Stereocontrolled Synthesis of Bicyclic Sulfamides via Pd-catalyzed Alkene Carboamination Reactions. Control of 1,3-Asymmetric Induction by Manipulating Mechanistic Pathways.

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Supporting Information

Experimental procedures and characterization data for new compounds in Tables 1–2 and Equations 3–5.

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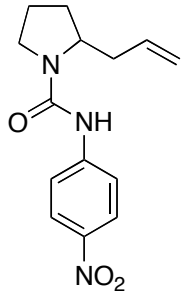
General: All reactions were carried out under a nitrogen atmosphere unless otherwise noted. Palladium acetate was purchased from Strem Chemical Co. and used without purification. All phosphine ligands were obtained from commercial sources and were used without further purification. All other reagents were obtained from commercial sources and were used as obtained unless otherwise noted. *tert*-Butyl 2-allylpyrrolidine-1-carboxylate,[1] *tert*-butyl 2-allylpiperidine-1-carboxylate,[1] (±)-(*E*,2*R**,5*S**)-*tert*-butyl 2-allyl-5-[3-(trimethylsilyl)allyl]pyrrolidine-1-carboxylate,[2] *N*-(4-methoxyphenyl)-2-oxooxazolidine-3-sulfonamide,[3] *N*-(4-chlorophenyl)-2-oxooxazolidine-3-sulfonamide,[4] *N*-benzyl-2-oxooxazolidine-3-sulfonamide,[3] *N*-(4-methoxybenzyl)-2-oxooxazolidine-3-sulfonamide[3] and decenyl triflate[3] were prepared according to published procedures. The aryl triflates employed were either purchased from commercial sources and used without further purification or were

prepared according to a literature procedure[5] and further purified via flash chromatography. 1-Cyclohexenyl triflate was purchased from Sigma Aldrich and used without further purification. Bulk quantities of lithium *tert*-butoxide were stored in a glovebox and small amounts were removed shortly before use. Toluene, THF, diethyl ether and dichloromethane were purified using a GlassContour solvent purification system. Benzotrifluoride was purified by distillation under N_2 prior to use. *tert*-Butanol was obtained from a Sigma Aldrich and used without purification. Yields refer to isolated yields of compounds estimated to be ≥95% pure as determined by ^{1}H NMR analysis unless otherwise noted. The yields reported in the supporting information describe the result of a single experiment, whereas yields reported in Tables 1–2, and Equations 3–5 are average yields of two or more experiments. Thus, the yields reported in the supporting information may differ from those shown in Tables 1–2 and Equations 3–5. Structural and stereochemical assignments were made on the basis of 2-D COSY and 1-D NOESY experiments. Ratios of diastereomers were determined by ^{1}H NMR analysis, both, prior to and following flash chromatography.

Preparation and Characterization of Substrates



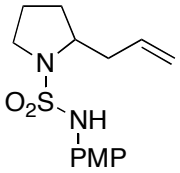
(±)-2-Allyl-*N*-(4-nitrophenyl)pyrrolidine-1-carboxamide (7). A round-bottom flask equipped with a stirbar was charged with *tert*-butyl 2-allylpyrrolidine-1-carboxylate (887 mg, 4.2 mmol) and dichloromethane (21 mL, 0.2 M). Trifluoroacetic acid (4.2, mL, 1.0 M) was added to the flask and the mixture was stirred until the starting material had been completely consumed as judged by TLC analysis (ca. 30 min). The solution was diluted with water, basified with NH_4OH to pH > 12, and transferred to a separatory funnel. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were dried over anhydrous sodium sulfate, filtered, and concentrated *in vacuo*. The crude product was dissolved in dichloromethane (21 mL, 0.2 M) and 4-nitrophenyl isocyanate (1.0 g, 6.3 mmol) was added. The reaction mixture was stirred at rt until starting material had been completely consumed as

