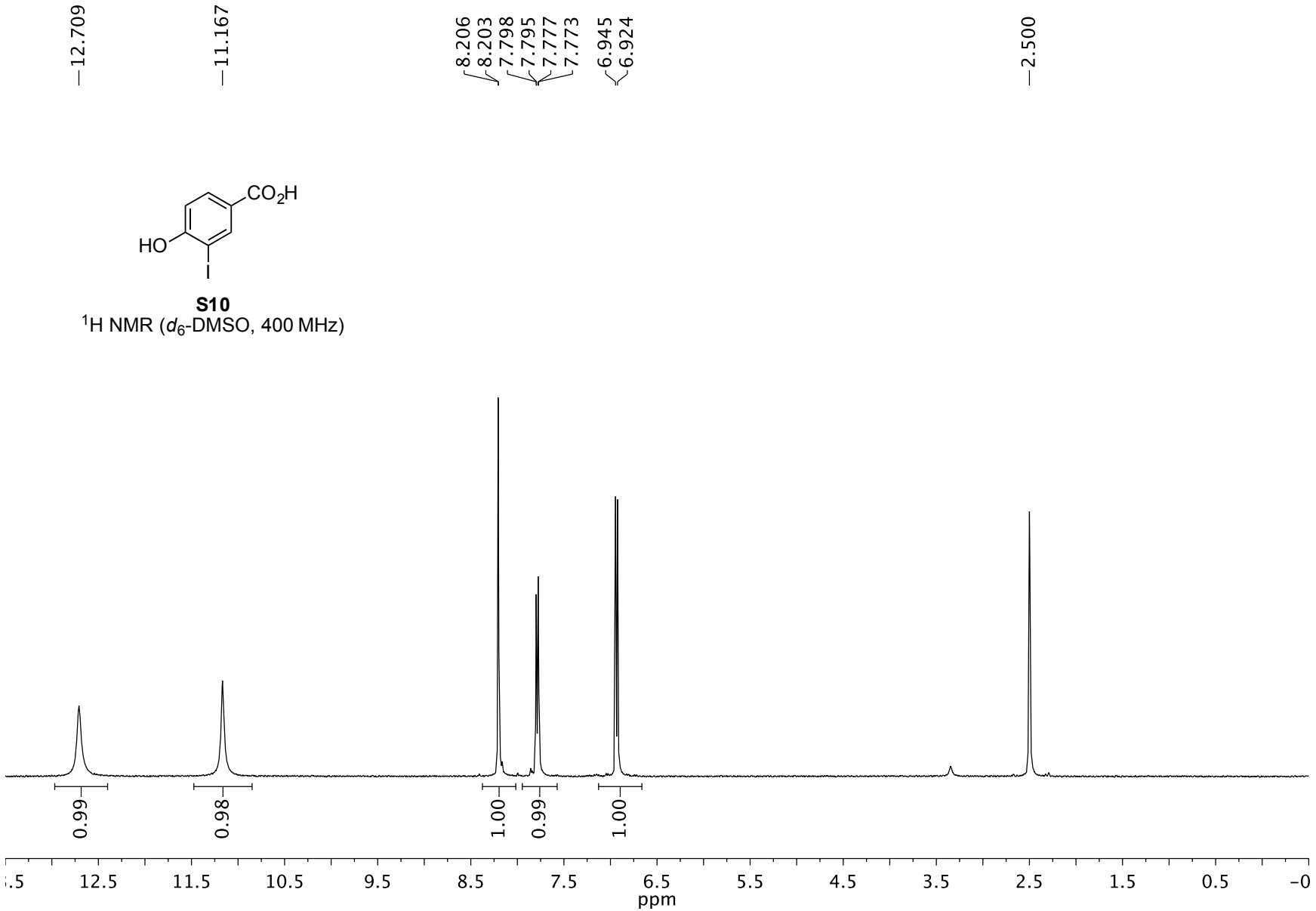
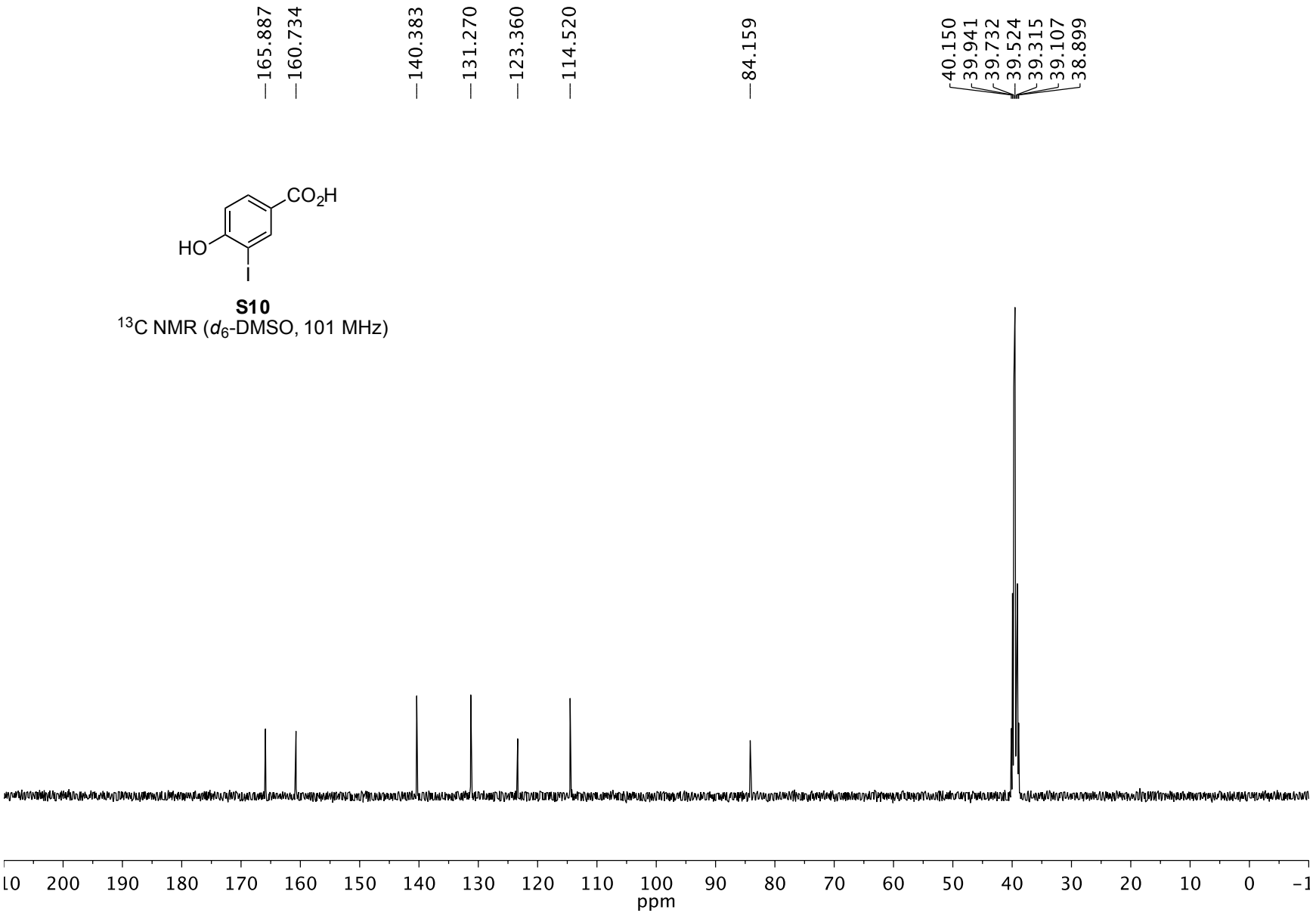
Cl
Cl
HO
Br
S9
13C NMR (CDCl3, 101 MHz)
ppm



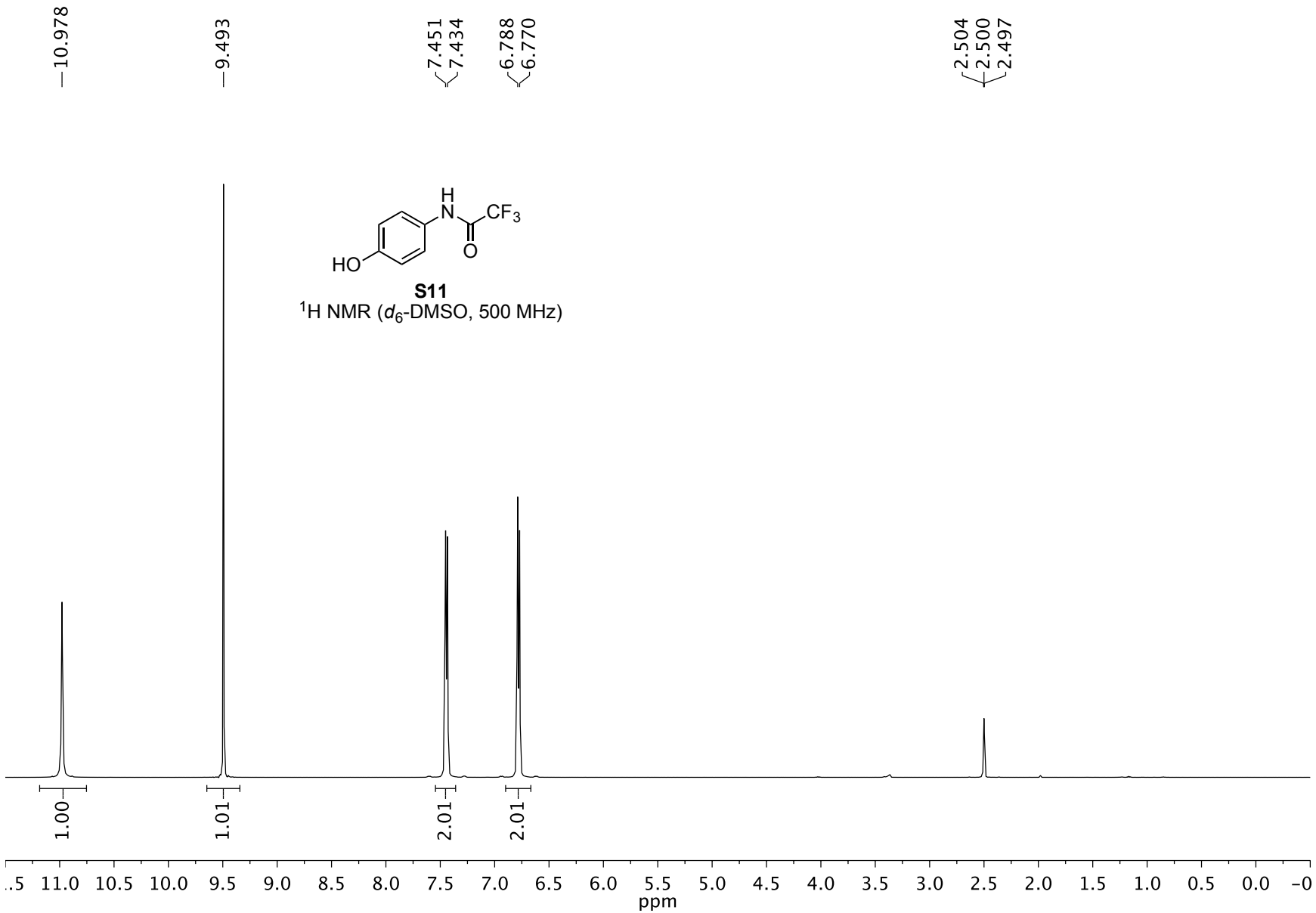
S10

^{1}H NMR (d_6-DMSO, 400 MHz)



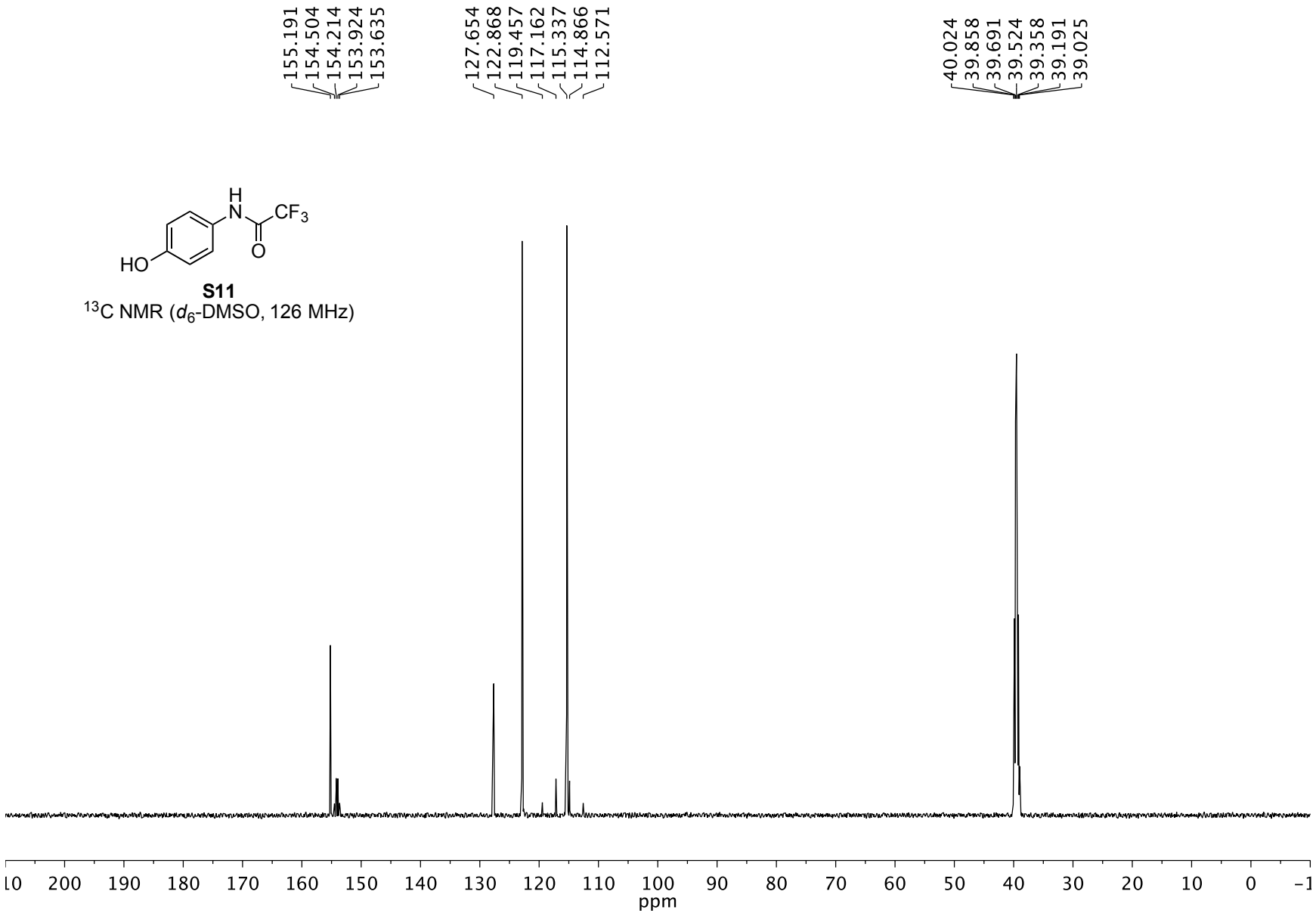
S10

^{13}C NMR (d_6-DMSO, 101 MHz)



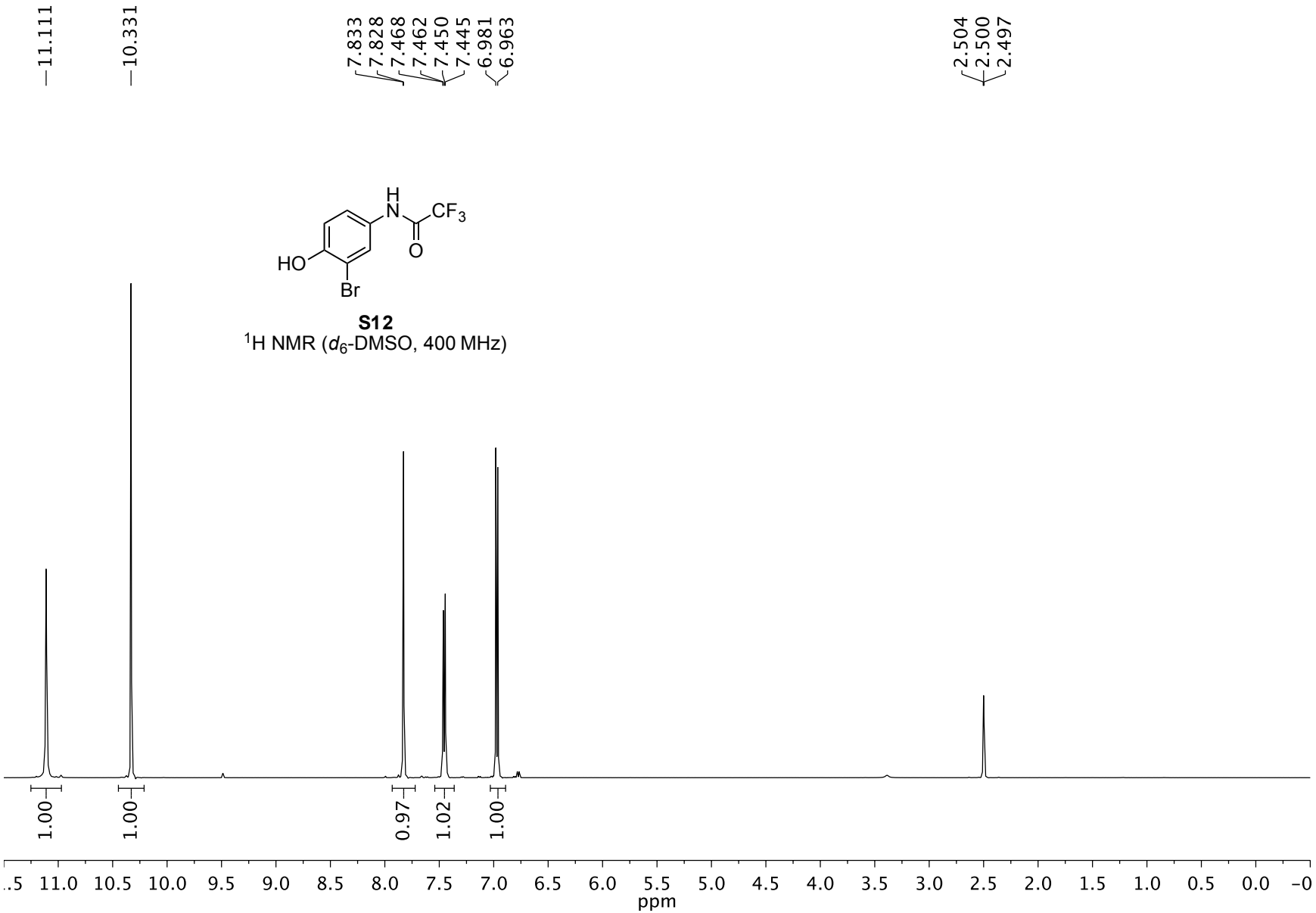
S11

^{1}H NMR (d_6-DMSO, 500 MHz)



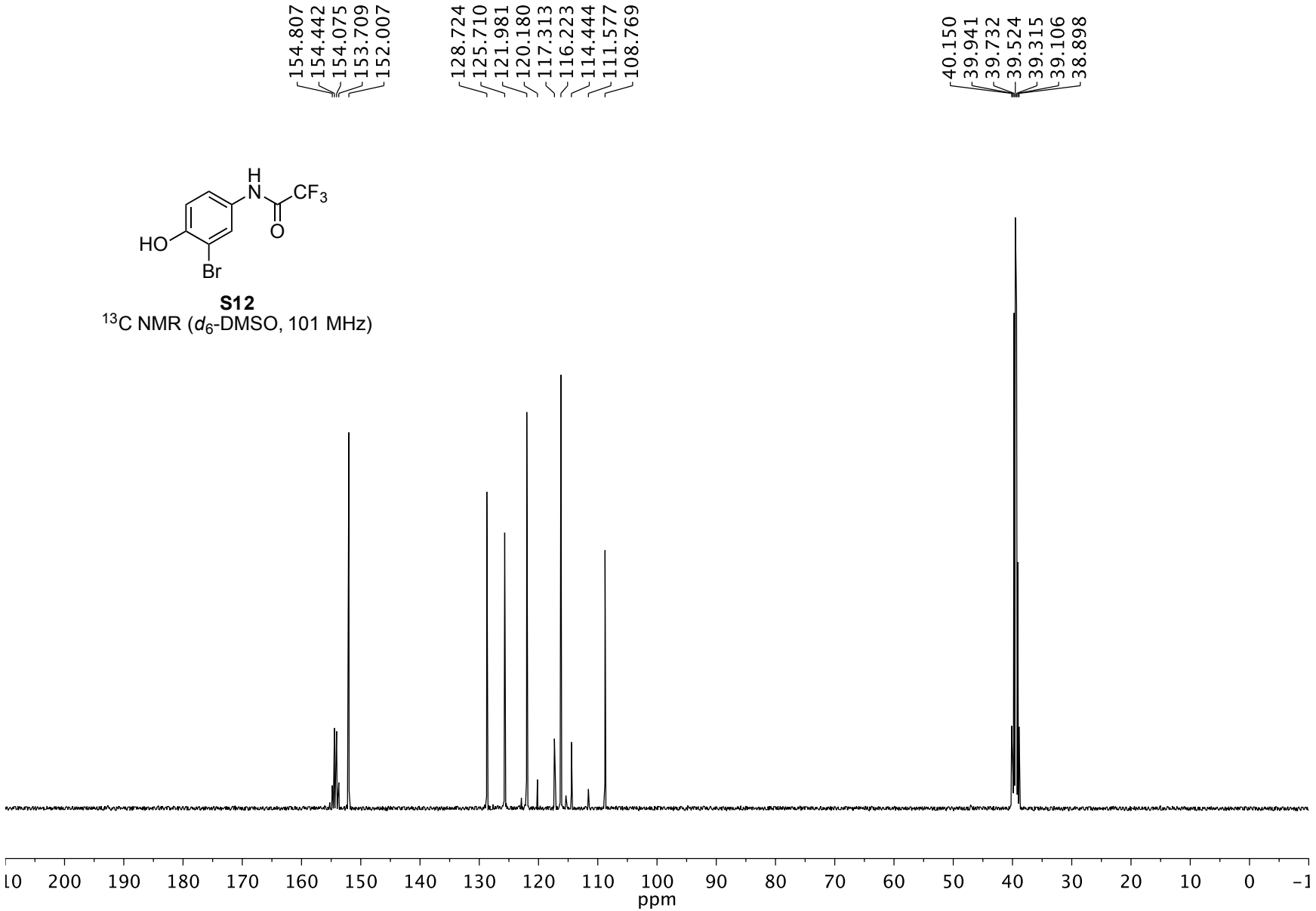
S11

^{13}C NMR (d_6-DMSO, 126 MHz)



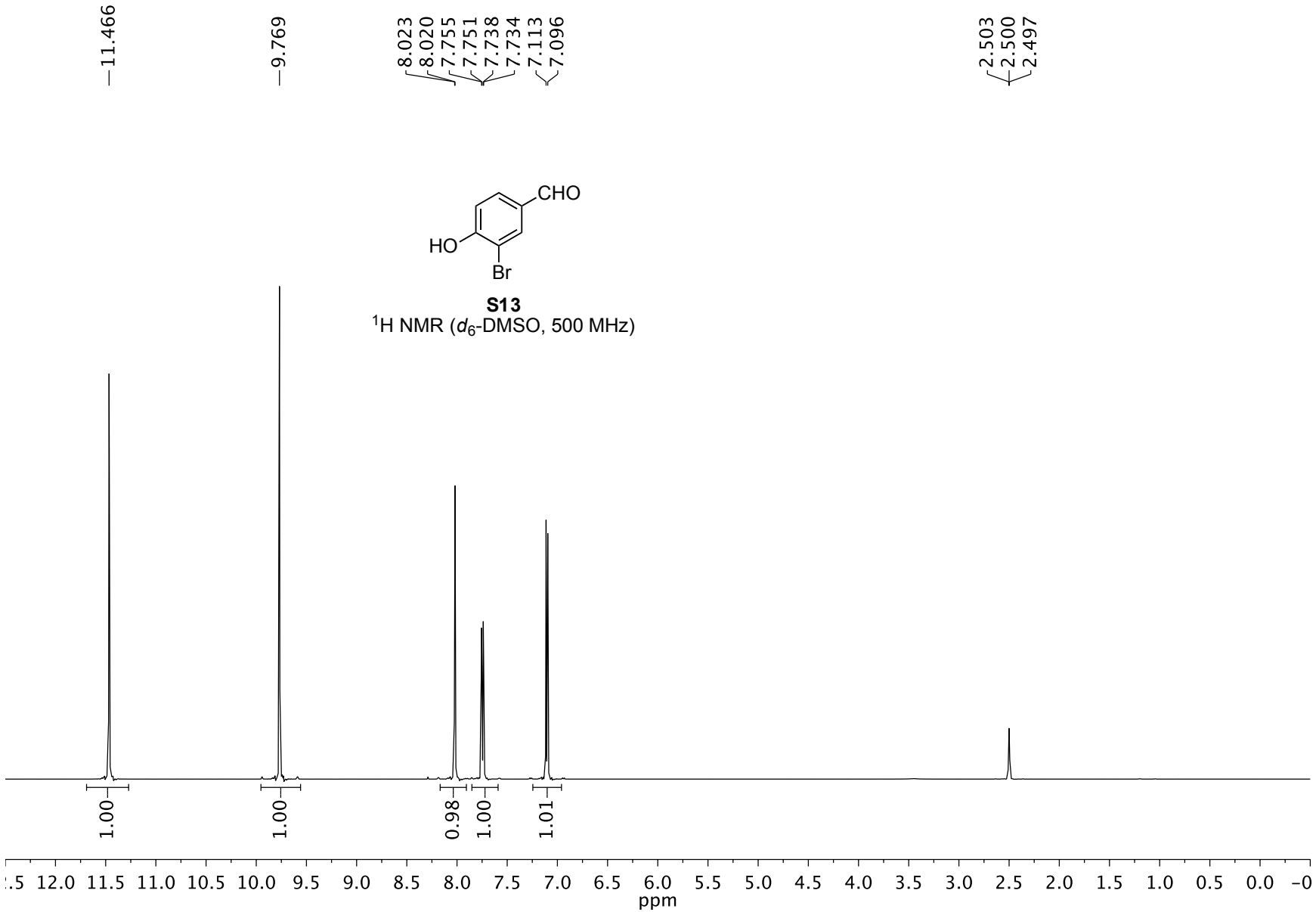
S12

^{1}H NMR (d_6-DMSO, 400 MHz)



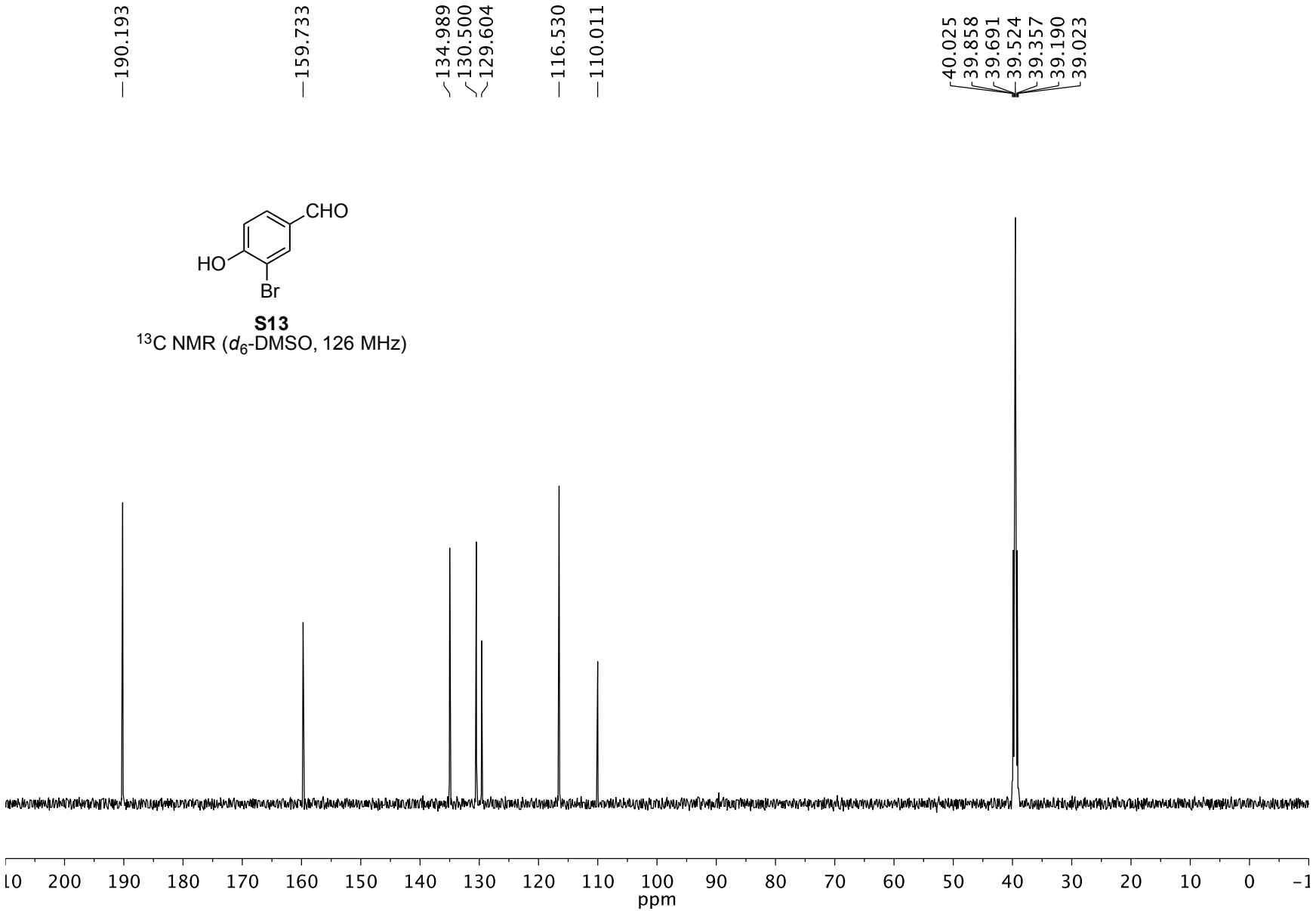
S12

^{13}C NMR (d_6-DMSO, 101 MHz)



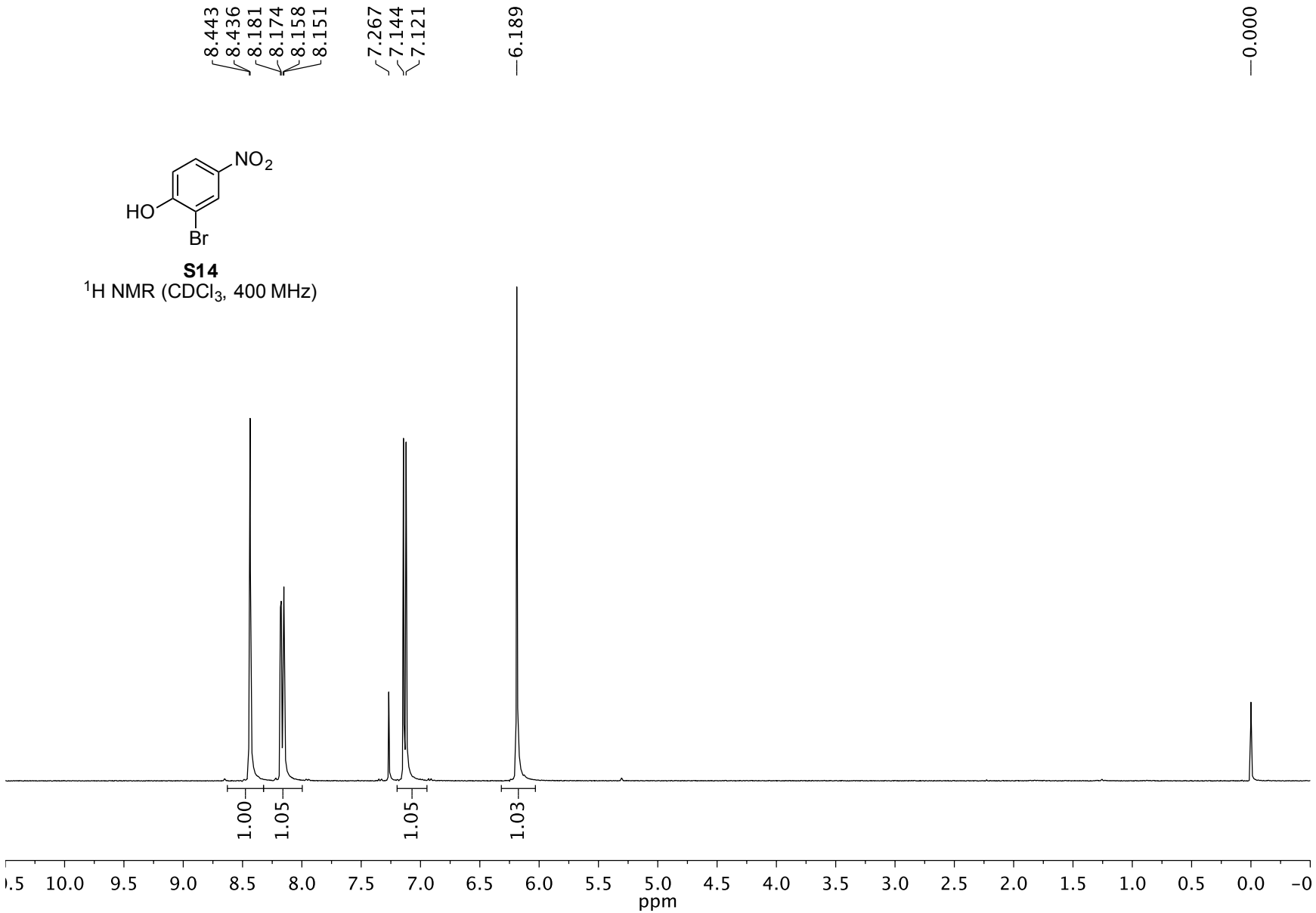
S13

^{1}H NMR (d_6-DMSO, 500 MHz)



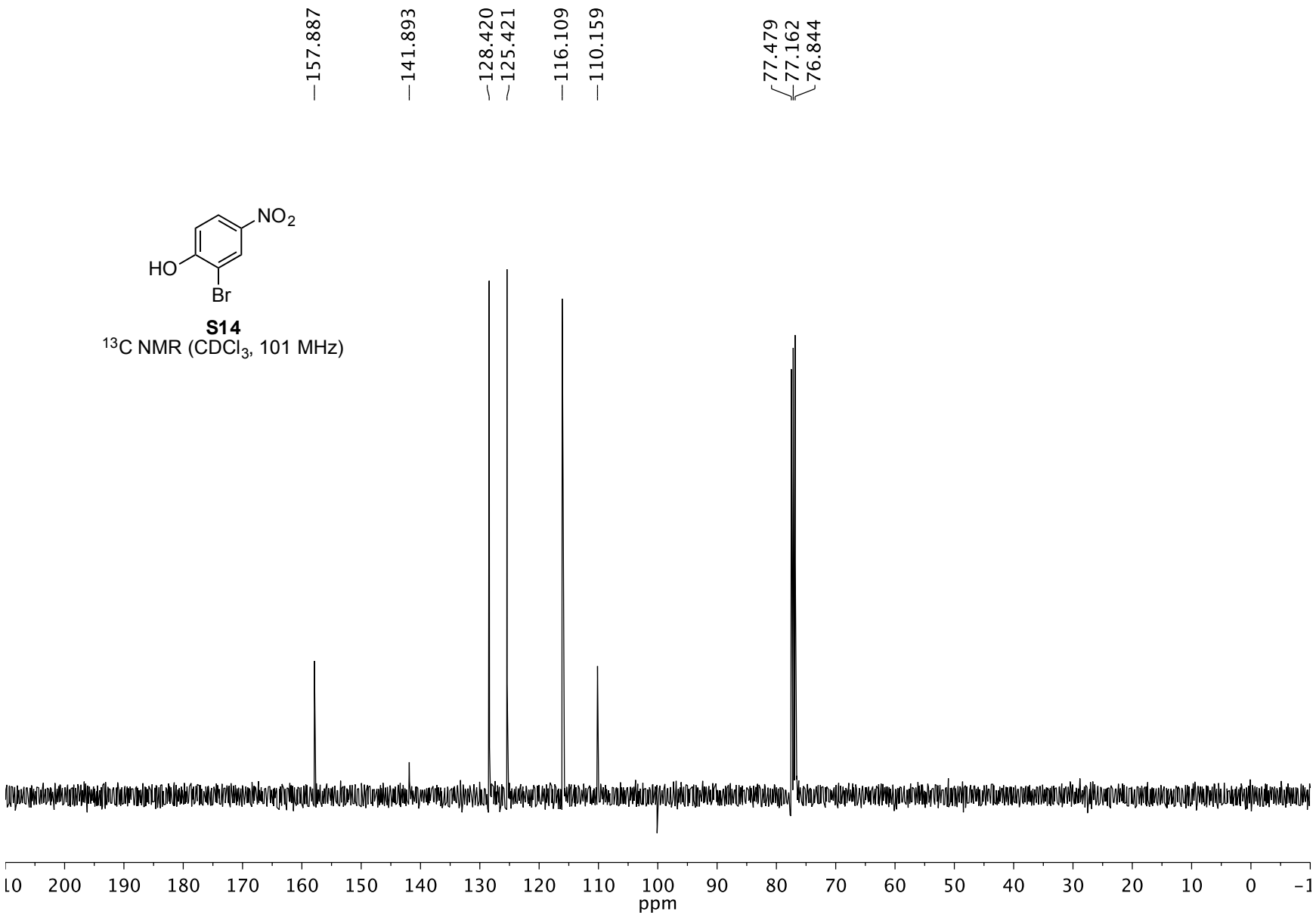
S13

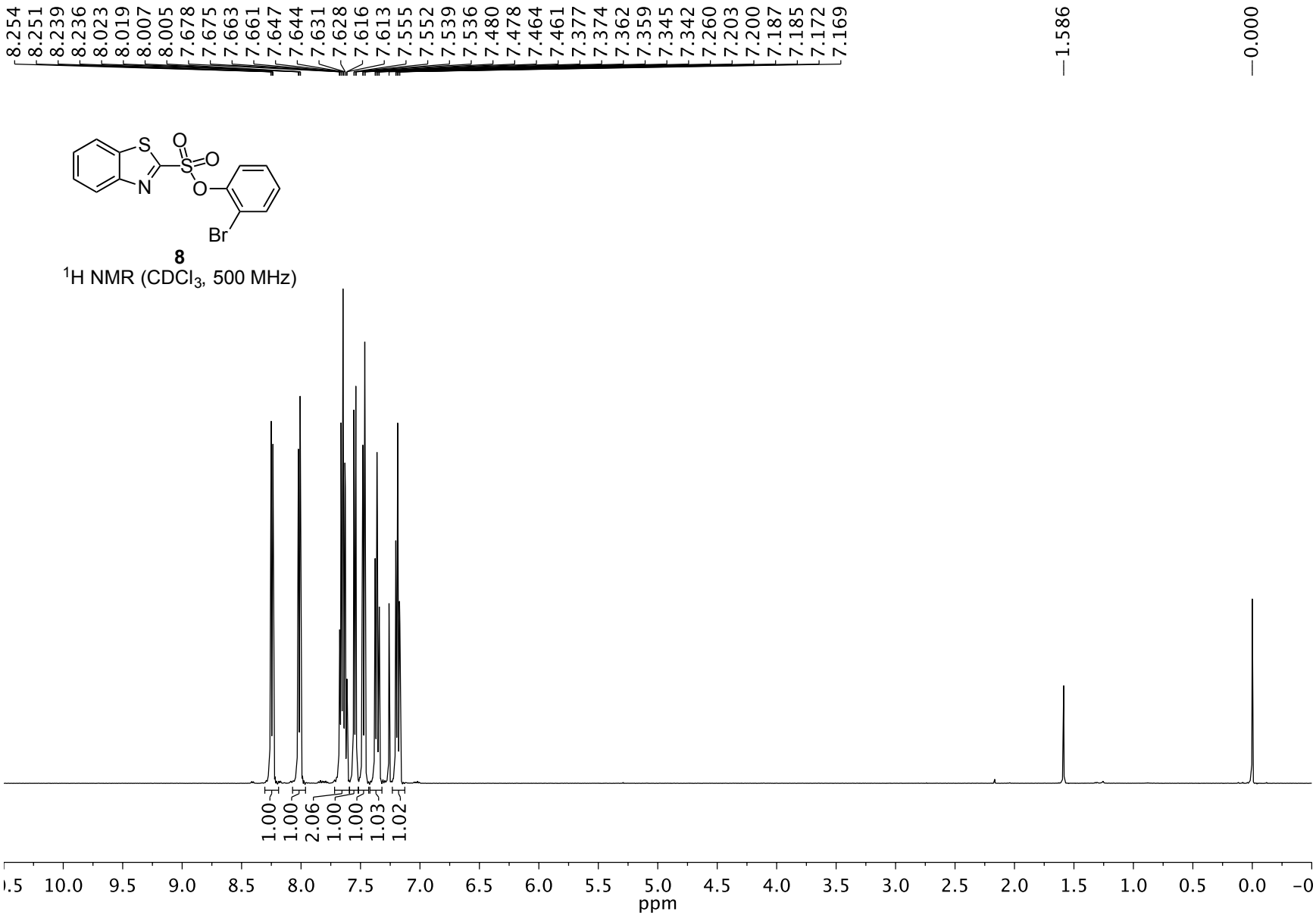
^{13}C NMR (d_6-DMSO, 126 MHz)

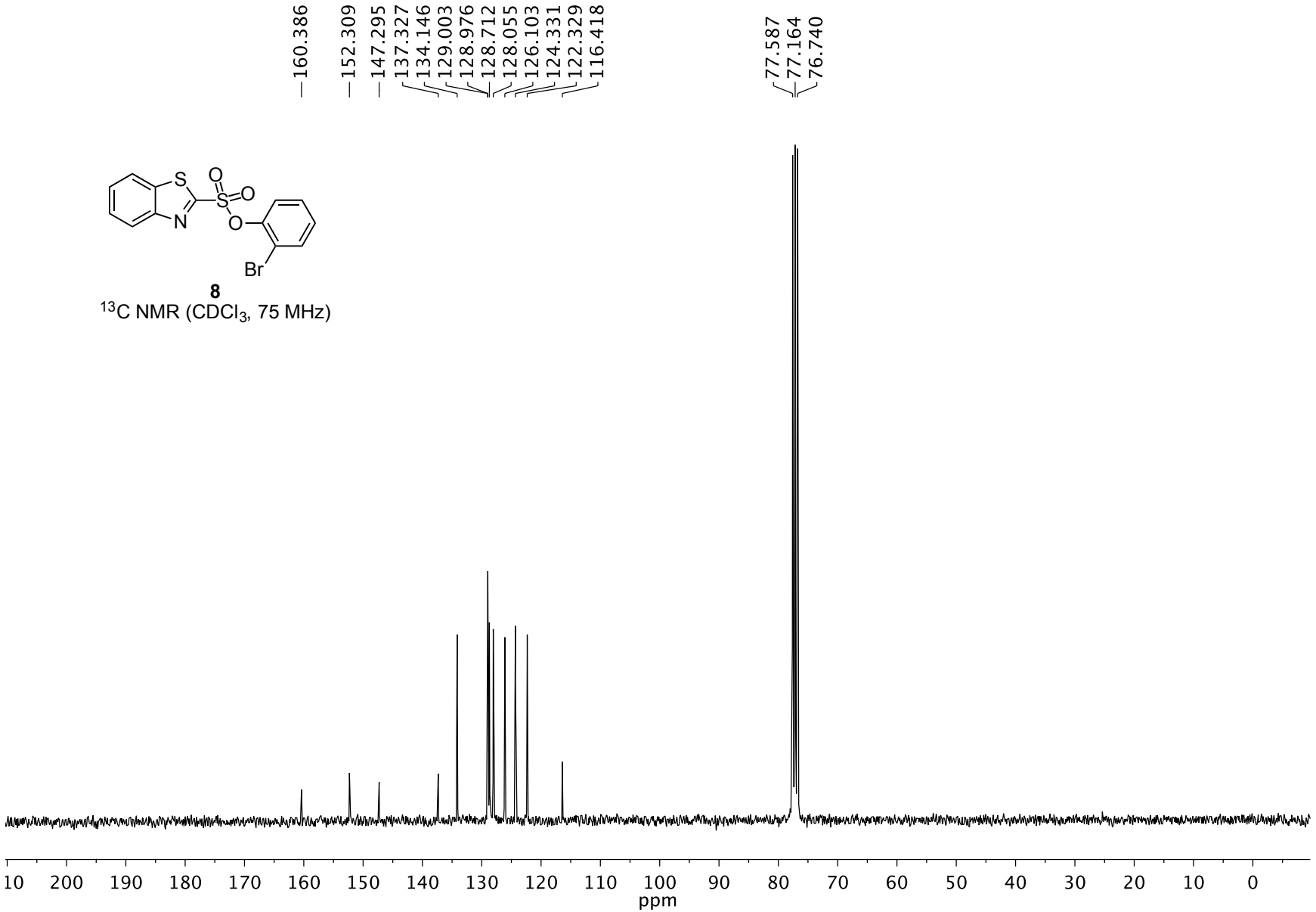


S14

^{1}H NMR ($CDCl_3$, 400 MHz)

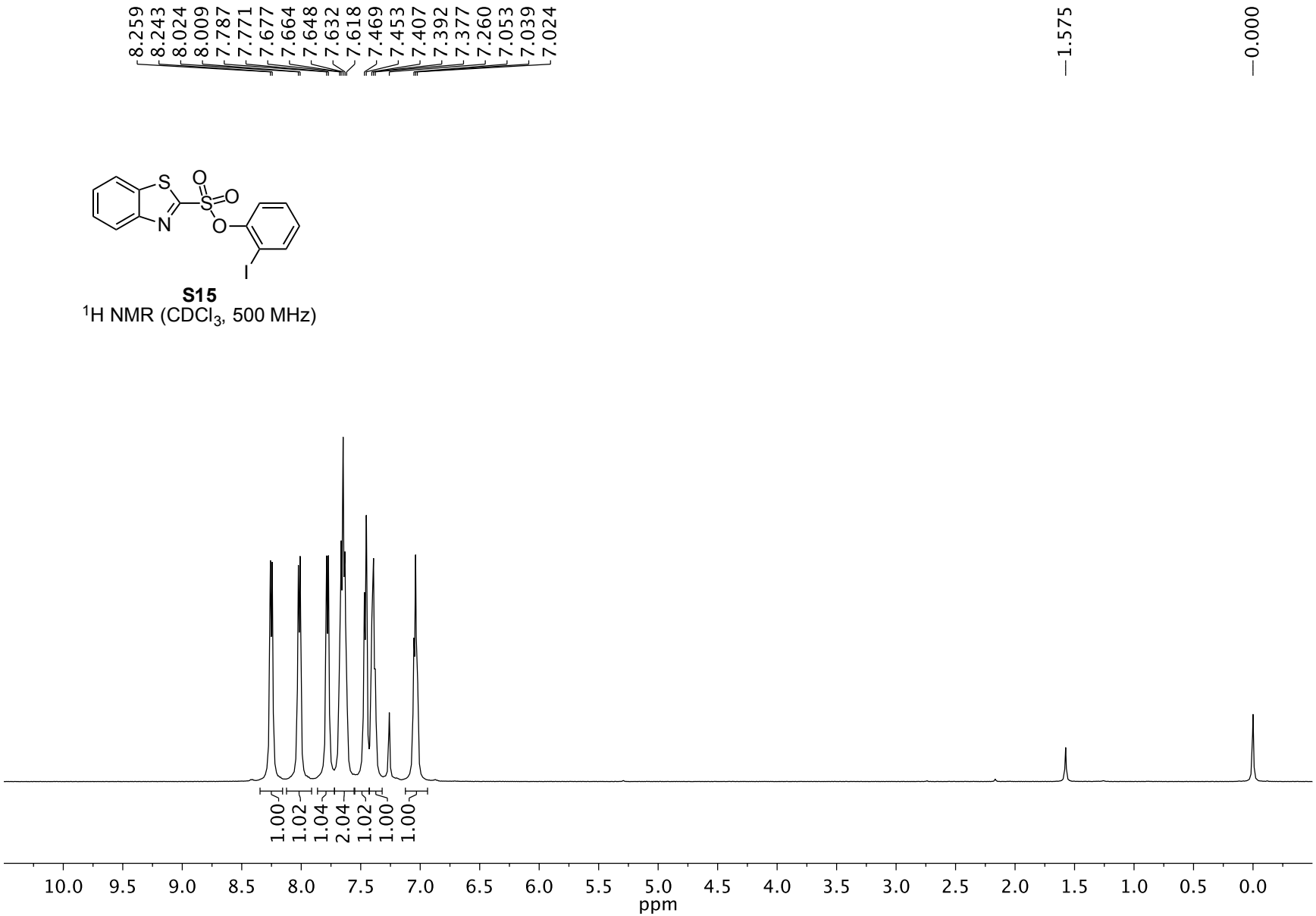

157.887
141.893
128.420
125.421
116.109
110.159
77.479
77.162
76.844
NO2
HO
Br
S14
13C NMR (CDCl3, 101 MHz)
ppm