judged by TLC analysis (ca. 1 h). The crude reaction mixture was concentrated *in vacuo*, and purified by flash chromatography on silica gel to afford a mixture of the title compound and 4-nitroanniline. The chromatographed material was dissolved in dichloromethane (35 mL) and washed with 1M HCl (2 x 15 mL) to remove any remaining 4-nitroanniline. This procedure afforded 290 mg (25%) of the title compound as a yellow solid: mp = 104–106 °C. ^{1}H NMR (700 MHz, $CDCl_3$) δ 8.15 (d, *J* = 9.1 Hz, 2 H), 7.58 (d, *J* = 9.1 Hz, 2 H), 6.64 (s, 1 H), 5.84–5.78 (m, 1 H), 5.17–5.09 (m, 2 H), 4.09 (s, br, 1 H), 3.53–3.46 (m, 2 H), 2.56 (dt, *J* = 12.4, 5.3 Hz, 1 H), 2.25–2.18 (m, 1 H), 2.09–2.02 (m, 1 H), 2.04–1.94 (m, 2 H), 1.85 (m, 1 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 152.7, 145.4, 142.3, 134.7, 125.1, 118.0, 117.9, 57.5, 46.5, 38.5, 29.6, 23.7; IR (film) 3314, 1652, 1501, 1329 cm^{-1}. MS (ESI) 276.1344 (276.1343 calcd for $C_{14}H_{17}N_3O_3$, M + H^+).

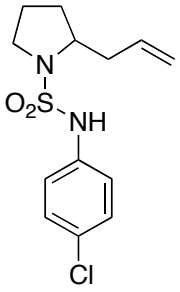
General Procedure for the Synthesis of Sulfamide Substrates 9.

The sulfamide substrates **9** were prepared by employing the following two-step procedure; the second step of which is modified from a published report.[4] A round-bottom flask equipped with a stirbar was charged with the appropriate *N*-Boc-protected amine (1.2 equiv) and dichloromethane (0.2 M). Trifluoroacetic acid (1.0 M) was added to the flask and the mixture was stirred at rt until the starting material had been completely consumed as judged by TLC analysis (ca. 30 min). The solution was then concentrated *in vacuo*. Toluene was added and the resulting solution was concentrated *in vacuo* to remove any excess TFA. The crude amine (TFA salt) was used without any additional purification.

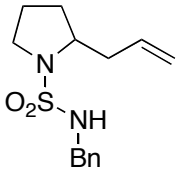
A separate flame dried flask was charged with the appropriate oxazolidinone substrate (1.0 equiv), 4-dimethylaminopyridine (0.2 equiv), and a stirbar, then was evacuated and backfilled with N_2. Acetonitrile was added, followed by Et_3N (3.0 equiv), and then the reaction vessel was placed in an oil bath at 75 °C. The appropriate amine TFA salt (1.2 equiv) as prepared above was added and the resulting mixture was stirred at 75 °C overnight (approximately 16 hours). The mixture was cooled to rt, solvent was removed via rotary evaporation, and the residue was partitioned between CH_2Cl_2 and 3 M HCl. The aqueous layer was extracted with CH_2Cl_2 and the combined organic layers were washed with brine and dried over anhydrous Na_2SO_4. Solvent was removed *in vacuo* and the resulting residue was purified by flash chromatography on silica gel.



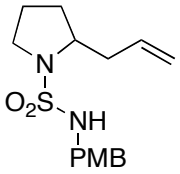
(±)-2-Allyl-*N*-(4-methoxyphenyl)pyrrolidine-1-sulfonamide (9a). The title compound was prepared from *N*-(4-methoxyphenyl)-2-oxooxazolidine-3-sulfonamide (825 mg, 4.0 mmol) and *tert*-butyl 2-allylpyrrolidine-1-carboxylate (1.06 g, 5.0 mmol) in two steps via the general procedure described above. This procedure afforded 808 mg (68%) of the title compound as a pale yellow oil. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.18 (d, *J* = 9.1 Hz, 2 H), 6.85 (d, *J* = 9.1 Hz, 2 H), 6.30 (s, br, 1 H), 5.70–5.61 (m, 1 H), 5.05–4.99 (m, 2 H), 3.79 (s, 3 H), 3.79–3.77 (m, 1 H), 3.36–3.27 (m, 2 H), 2.46–2.41 (m, 1 H), 2.12 (dt, *J* = 13.9, 8.5 Hz, 1 H), 1.86–1.73 (m, 3 H), 1.70–1.66 (m, 1 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 157.2, 134.5, 130.1, 123.7, 117.5, 114.4, 60.3, 55.5, 49.1, 39.9, 30.1, 24.2; IR (film) 3267, 1327, 1245, 1146 cm^{-1}. MS (ESI) 297.1274 (297.1267 calcd for $C_{14}H_{20}N_2O_3S$, M + H$^+$).



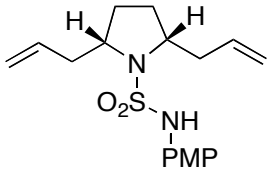
(±)-2-Allyl-*N*-(4-chlorophenyl)pyrrolidine-1-sulfonamide (S1). The title compound was prepared from *N*-(4-chlorophenyl)-2-oxooxazolidine-3-sulfonamide (4.1 g, 15.0 mmol) and *tert*-butyl 2-allylpyrrolidine-1-carboxylate (3.8 g, 18.0 mmol) in two steps via the general procedure described above. This procedure afforded 1.74 g (39%) of the title compound as a pale yellow solid: mp = 46–49 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.27 (d, *J* = 9.0 Hz, 2 H), 7.15 (d, *J* = 8.5 Hz, 2 H), 7.02 (s, 1 H), 5.71–5.63 (m, 1 H), 5.06–5.02 (m, 2 H), 3.88–3.84 (m, 1 H), 3.40–3.35 (m, 1 H), 3.30–3.25 (m, 1 H), 2.48–2.44 (m, 1 H), 2.19–2.14 (m, 1 H), 1.85–1.70 (m, 4 H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 136.0, 134.2, 129.8, 129.4, 121.4, 117.8, 60.4, 49.2, 39.7, 30.2, 24.2; IR (film) 3265, 1490, 1324, 1148 cm^{-1}. MS (ESI) 301.0774 (301.0772 calcd for $C_{13}H_{17}ClN_2O_2S$, M + H$^+$).



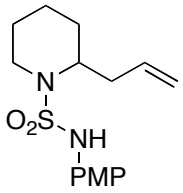
(±)-2-Allyl-*N*-benzylpyrrolidine-1-sulfonamide (S2). The title compound was prepared from *N*-benzyl-2-oxooxazolidine-3-sulfonamide (2.1 g, 8.3 mmol) and *tert*-butyl 2-allylpyrrolidine-1-carboxylate (2.1 g, 10.0 mmol) in two steps via the general procedure described above. This procedure afforded 1.22 g (52%) of the title compound as a pale yellow solid: mp = 38–41 °C. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.30–7.20 (m, 5 H), 5.72–5.64 (m, 1 H), 5.03–4.96 (m, 2 H), 4.68 (s, br, 1 H), 4.15 (s, 2 H), 3.76 (ddt, *J* = 9.0, 7.8, 3.9 Hz, 1 H), 3.31–3.24 (m, 1 H), 3.16 (ddd, *J* = 9.5, 6.6, 4.9 Hz, 1 H), 2.46 (dddt, *J* = 13.7, 6.8, 4.0, 1.4 Hz, 1 H), 2.18–2.10 (m, 1 H), 1.84–1.69 (m, 3 H), 1.68–1.61 (m, 1 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 137.0, 134.6, 128.7, 127.9, 127.9, 117.5, 59.6, 49.0, 47.4, 40.1, 30.3, 24.3; IR (film) 3282, 1312, 1143 cm^{-1}. MS (ESI) 281.1325 (281.1318 calcd for $C_{14}H_{20}N_2O_2S$, M + H$^+$).