8.254
8.251
8.239
8.236
8.023
8.019
8.007
8.005
7.678
7.675
7.663
7.661
7.647
7.644
7.631
7.628
7.616
7.613
7.555
7.552
7.539
7.536
7.480
7.478
7.464
7.461
7.377
7.374
7.362
7.359
7.345
7.342
7.260
7.203
7.200
7.187
7.185
7.172
7.169
1.586
0.000
S
O
S
O
N
O
Br
8
1H NMR (CDCl3, 500 MHz)
1.00
1.00
2.06
1.00
1.00
1.03
1.02
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm



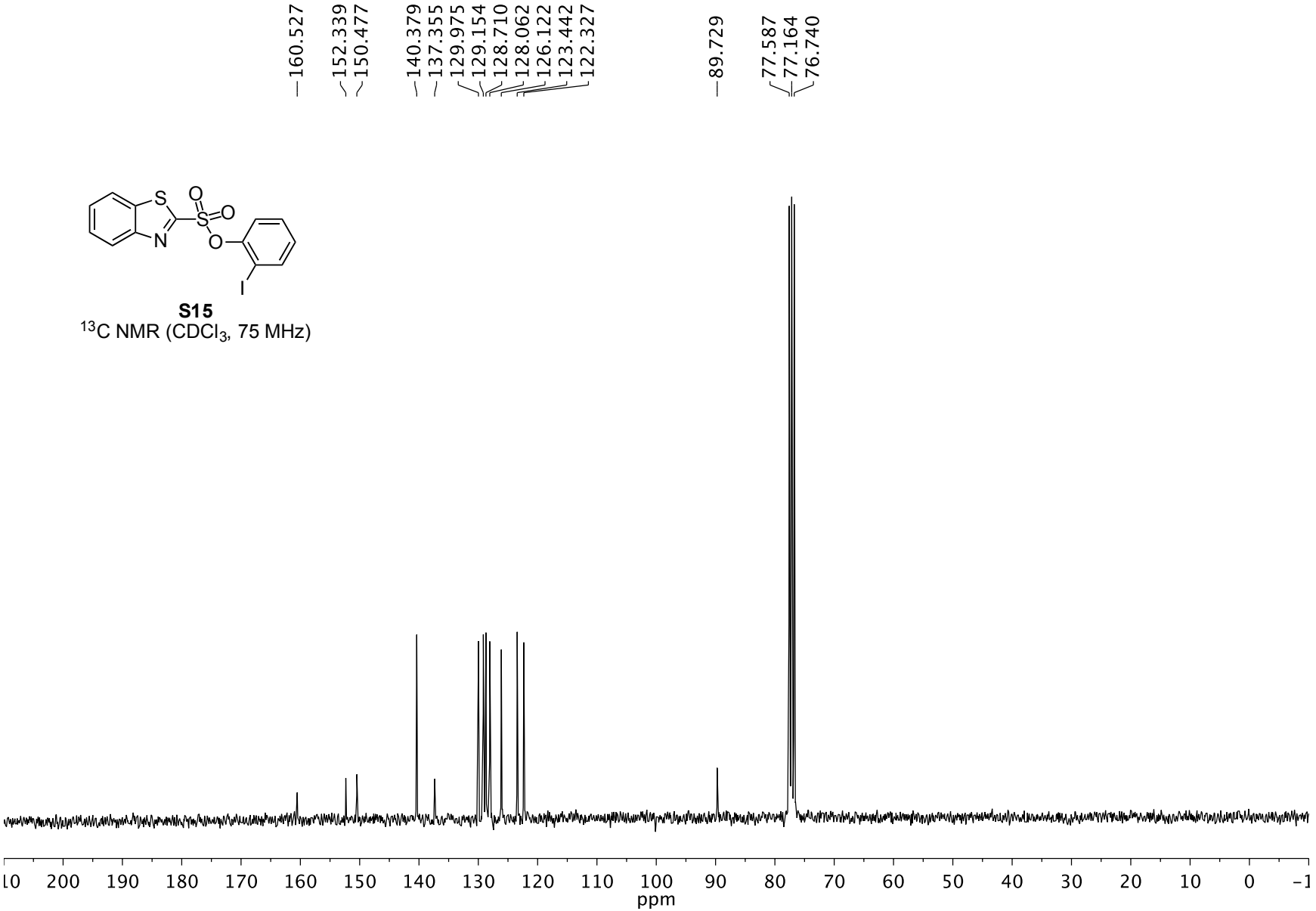
8

^{13}C NMR ($CDCl_3$, 75 MHz)



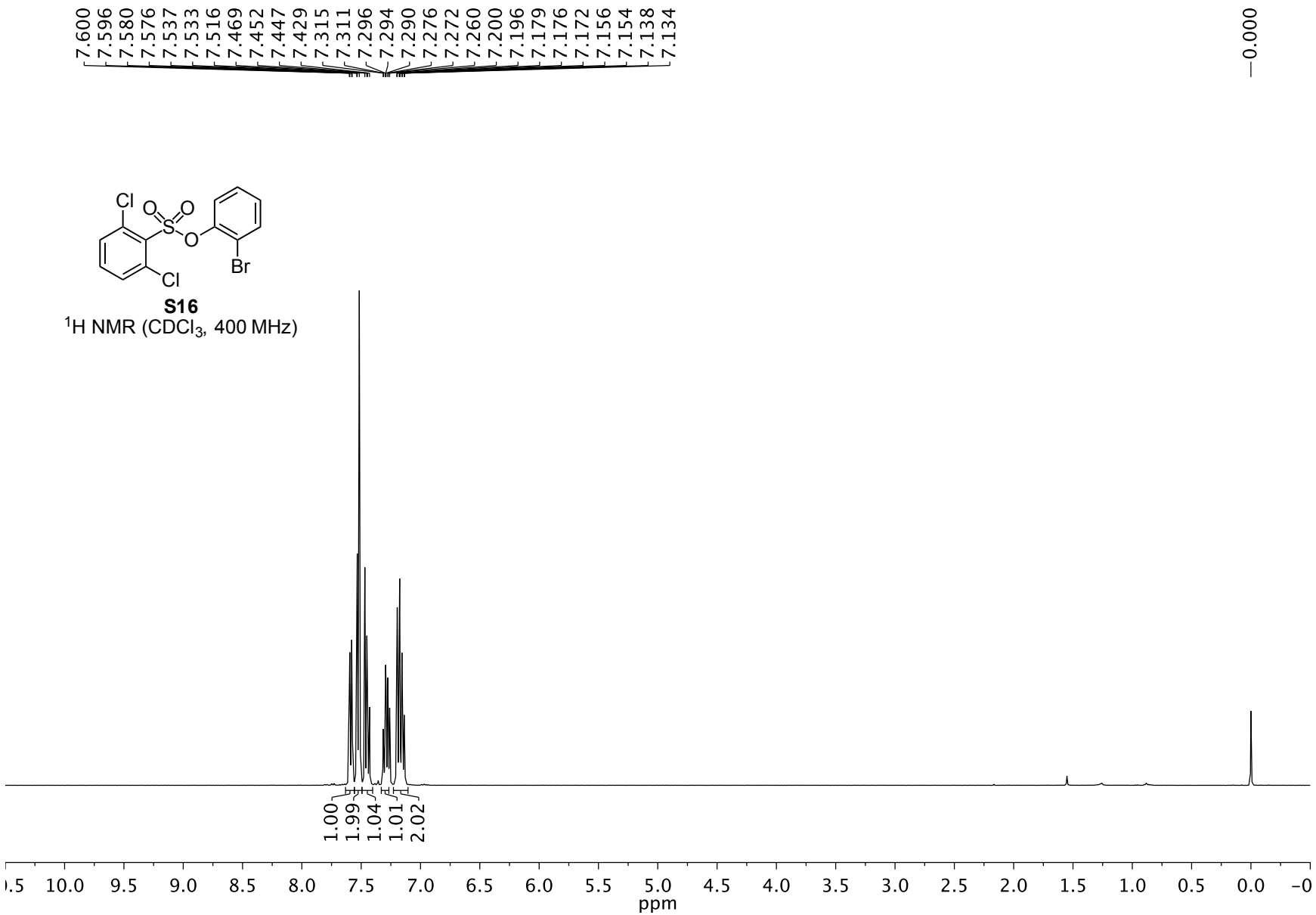
S15

^{1}H NMR ($CDCl_3$, 500 MHz)



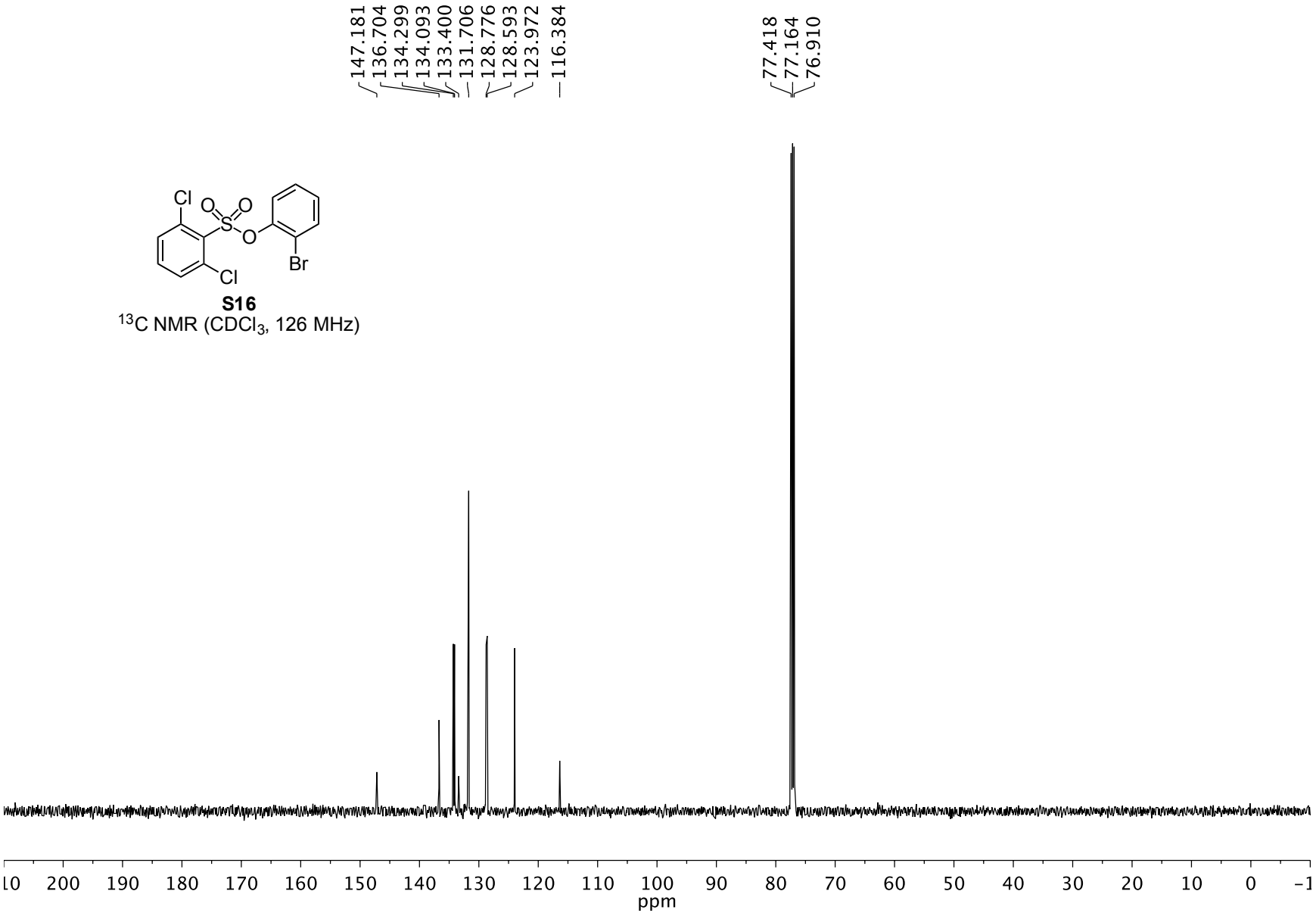
S15

^{13}C NMR ($CDCl_3$, 75 MHz)



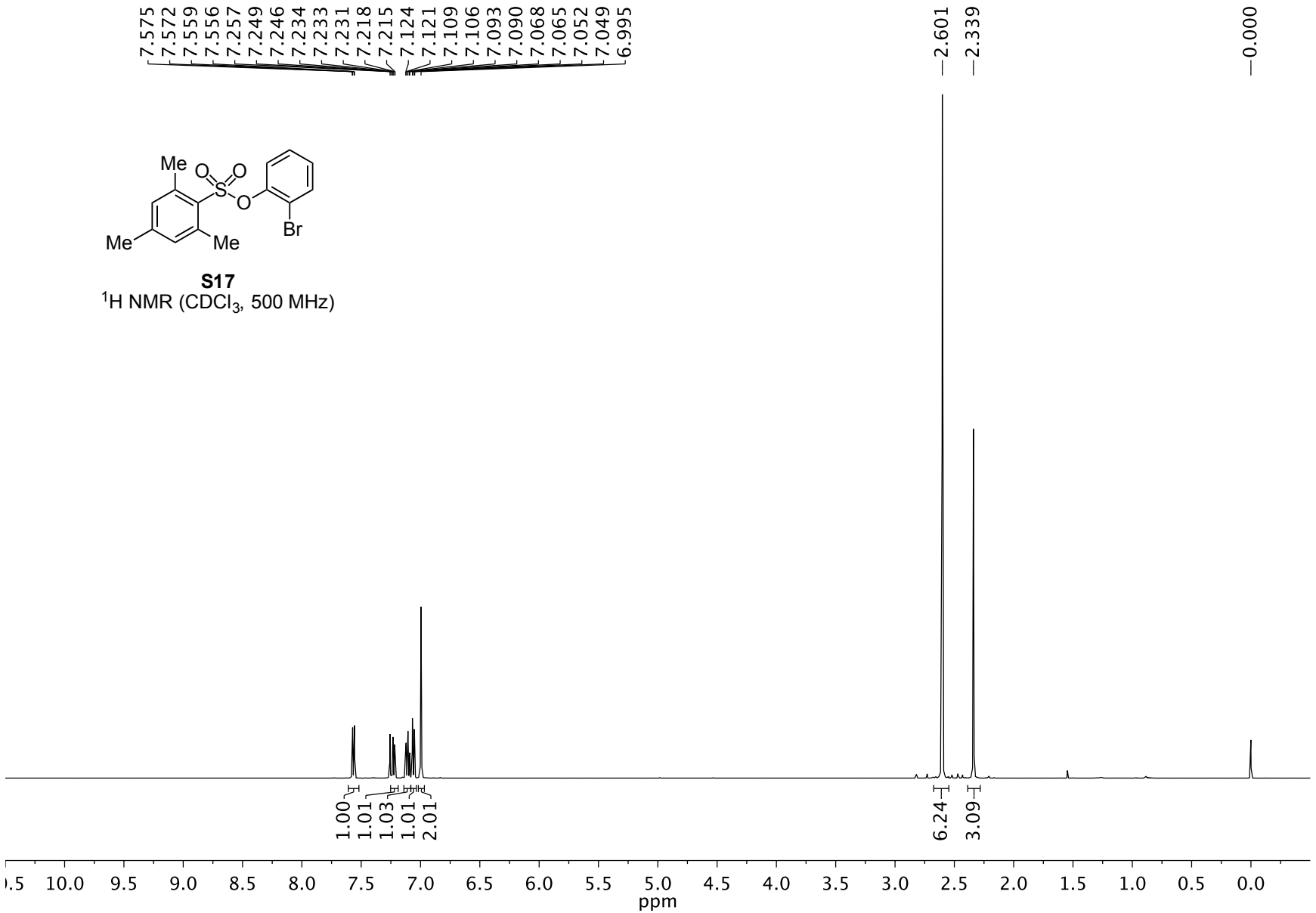
S16

^{1}H NMR ($CDCl_3$, 400 MHz)

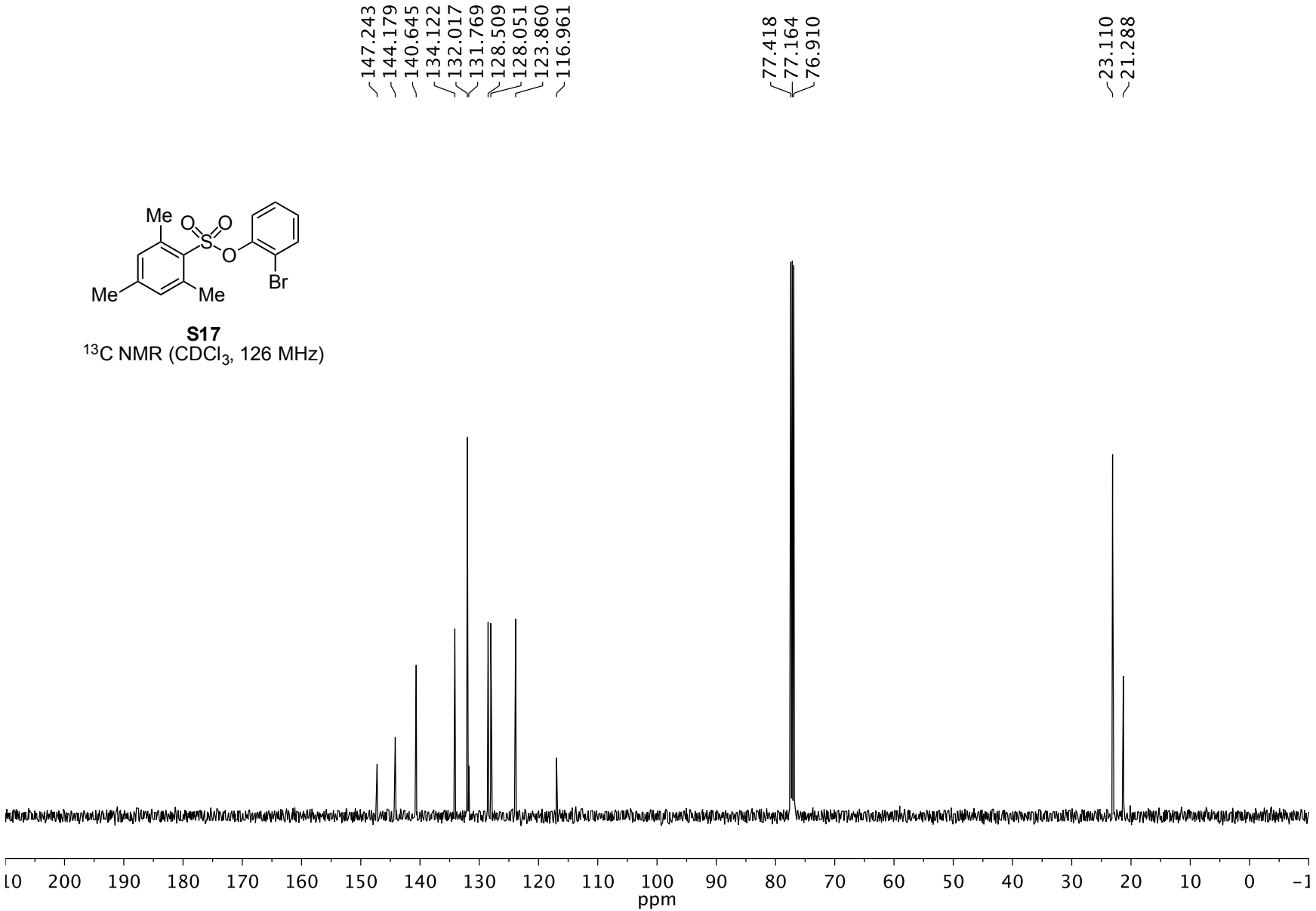


S16

^{13}C NMR ($CDCl_3$, 126 MHz)

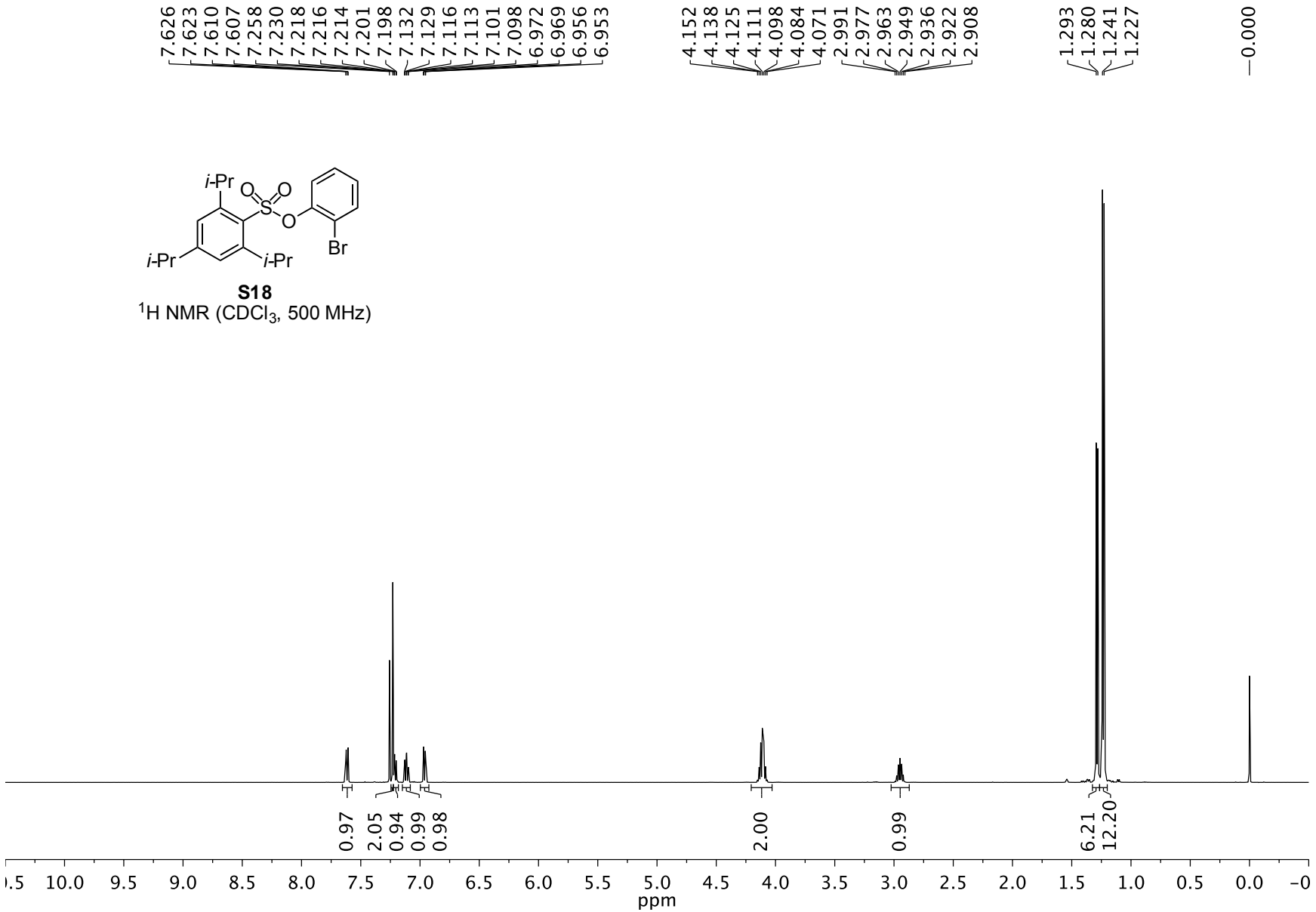


S17
^{1}H NMR ($CDCl_3$, 500 MHz)



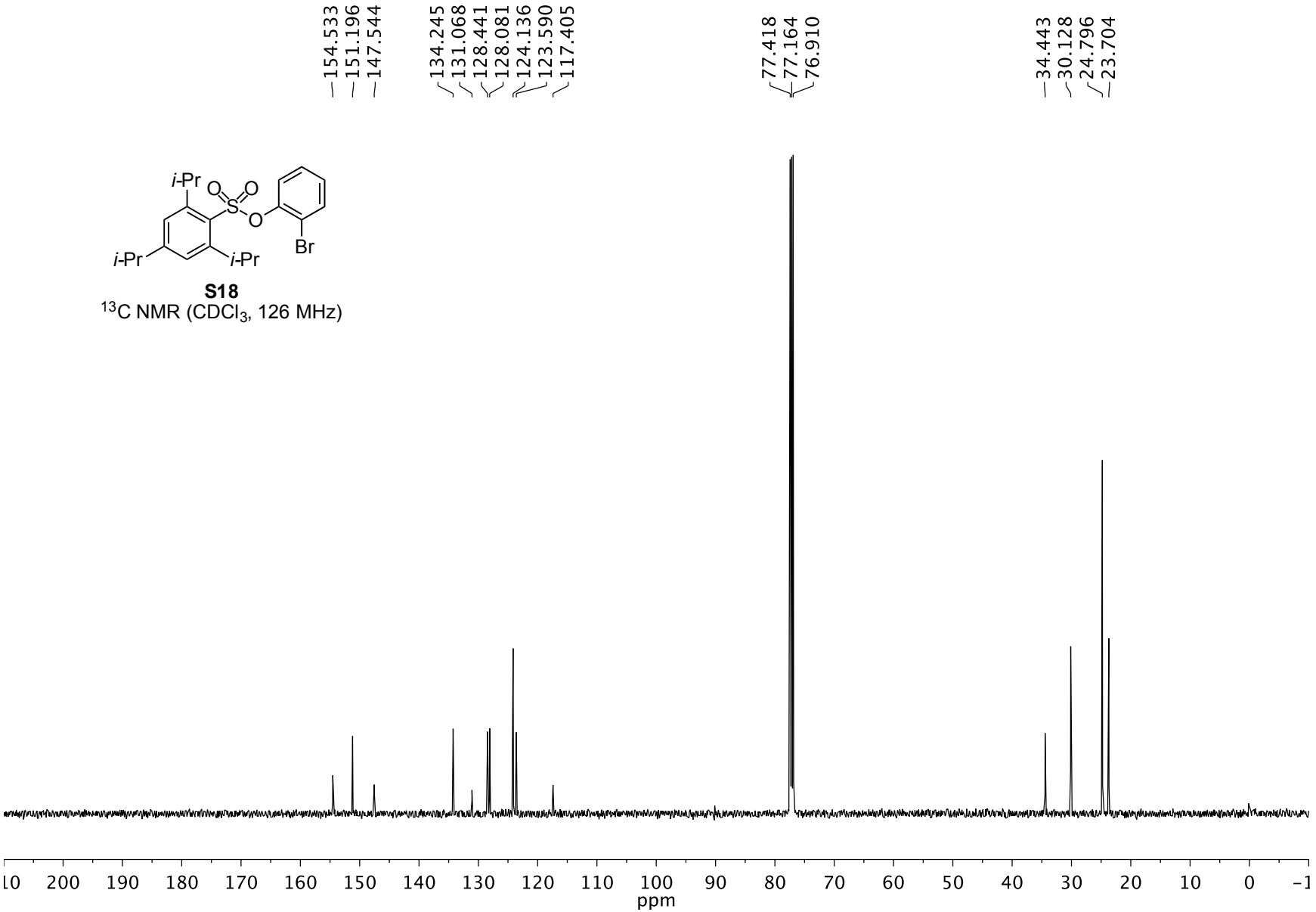
S17

^{13}C NMR ($CDCl_3$, 126 MHz)



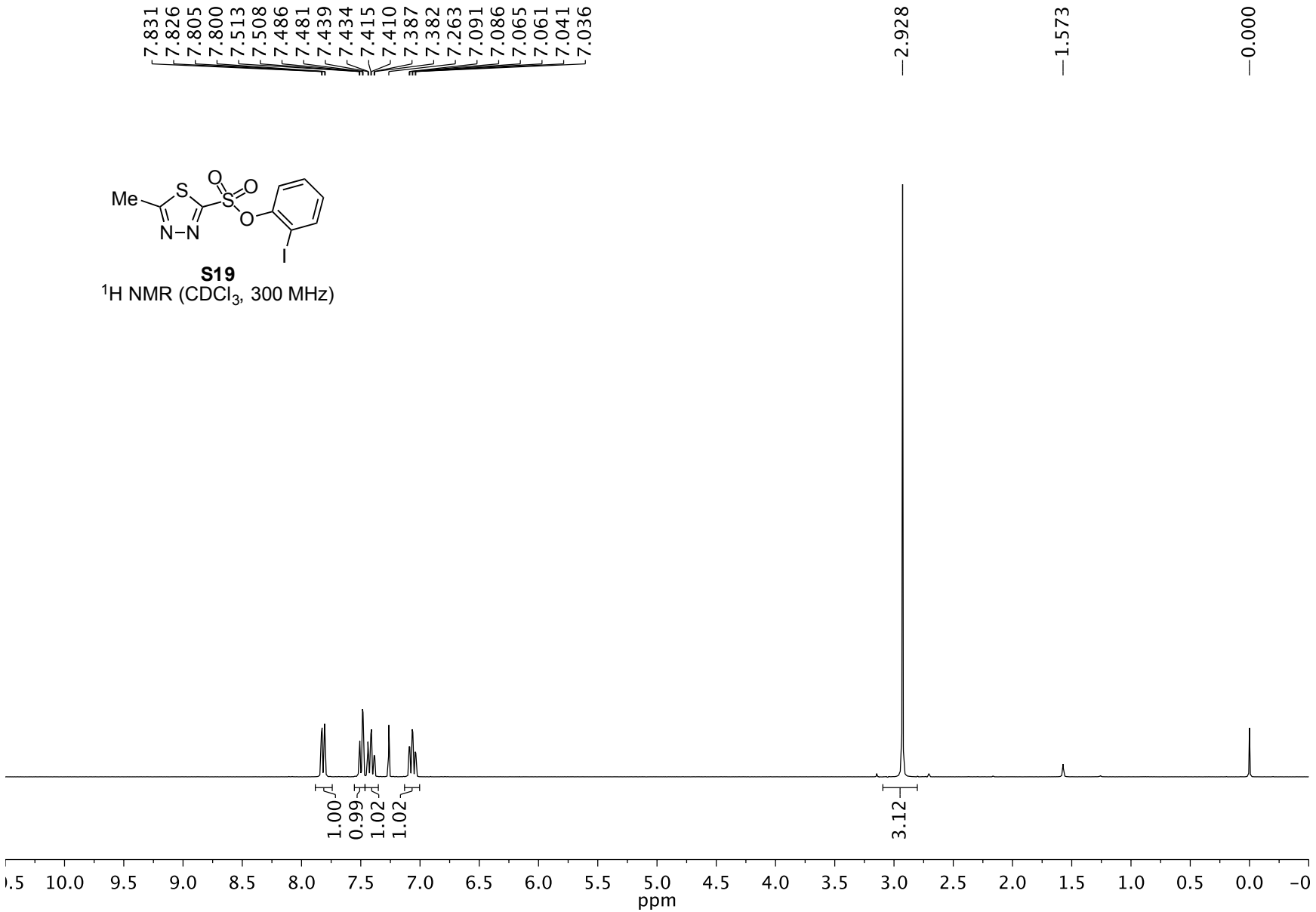
S18

^{1}H NMR ($CDCl_3$, 500 MHz)



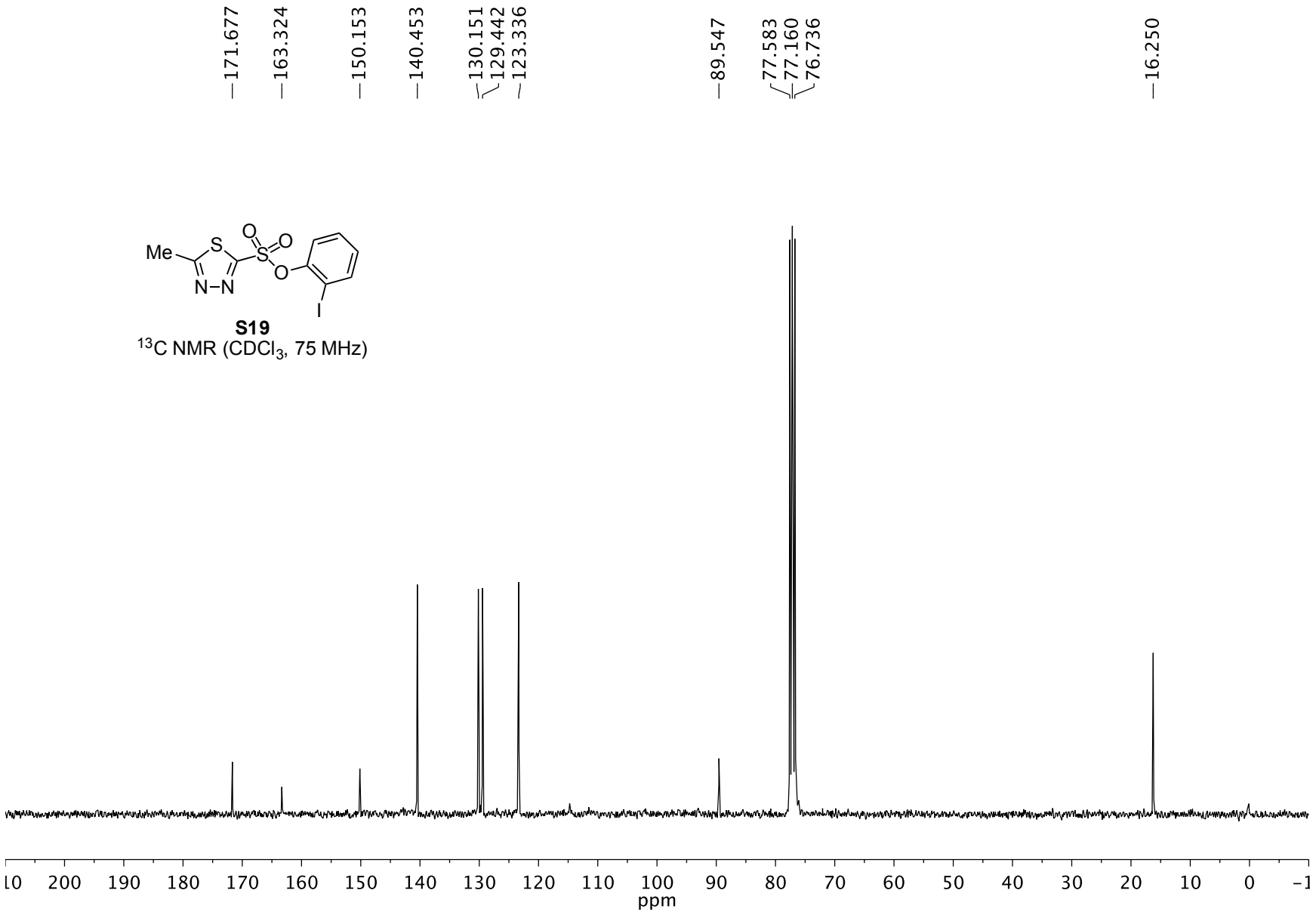
S18

^{13}C NMR ($CDCl_3$, 126 MHz)



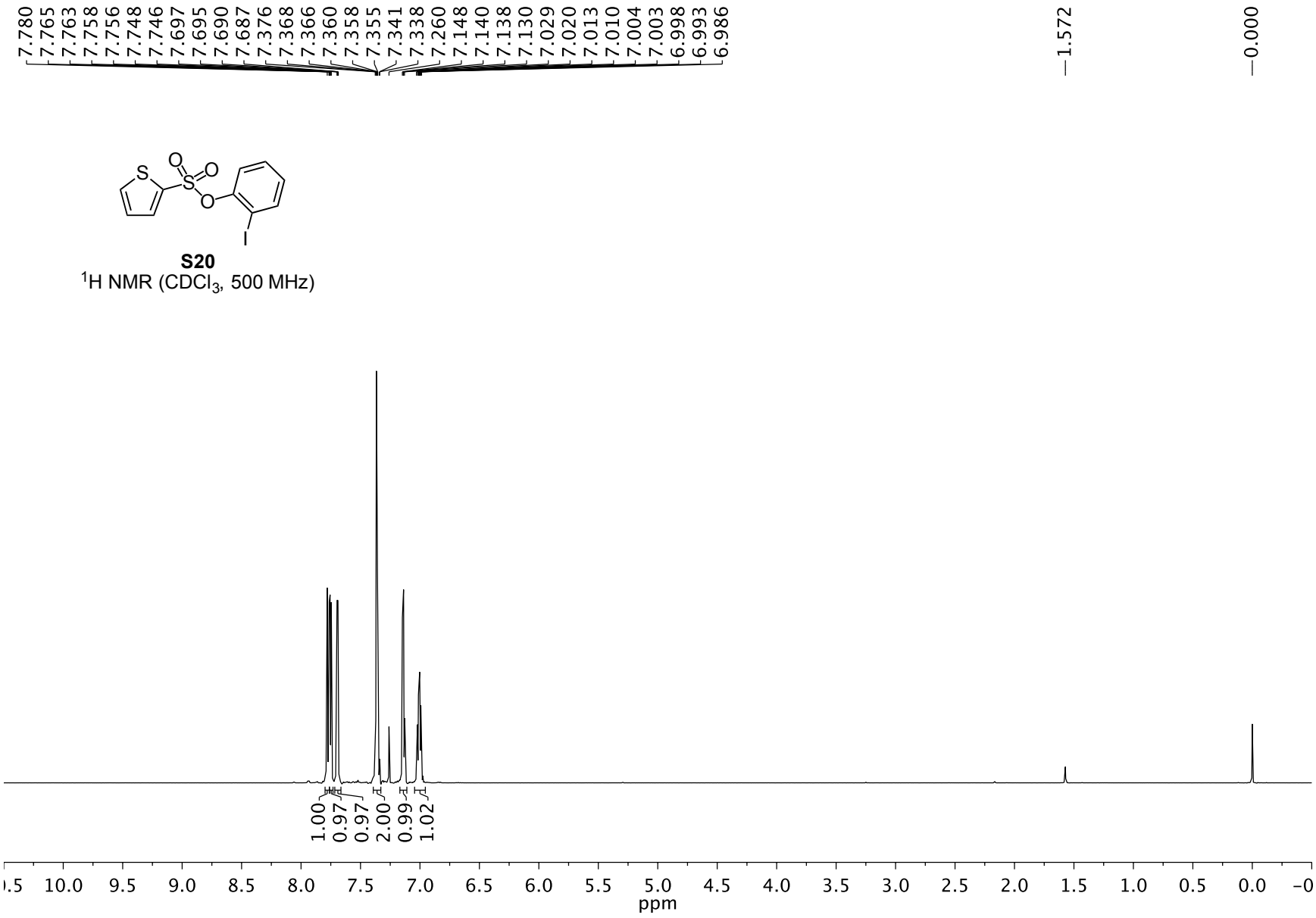
S19

^{1}H NMR ($CDCl_3$, 300 MHz)



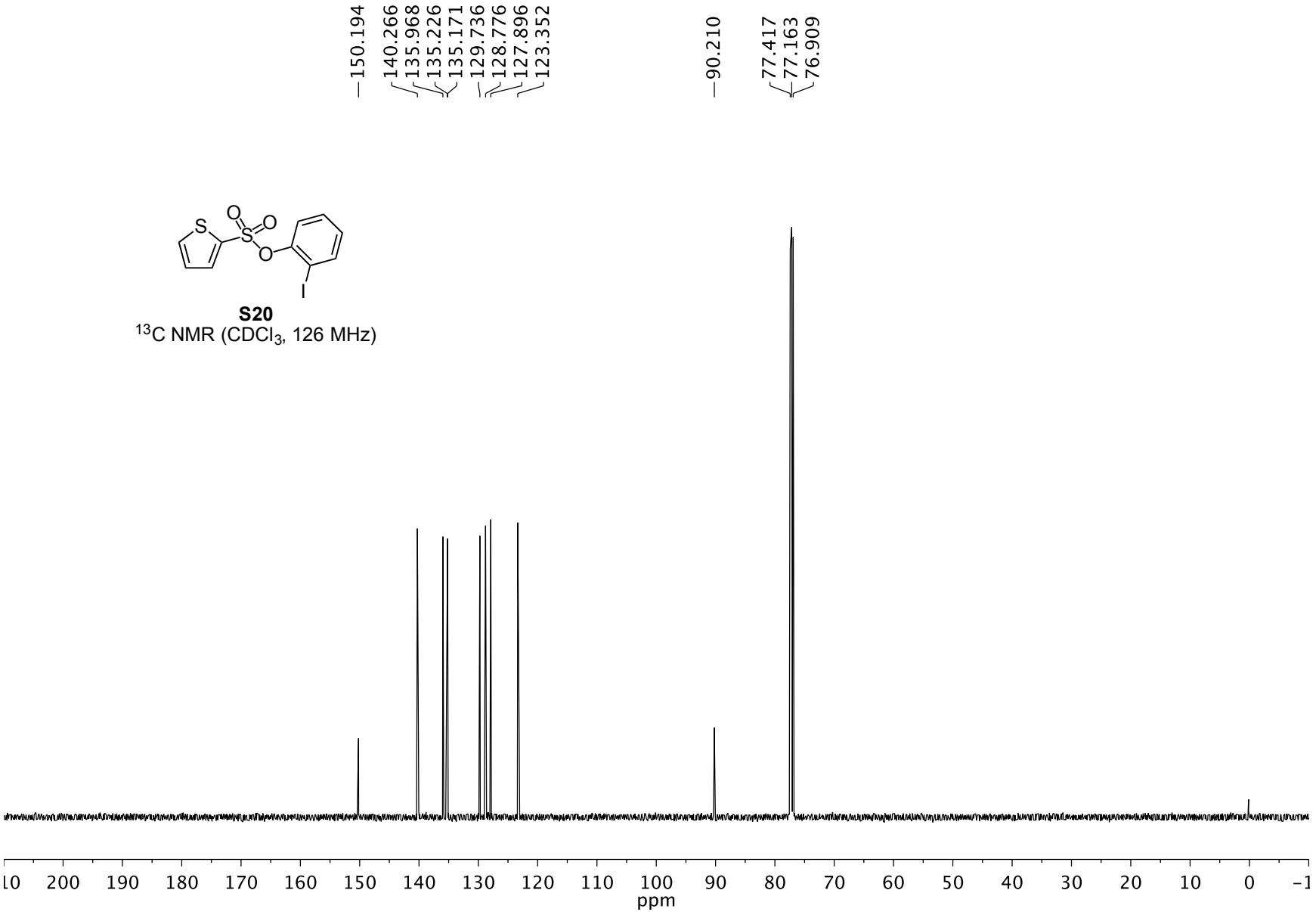
S19

^{13}C NMR ($CDCl_3$, 75 MHz)



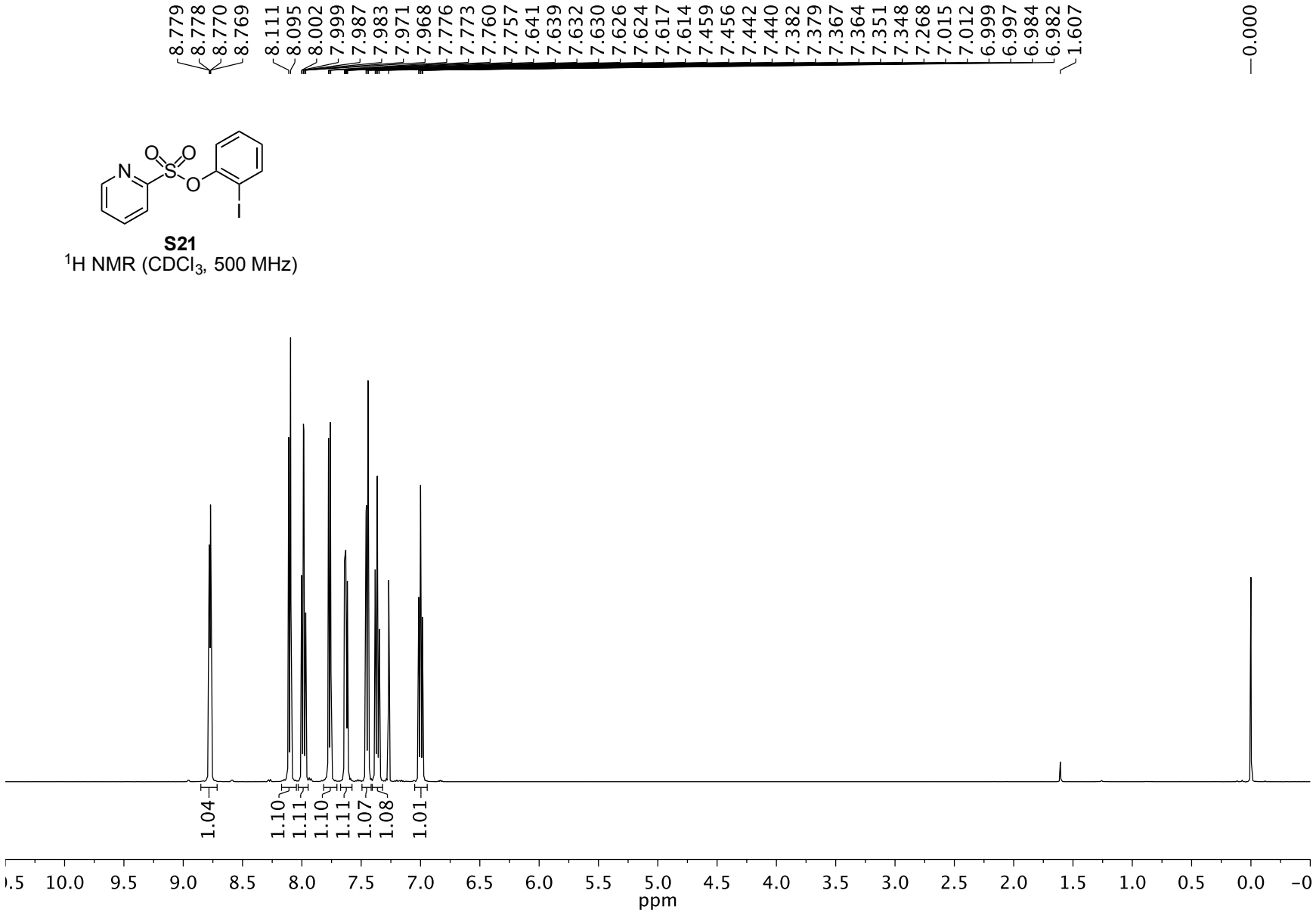
S20

^{1}H NMR ($CDCl_3$, 500 MHz)