(±)-2-Allyl-*N*-(4-methoxybenzyl)pyrrolidine-1-sulfonamide (S3). The title compound was prepared from *N*-(4-methoxybenzyl)-2-oxooxazolidine-3-sulfonamide (2.4 g, 8.3 mmol) and *tert*-butyl 2-allylpyrrolidine-1-carboxylate (2.1 g, 10.0 mmol) in two steps via the general procedure described above. This procedure afforded 1.10 g (43%) of the title compound as a yellow solid: mp = 39–42 °C. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.25 (d, *J* = 9.1 Hz, 2 H), 6.88 (d, *J* = 8.4 Hz, 2 H), 5.77 (ddt, *J* = 17.2, 10.2, 7.1 Hz, 1 H), 5.12–5.04 (m, 2 H), 4.16 (s, 2 H), 3.88–3.79 (m, 1 H), 3.80 (s, 3 H), 3.37 (dt, *J* = 9.9, 7.3 Hz, 1 H), 3.25 (ddd, *J* = 9.7, 6.7, 5.1 Hz, 1 H), 2.56–2.53 (m, 1 H), 2.27–2.19 (m, 1 H), 1.95–1.79 (m, 3H), 1.75–1.69 (m, 1 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.3, 134.7, 129.3, 129.0, 117.5, 114.1, 59.6, 55.3, 49.1, 47.0, 40.1, 30.3, 24.3; IR (film) 3289, 1302, 1247, 1144 cm^{-1}. MS (ESI) 311.1416 (311.1424 calcd for $C_{15}H_{22}N_2O_3S$, M + H$^+$).



(2*S*,5*R*)-2,5-Diallyl-*N*-(4-methoxyphenyl)pyrrolidine-1-sulfonamide (9b). The title compound was prepared from *N*-(4-methoxyphenyl)-2-oxooxazolidine-3-sulfonamide (1.6 g, 5.9 mmol) and (±)-(*E*,2*R**,5*S**)-*tert*-butyl 2-allyl-5-[3-(trimethylsilyl)allyl]pyrrolidine-1-carboxylate (2.3 g, 7.1 mmol) in two steps via a minor modification to the general procedure described above. The first step (*N*-Boc removal via TFA) was stirred overnight at reflux to effect protodesilyation of the starting material as opposed to being stirred for only 30 min at rt.[2] This procedure afforded 1.46 g (73%) of the title compound as a off-white solid: mp = 57–60 °C. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.19 (d, *J* = 8.4 Hz, 2 H), 6.85 (d, *J* = 8.4 Hz, 2 H), 5.75–5.67 (m, 2 H), 5.07–5.02 (m, 4 H), 3.79 (s, 3 H), 3.79–3.74 (m, 2 H), 2.50 (dt, *J* = 12.0, 5.5 Hz, 2 H), 2.16 (dt, *J* = 14.8, 8.3 Hz, 2 H), 1.77–1.71 (m, 2 H), 1.68–1.62 (m, 2 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 157.2, 134.6, 130.0, 123.7, 117.5, 114.4, 61.6, 55.4, 40.4, 29.0; IR (film) 3268, 1508, 1247, 1151 cm^{-1}. MS (ESI) 337.1580 (337.1580 calcd for $C_{17}H_{24}N_2O_3S$, M + H^+).



(±)-2-Allyl-*N*-(4-methoxyphenyl)piperidine-1-sulfonamide (9c). The title compound was prepared from *N*-(4-methoxyphenyl)-2-oxooxazolidine-3-sulfonamide (1.6 g, 6.0 mmol) and *tert*-butyl 2-allylpiperidine-1-carboxylate (1.6 g, 7.2 mmol) in two steps via the general procedure described above with one change. Instead of employing 2-allyl piperidine as the TFA salt, it was basified with NH_4OH and used as the free base, similar to the procedure employed for the preparation of **5**. This procedure afforded 521 mg (28%) of the title compound as a yellow oil. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.11 (d, *J* = 8.4 Hz, 2 H), 6.85 (d, *J* = 8.4 Hz, 2 H), 6.16 (s, 1 H), 5.68 (ddt, *J* = 17.2, 10.1, 7.1 Hz, 1 H), 5.09–5.01 (m, 2 H), 3.97–3.93 (m, 1 H), 3.79 (s, 3 H), 3.63–3.58 (m, 1 H), 2.99 (td, *J* = 13.3, 2.8 Hz, 1 H), 2.42–2.31 (m, 2 H), 1.61–1.39 (m, 5 H), 1.35–1.23 (m, 1 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 157.1, 135.0, 130.1, 123.3, 117.3, 114.4,

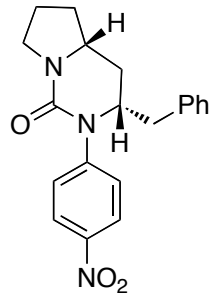
55.5, 53.3, 41.4, 34.1, 26.7, 24.8, 18.0; IR (film) 3272, 1509, 1246, 1142 cm^{-1}. MS (ESI) 311.1422 (311.1424 calcd for $C_{15}H_{22}N_2O_3S$, M + H^+).