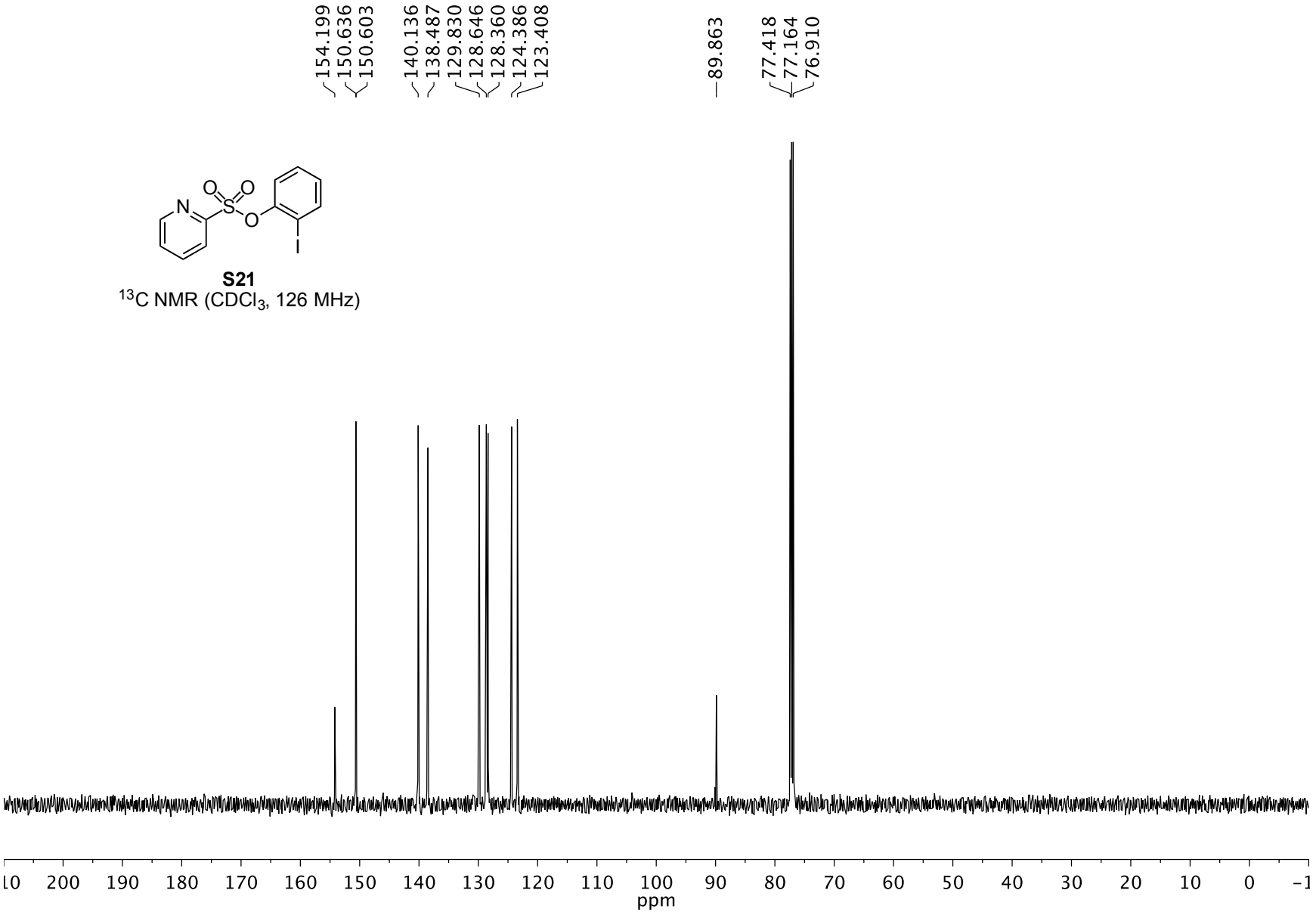
S20

^{13}C NMR ($CDCl_3$, 126 MHz)



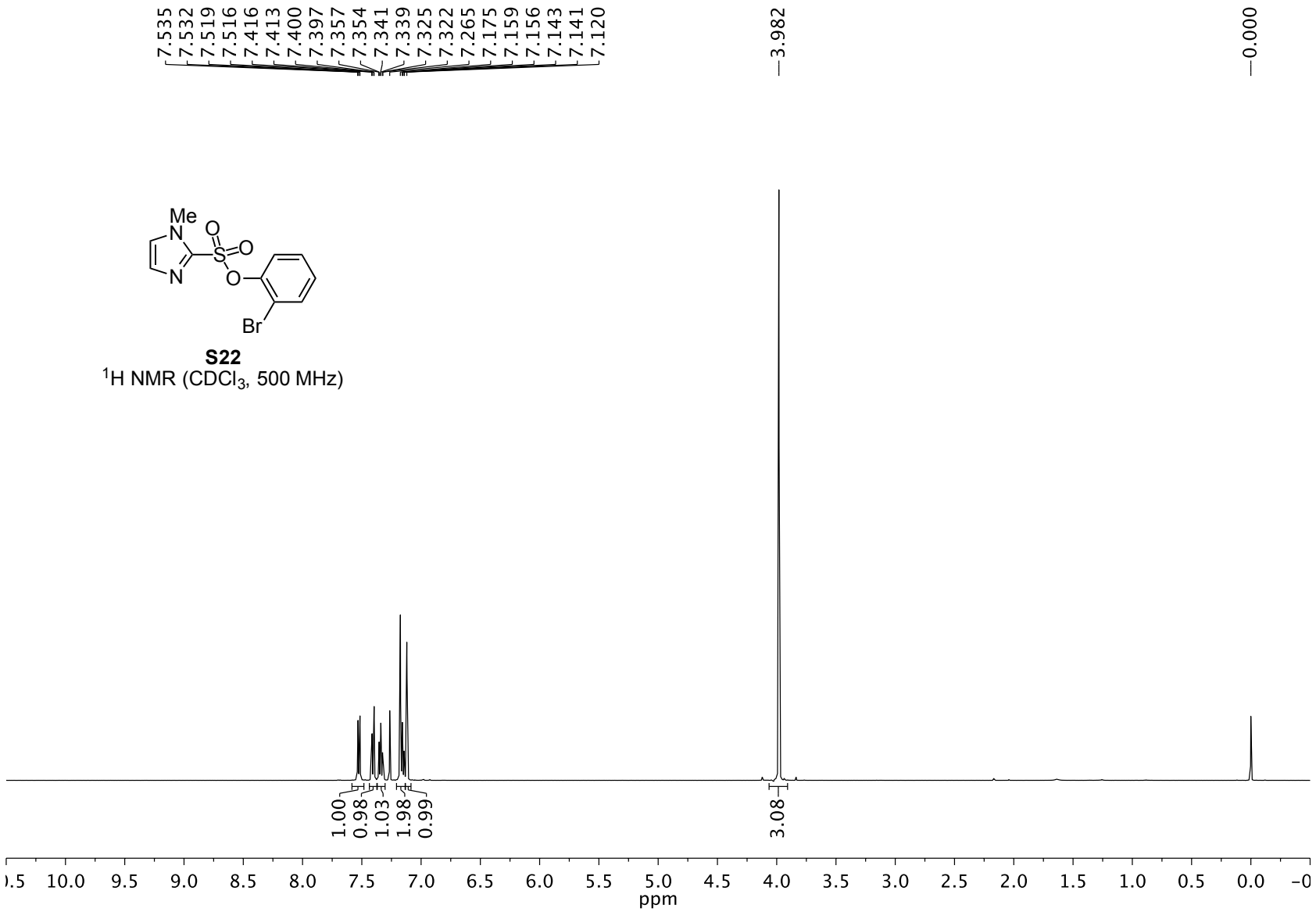
S21

^{1}H NMR ($CDCl_3$, 500 MHz)



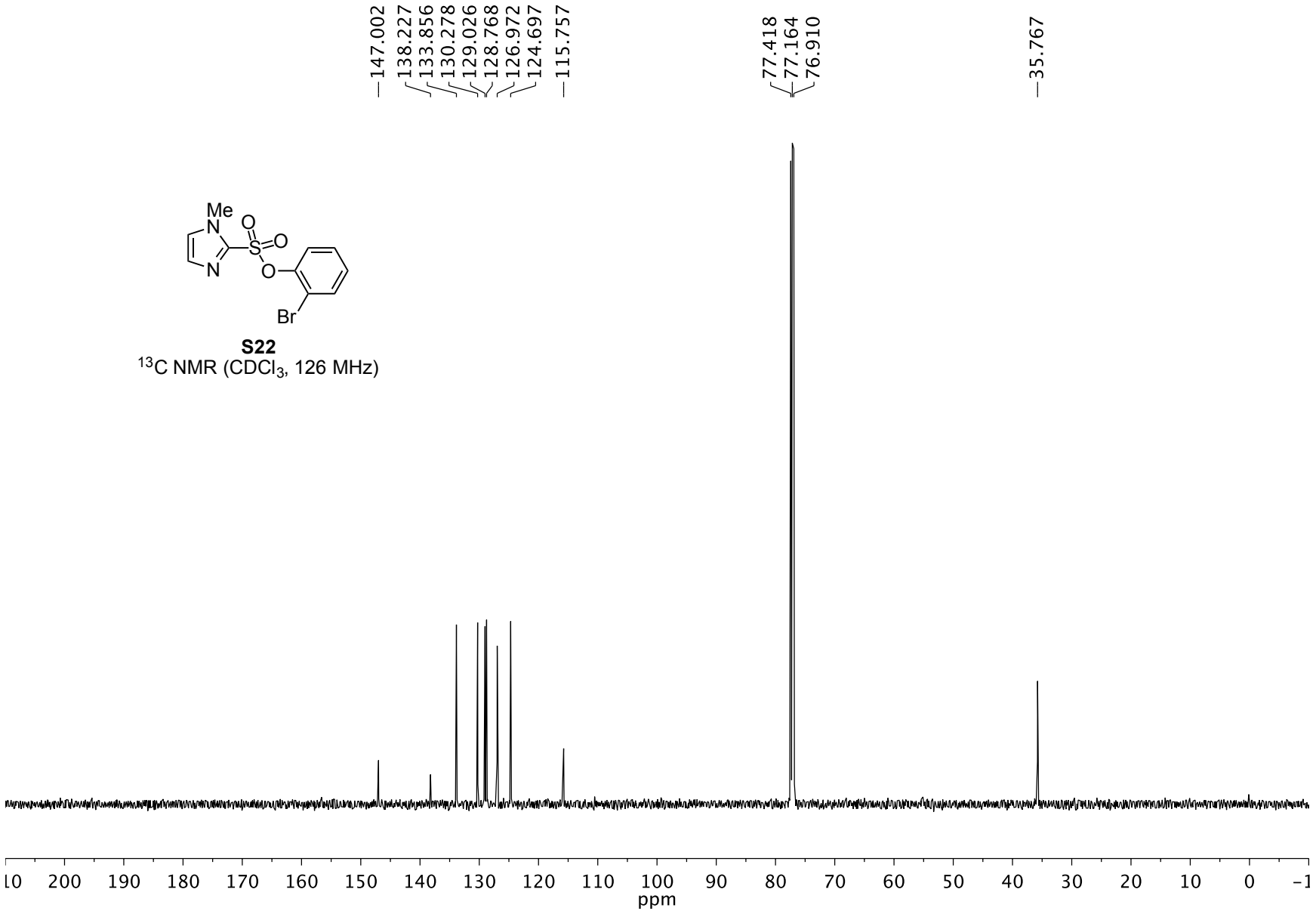
S21

^{13}C NMR ($CDCl_3$, 126 MHz)



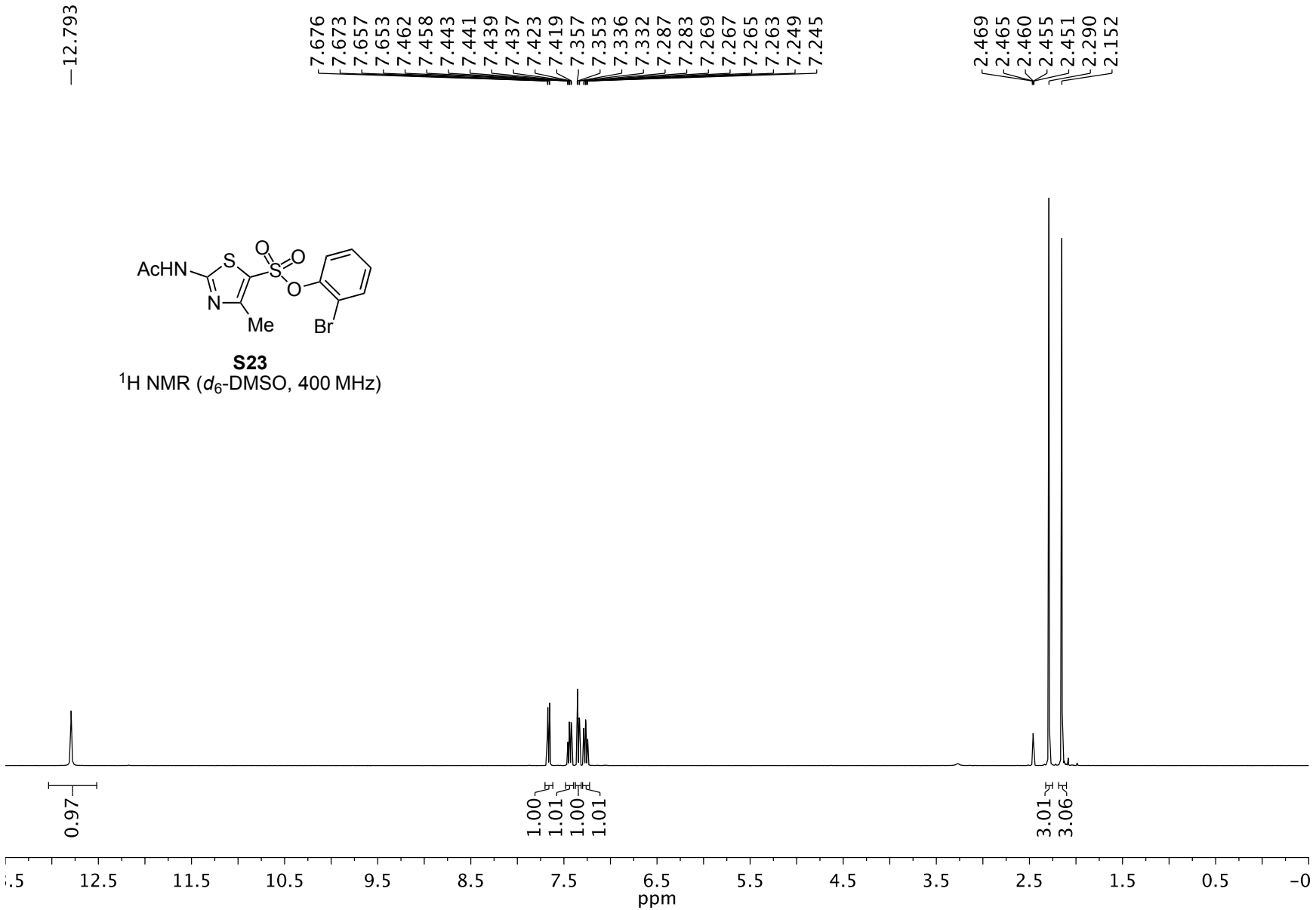
S22

^{1}H NMR ($CDCl_3$, 500 MHz)

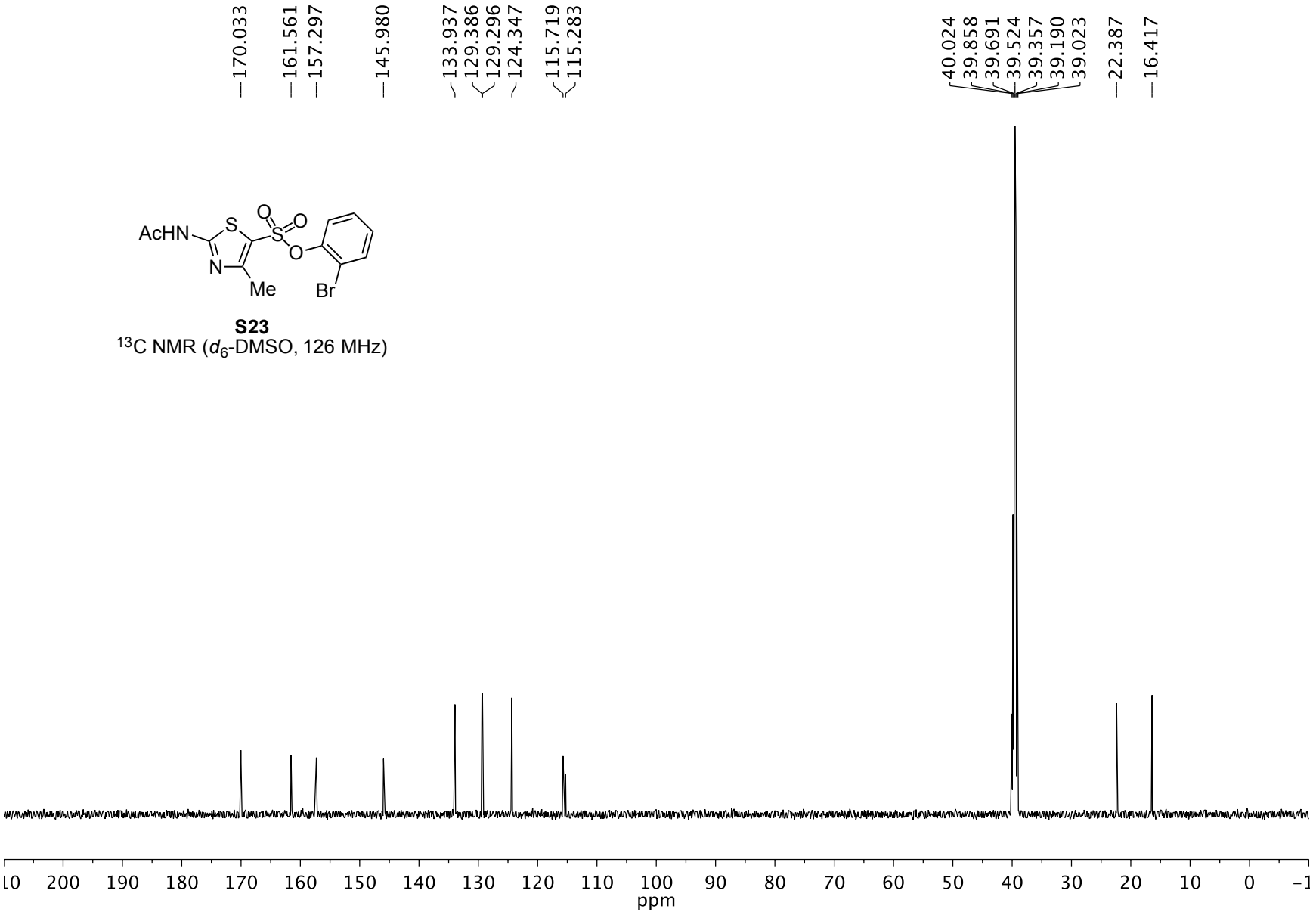


S22

^{13}C NMR ($CDCl_3$, 126 MHz)

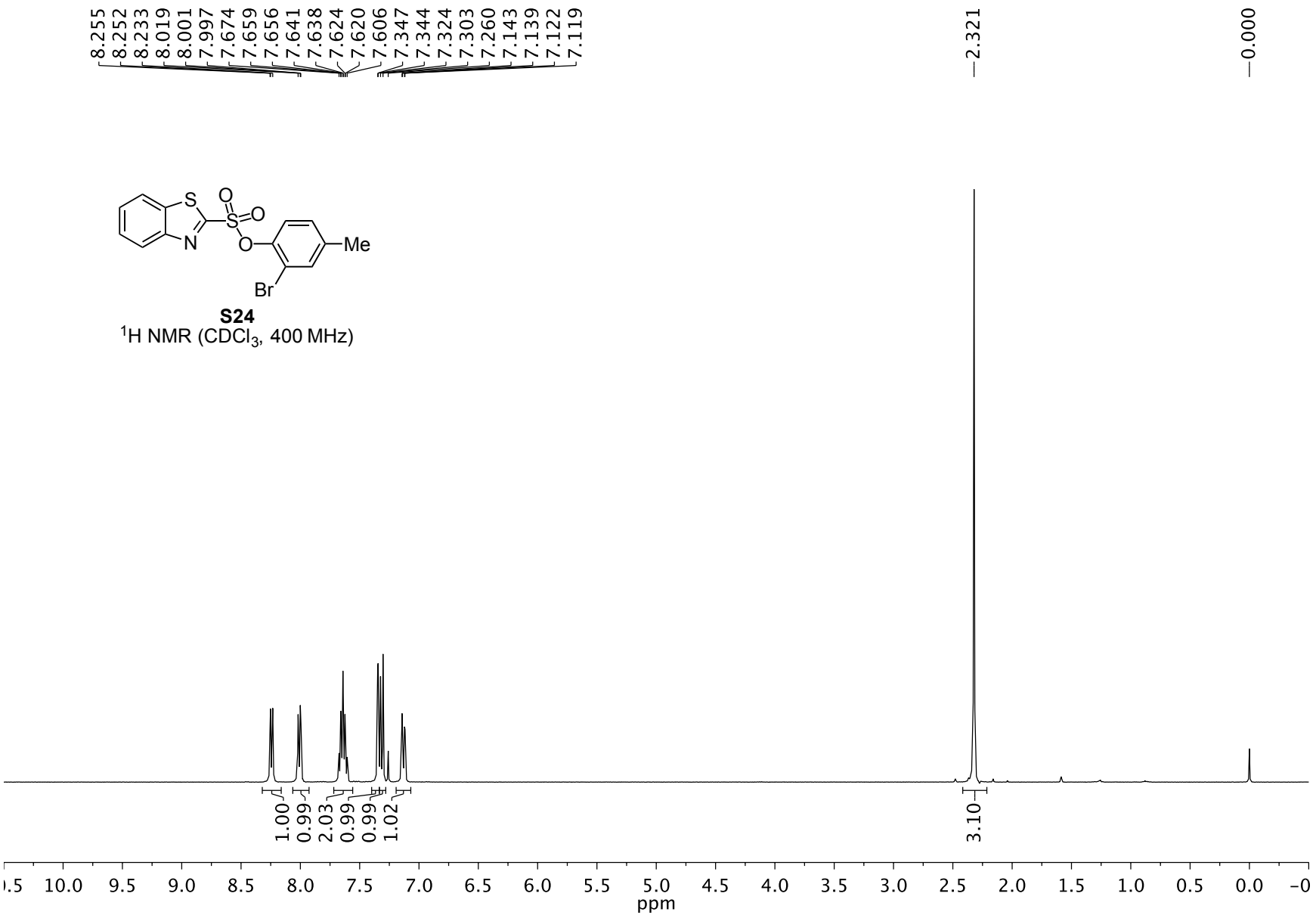


S23
^{1}H NMR (d_6-DMSO, 400 MHz)



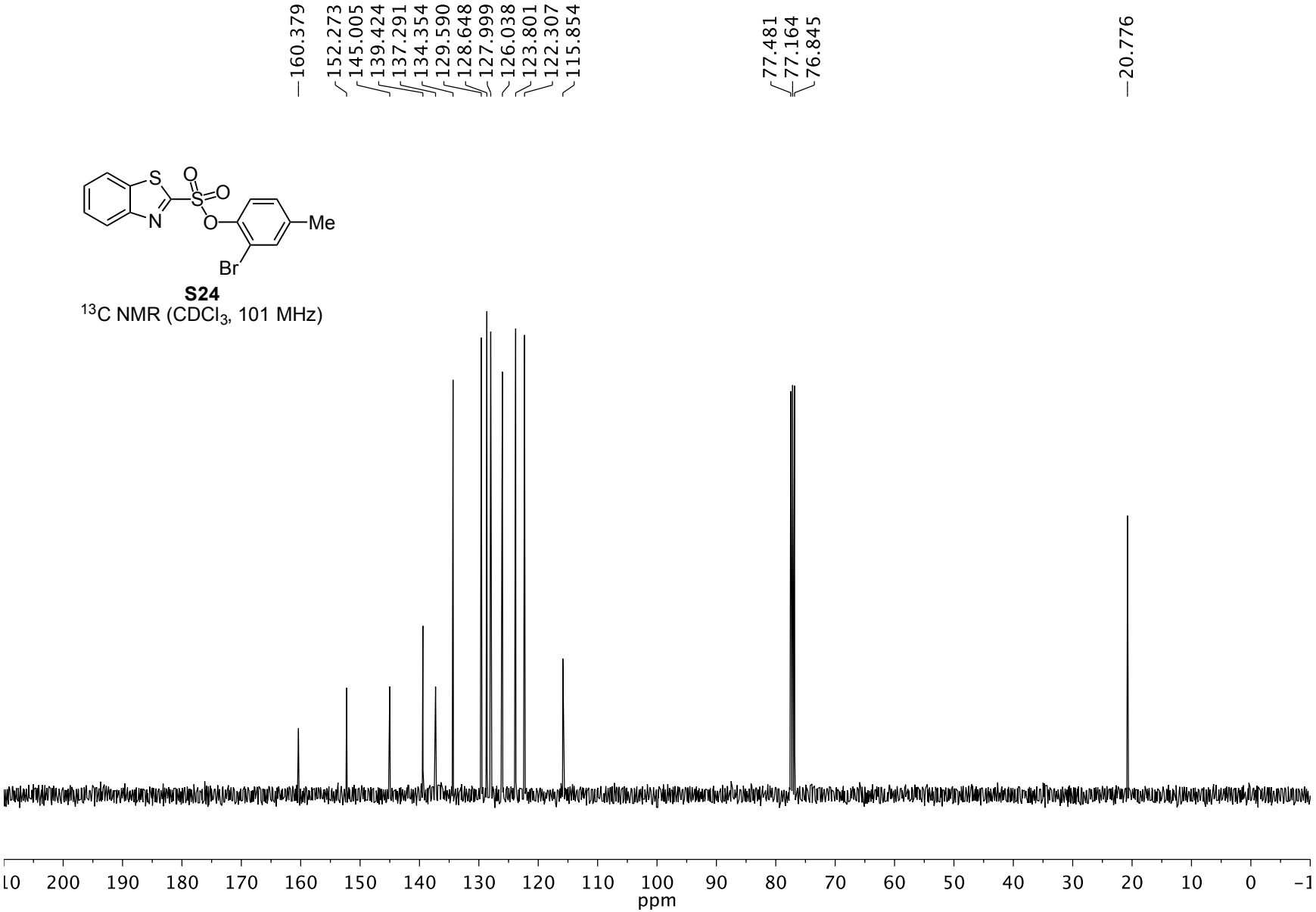
S23

^{13}C NMR (d_6-DMSO, 126 MHz)



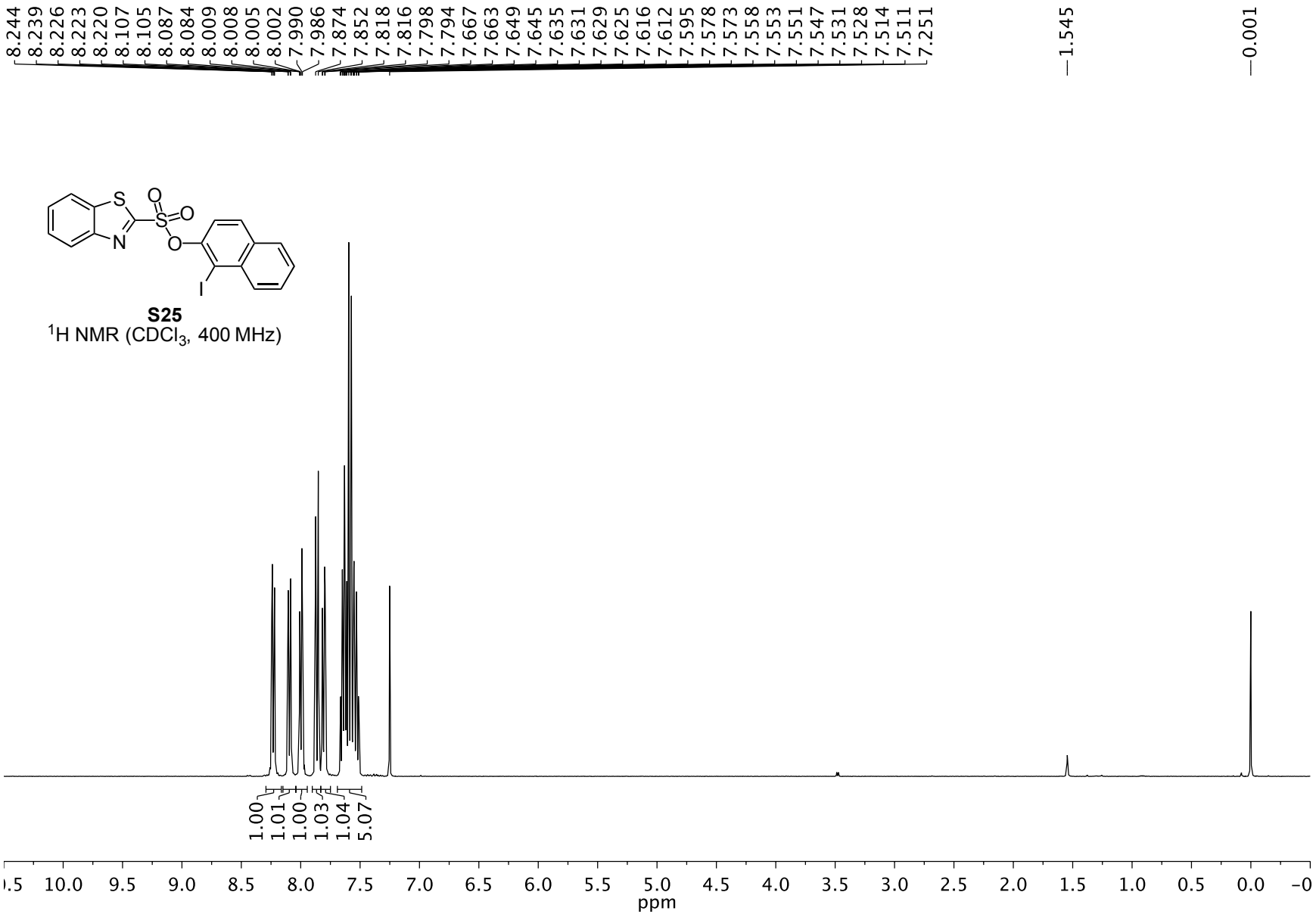
S24

^{1}H NMR ($CDCl_3$, 400 MHz)



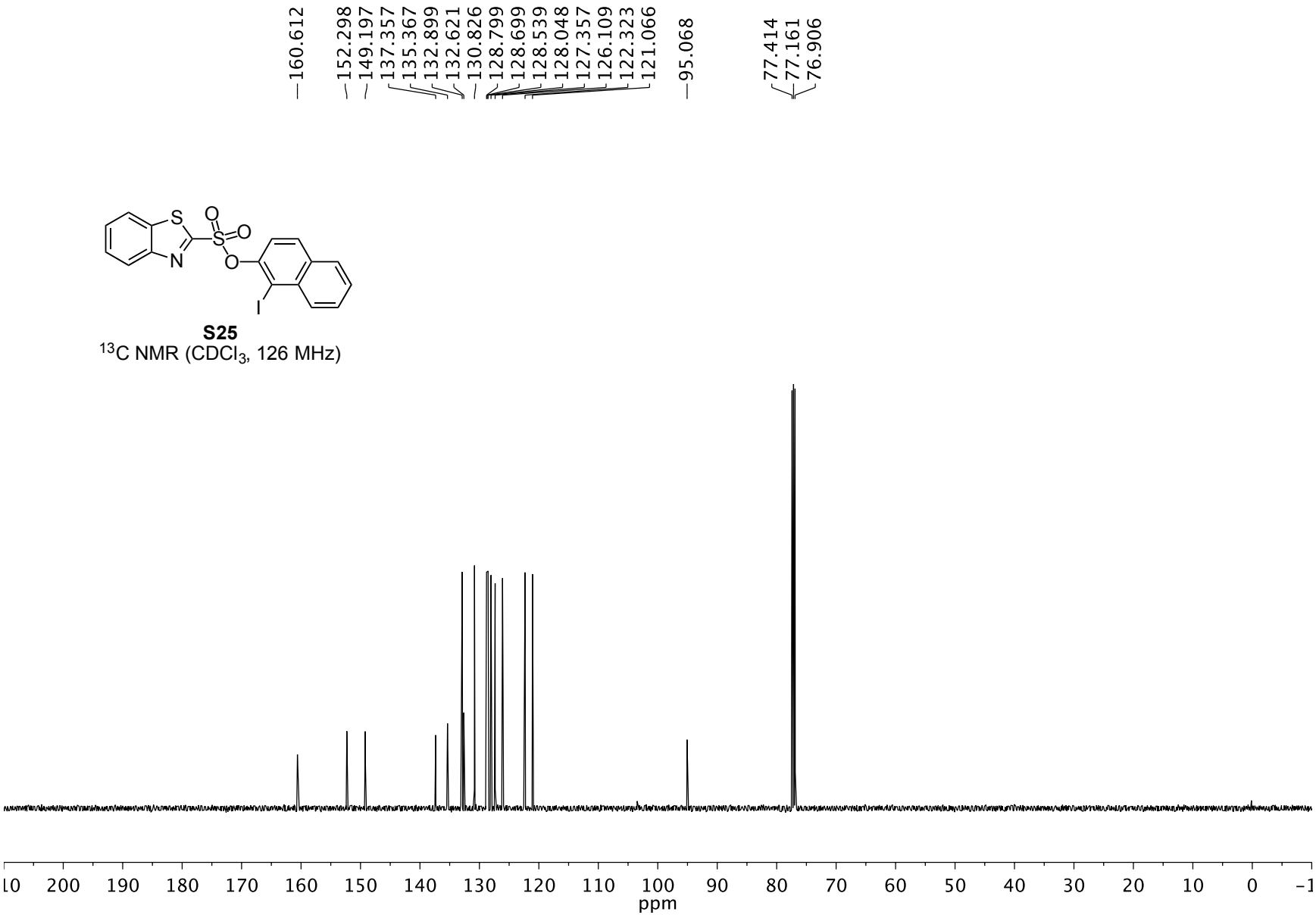
S24

^{13}C NMR ($CDCl_3$, 101 MHz)



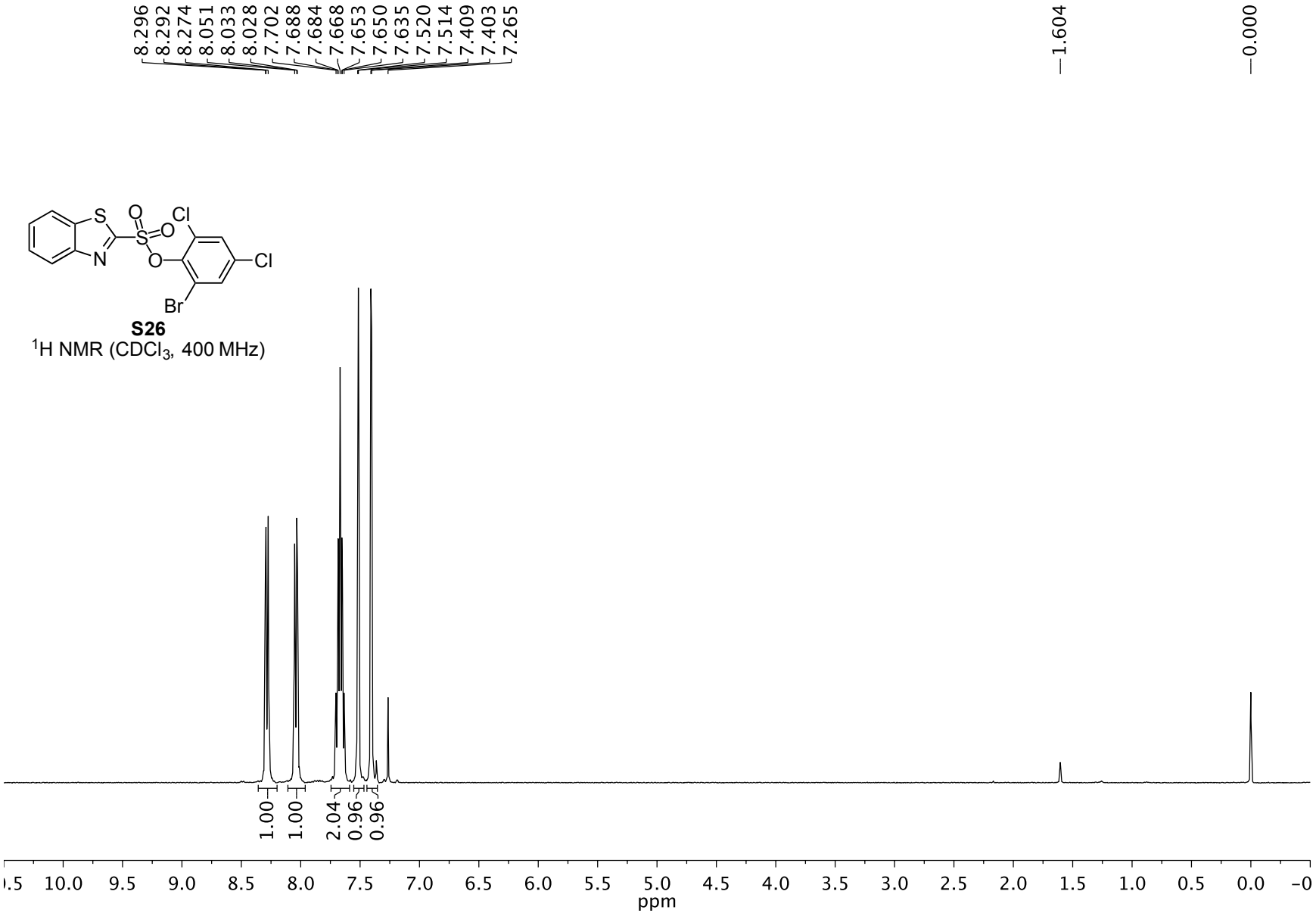
S25

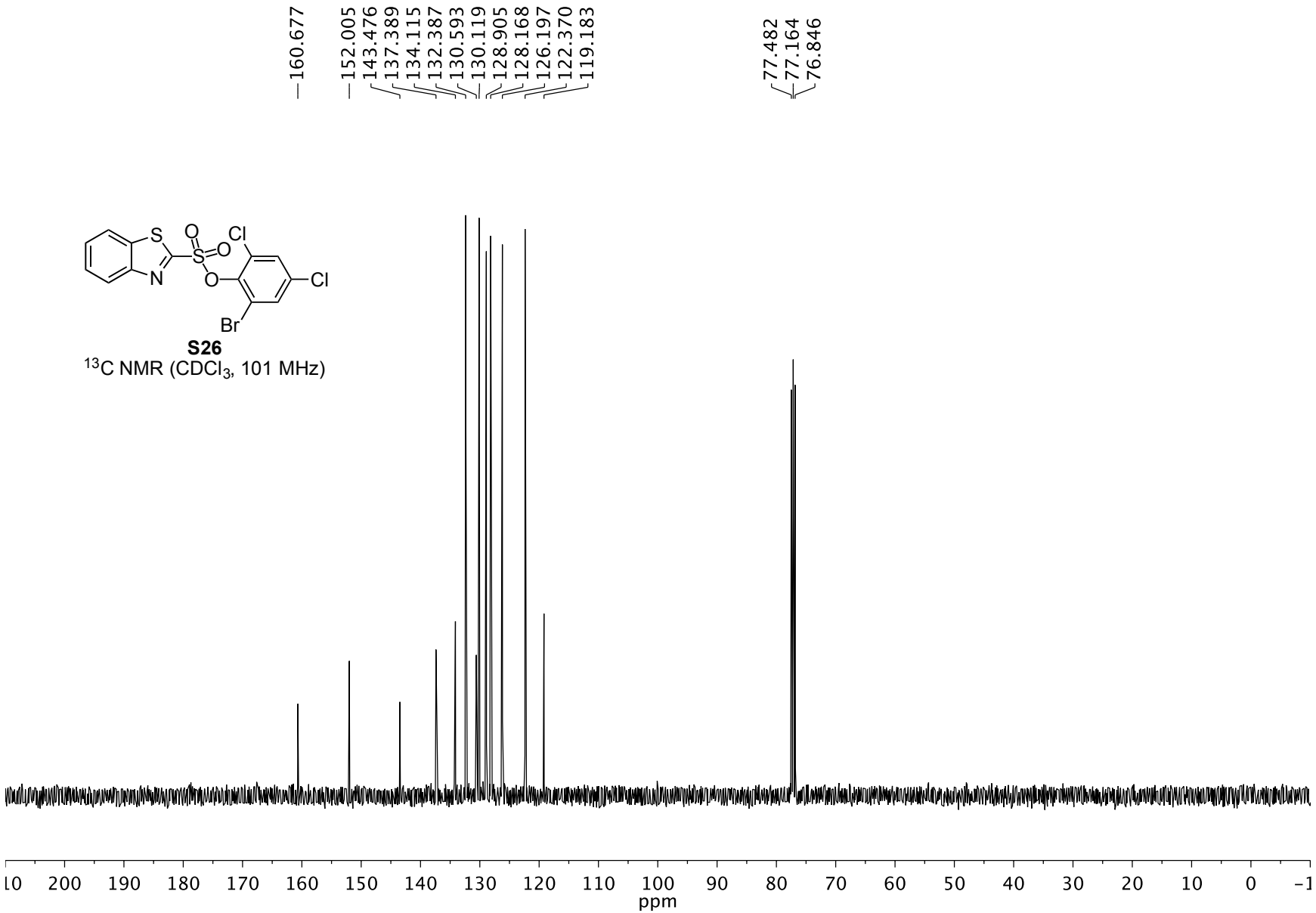
^{1}H NMR ($CDCl_3$, 400 MHz)



S25

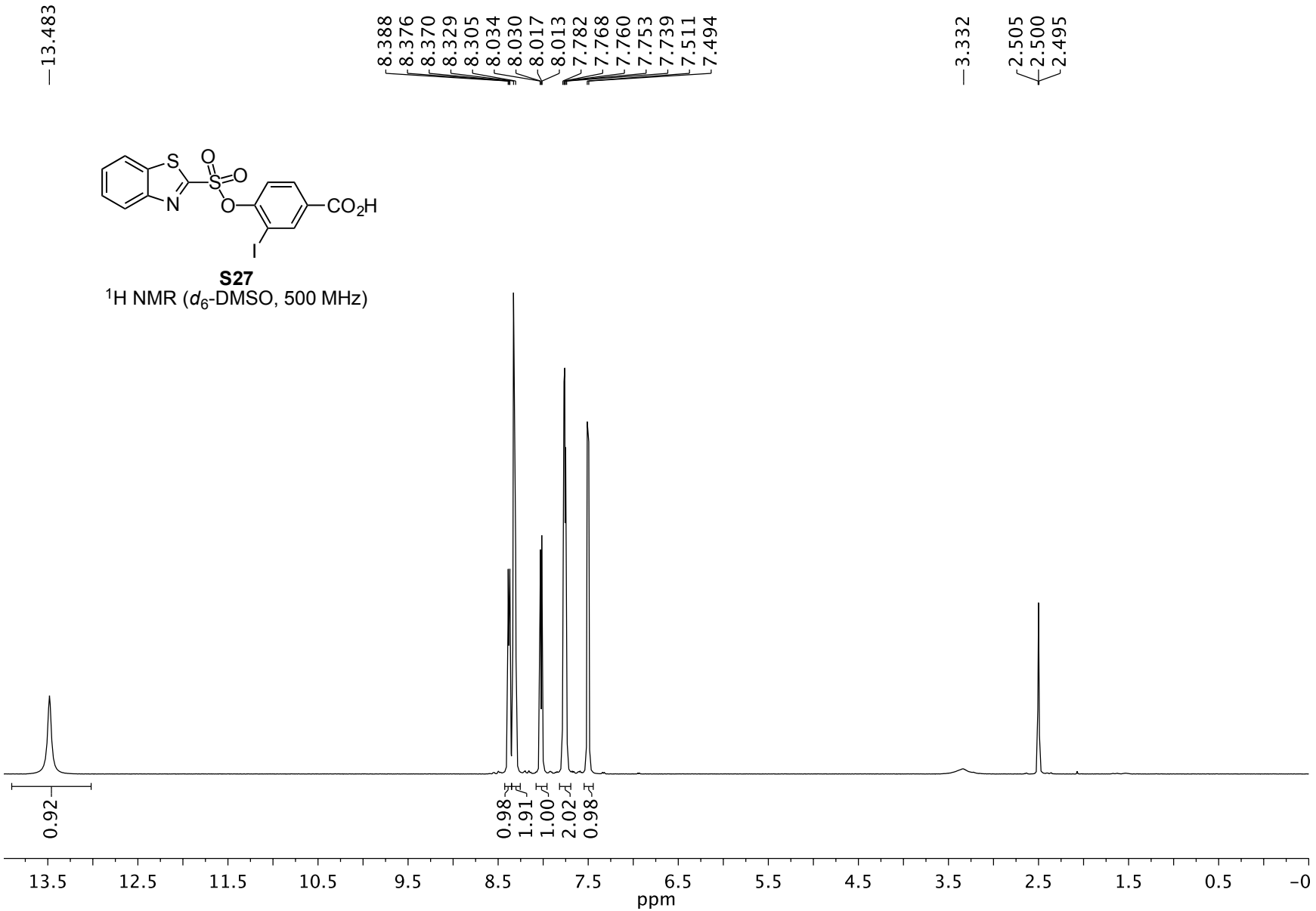
^{13}C NMR ($CDCl_3$, 126 MHz)


8.296
8.292
8.274
8.051
8.033
8.028
7.702
7.688
7.684
7.668
7.653
7.650
7.635
7.520
7.514
7.409
7.403
7.265
1.604
0.000
S
O
Cl
S
O
N
O
Cl
Br
S26
1H NMR (CDCl3, 400 MHz)
1.00
1.00
2.04
0.96
0.96
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm



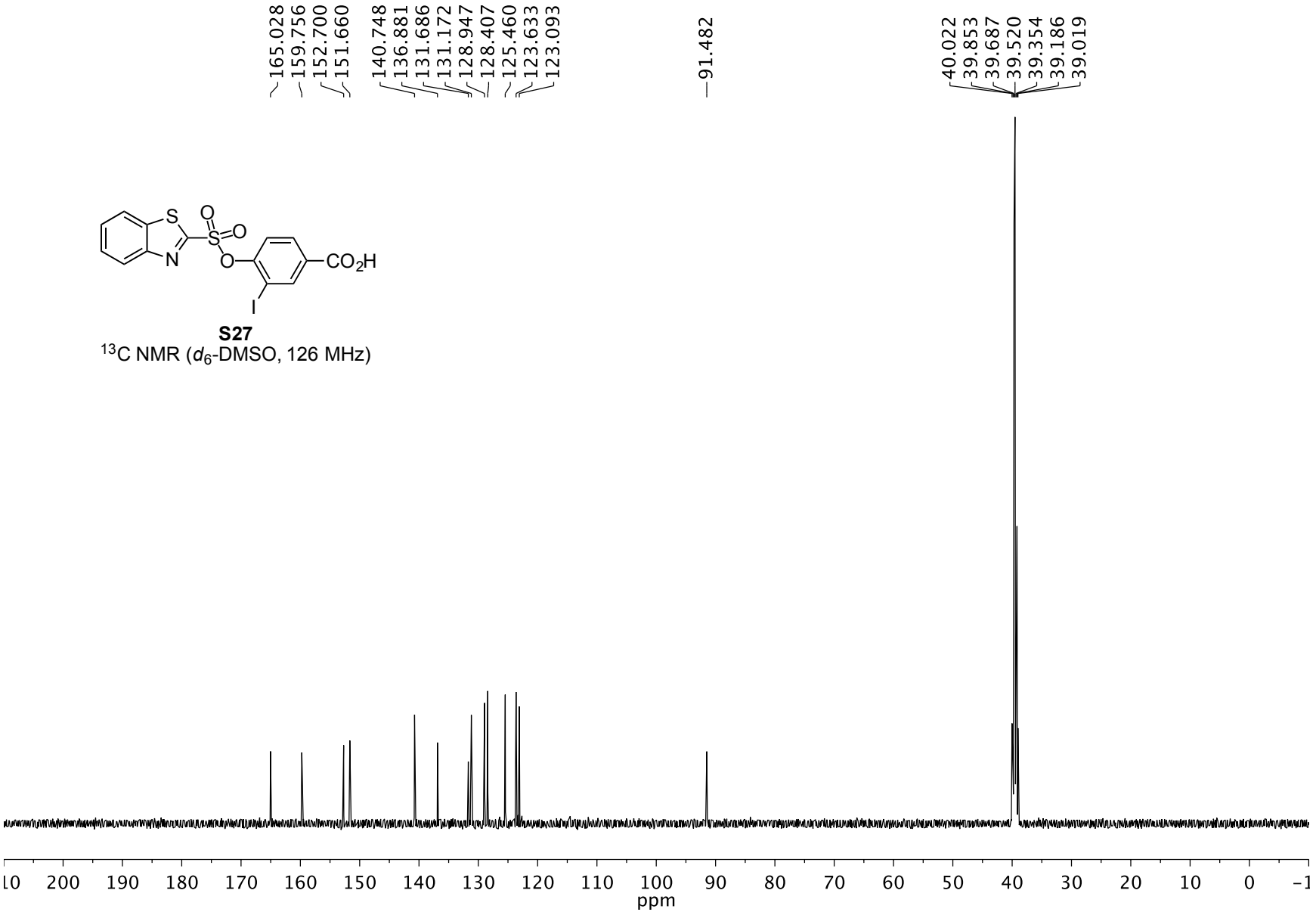
S26

^{13}C NMR ($CDCl_3$, 101 MHz)



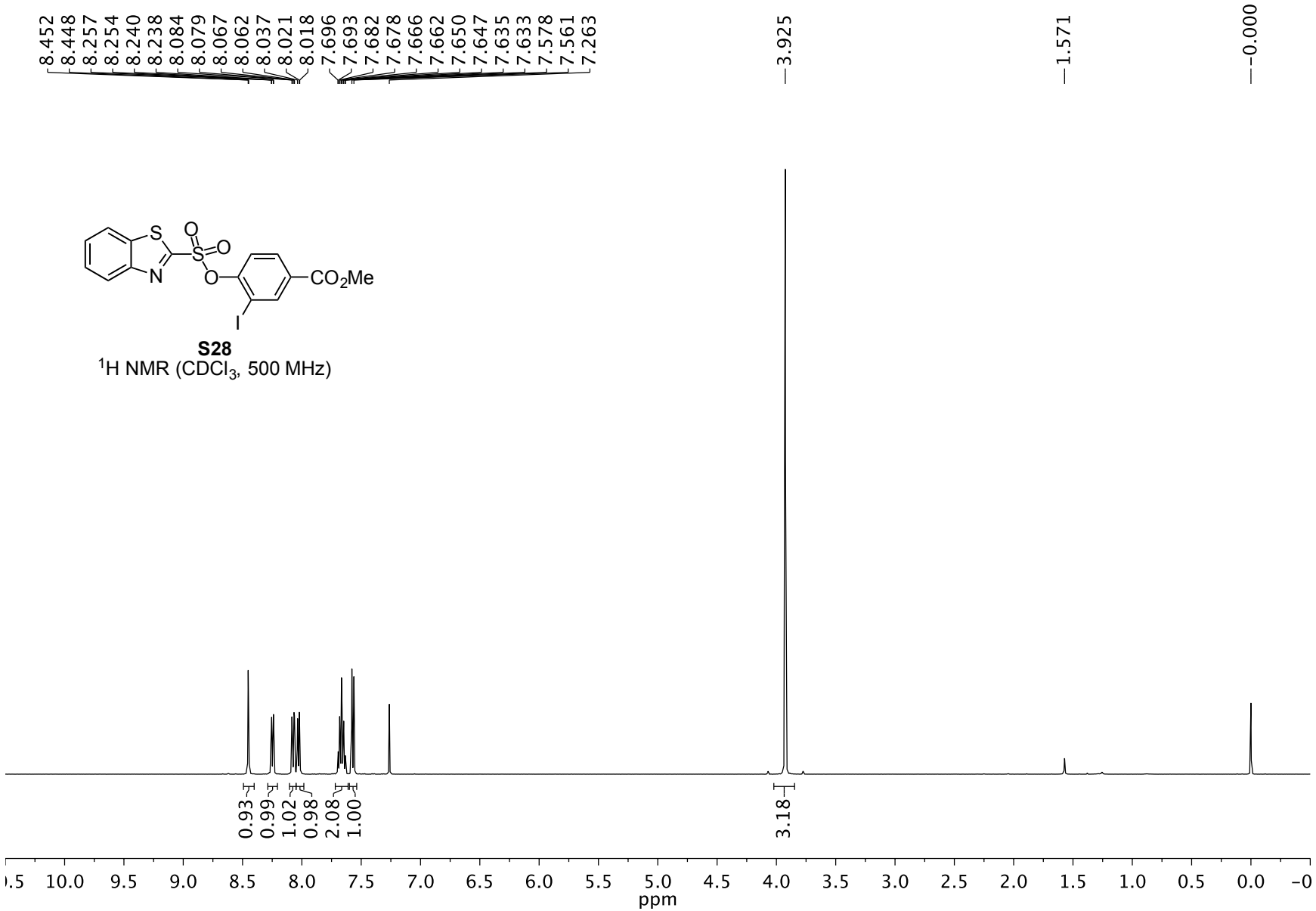
S27

^{1}H NMR (d_6-DMSO, 500 MHz)



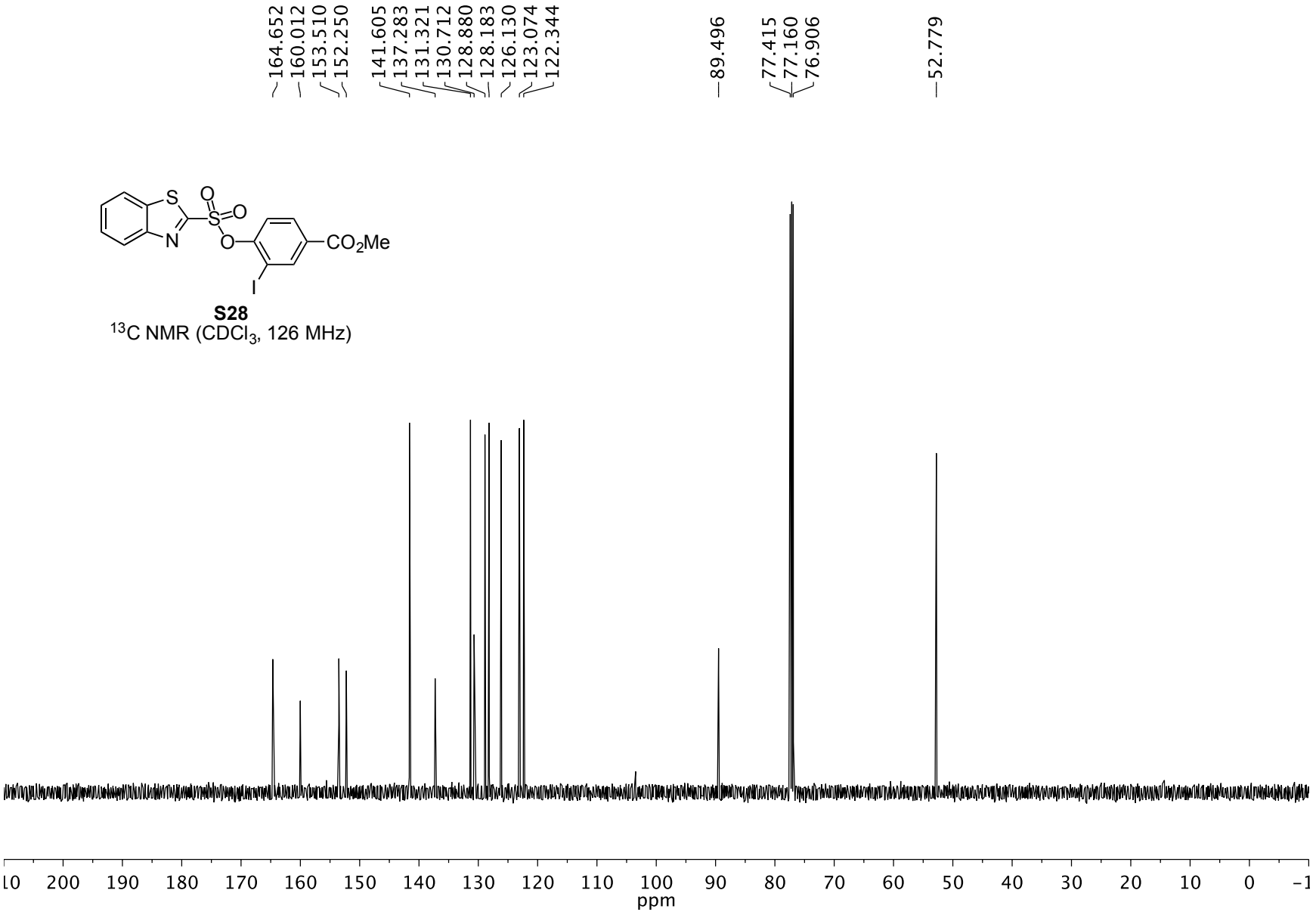
S27

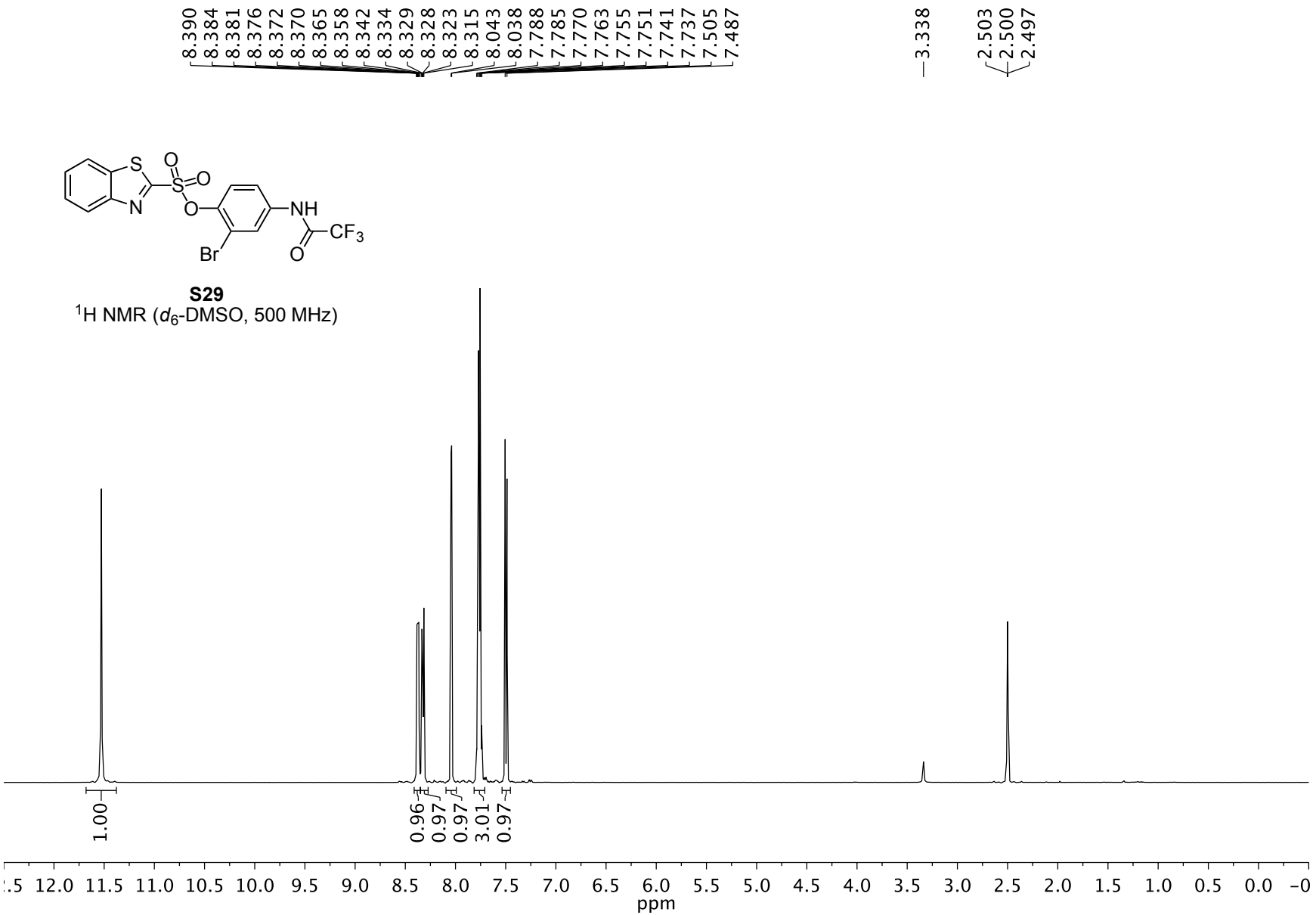
^{13}C NMR (d_6-DMSO, 126 MHz)



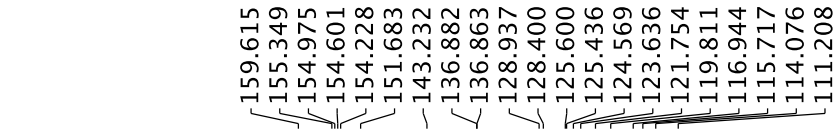
S28

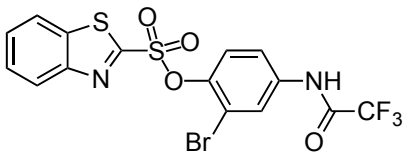
^{1}H NMR ($CDCl_3$, 500 MHz)


164.652
160.012
153.510
152.250
141.605
137.283
131.321
130.712
128.880
128.183
126.130
123.074
122.344
89.496
77.415
77.160
76.906
52.779
S
O
O
S
N
O
CO2Me
I
S28
13C NMR (CDCl3, 126 MHz)
ppm

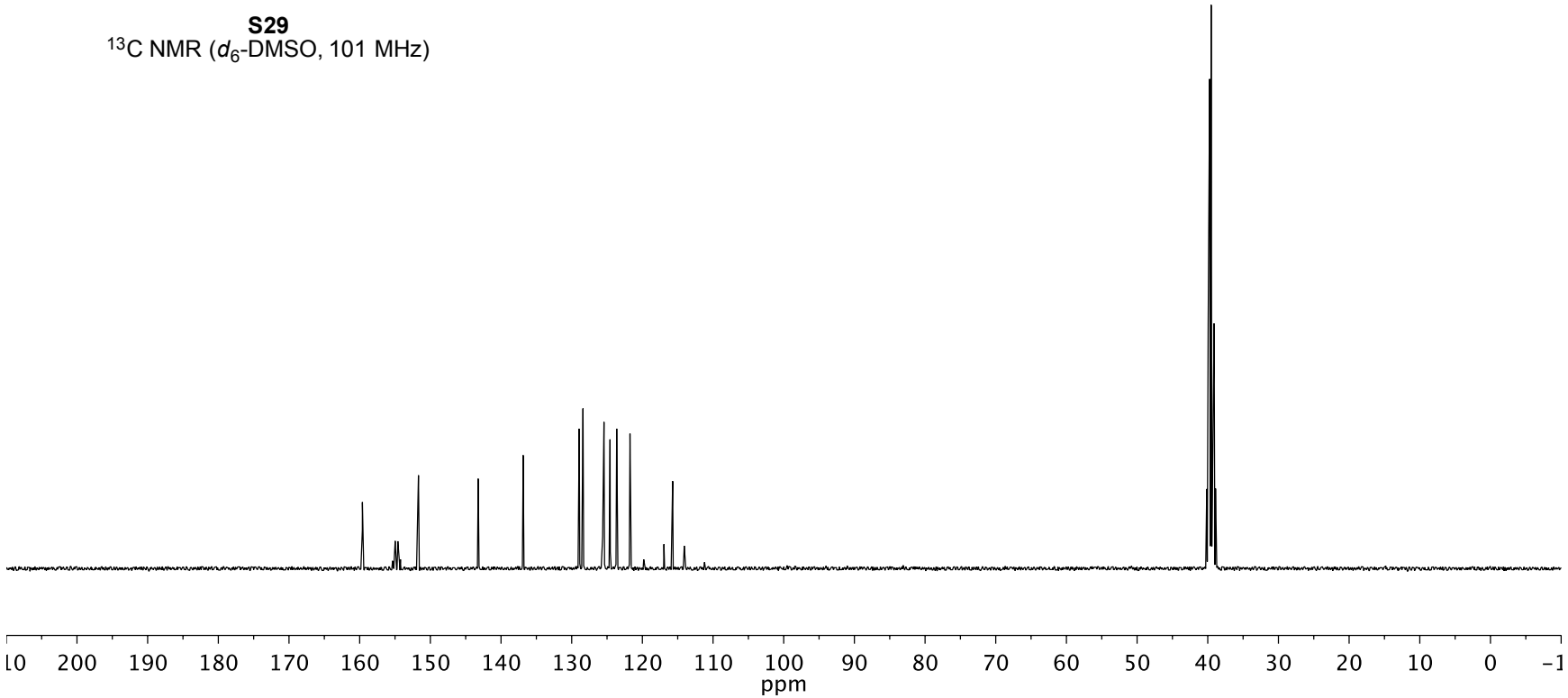


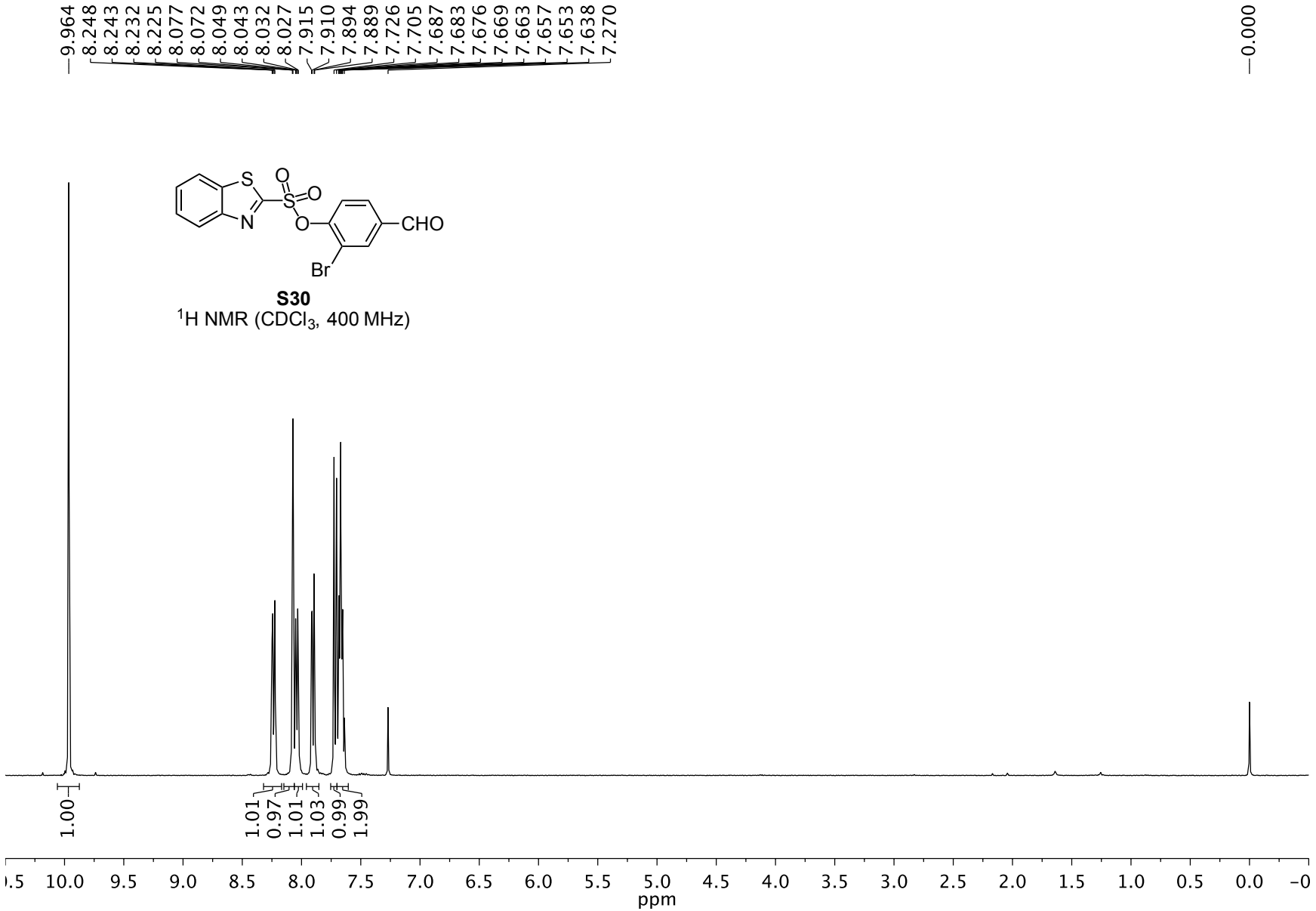
S29
^{1}H NMR (d_6-DMSO, 500 MHz)





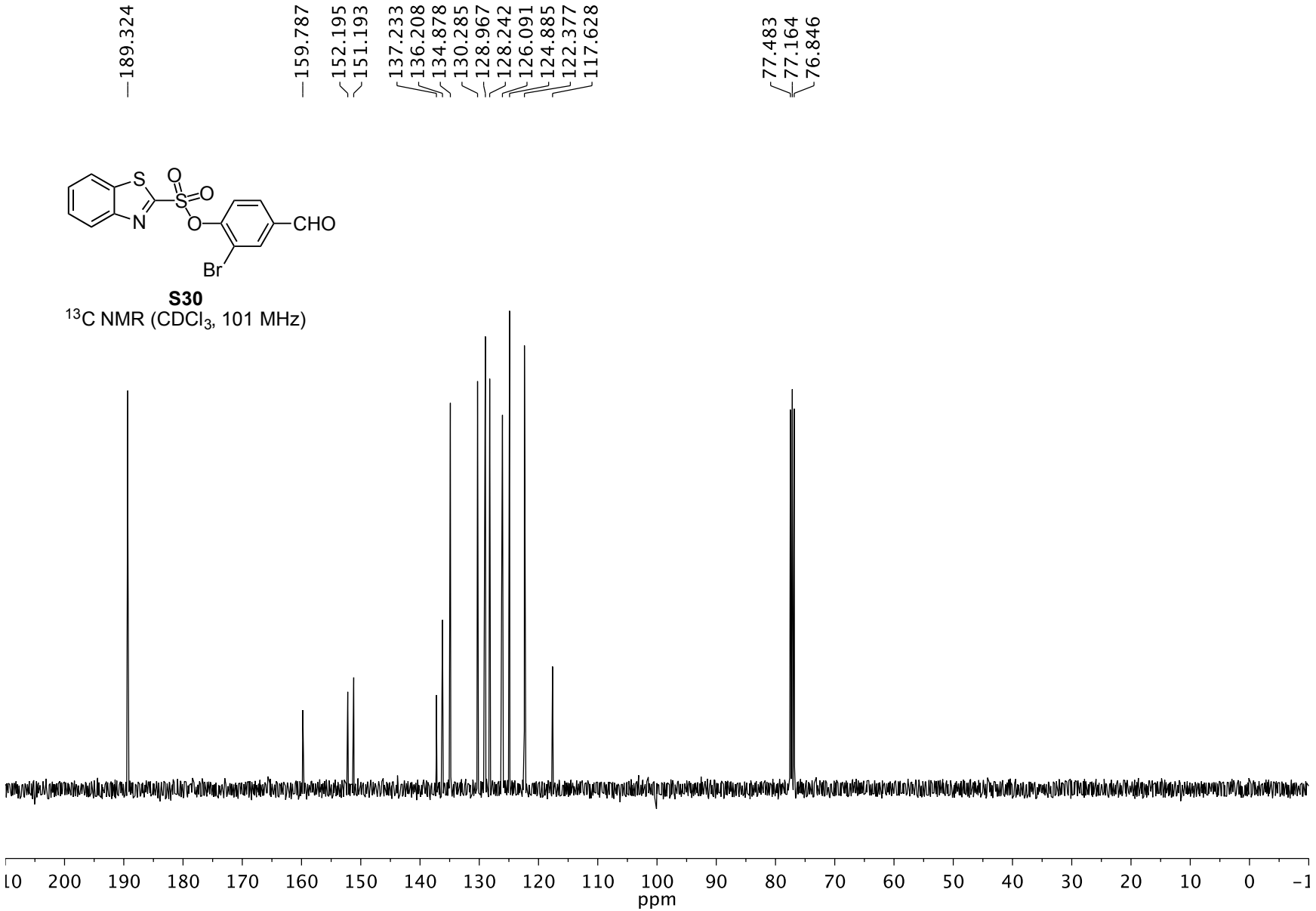
S29
^{13}C NMR (d_6-DMSO, 101 MHz)

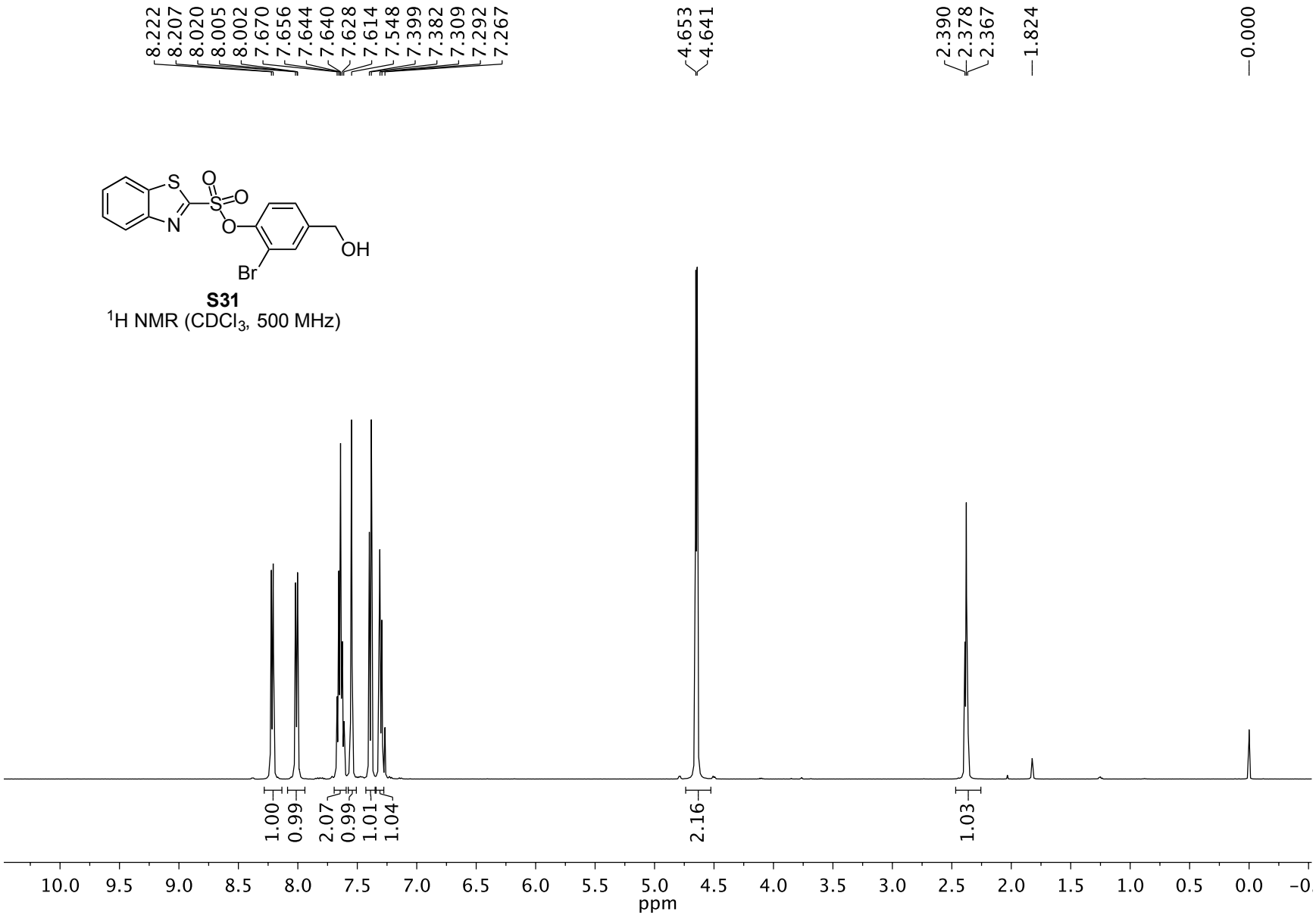




S30

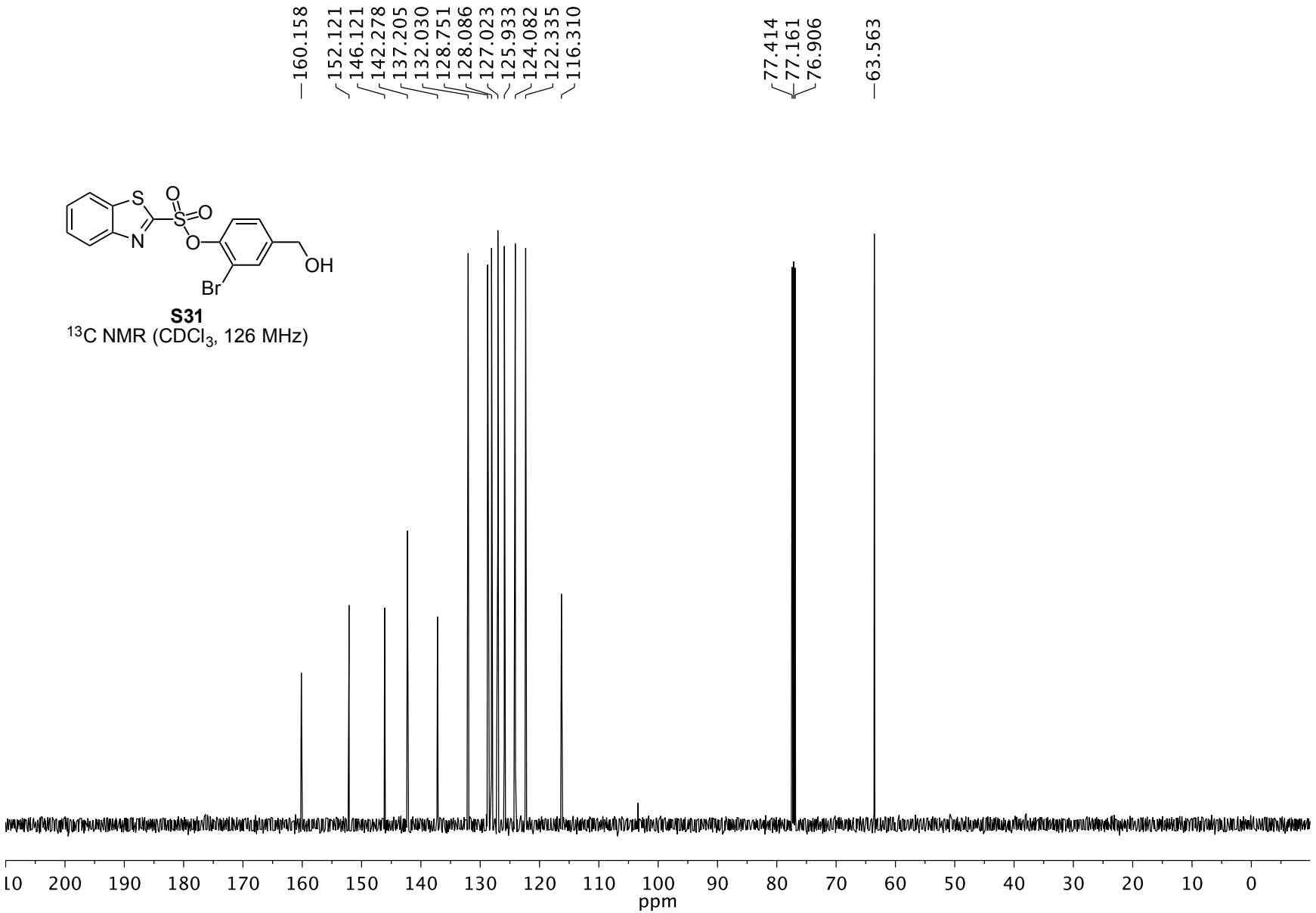
^{1}H NMR ($CDCl_3$, 400 MHz)


189.324
159.787
152.195
151.193
137.233
136.208
134.878
130.285
128.967
128.242
126.091
124.885
122.377
117.628
77.483
77.164
76.846
S
O
O
S
O
N
O
CHO
Br
S30
13C NMR (CDCl3, 101 MHz)
ppm



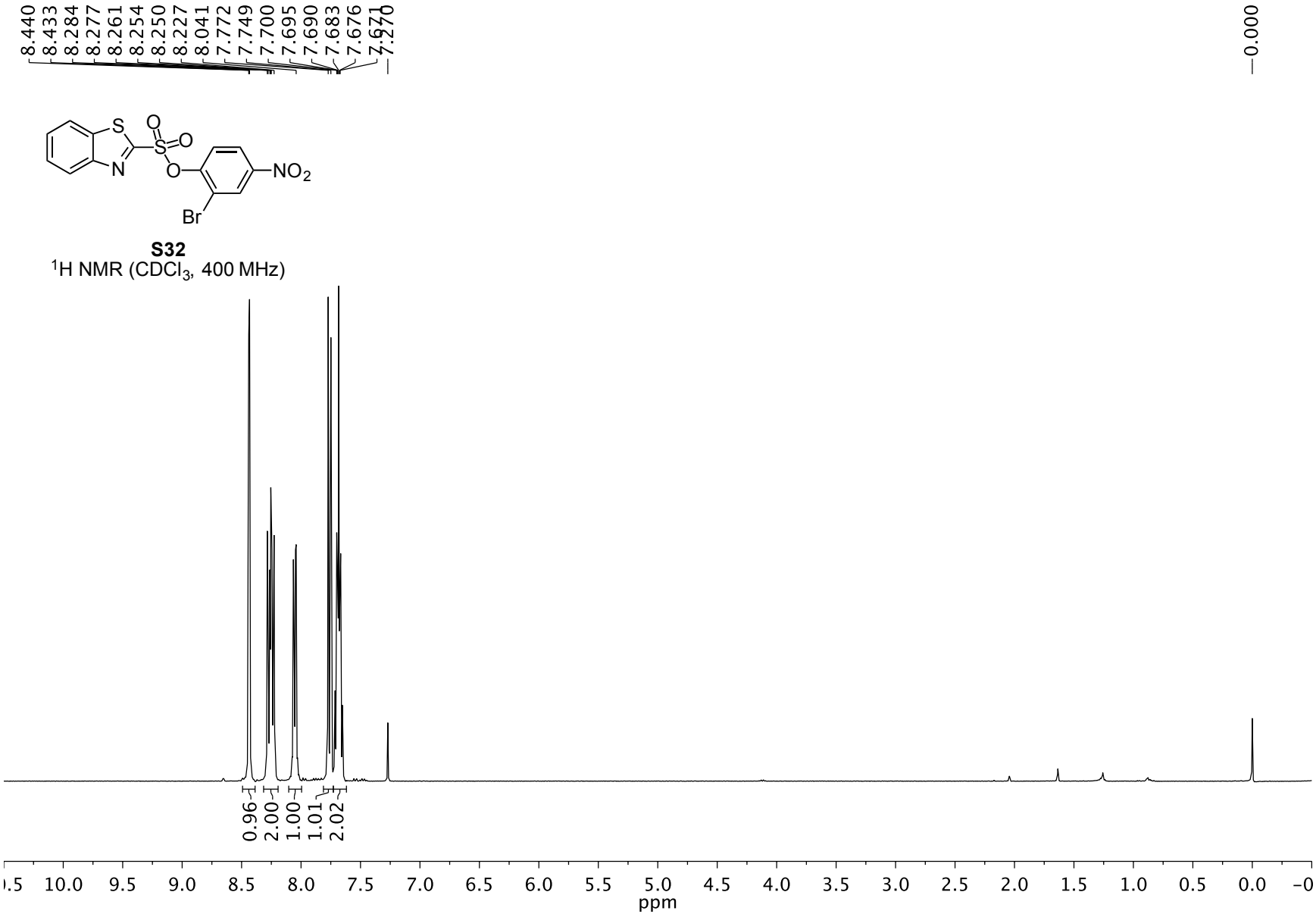
S31

^{1}H NMR ($CDCl_3$, 500 MHz)



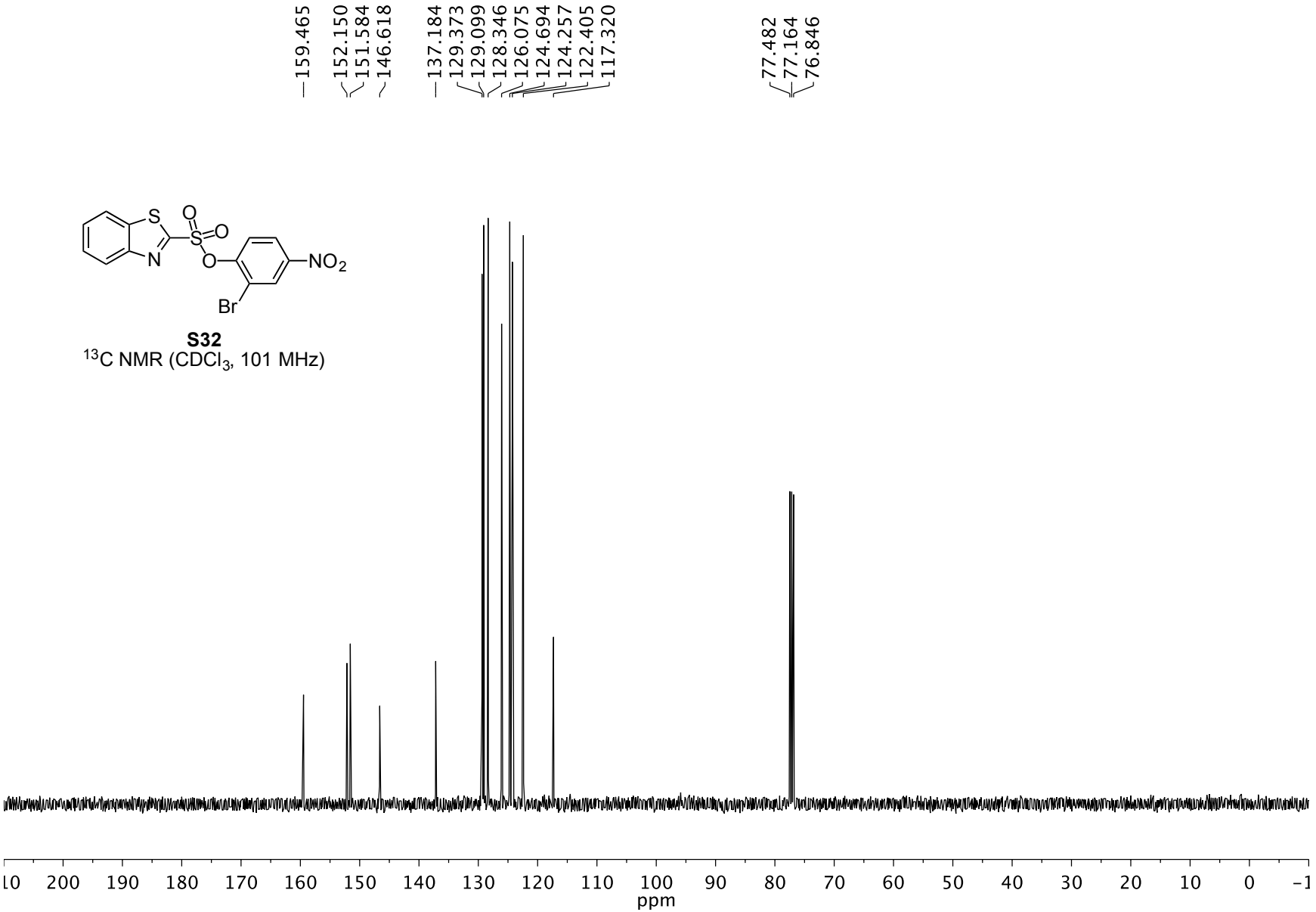
S31

^{13}C NMR ($CDCl_3$, 126 MHz)



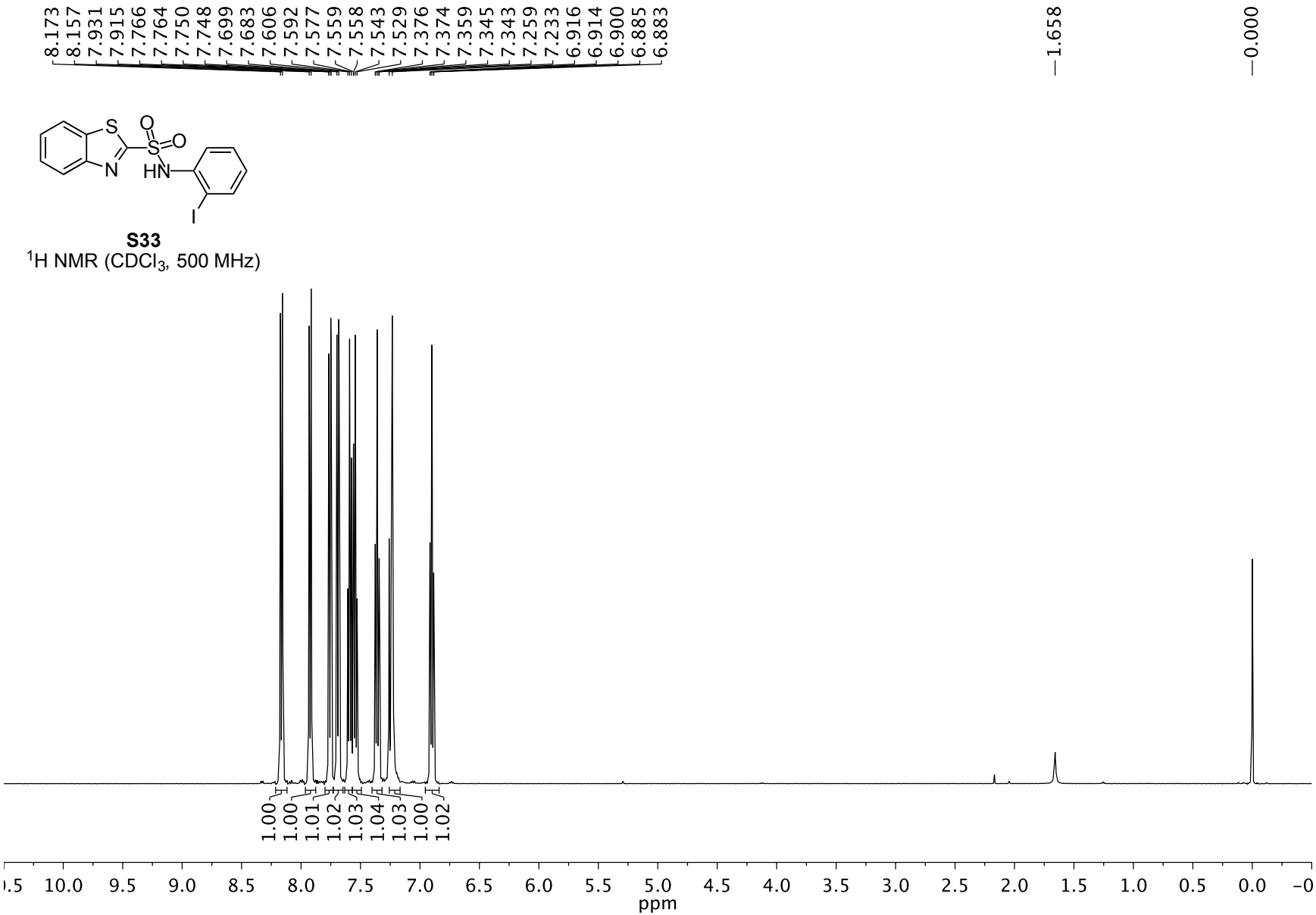
S32

^{1}H NMR ($CDCl_3$, 400 MHz)



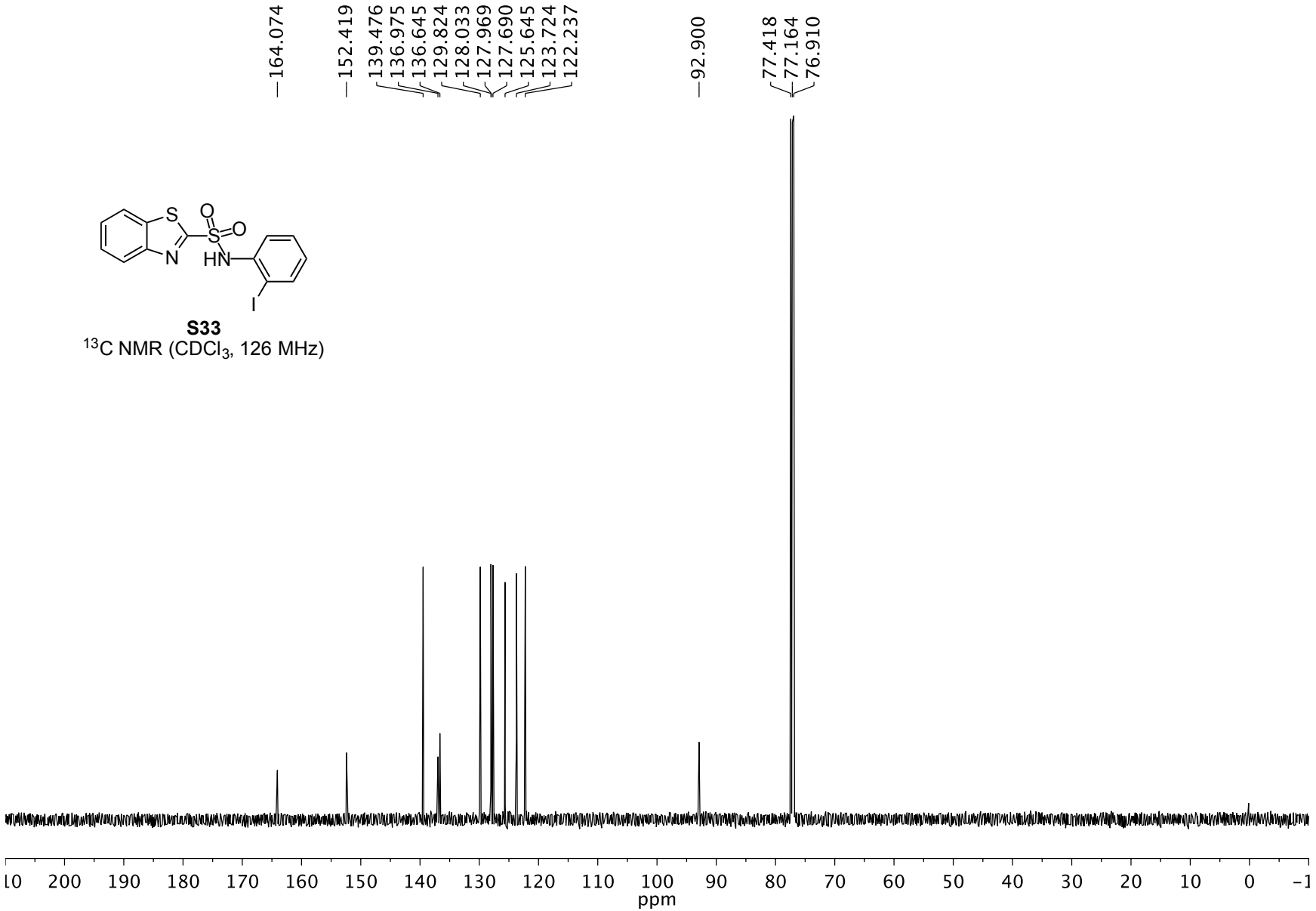
S32

^{13}C NMR ($CDCl_3$, 101 MHz)



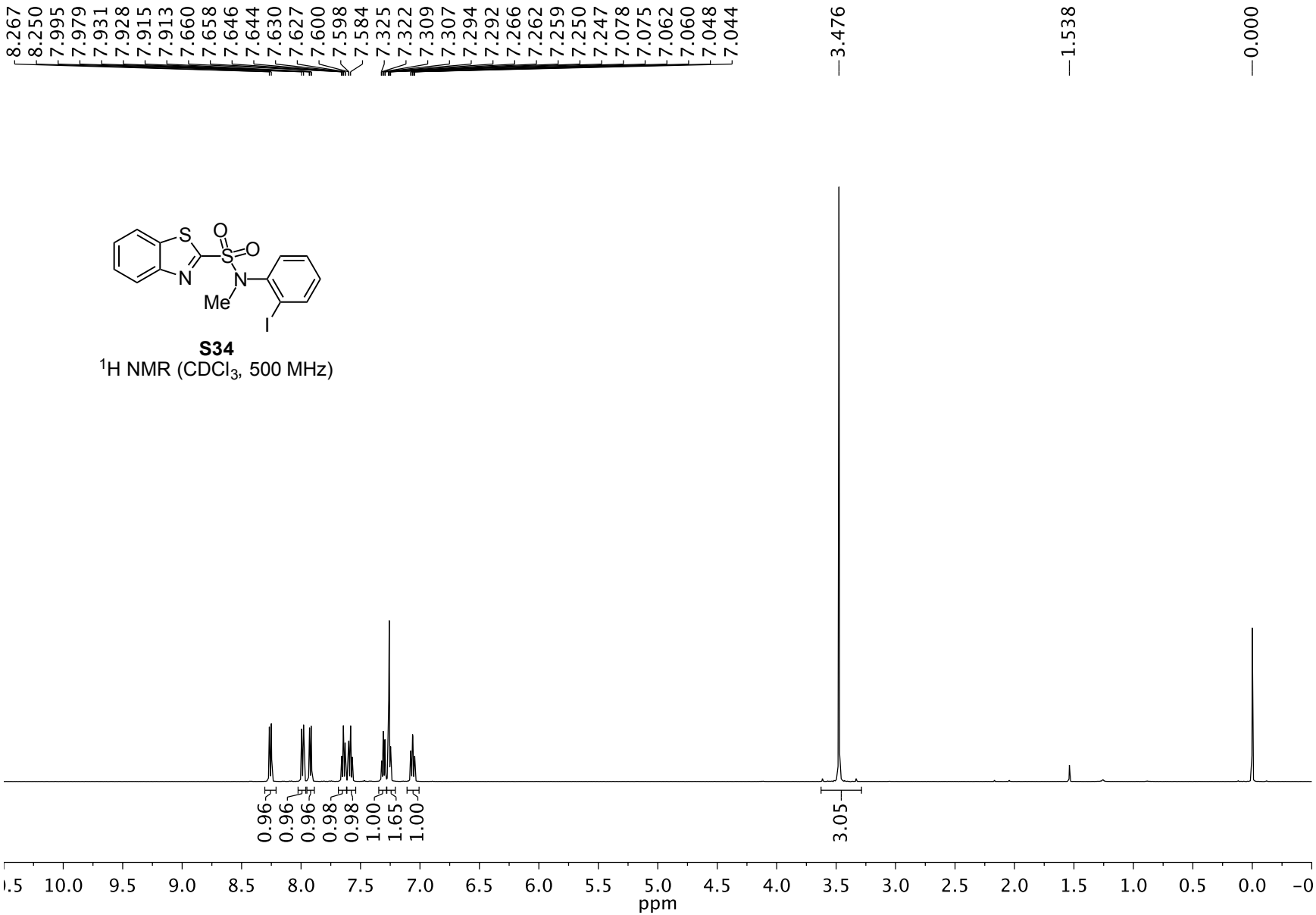
S33

^{1}H NMR ($CDCl_3$, 500 MHz)



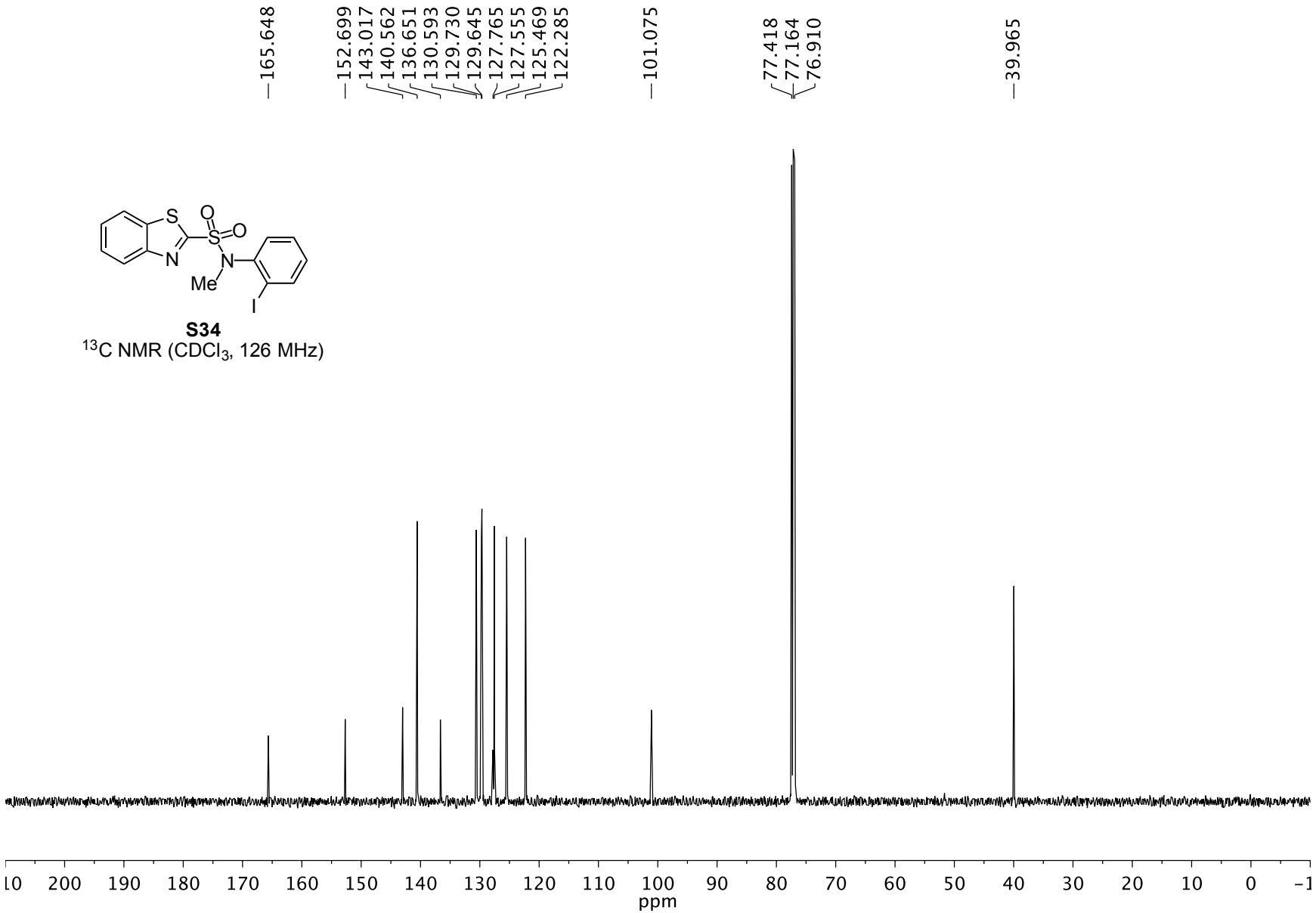
S33

^{13}C NMR ($CDCl_3$, 126 MHz)



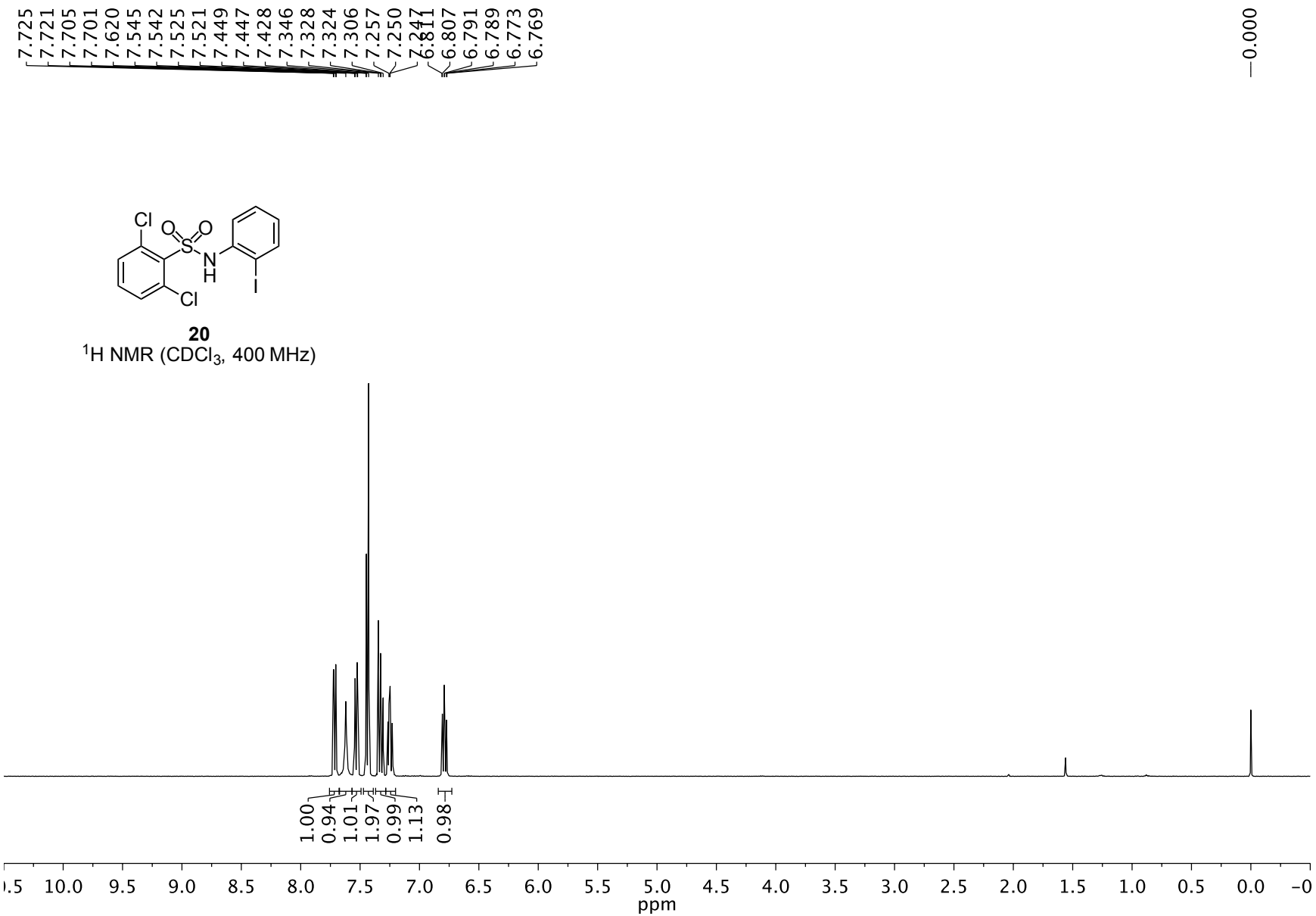
S34

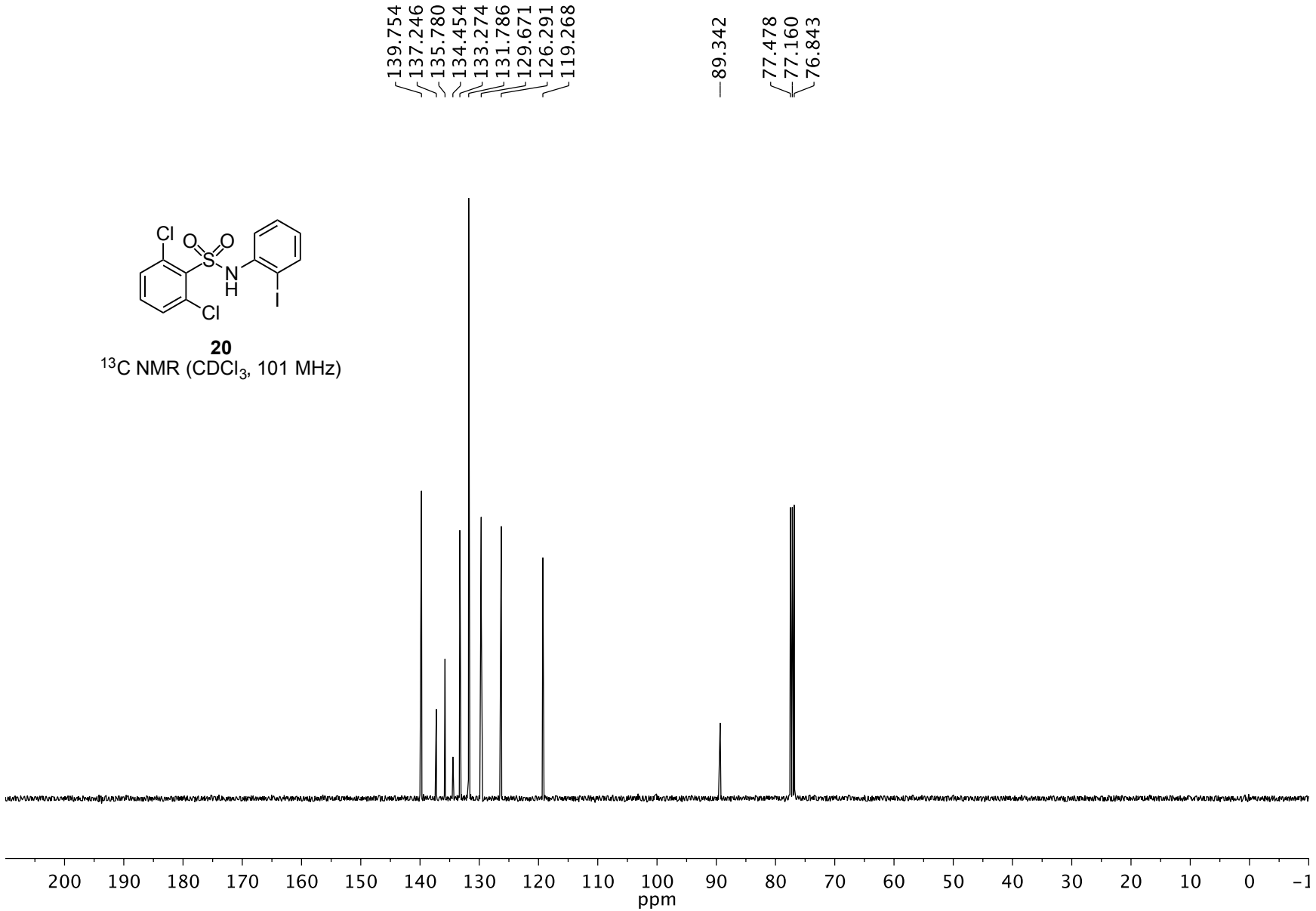
^{1}H NMR ($CDCl_3$, 500 MHz)



S34

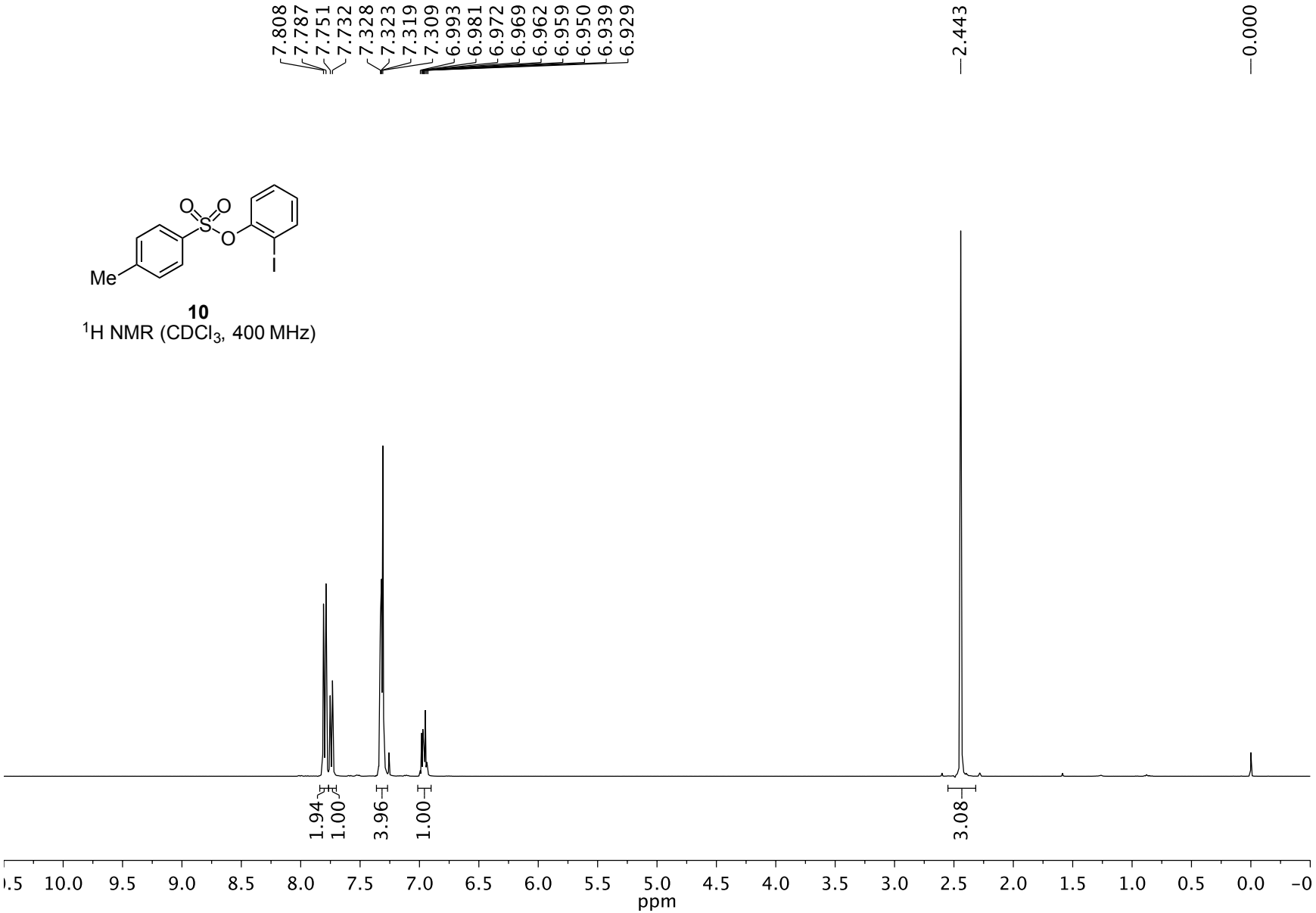
^{13}C NMR ($CDCl_3$, 126 MHz)


7.725
7.721
7.705
7.701
7.620
7.545
7.542
7.525
7.521
7.449
7.447
7.428
7.346
7.328
7.324
7.306
7.257
7.250
7.247
6.811
6.807
6.791
6.789
6.773
6.769
0.000
Cl
O
S
O
N
H
Cl
I
20
1H NMR (CDCl3, 400 MHz)
1.00
0.94
1.01
1.97
0.99
1.13
0.98
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm



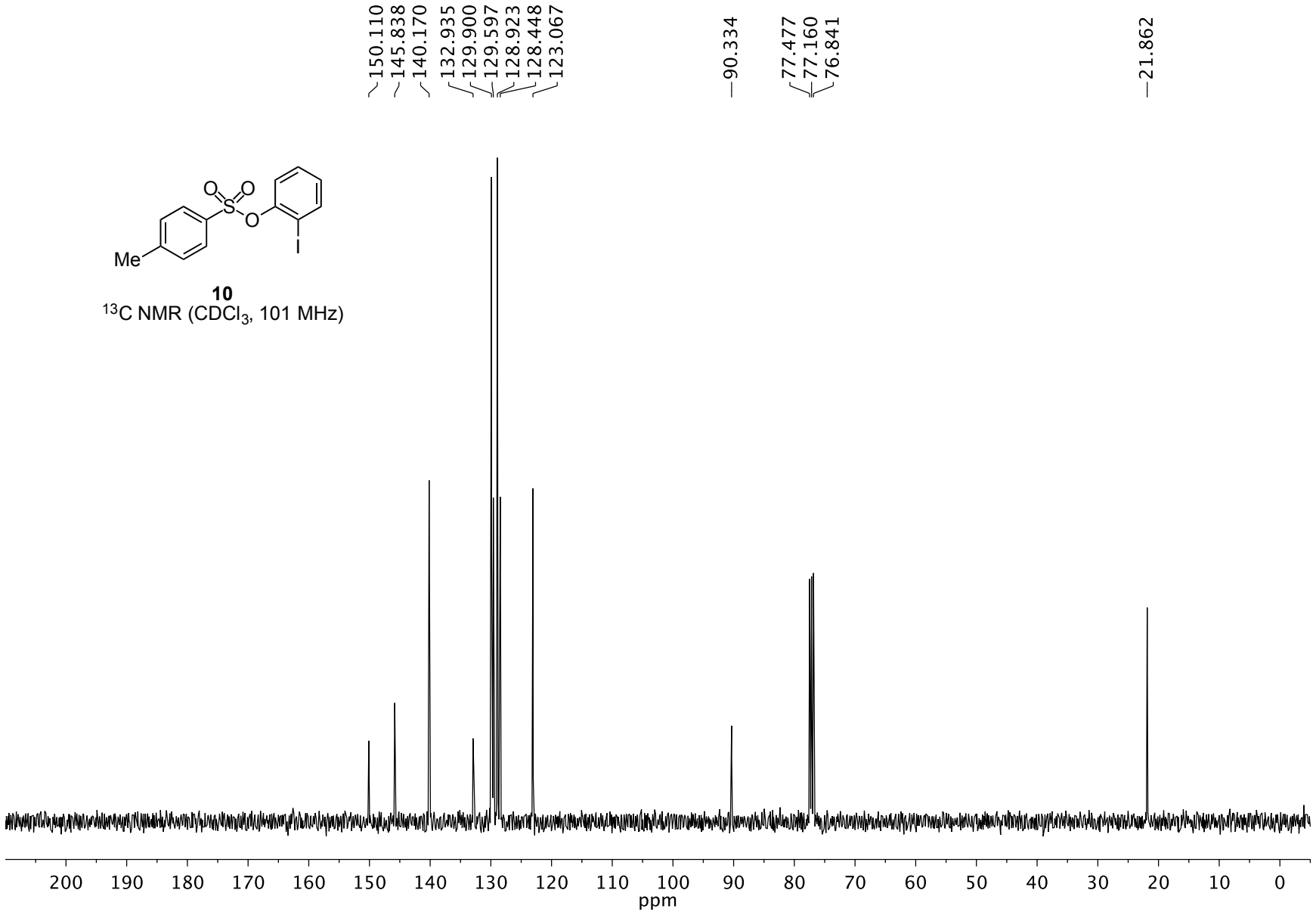
20

^{13}C NMR ($CDCl_3$, 101 MHz)



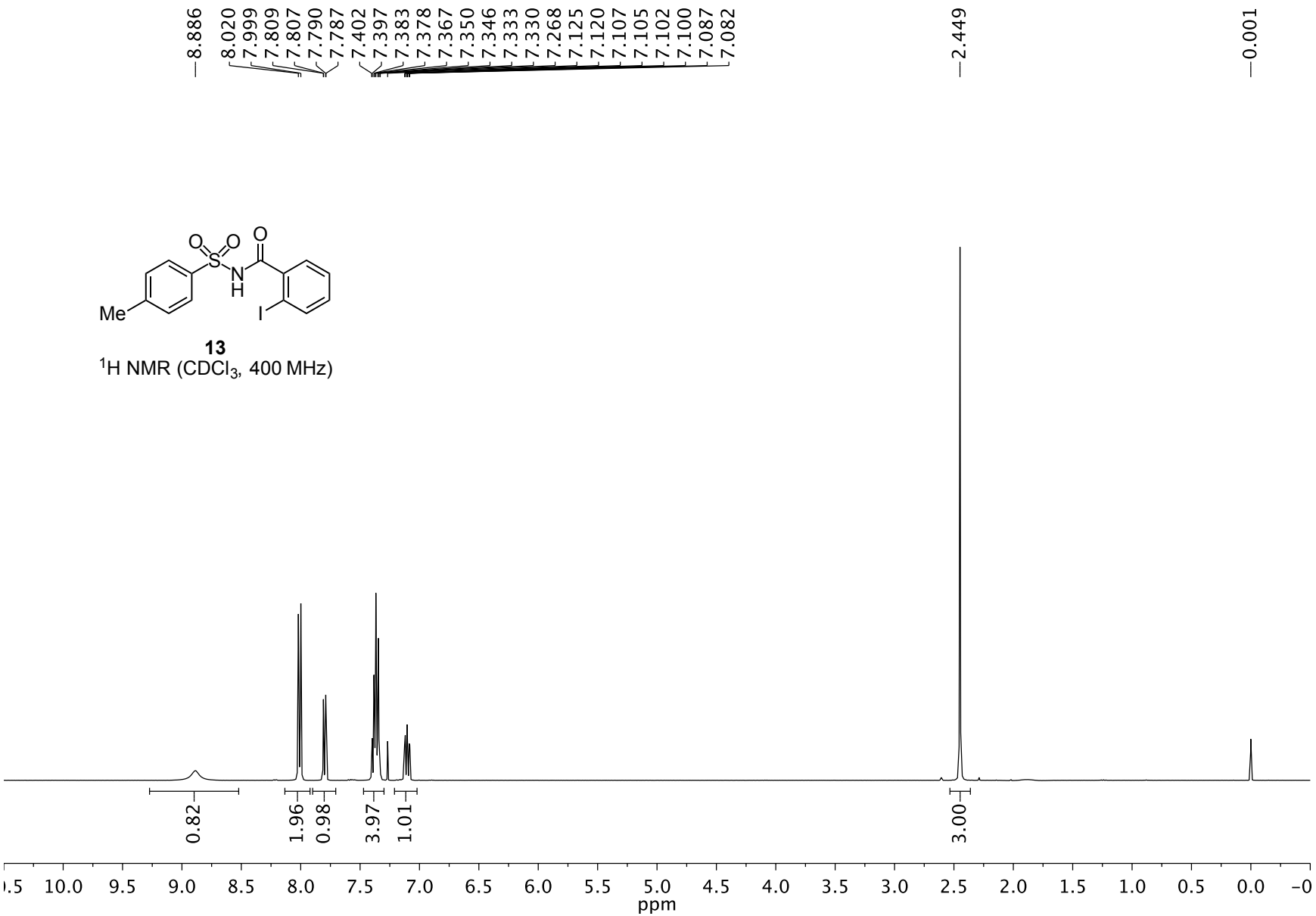
10

^{1}H NMR ($CDCl_3$, 400 MHz)



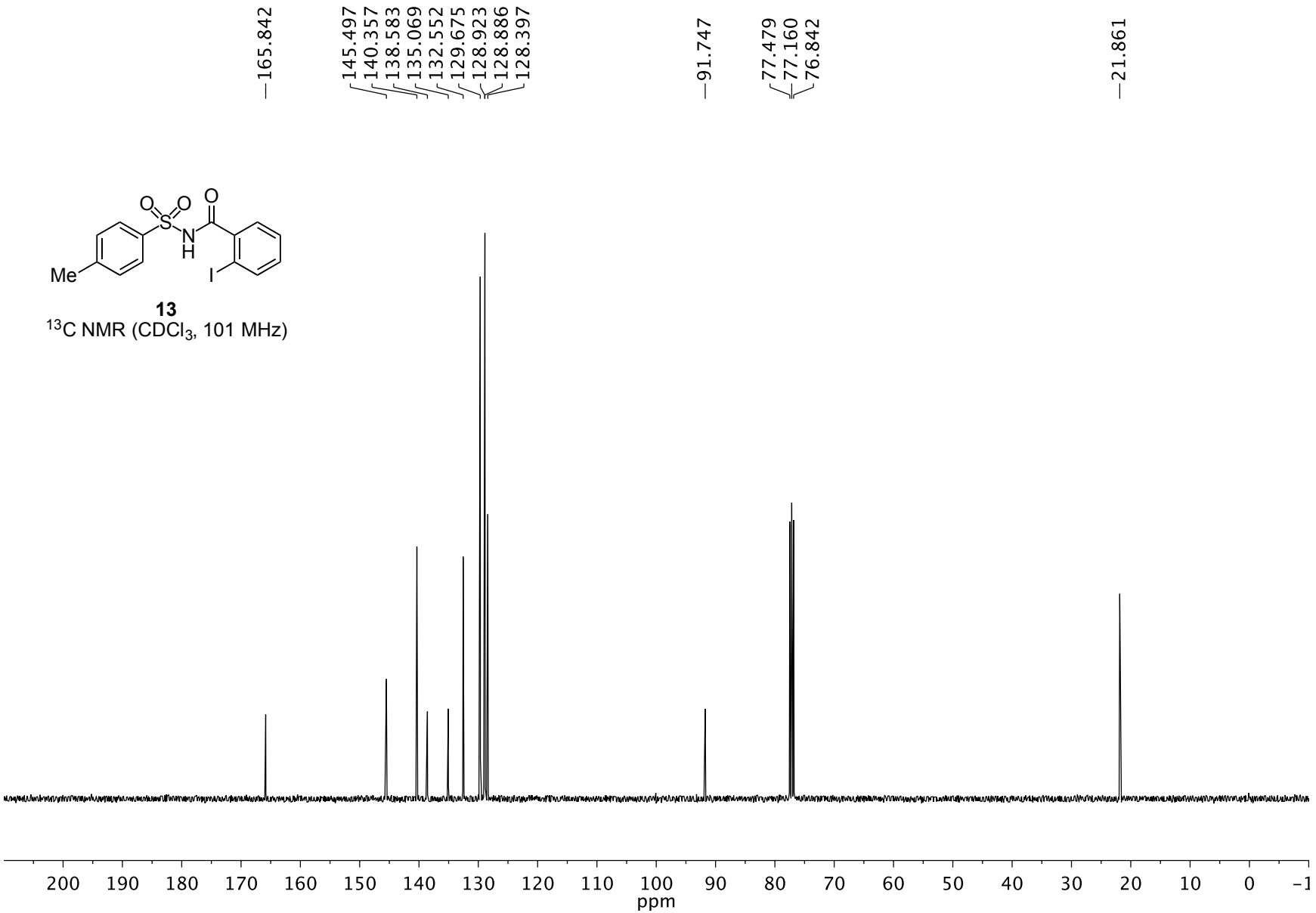
10

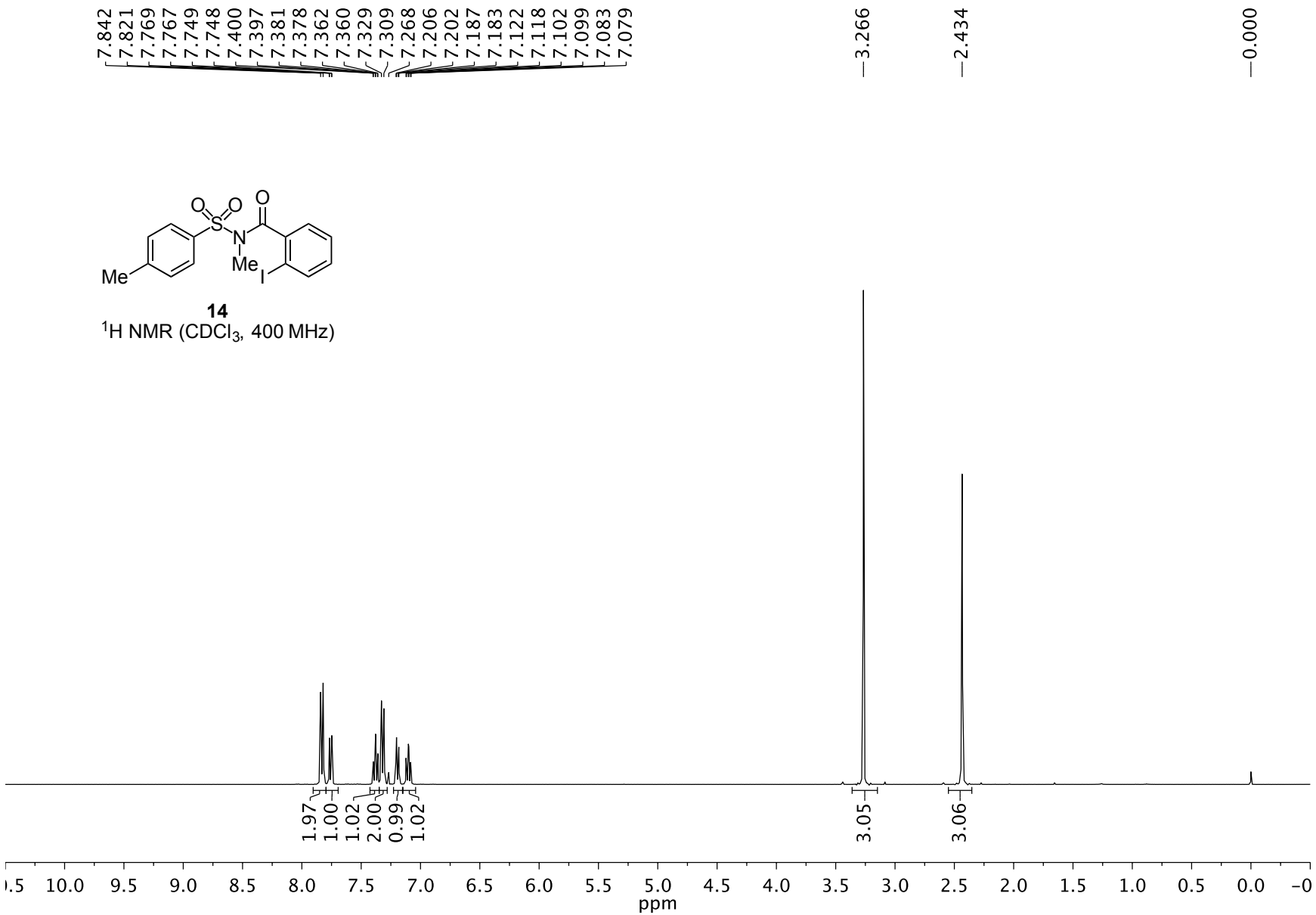
^{13}C NMR ($CDCl_3$, 101 MHz)



13

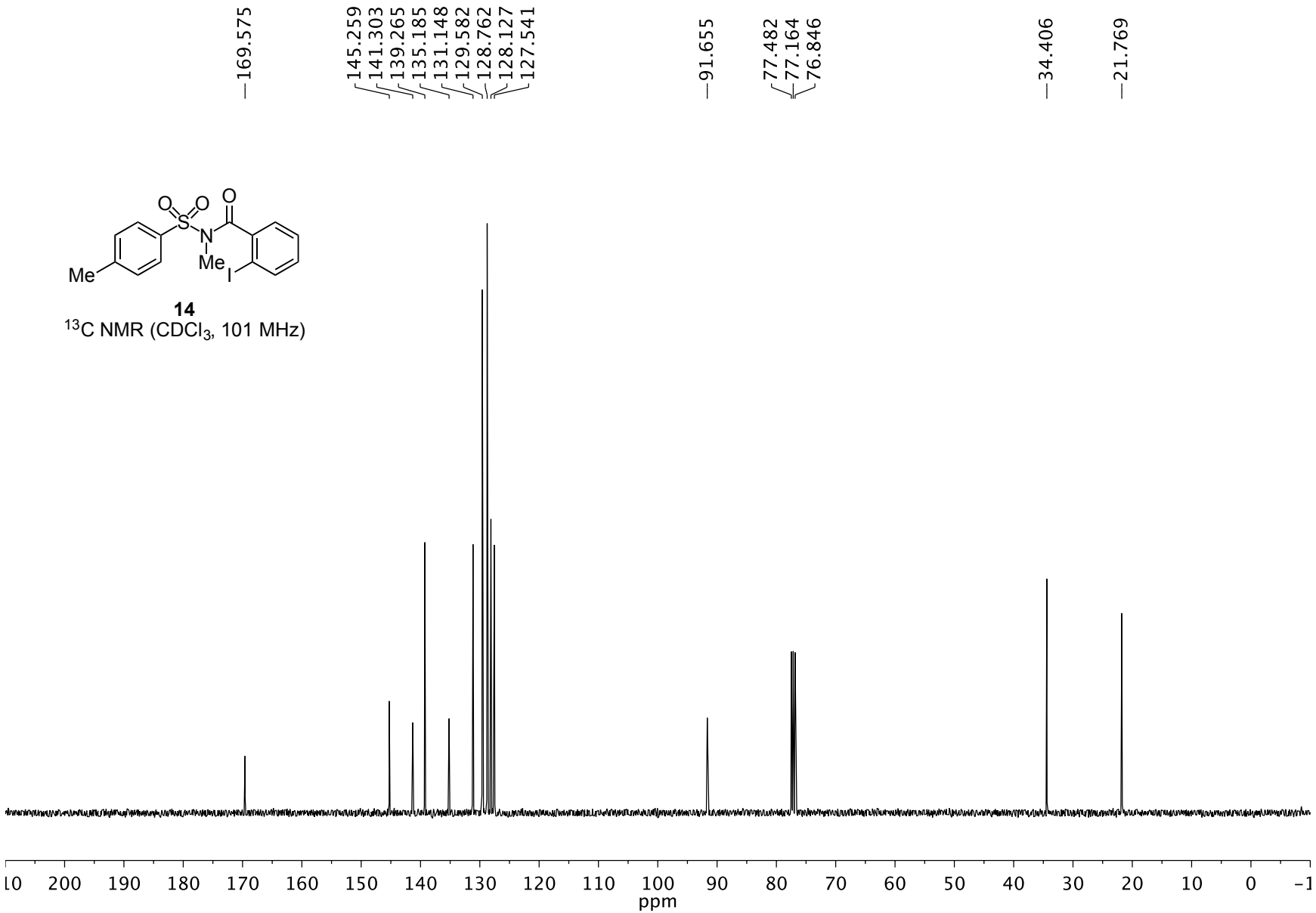
^{1}H NMR ($CDCl_3$, 400 MHz)

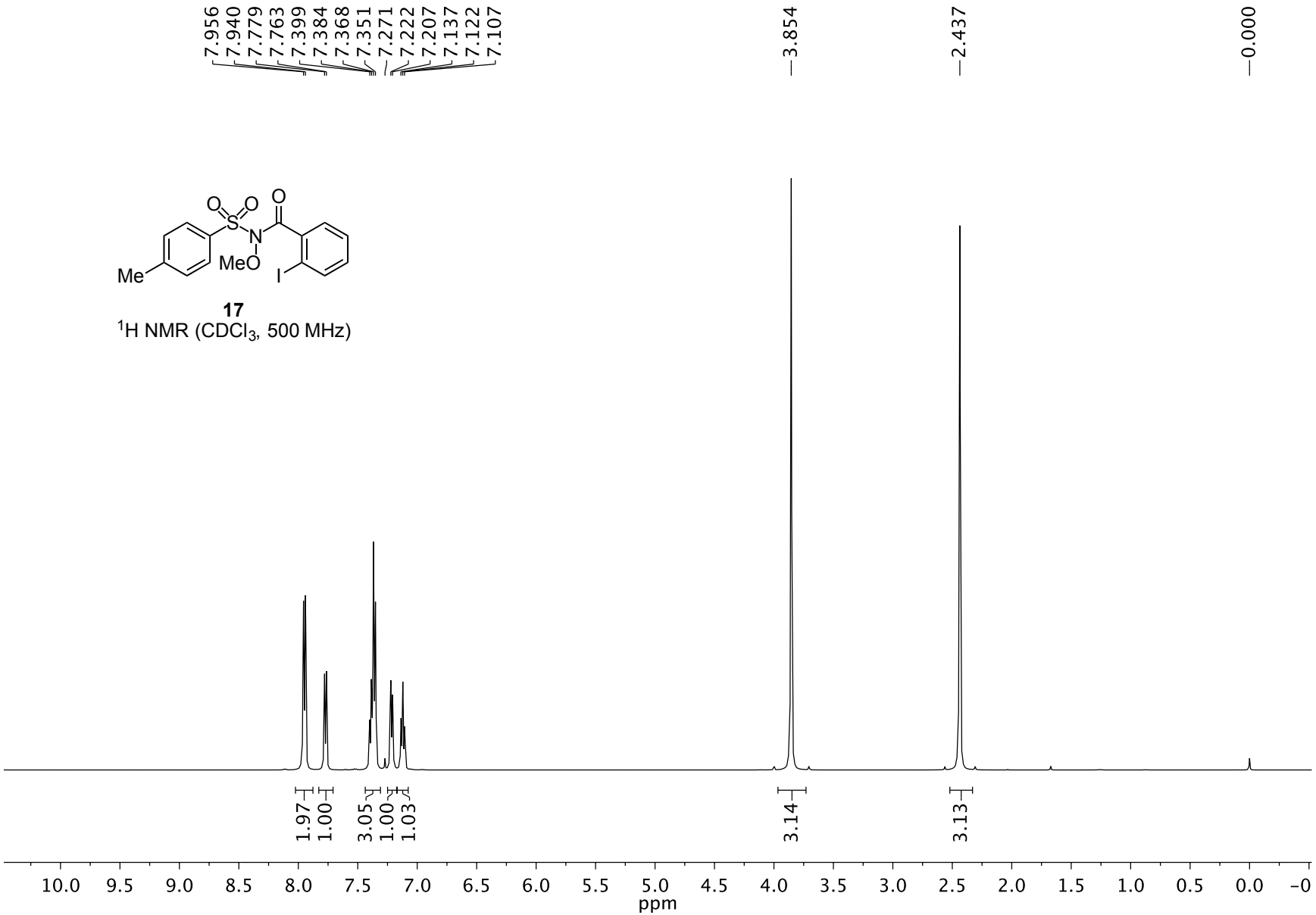

165.842
145.497
140.357
138.583
135.069
132.552
129.675
128.923
128.886
128.397
91.747
77.479
77.160
76.842
21.861
O
O
S
N
H
O
Me
I
13
13C NMR (CDCl3, 101 MHz)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
ppm



14

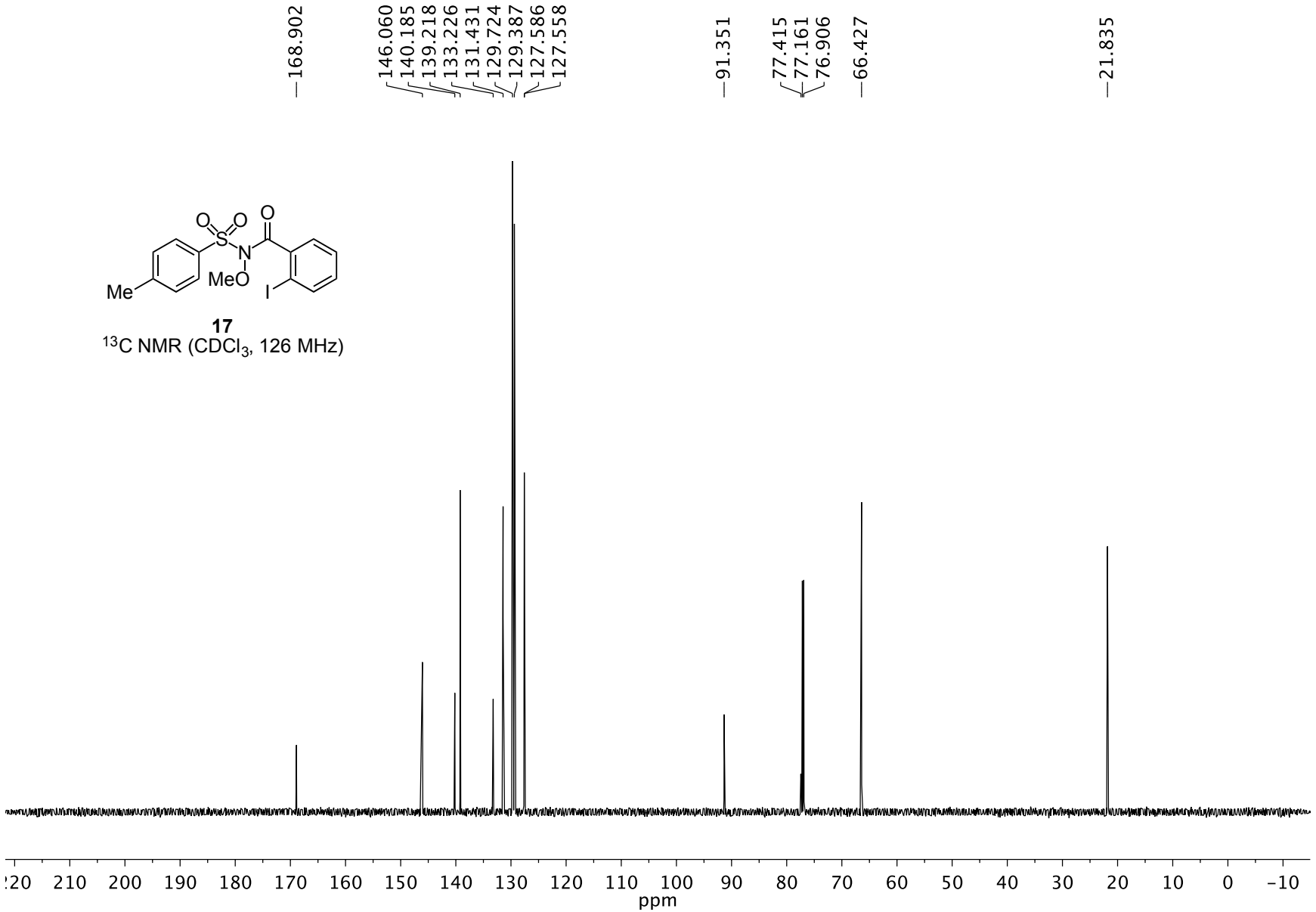
^{1}H NMR ($CDCl_3$, 400 MHz)

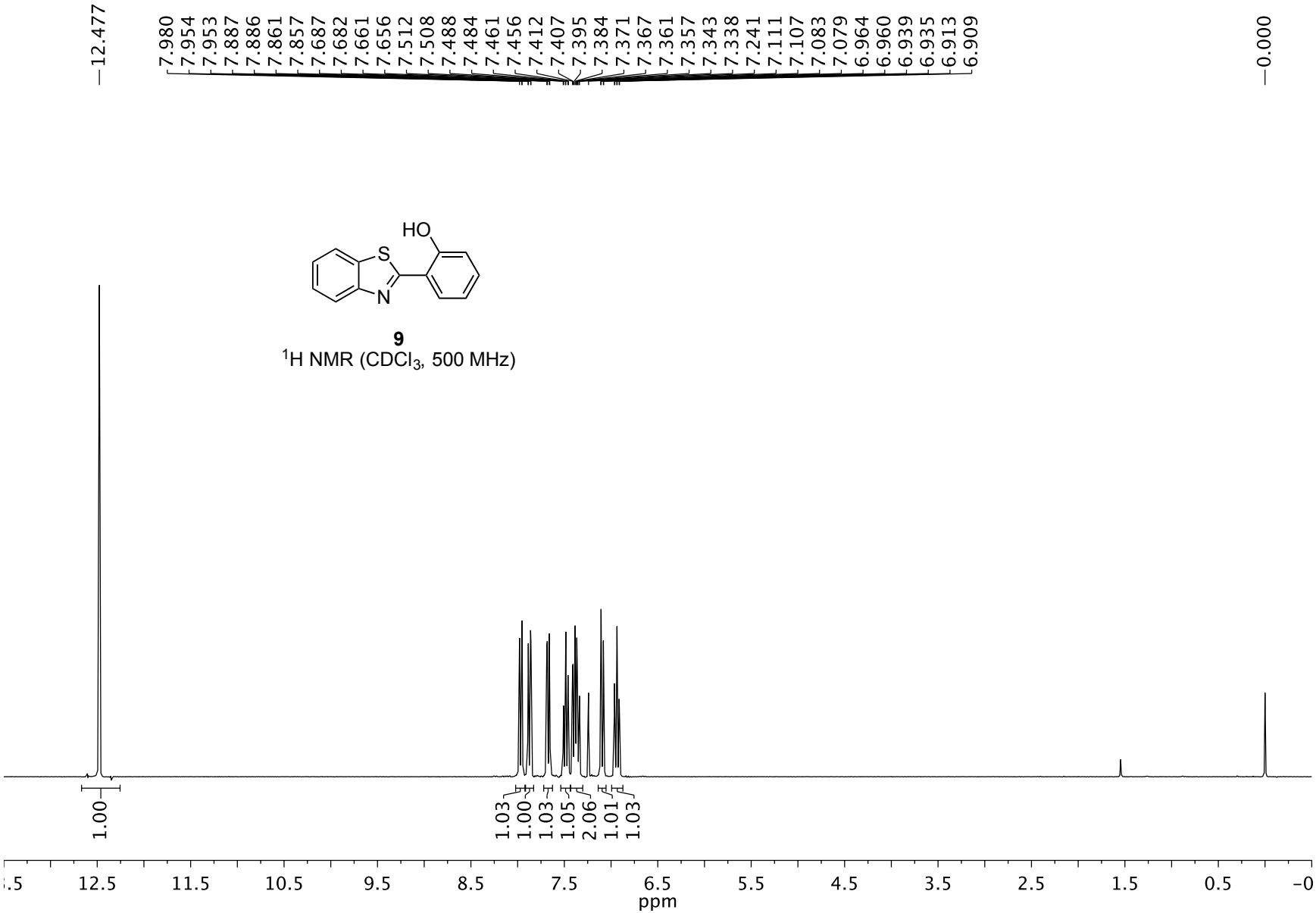

169.575
145.259
141.303
139.265
135.185
131.148
129.582
128.762
128.127
127.541
91.655
77.482
77.164
76.846
34.406
21.769
O
O
O
S
N
Me
Me
I
14
13C NMR (CDCl3, 101 MHz)
ppm



17

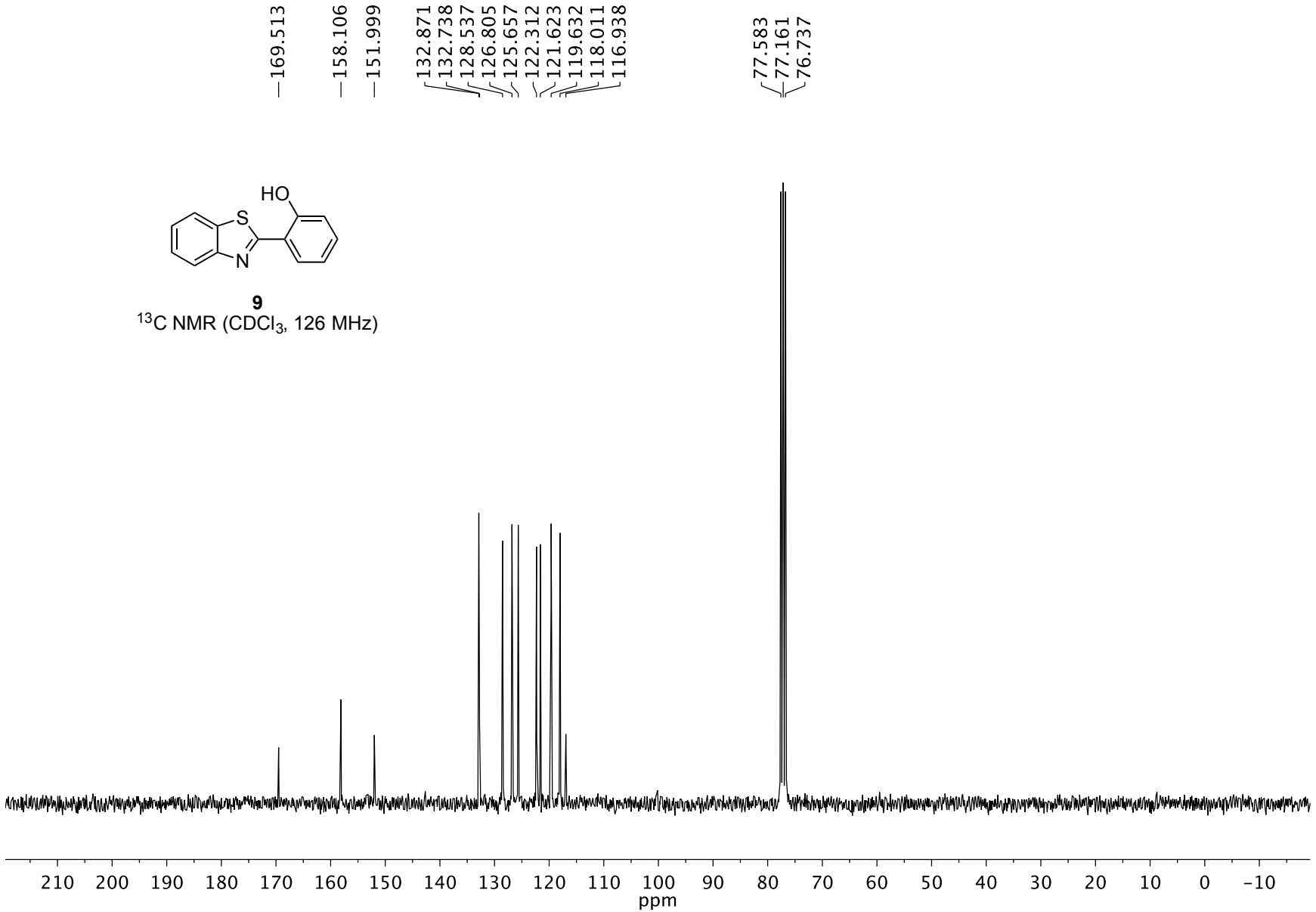
^{1}H NMR ($CDCl_3$, 500 MHz)


168.902
146.060
140.185
139.218
133.226
131.431
129.724
129.387
127.586
127.558
91.351
77.415
77.161
76.906
66.427
21.835
O
O
O
S
N
MeO
Me
I
17
13C NMR (CDCl3, 126 MHz)
ppm



9

^{1}H NMR ($CDCl_3$, 500 MHz)



9

^{13}C NMR ($CDCl_3$, 126 MHz)

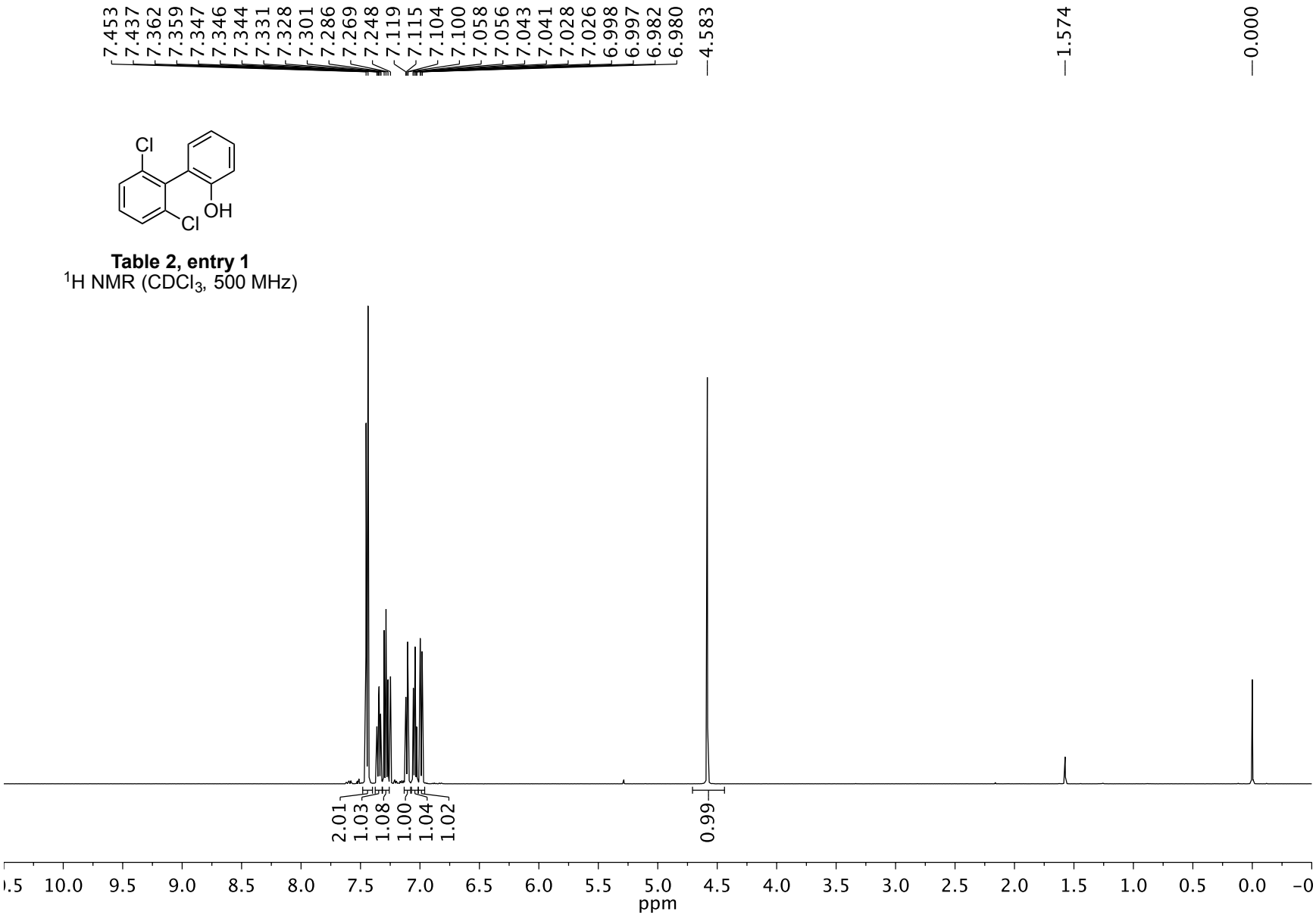


Table 2, entry 1
^{1}H NMR ($CDCl_3$, 500 MHz)

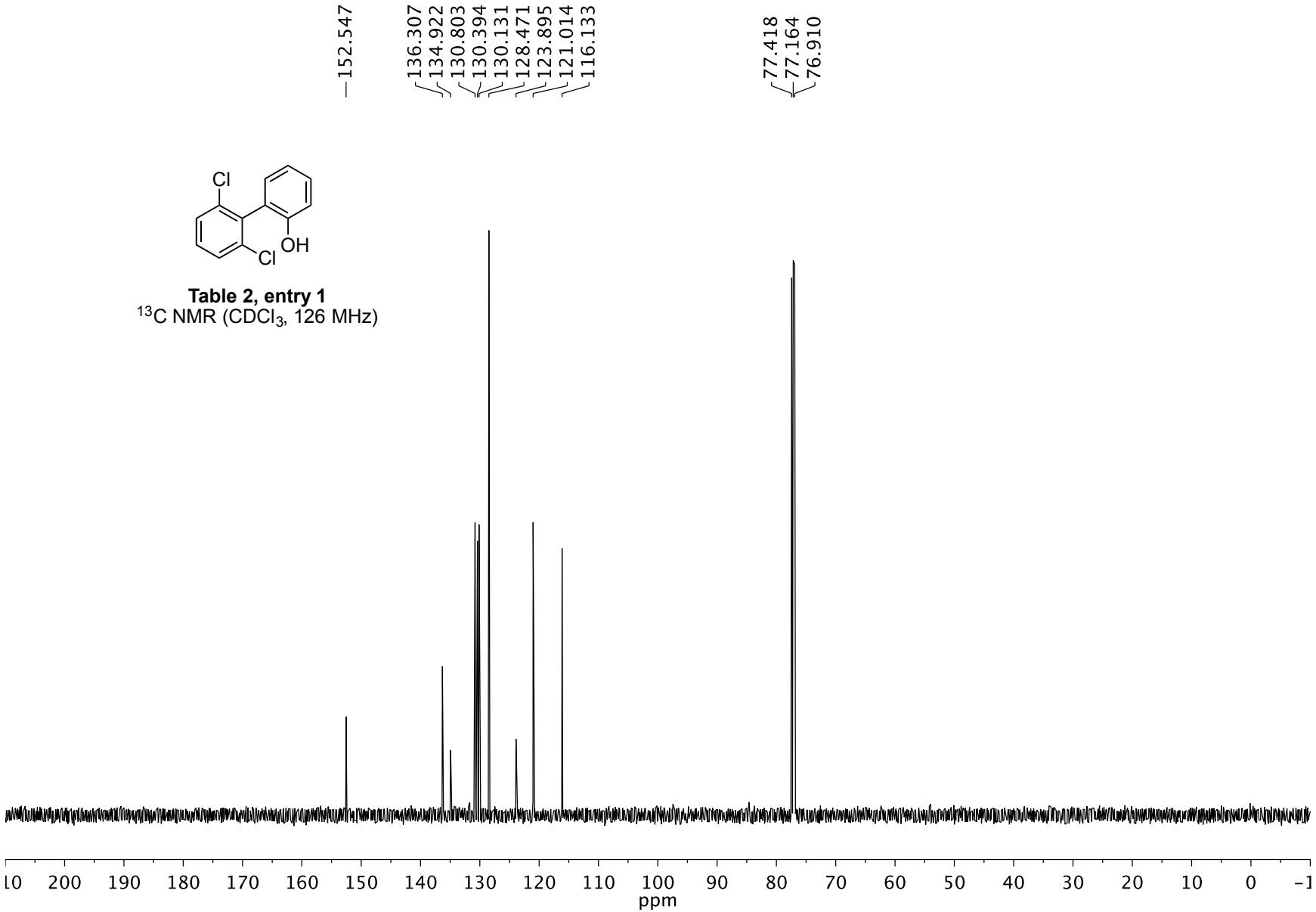


Table 2, entry 1
^{13}C NMR ($CDCl_3$, 126 MHz)

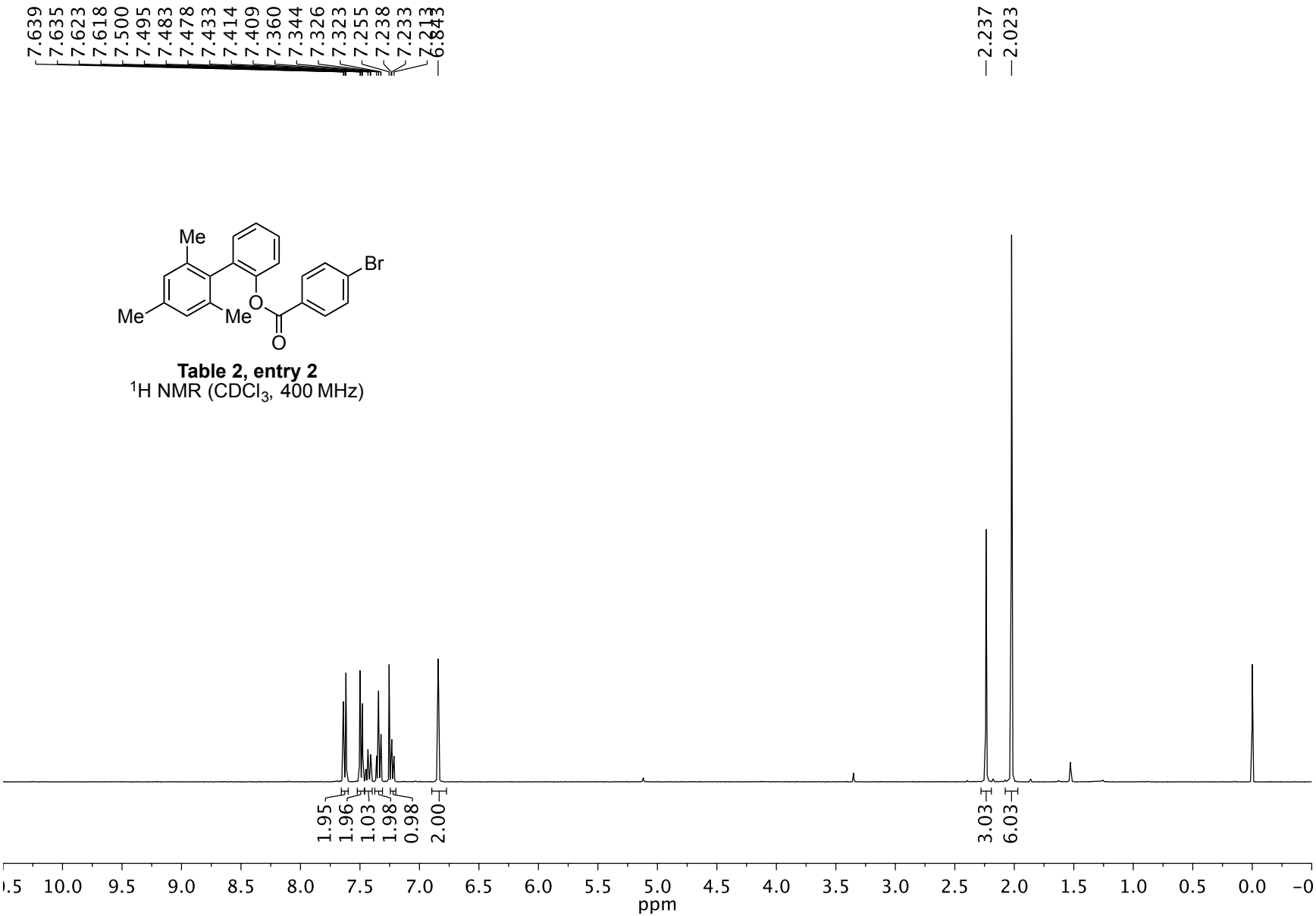


Table 2, entry 2
^{1}H NMR ($CDCl_3$, 400 MHz)

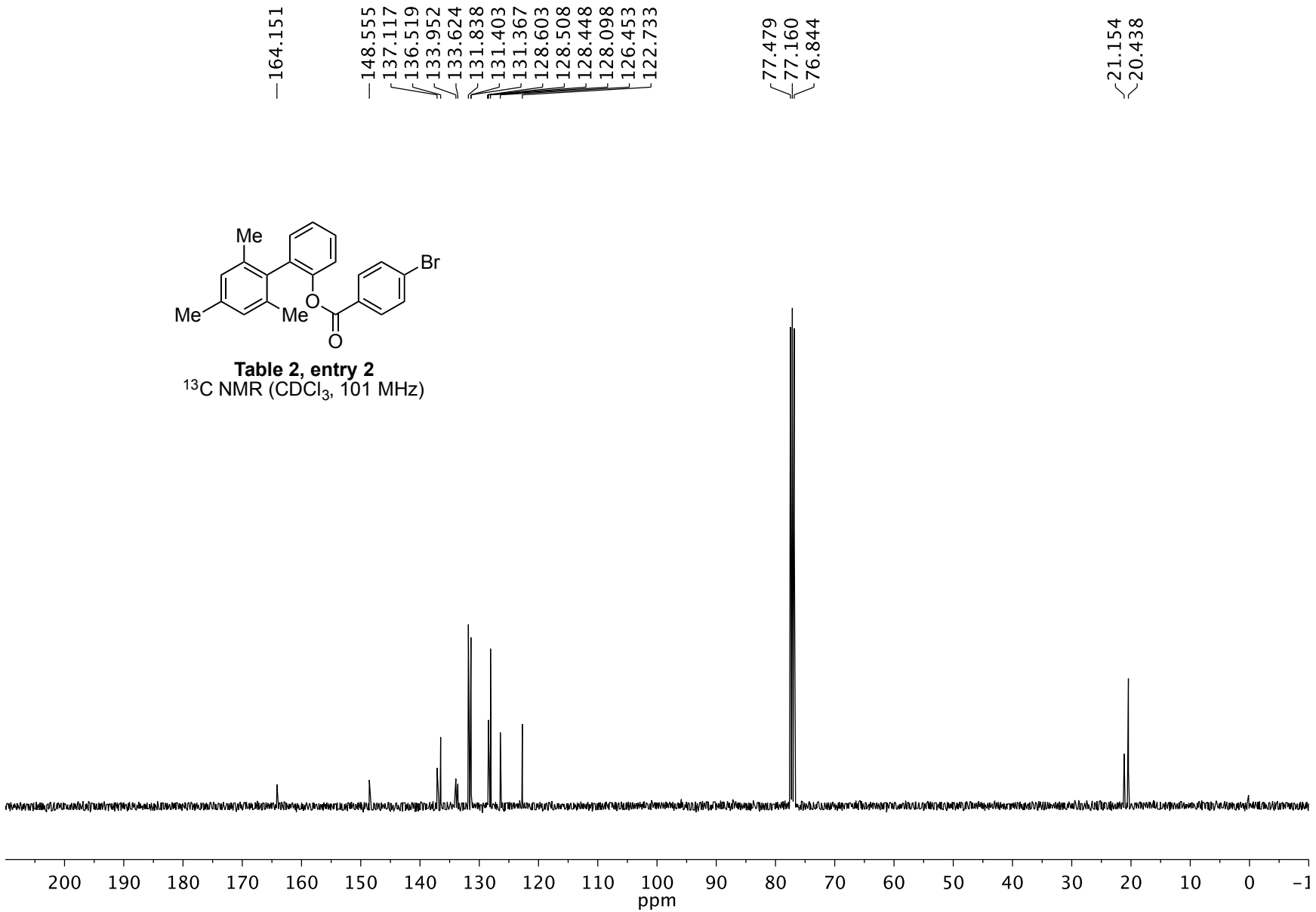


Table 2, entry 2
^{13}C NMR ($CDCl_3$, 101 MHz)

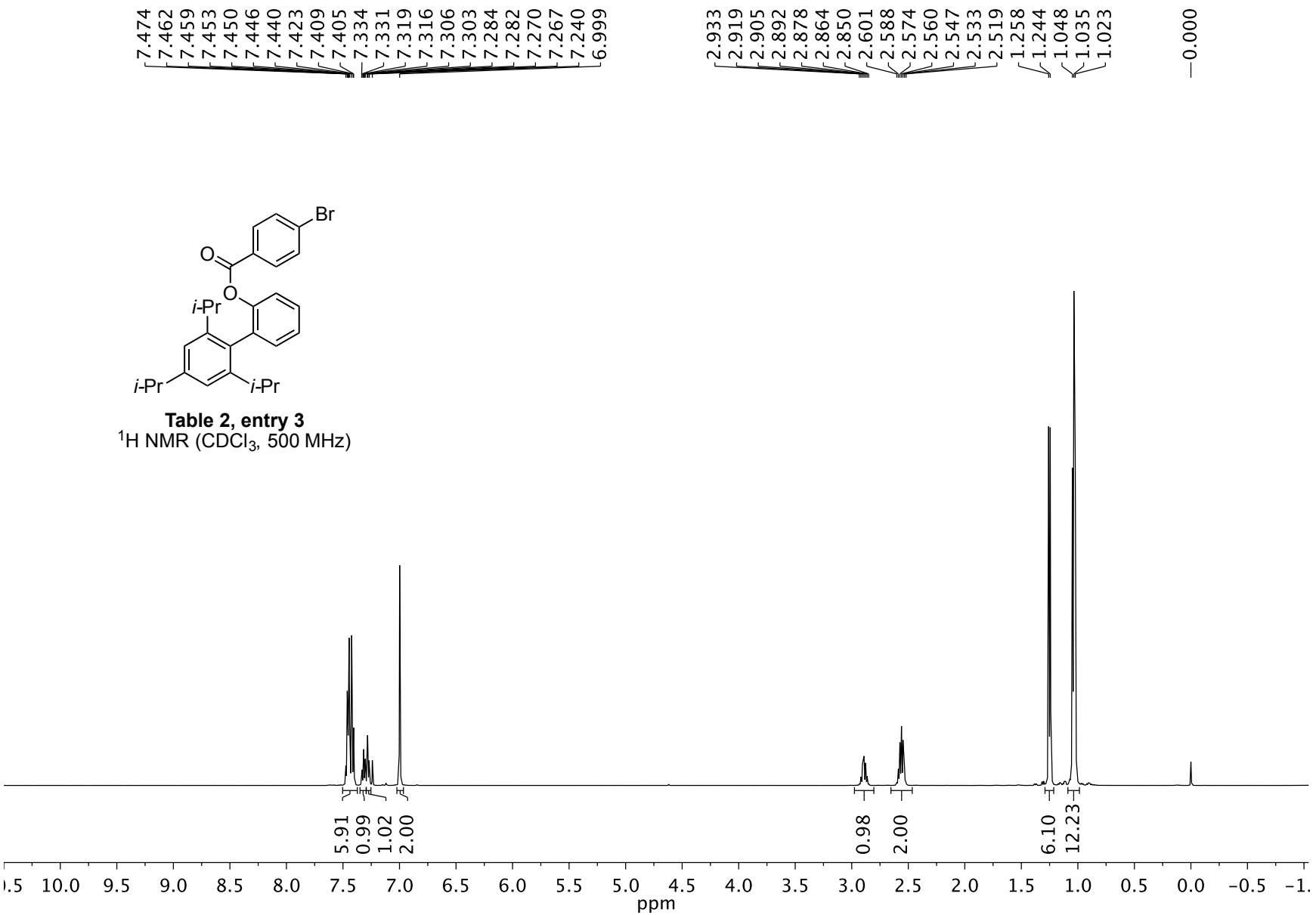


Table 2, entry 3
^{1}H NMR ($CDCl_3$, 500 MHz)

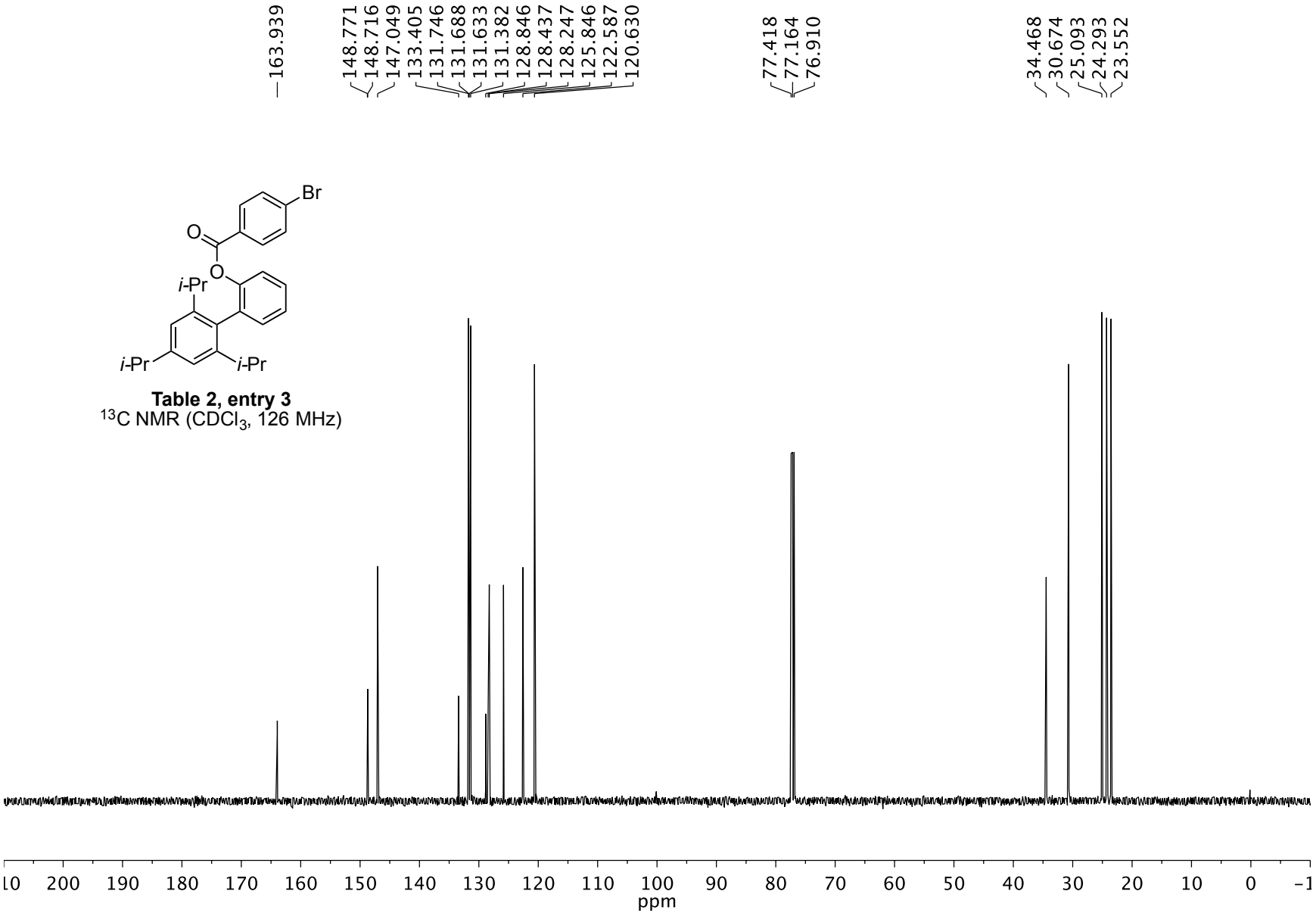


Table 2, entry 3
^{13}C NMR ($CDCl_3$, 126 MHz)

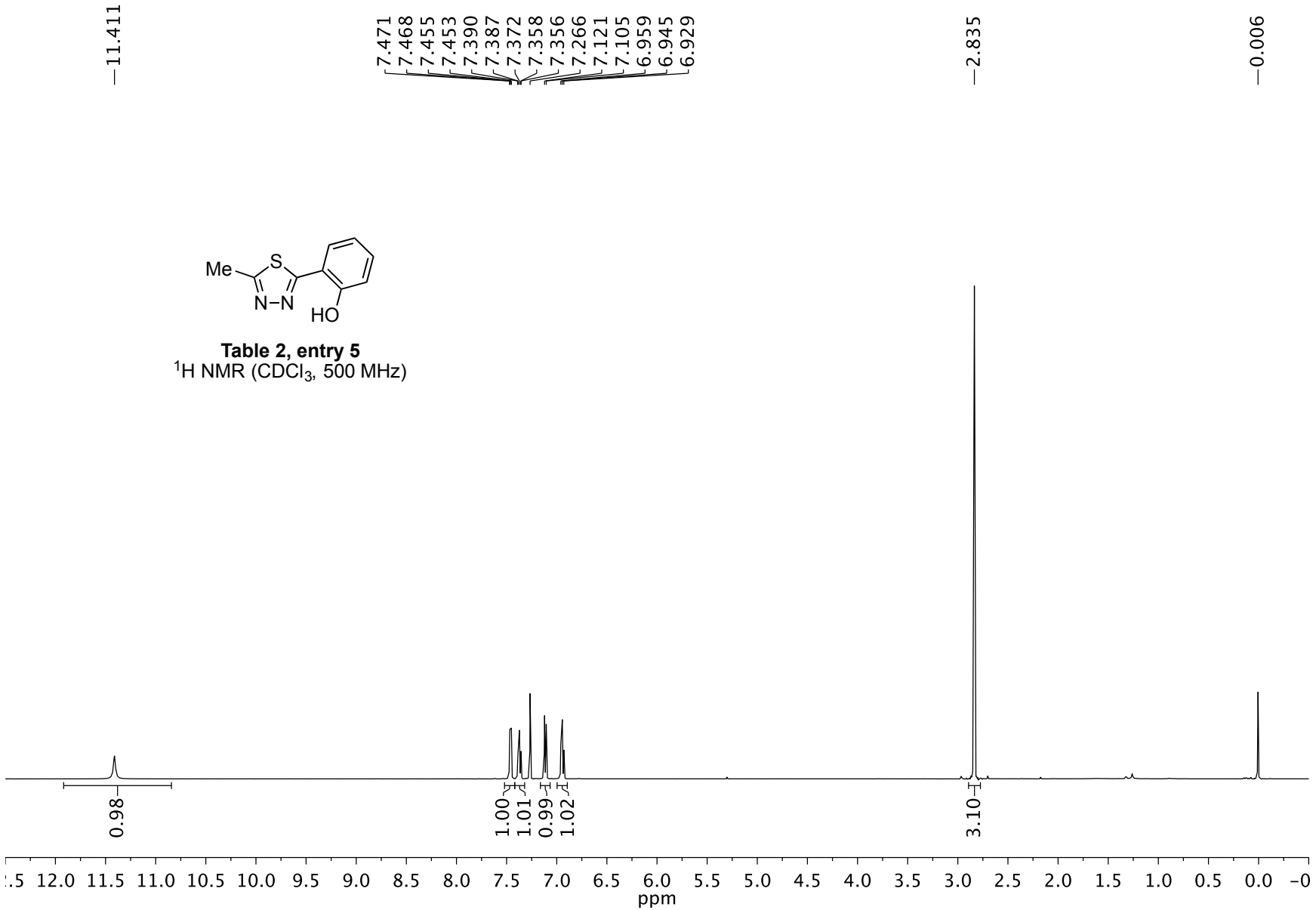


Table 2, entry 5
^{1}H NMR ($CDCl_3$, 500 MHz)

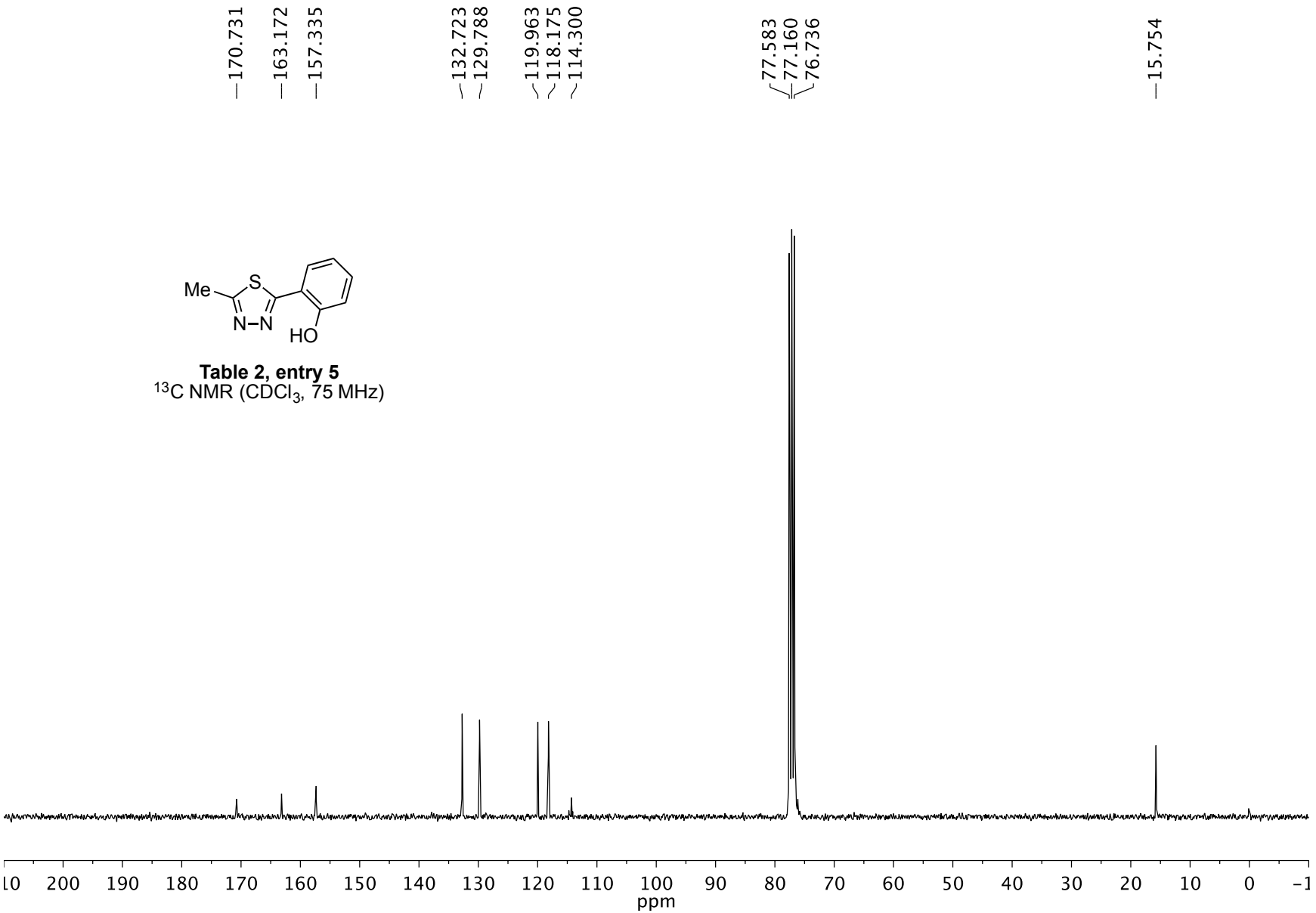
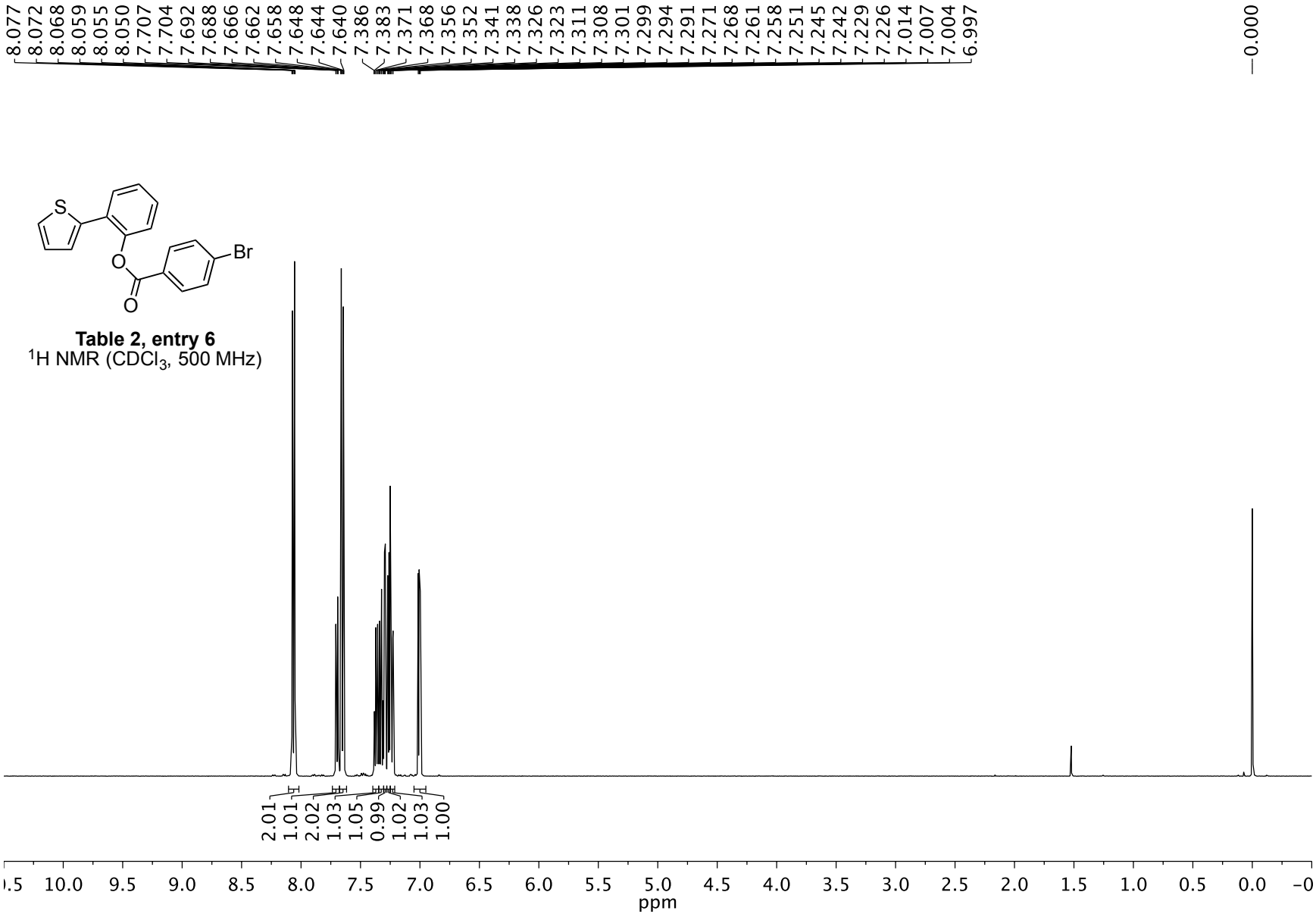


Table 2, entry 5
^{13}C NMR ($CDCl_3$, 75 MHz)


8.077
8.072
8.068
8.059
8.055
8.050
7.707
7.704
7.692
7.688
7.666
7.662
7.658
7.648
7.644
7.640
7.386
7.383
7.371
7.368
7.356
7.352
7.341
7.338
7.326
7.323
7.311
7.308
7.301
7.299
7.294
7.291
7.271
7.268
7.261
7.258
7.251
7.245
7.242
7.229
7.226
7.014
7.007
7.004
6.997
0.000
S
O
O
Br
Table 2, entry 6
1H NMR (CDCl3, 500 MHz)
2.01
1.01
2.02
1.03
1.05
0.99
1.02
1.03
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm

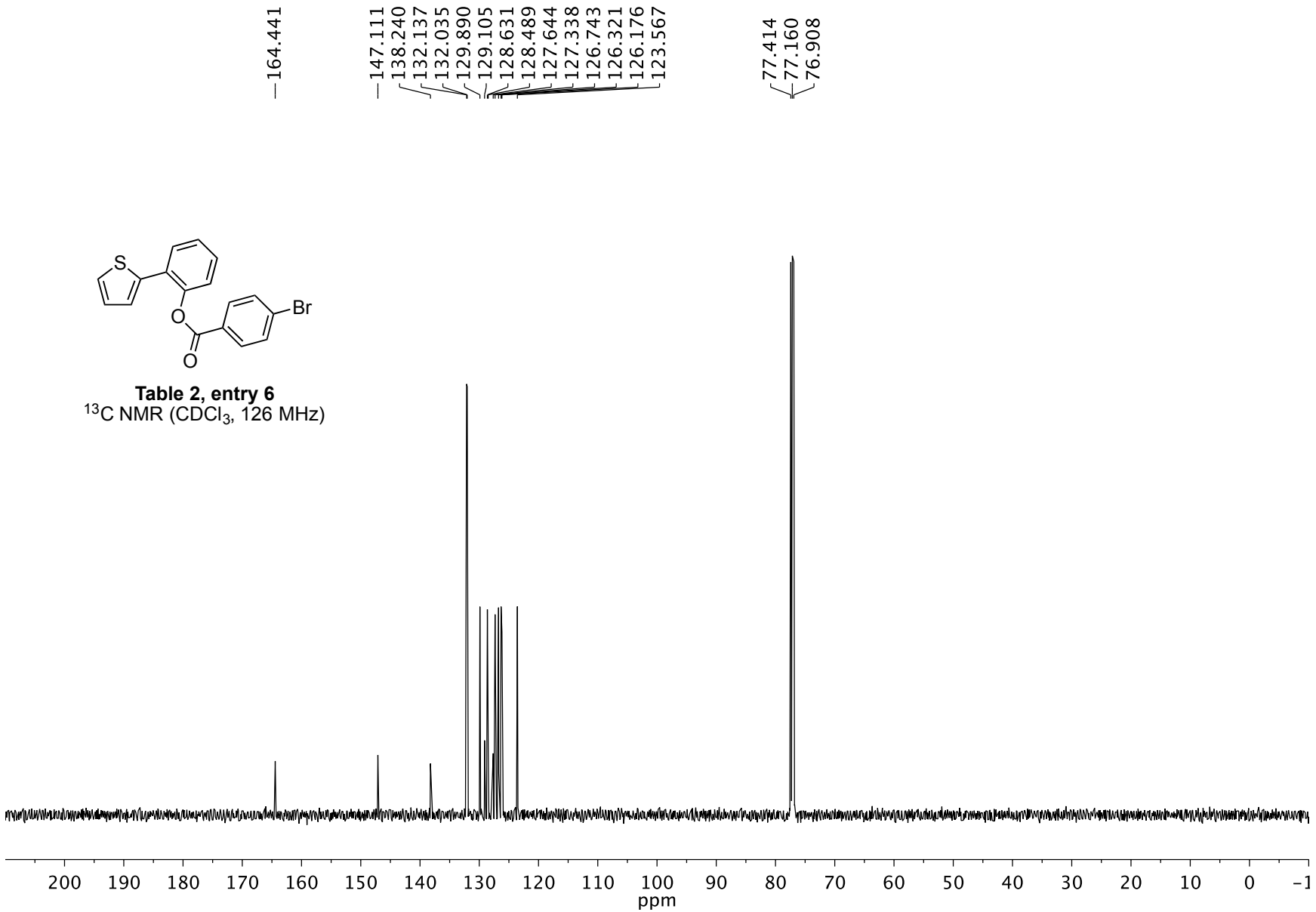
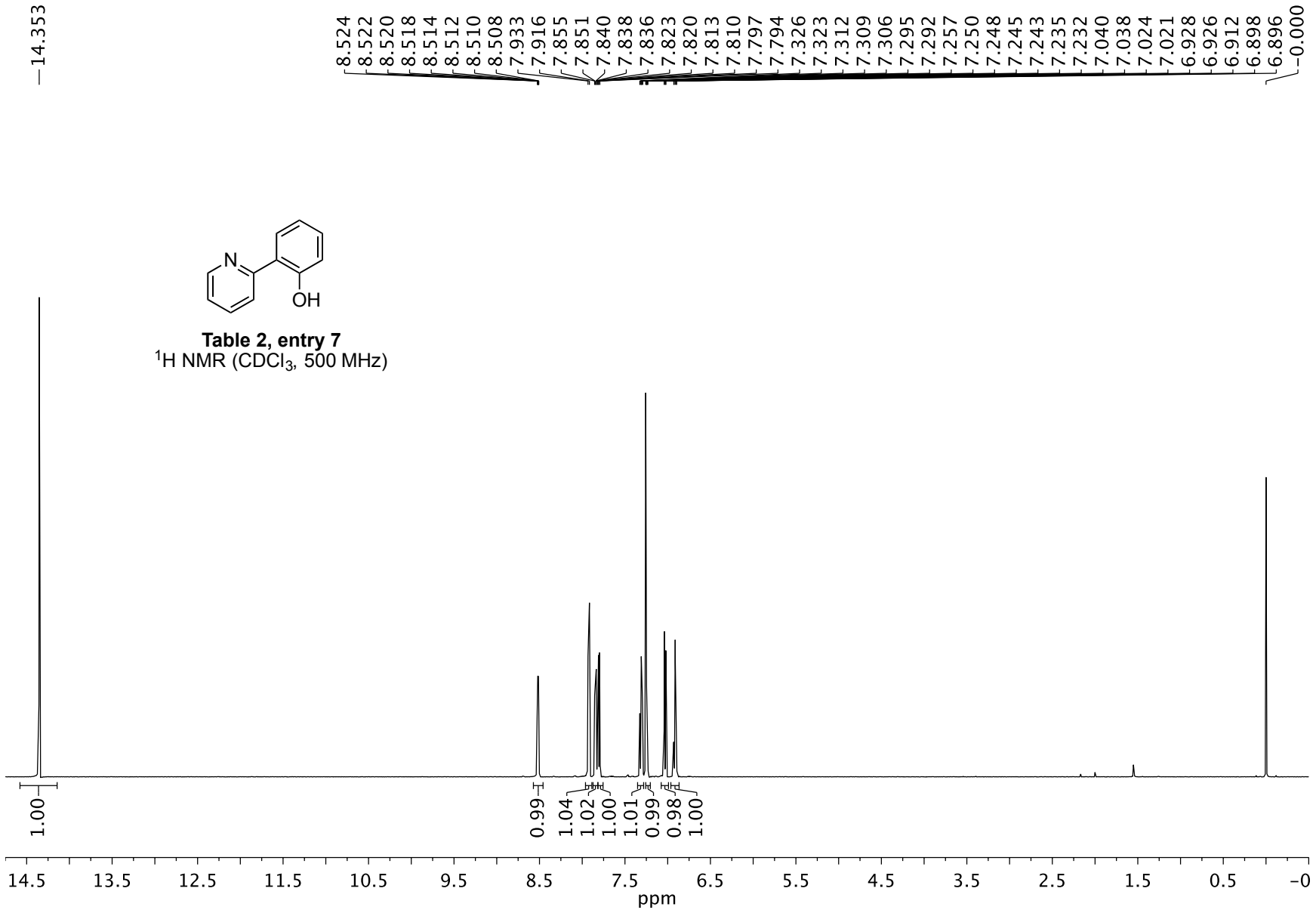


Table 2, entry 6
^{13}C NMR ($CDCl_3$, 126 MHz)


14.353
8.524
8.522
8.520
8.518
8.514
8.512
8.510
8.508
7.933
7.916
7.855
7.851
7.840
7.838
7.836
7.823
7.820
7.813
7.810
7.797
7.794
7.326
7.323
7.312
7.309
7.306
7.295
7.292
7.257
7.250
7.248
7.245
7.243
7.235
7.232
7.040
7.038
7.024
7.021
6.928
6.926
6.912
6.898
6.896
0.000
N
OH
Table 2, entry 7
1H NMR (CDCl3, 500 MHz)
1.00
0.99
1.04
1.02
1.00
1.01
0.99
0.98
1.00
14.5
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0
ppm

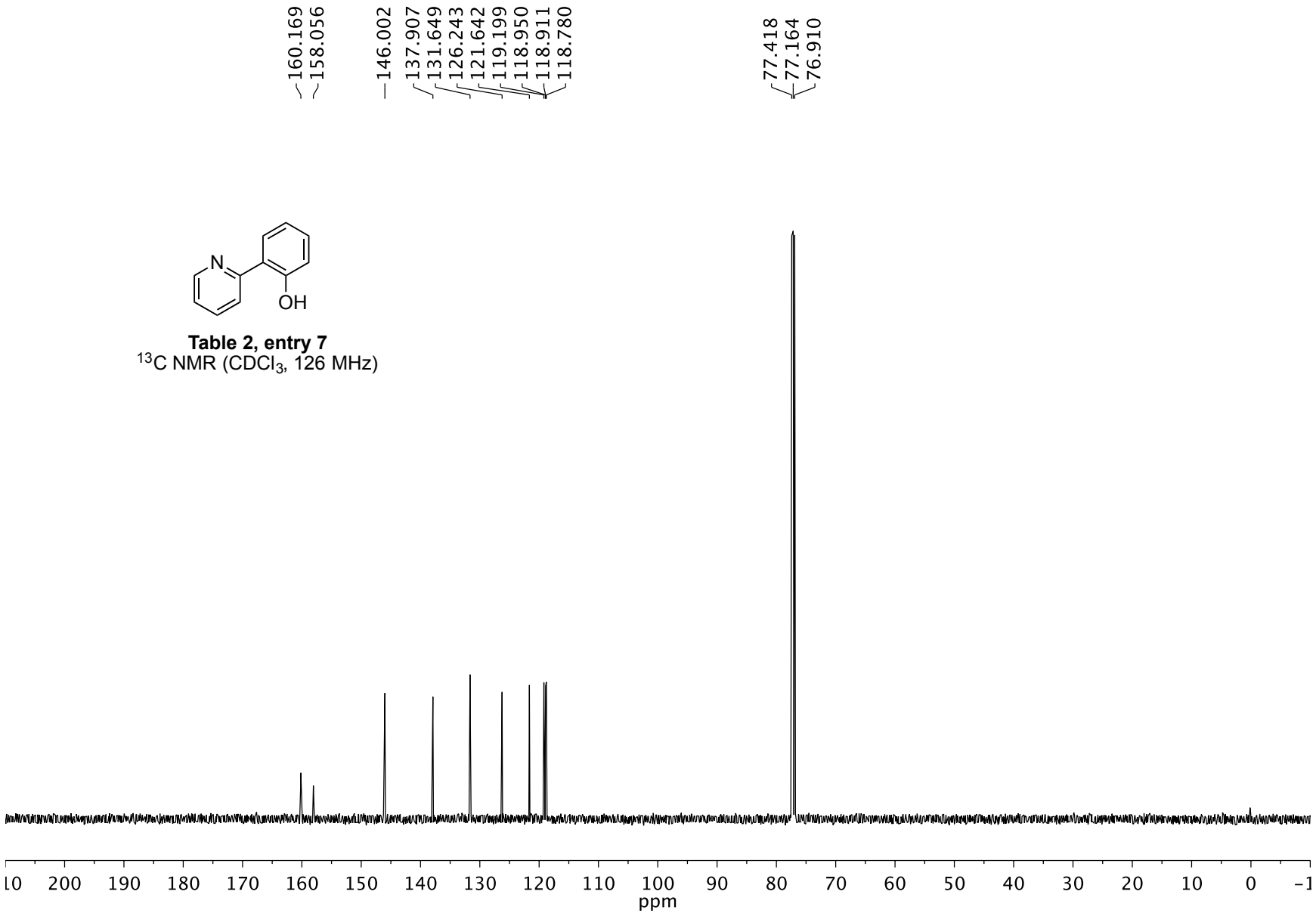


Table 2, entry 7
^{13}C NMR ($CDCl_3$, 126 MHz)

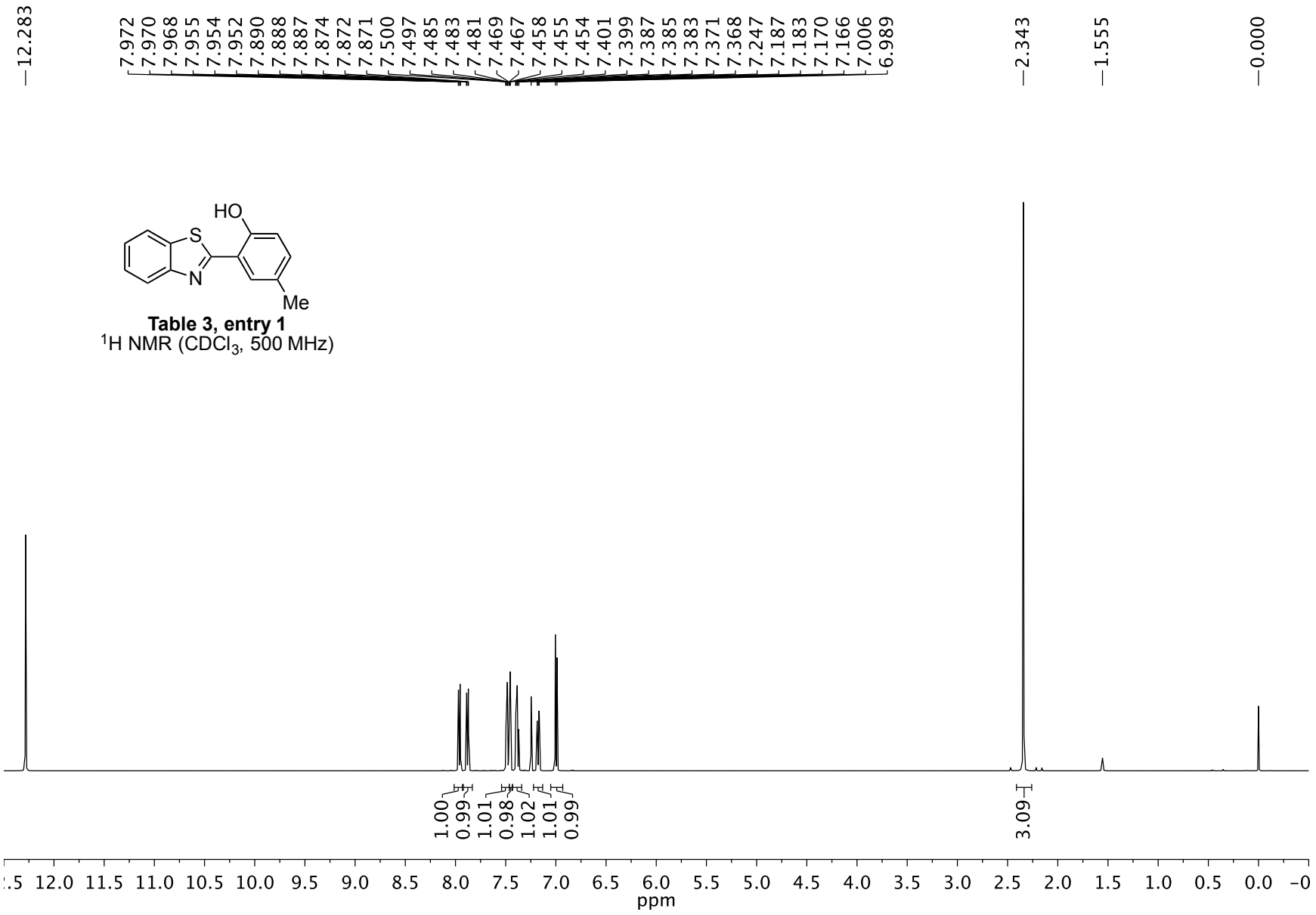


Table 3, entry 1
^{1}H NMR ($CDCl_3$, 500 MHz)

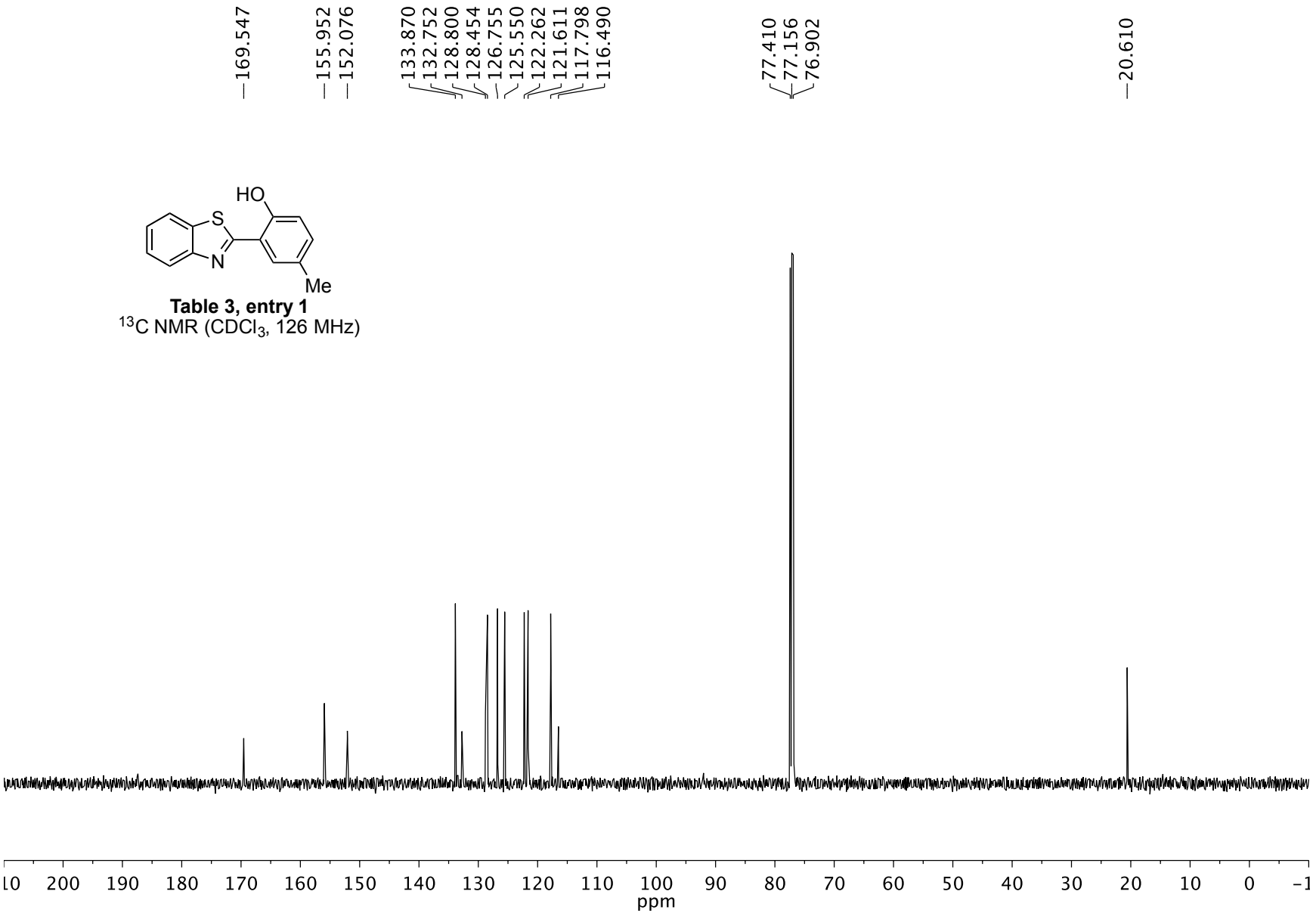


Table 3, entry 1
^{13}C NMR ($CDCl_3$, 126 MHz)

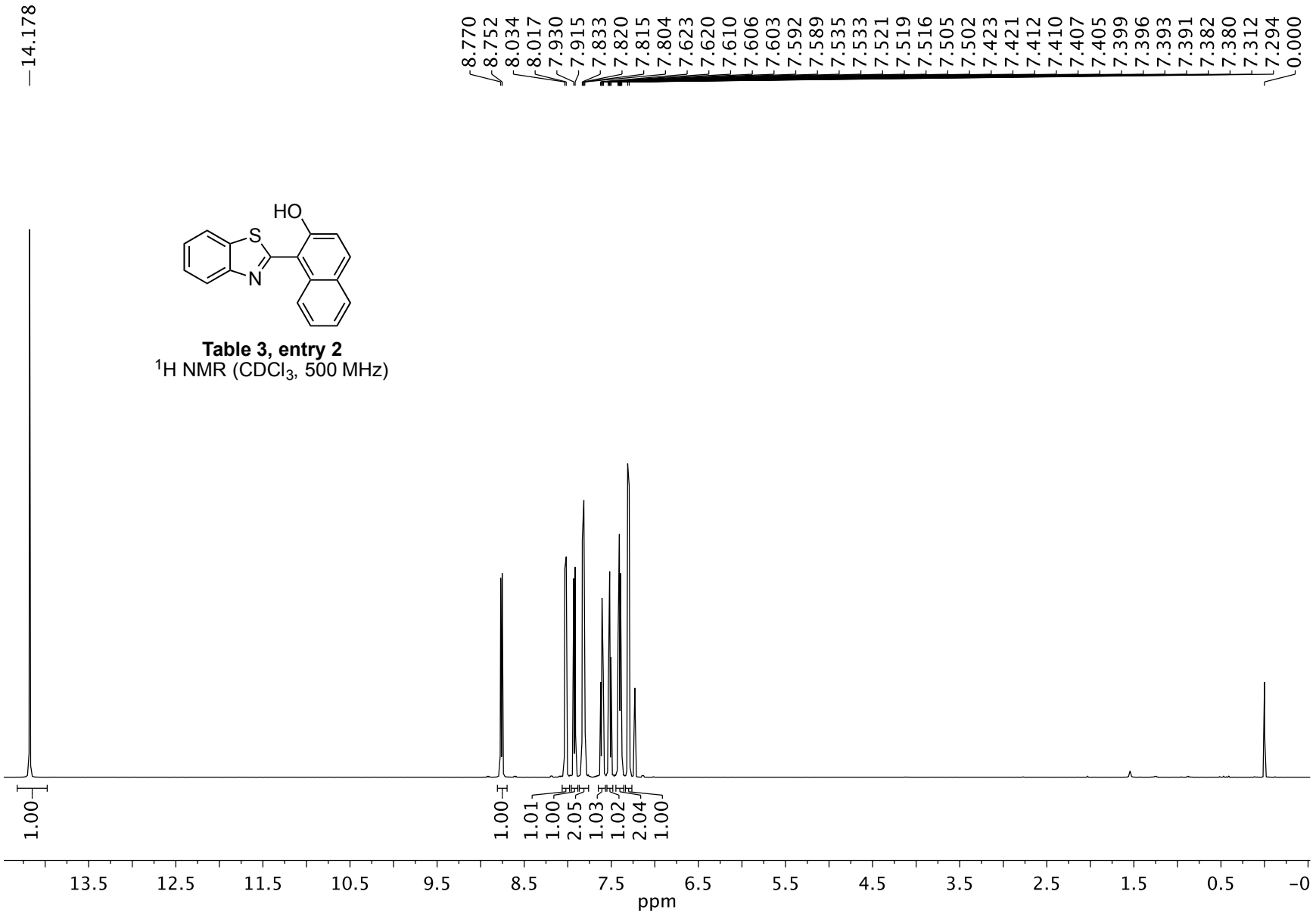


Table 3, entry 2
^{1}H NMR ($CDCl_3$, 500 MHz)

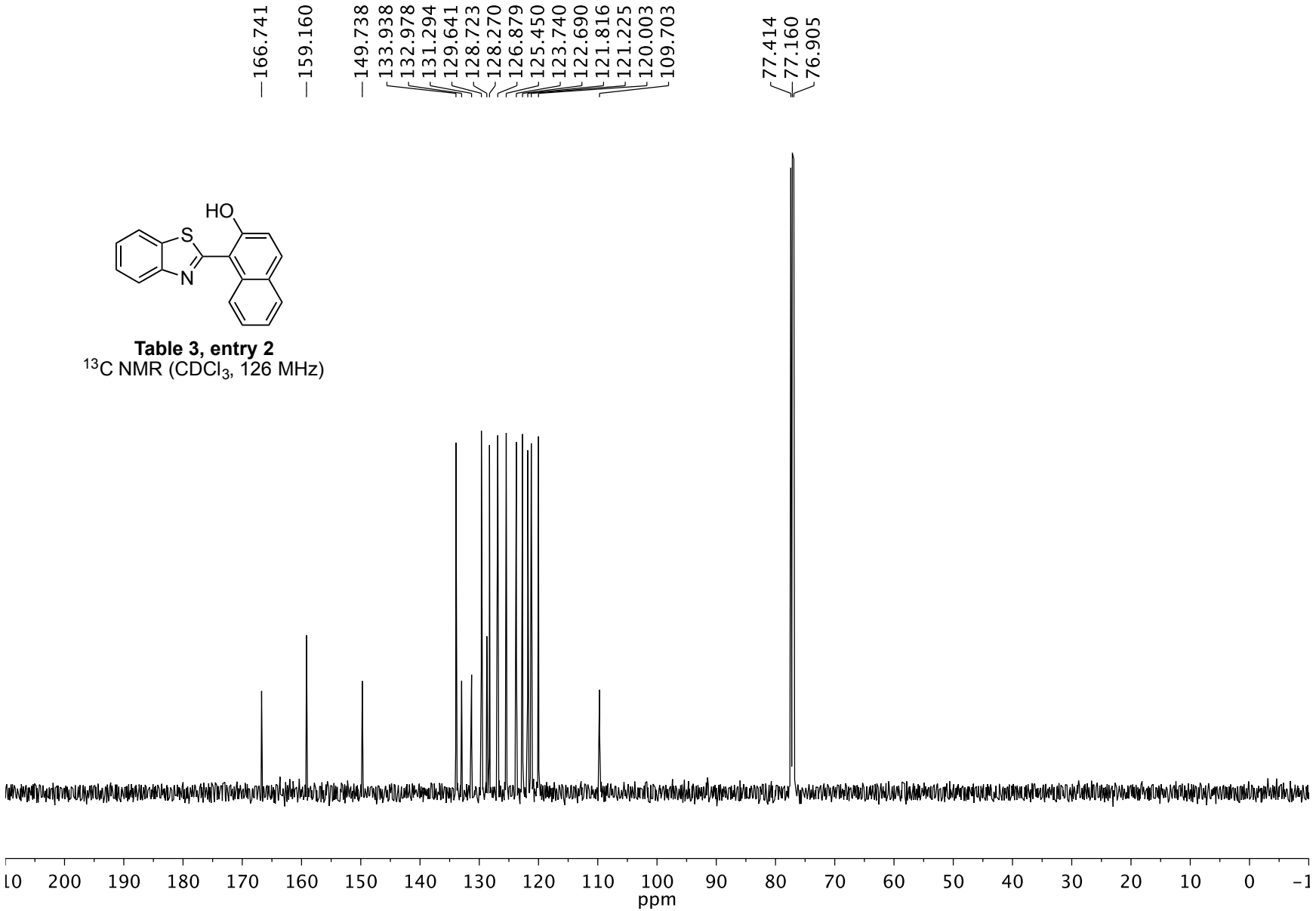
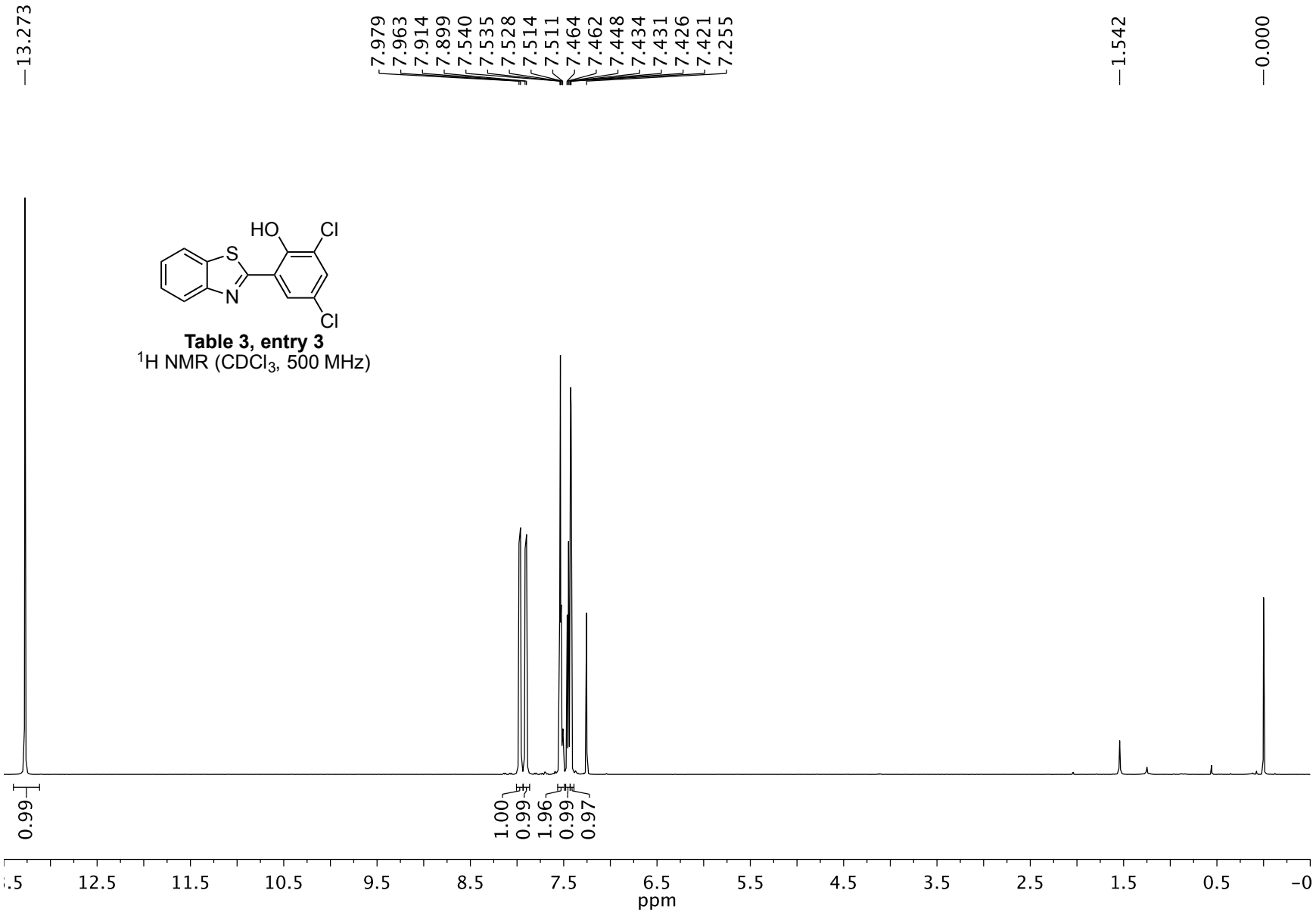


Table 3, entry 2
^{13}C NMR ($CDCl_3$, 126 MHz)


13.273
7.979
7.963
7.914
7.899
7.540
7.535
7.528
7.514
7.511
7.464
7.462
7.448
7.434
7.431
7.426
7.421
7.255
1.542
0.000
HO
Cl
S
N
Cl
Table 3, entry 3
1H NMR (CDCl3, 500 MHz)
0.99
1.00
0.99
1.96
0.99
0.97
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
ppm

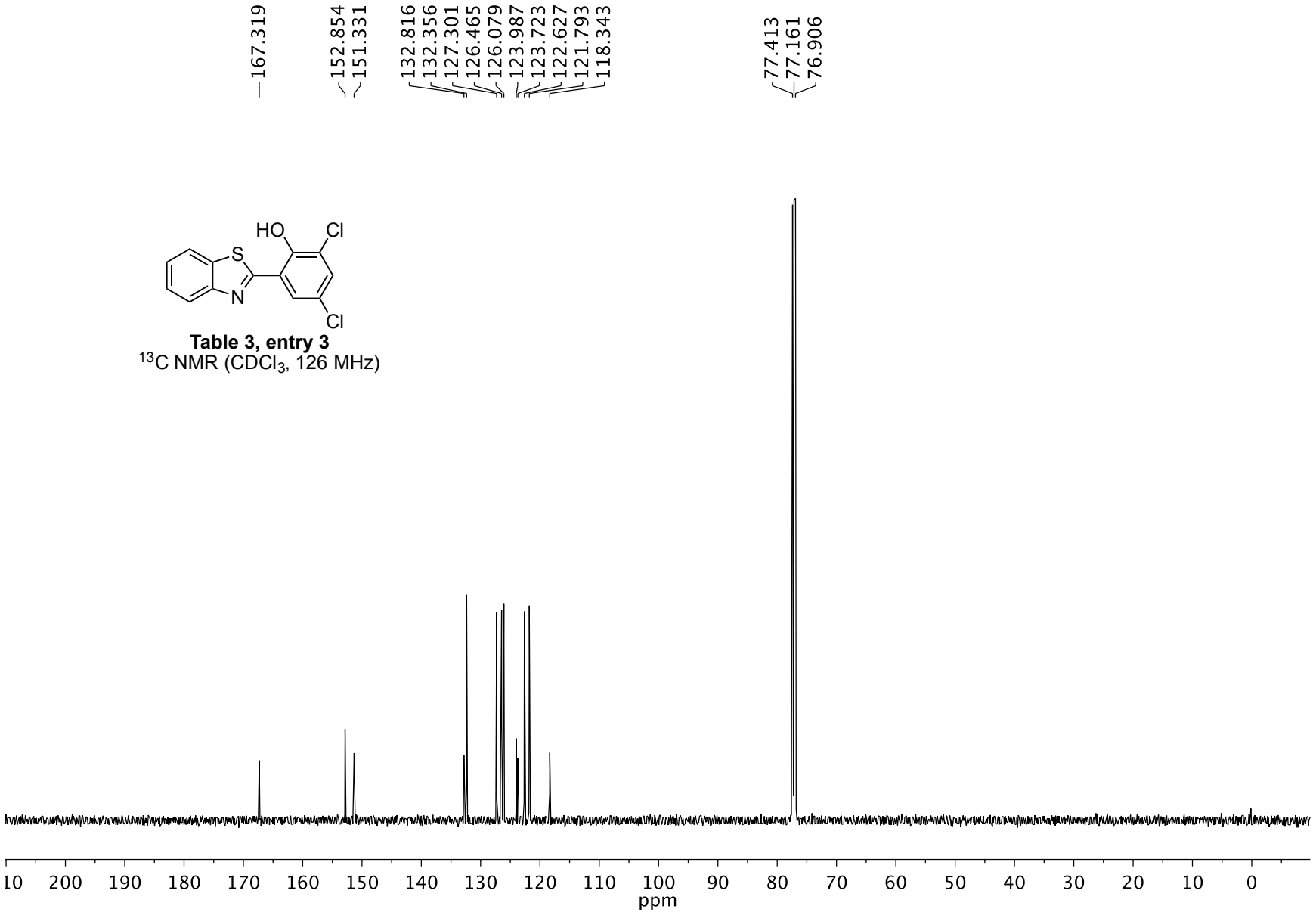


Table 3, entry 3
^{13}C NMR ($CDCl_3$, 126 MHz)

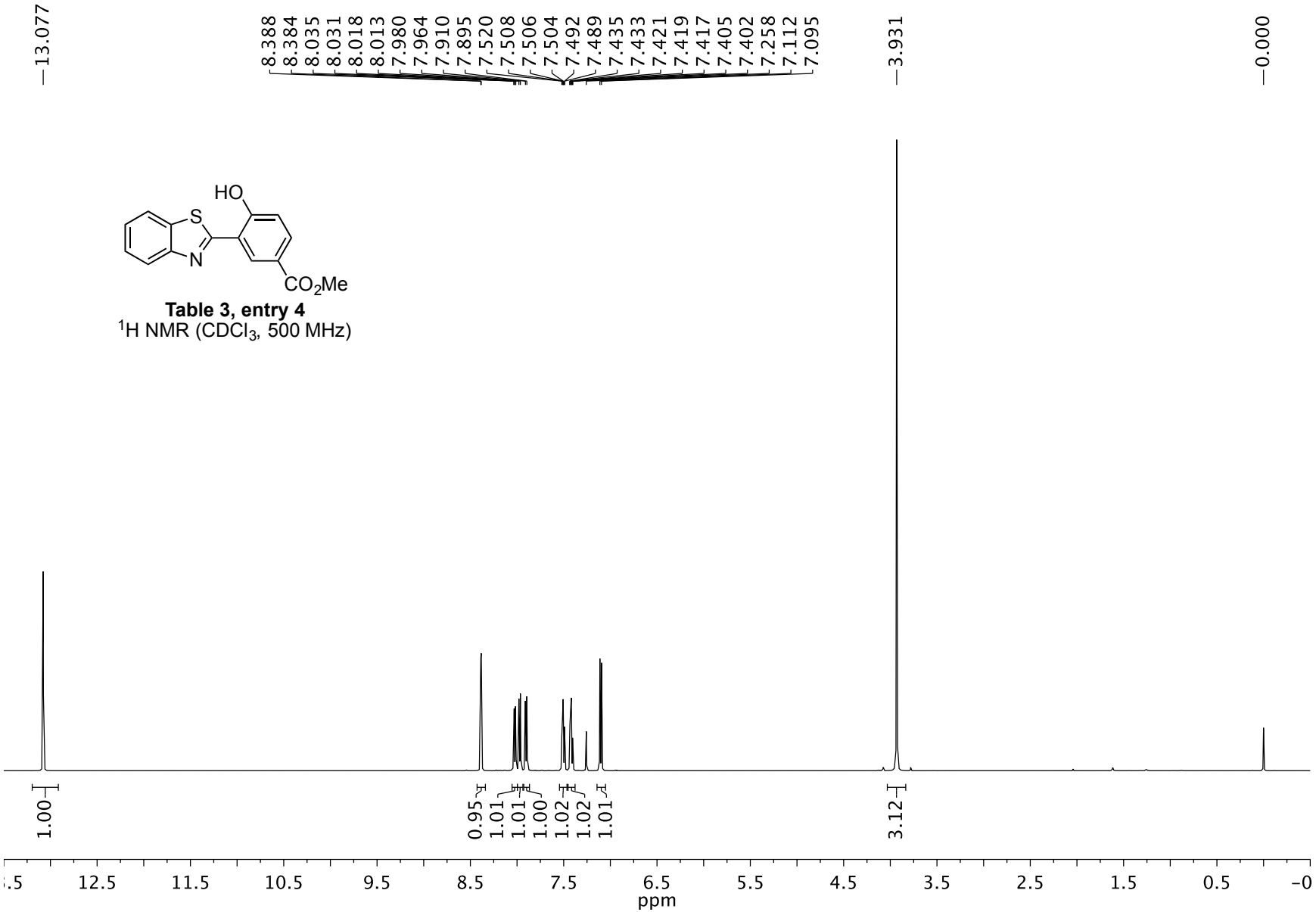


Table 3, entry 4
^{1}H NMR ($CDCl_3$, 500 MHz)

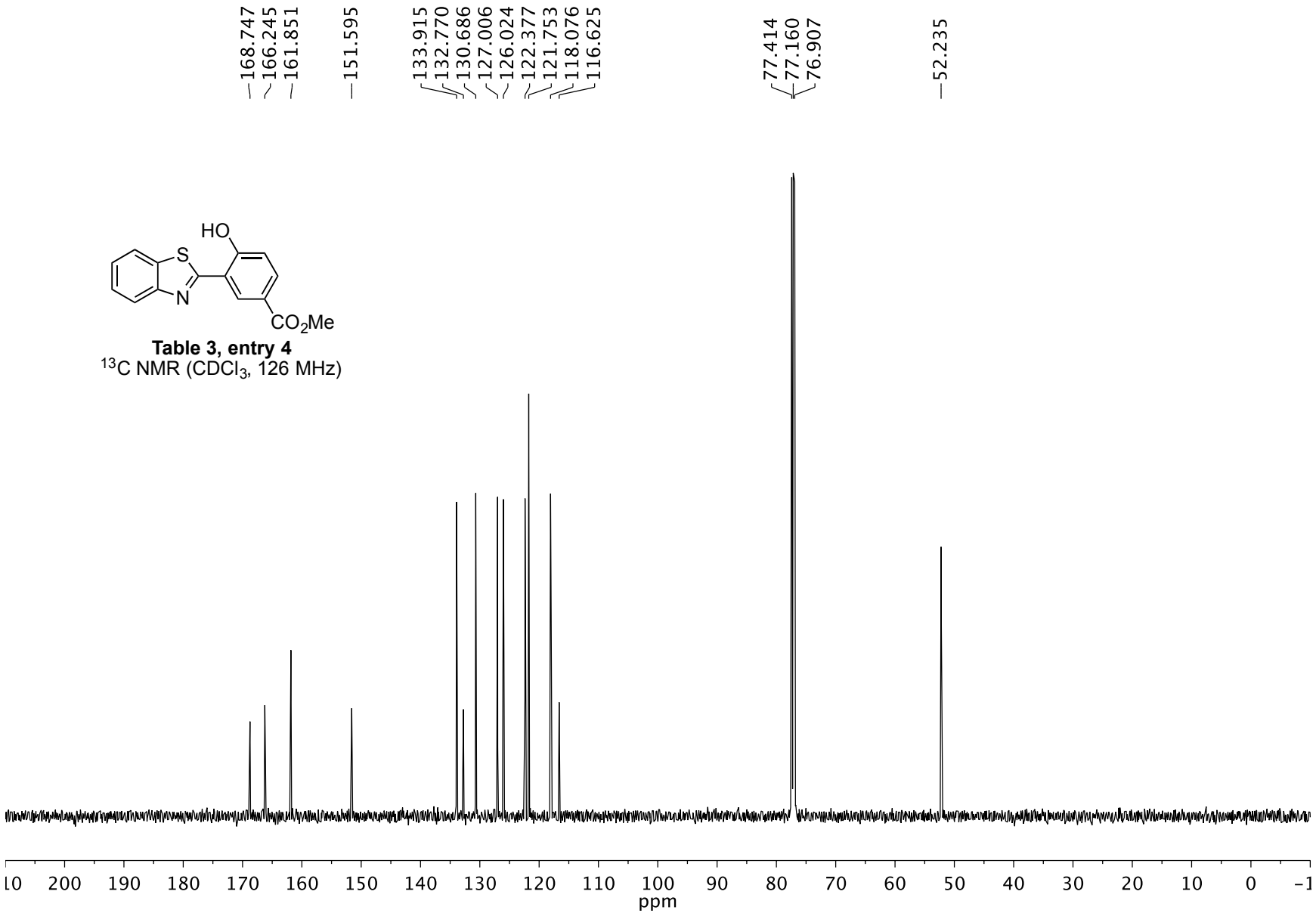


Table 3, entry 4
^{13}C NMR ($CDCl_3$, 126 MHz)

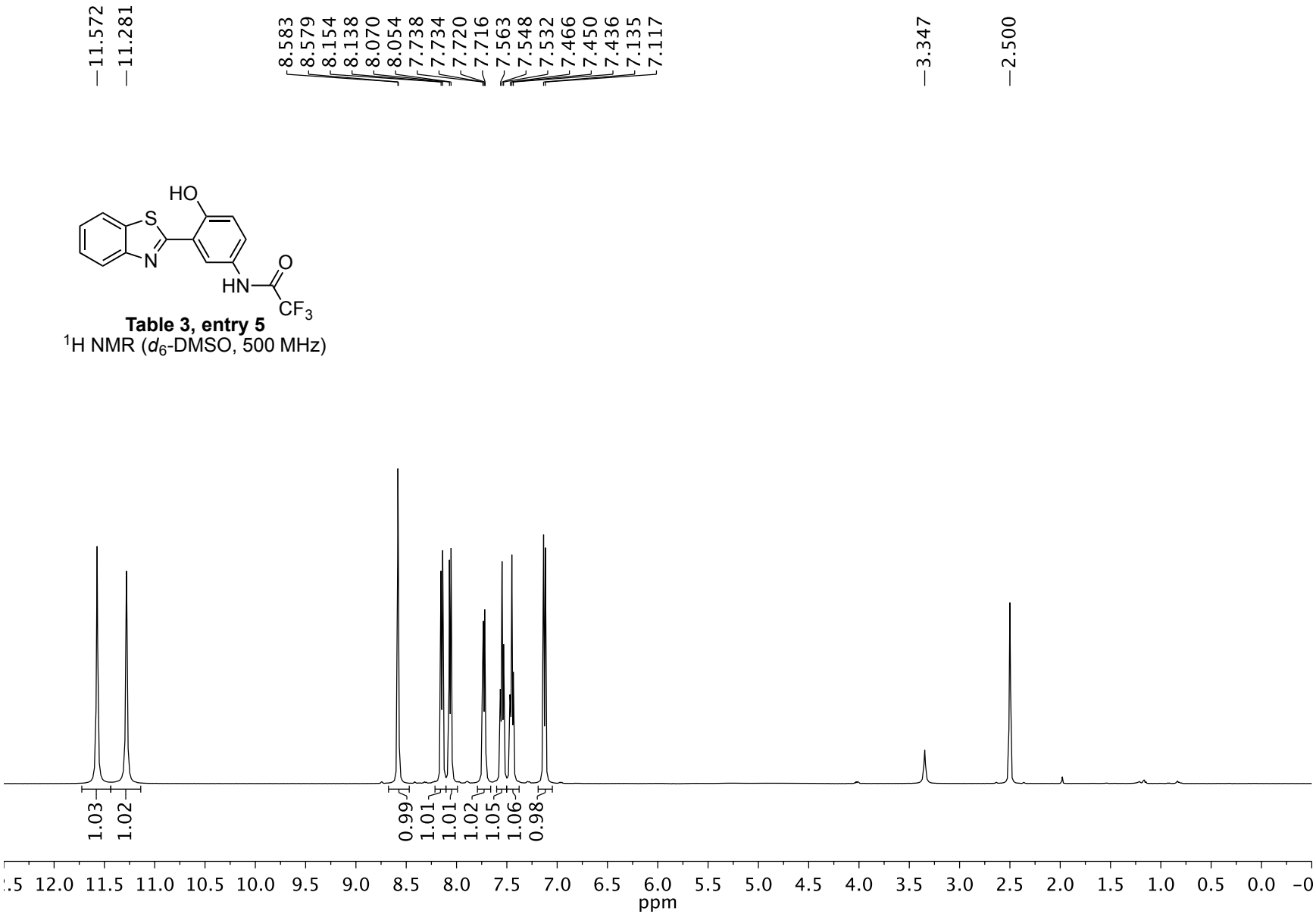


Table 3, entry 5
^{1}H NMR (d_6-DMSO, 500 MHz)

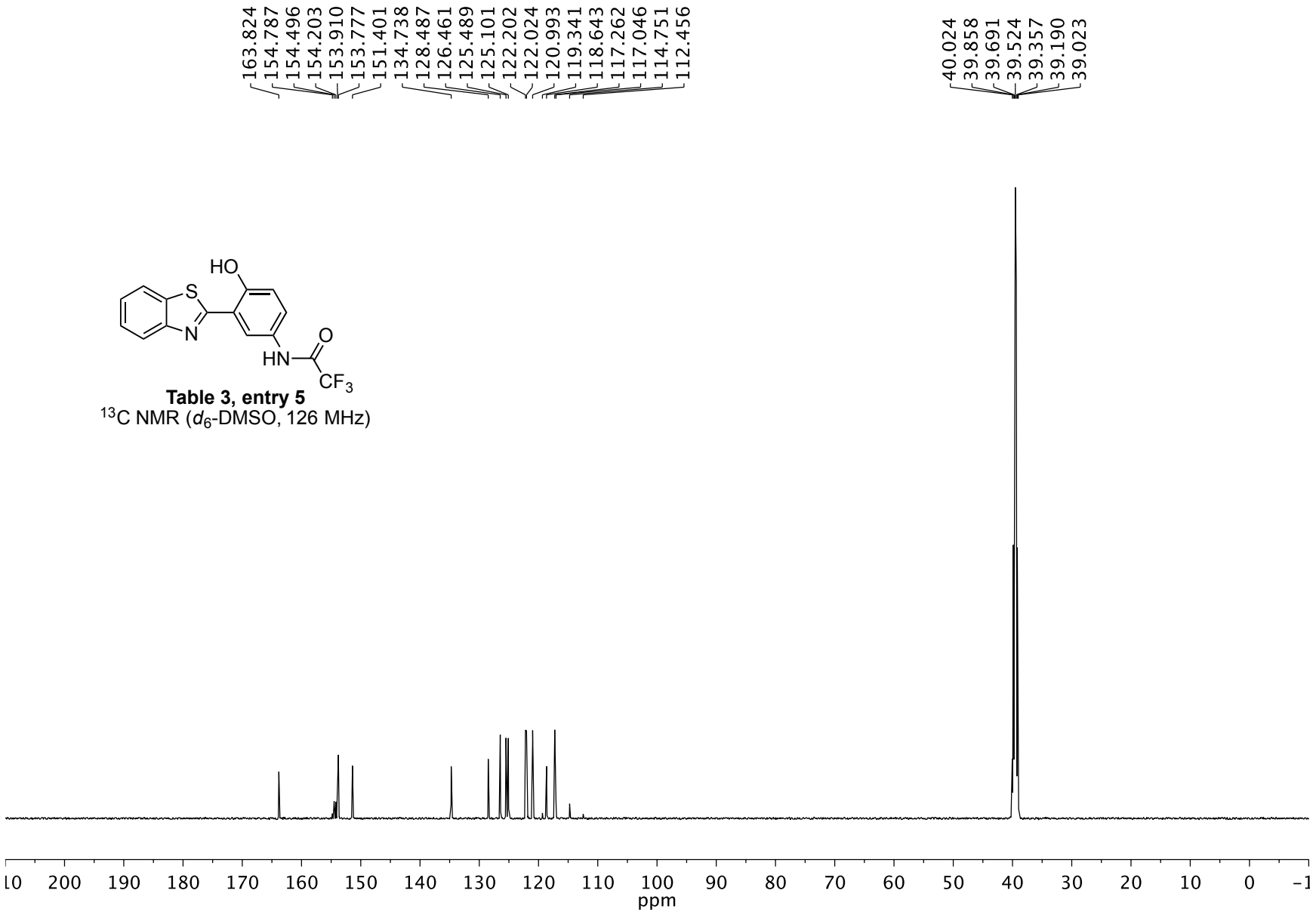
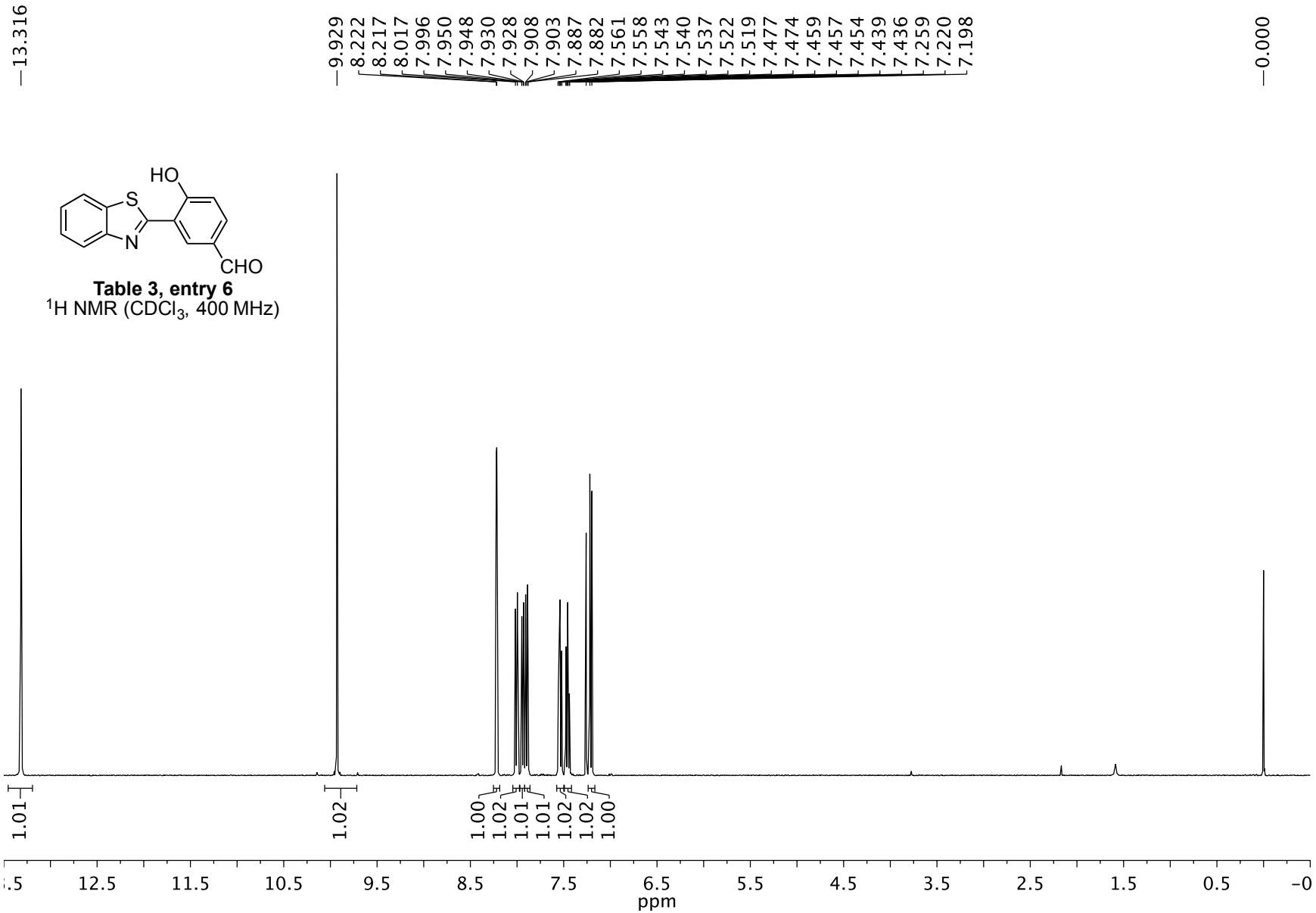


Table 3, entry 5
^{13}C NMR (d_6-DMSO, 126 MHz)


13.316
9.929
8.222
8.217
8.017
7.996
7.950
7.948
7.930
7.928
7.908
7.903
7.887
7.882
7.561
7.558
7.543
7.540
7.537
7.522
7.519
7.477
7.474
7.459
7.457
7.454
7.439
7.436
7.259
7.220
7.198
0.000
HO
S
N
CHO
Table 3, entry 6
1H NMR (CDCl3, 400 MHz)
1.01
1.02
1.00
1.02
1.01
1.01
1.02
1.02
1.00
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
ppm

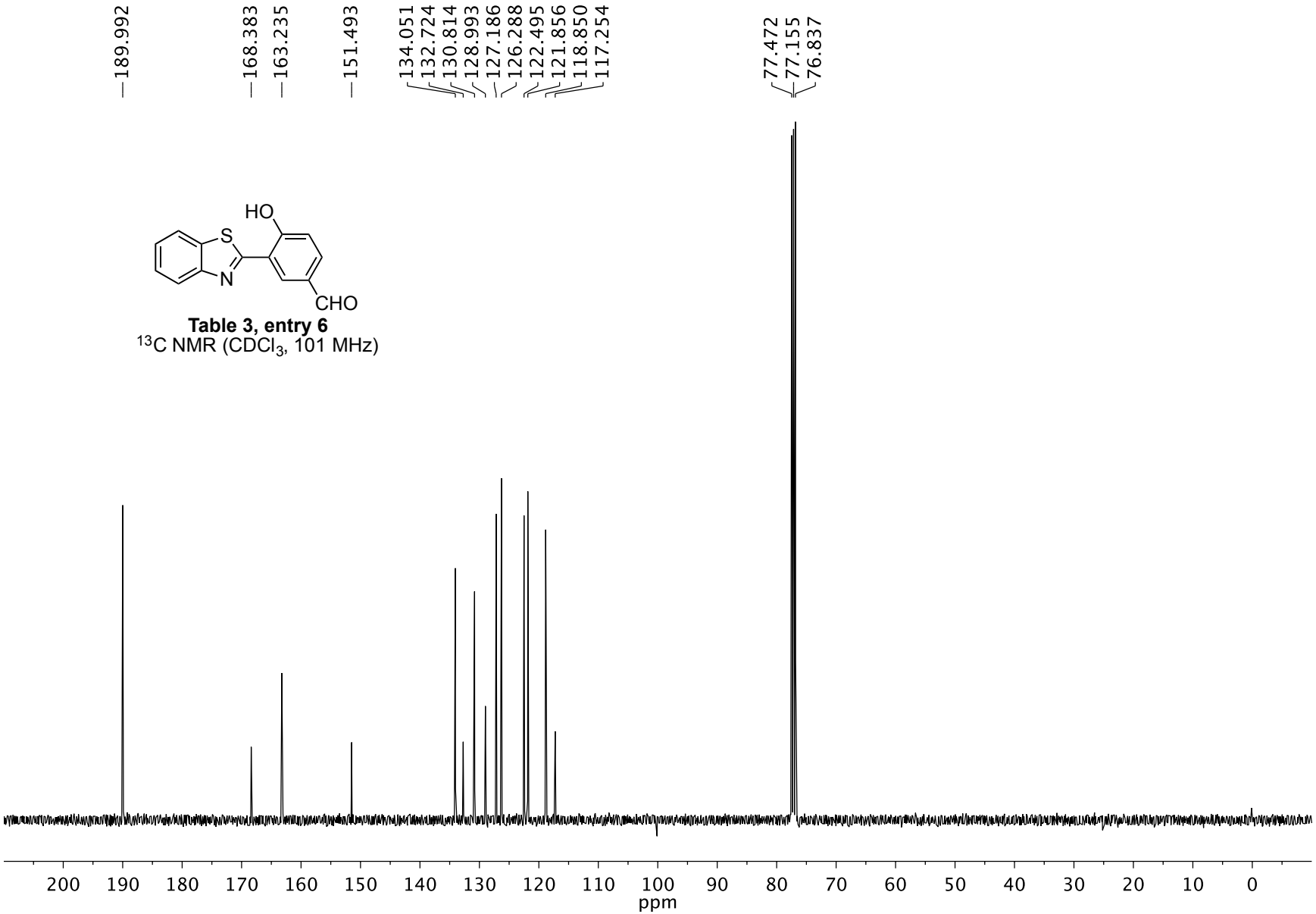
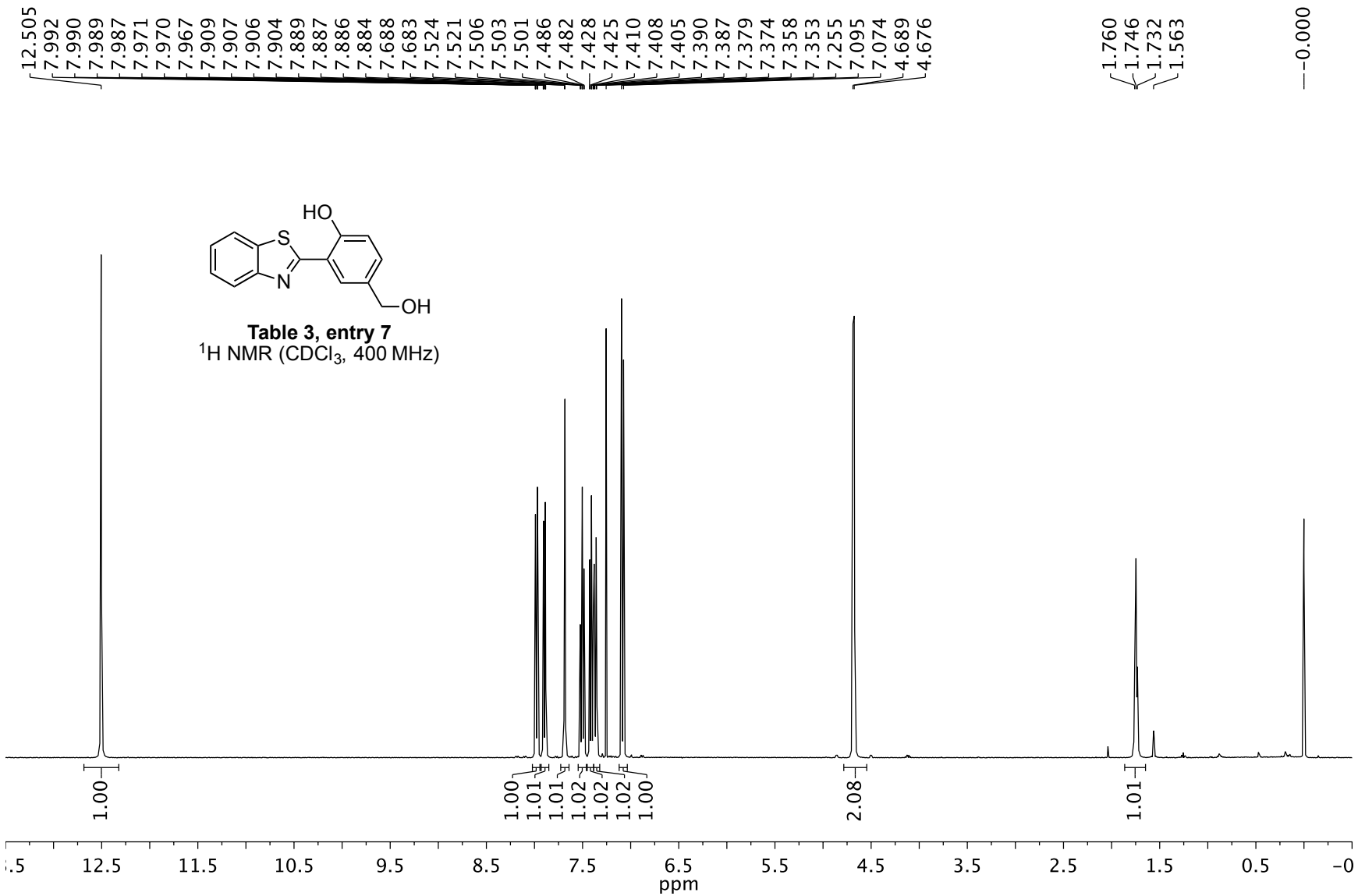


Table 3, entry 6
^{13}C NMR ($CDCl_3$, 101 MHz)


12.505
7.992
7.990
7.989
7.987
7.971
7.970
7.967
7.909
7.907
7.906
7.904
7.889
7.887
7.886
7.884
7.688
7.683
7.524
7.521
7.506
7.503
7.501
7.486
7.482
7.428
7.425
7.410
7.408
7.405
7.390
7.387
7.379
7.374
7.358
7.353
7.255
7.095
7.074
4.689
4.676
1.760
1.746
1.732
1.563
0.000
HO
S
N
OH
Table 3, entry 7
1H NMR (CDCl3, 400 MHz)
1.00
1.00
1.01
1.01
1.02
1.02
1.02
1.00
2.08
1.01
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
ppm

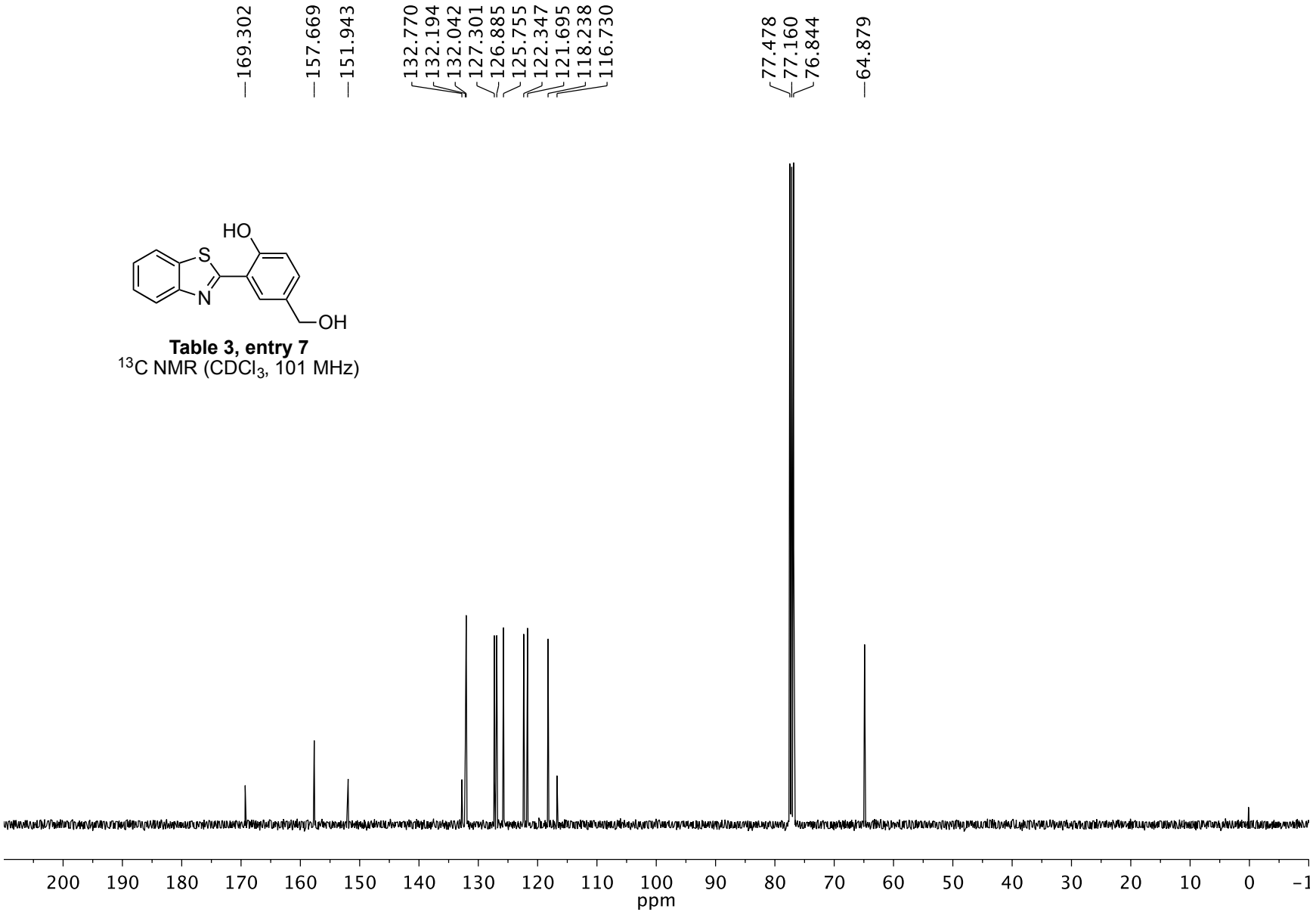


Table 3, entry 7
^{13}C NMR ($CDCl_3$, 101 MHz)

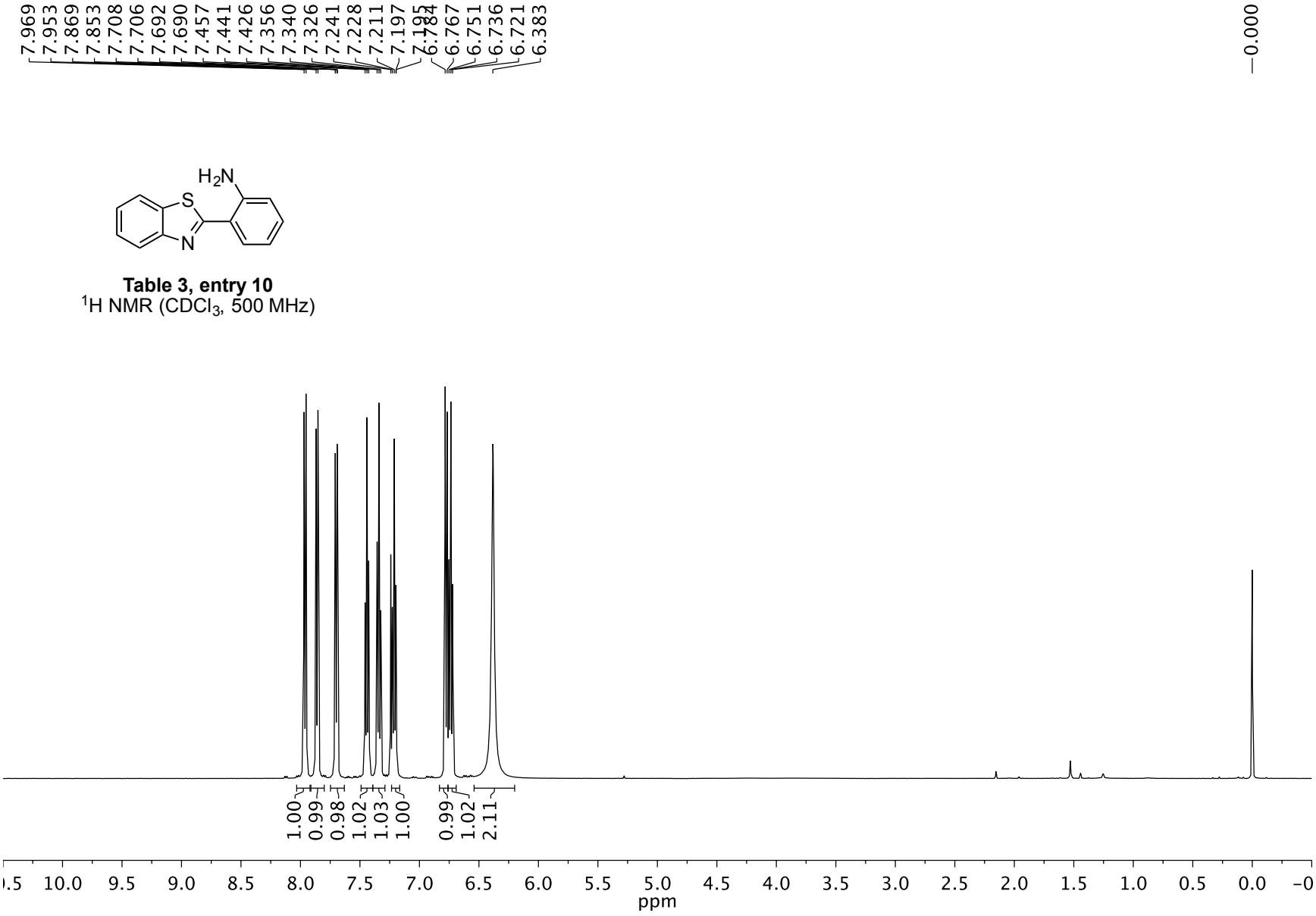


Table 3, entry 10
^{1}H NMR ($CDCl_3$, 500 MHz)

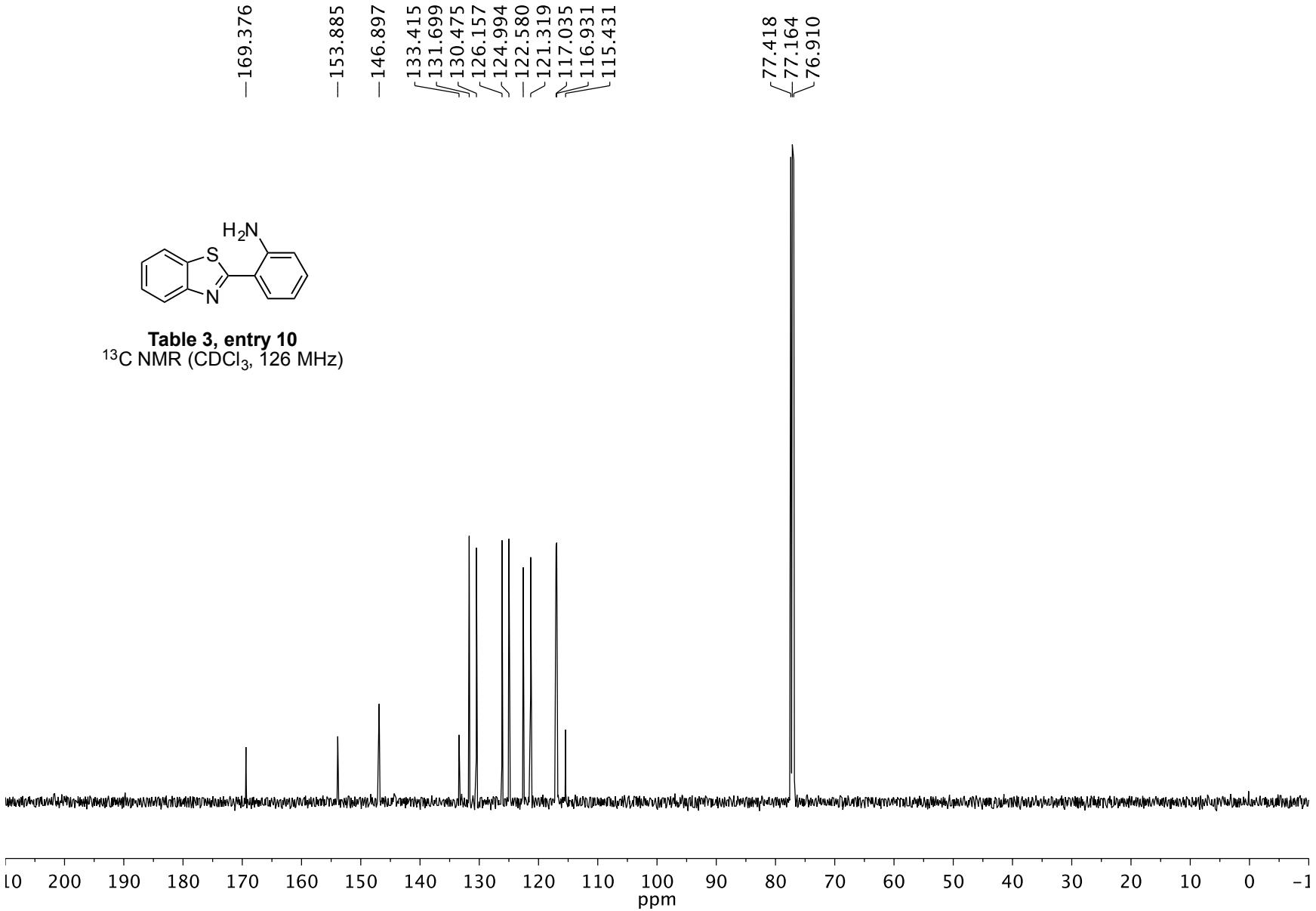


Table 3, entry 10
^{13}C NMR ($CDCl_3$, 126 MHz)

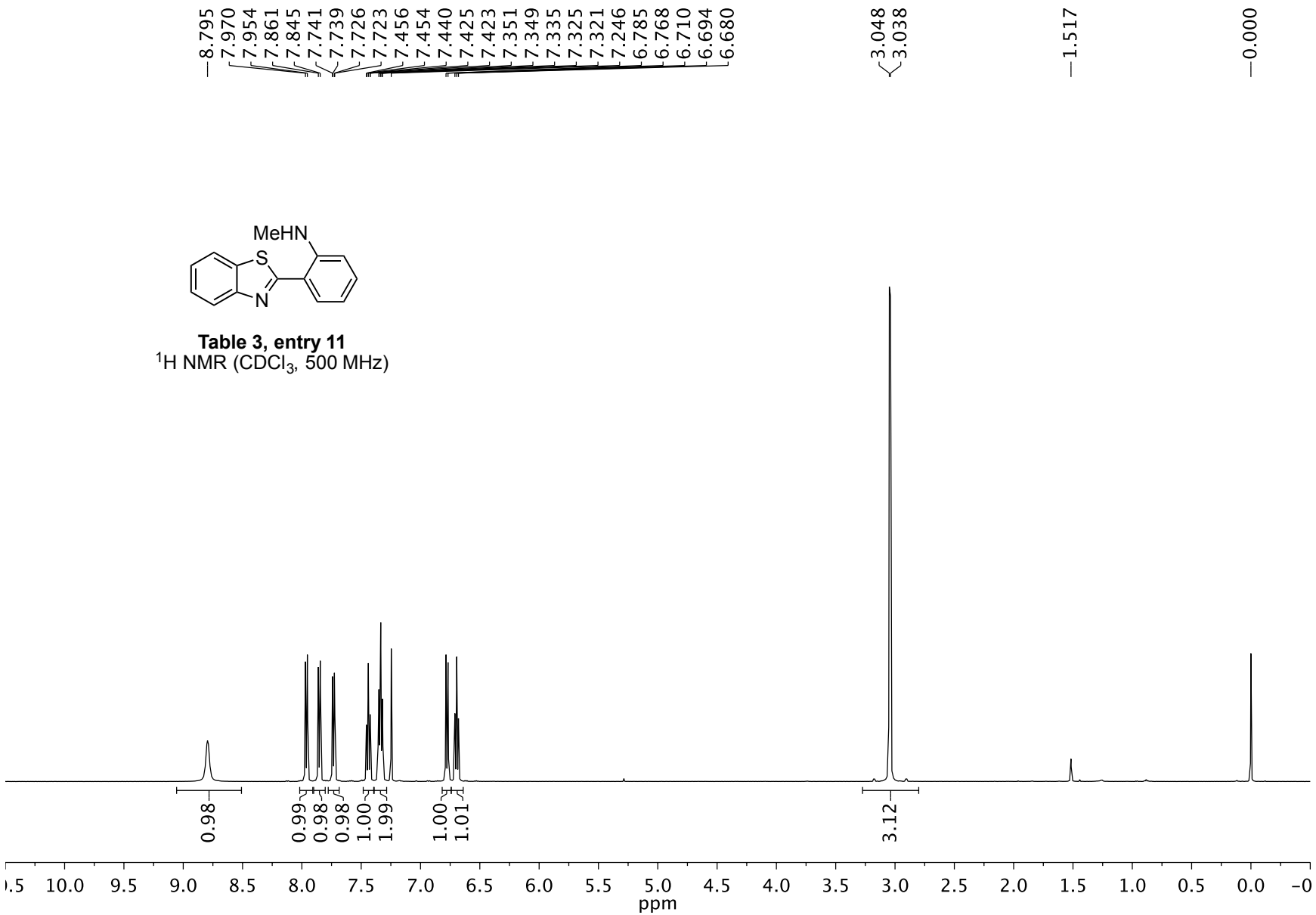


Table 3, entry 11
^{1}H NMR ($CDCl_3$, 500 MHz)

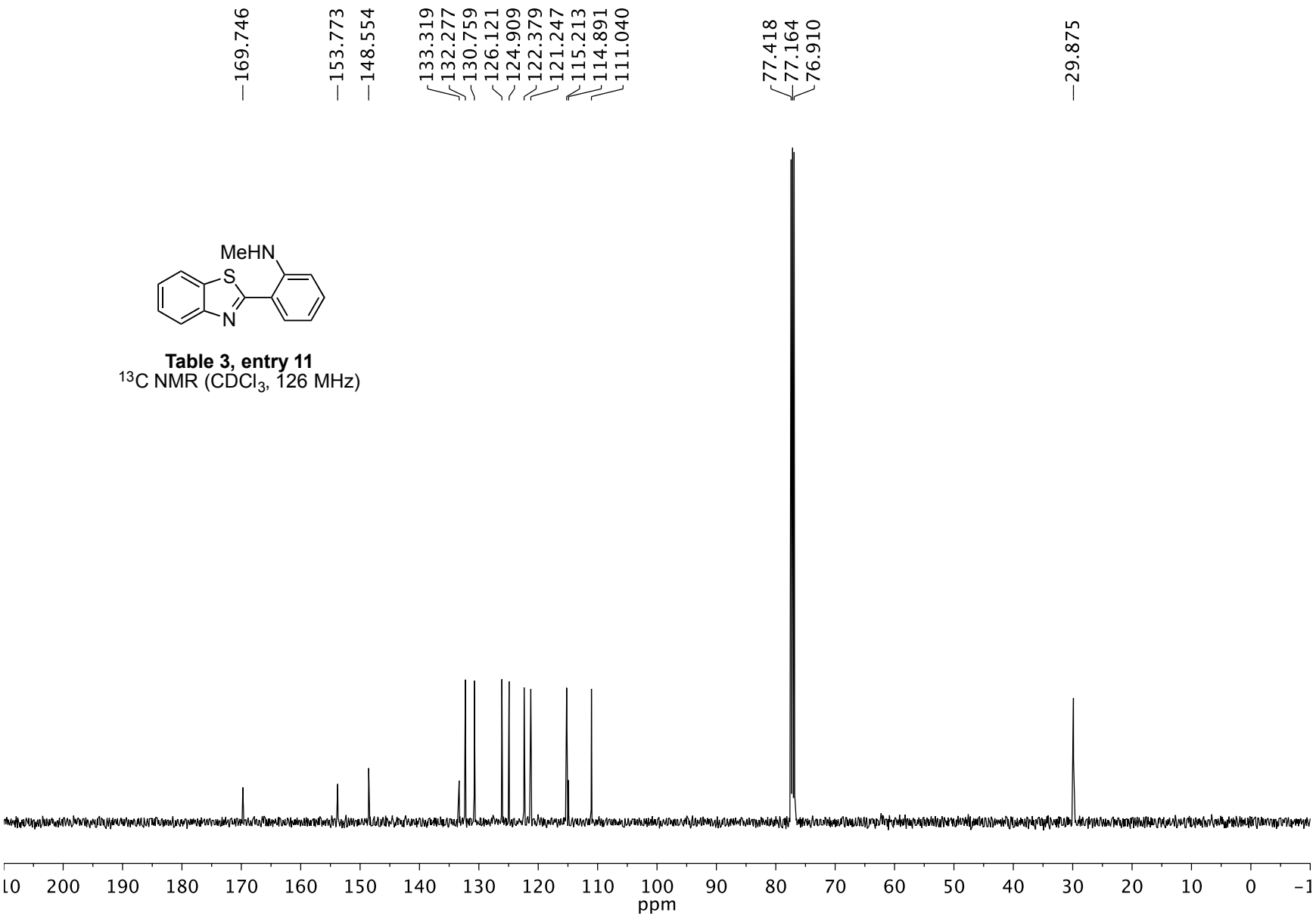
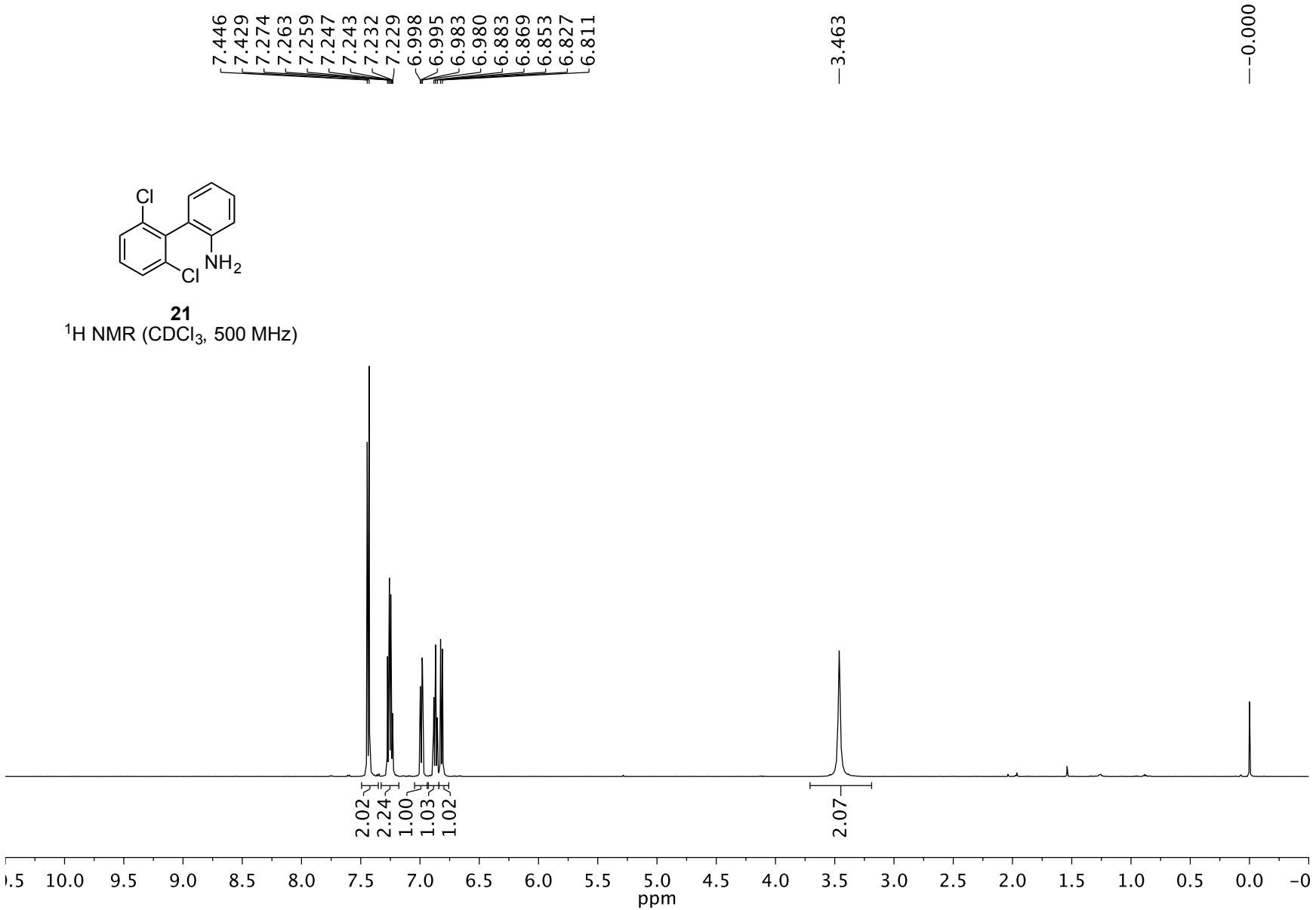
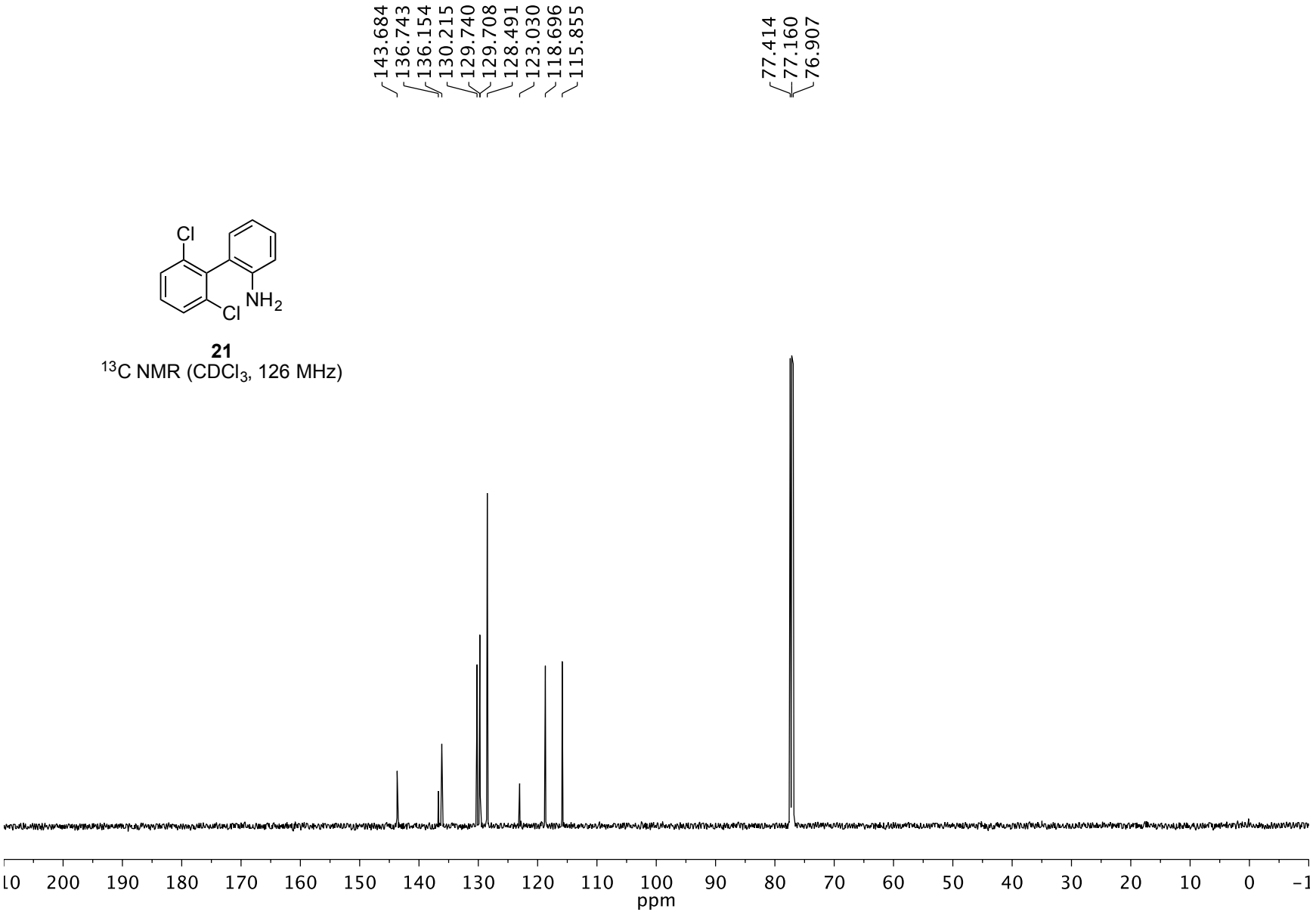


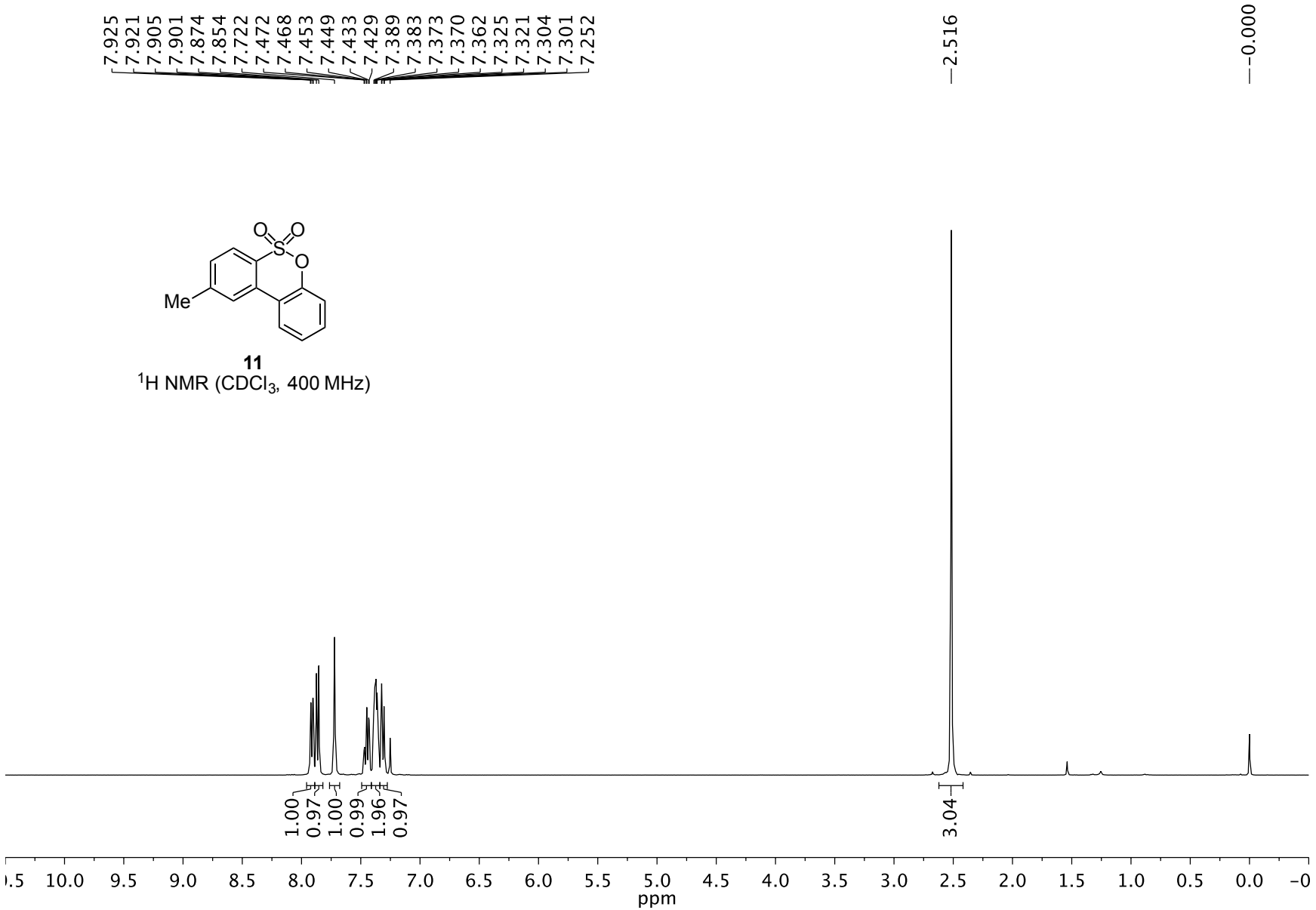
Table 3, entry 11
^{13}C NMR ($CDCl_3$, 126 MHz)

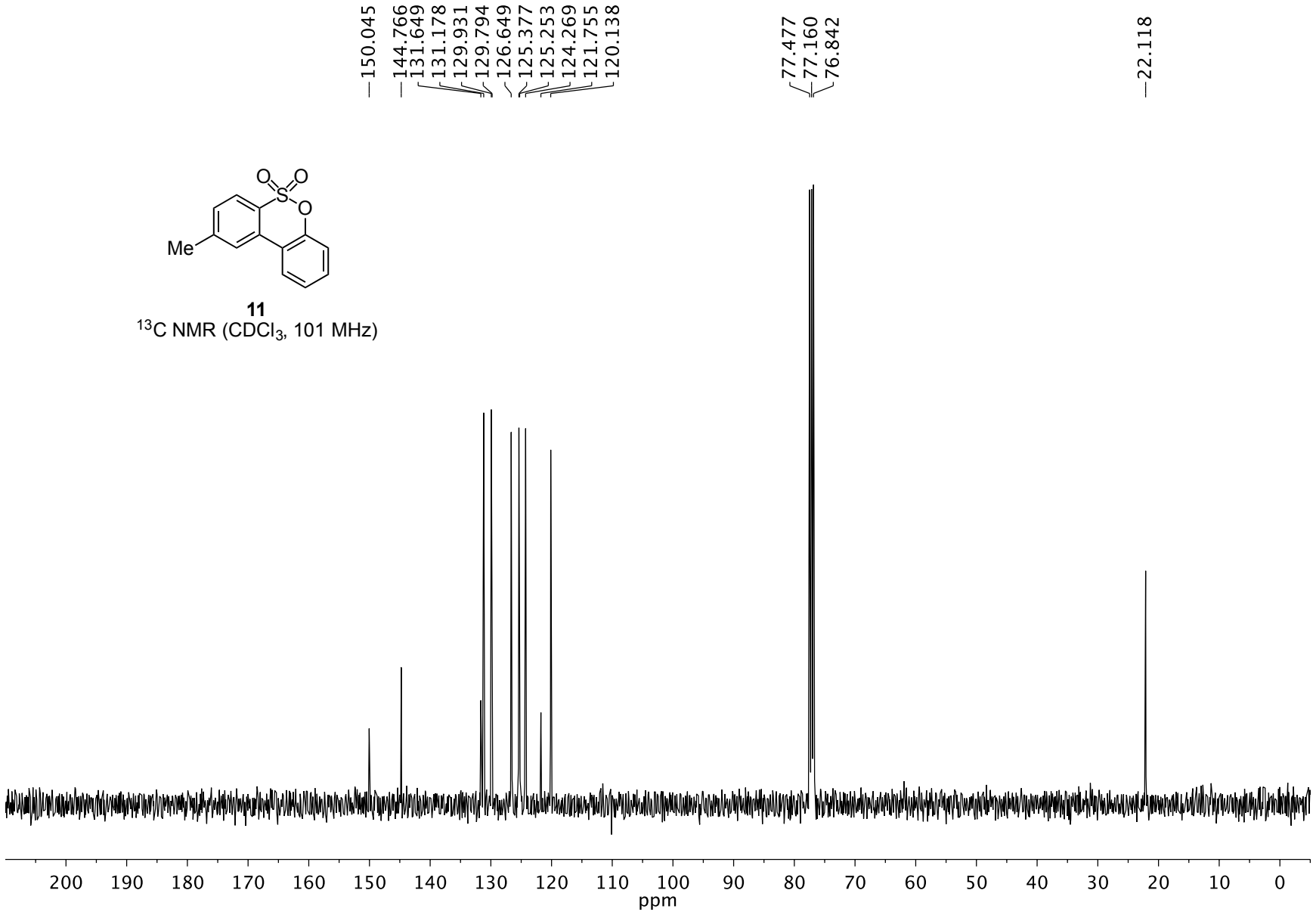


21

^{1}H NMR ($CDCl_3$, 500 MHz)

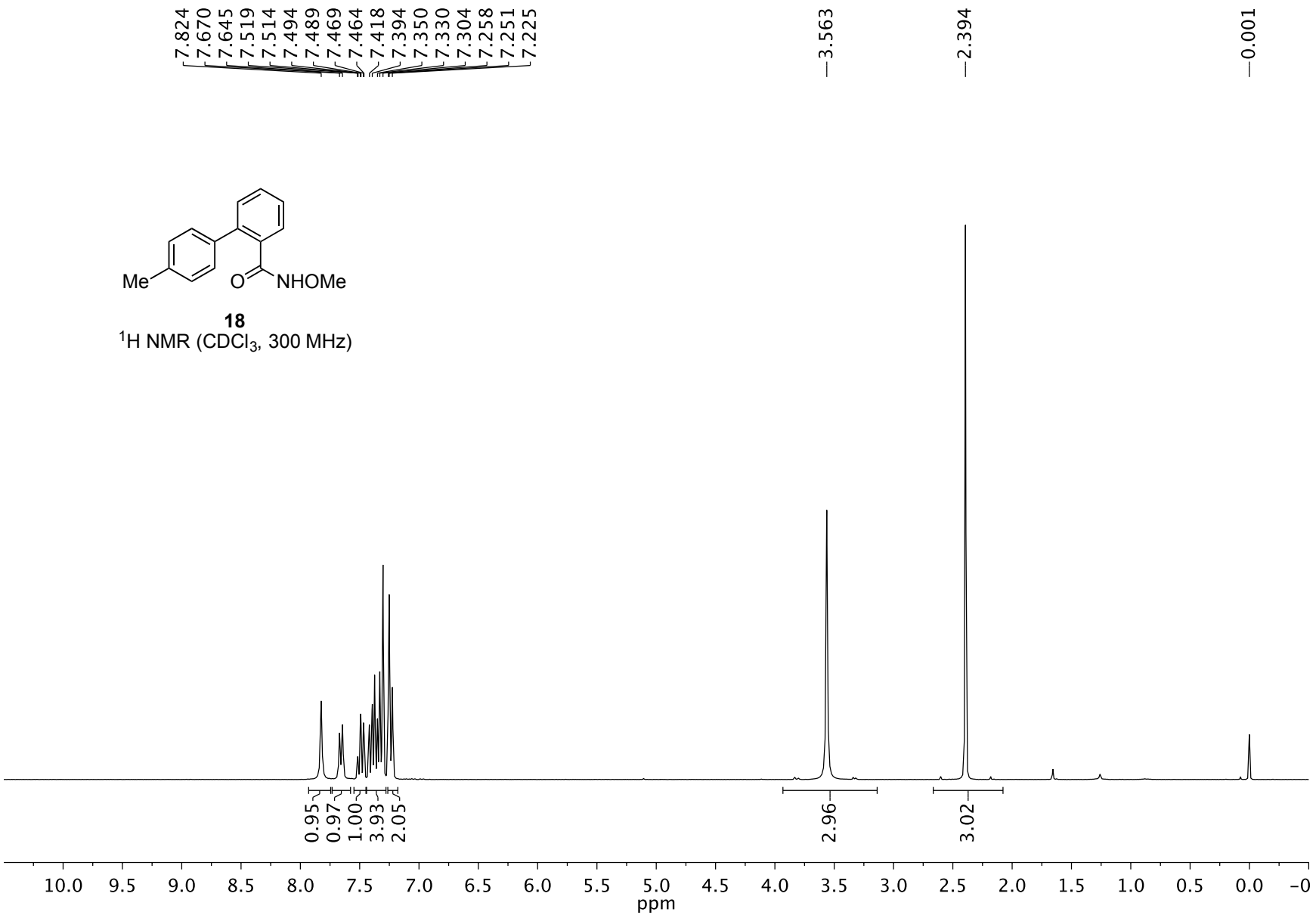

143.684
136.743
136.154
130.215
129.740
129.708
128.491
123.030
118.696
115.855
77.414
77.160
76.907
Cl
Cl
NH2
21
13C NMR (CDCl3, 126 MHz)
ppm

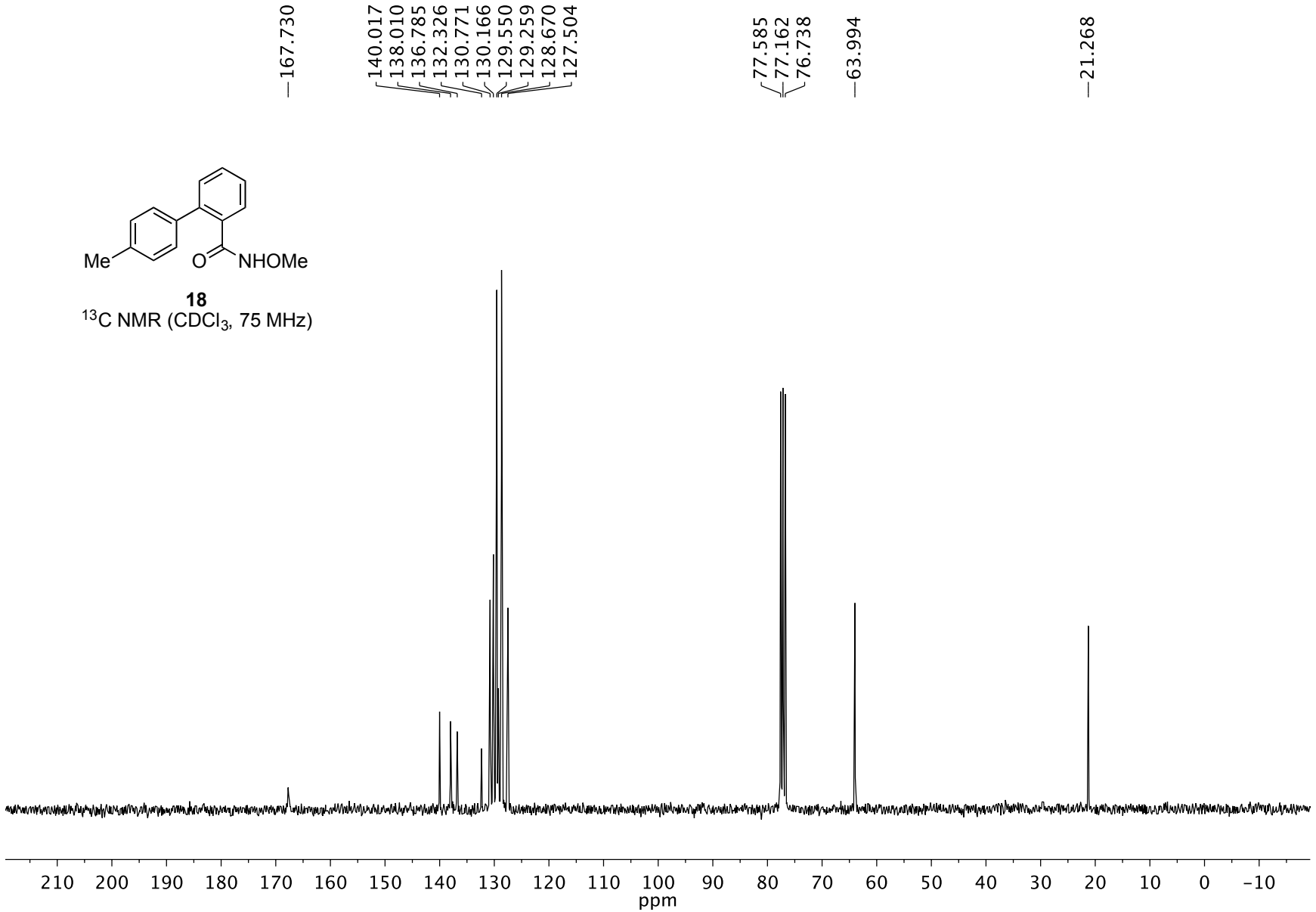

7.925
7.921
7.905
7.901
7.874
7.854
7.722
7.472
7.468
7.453
7.449
7.433
7.429
7.389
7.383
7.373
7.370
7.362
7.325
7.321
7.304
7.301
7.252
2.516
0.000
Me
11
1H NMR (CDCl3, 400 MHz)
1.00
0.97
1.00
0.99
1.96
0.97
3.04
ppm



11

^{13}C NMR ($CDCl_3$, 101 MHz)


7.824
7.670
7.645
7.519
7.514
7.494
7.489
7.469
7.464
7.418
7.394
7.350
7.330
7.304
7.258
7.251
7.225
3.563
2.394
0.001
Me
O
NHOMe
18
1H NMR (CDCl3, 300 MHz)
0.95
0.97
1.00
3.93
2.05
2.96
3.02
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
ppm


167.730
140.017
138.010
136.785
132.326
130.771
130.166
129.550
129.259
128.670
127.504
77.585
77.162
76.738
63.994
21.268
Me
O
NHOMe
18
13C NMR (CDCl3, 75 MHz)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
ppm