Preparation and Characterization of Bicyclic Products

General Procedure for Synthesis of Bicyclic Ureas and Sulfamides

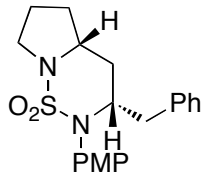
General Procedure A (for reactions carried out in benzotrifluoride): A test tube was charged with $Pd(OAc)_2$ (0.04 equiv), a phosphine ligand (0.1 equiv), and Li*O*t*Bu (2.0 equiv). The test tube was purged with N_2 then the appropriate aryl triflate (2.0 equiv) was added, followed by the appropriate substrate (1.0 equiv) in benzotrifluoride (0.2 M). The tube was heated to 100 °C and stirred overnight or until the starting material was completely consumed as judged by ^1H NMR analysis. The mixture was cooled to room temperature and saturated aqueous NH_4Cl (5 mL/mmol substrate) and dichloromethane (5 mL/mmol substrate) were added. The layers were separated and concentrated *in vacuo*. The crude material was purified by flash chromatography on silica gel.

General Procedure B (for reactions carried out in *tert*-butanol): A test tube was charged with $Pd(OAc)_2$ (0.04 equiv), a phosphine ligand (0.1 equiv), and Li*O*t*Bu (2.0–3.0 equiv). The test tube was purged with N_2 then the appropriate aryl or alkenyl triflate (2.0–3.0 equiv) was added, followed by the appropriate substrate (1.0 equiv) in *tert*-butanol (0.1 M). The tube was heated to 82 °C and stirred overnight or until the starting material was completely consumed as judged by ^1H NMR analysis. The mixture was cooled to room temperature and concentrated *in vacuo*. The crude material was purified by flash chromatography on silica gel.

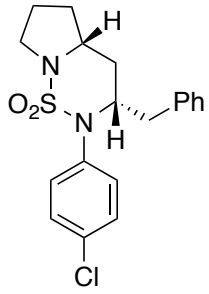


(±)-(3*S,4a*R**)-3-Benzyl-2-(4-nitrophenyl)hexahydropyrrolo[1,2-*c*]pyrimidin-1(2*H*)-one (8).** General procedure A was employed for the coupling of **7** (55 mg, 0.2 mmol) and phenyl triflate

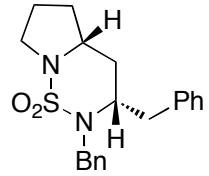
(65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and RuPhos (9.3 mg, 0.02 mmol). This procedure afforded 66 mg (94%) of the title compound as a yellow solid and as a 2:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 51–55 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 8.26 (d, *J* = 9.1 Hz, 2 H), 7.56 (d, *J* = 8.4 Hz, 2 H), 7.29–7.23 (m, 3 H), 7.04 (d, *J* = 7.0 Hz, 2 H), 4.14 (tt, *J* = 10.6, 3.9 Hz, 1 H), 3.58–3.47 (m, 3 H), 2.85 (dd, *J* = 13.5, 3.8 Hz, 1 H), 2.32 (dd, *J* = 13.4, 10.1 Hz, 1 H), 2.26–1.46 (m, 6 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 153.5, 147.5, 145.2, 137.0, 129.0, 128.7, 128.6, 126.7, 124.0, 58.2, 54.7, 46.0, 41.6, 35.0, 33.5, 23.0; IR (film) 1639, 1515, 1339 cm^{-1}. MS (ESI) 352.1656 (352.1656 calcd for $C_{20}H_{21}N_3O_3$, M + H$^+$).



(±)-(3*S,4a*R**)-3-Benzyl-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10a).** General procedure B was employed for the coupling of **9a** (59 mg, 0.2 mmol) and phenyl triflate (65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 67 mg (90%) of the title compound as a white solid and as a 7:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 45–48 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.39 (d, *J* = 8.4 Hz, 2 H), 7.29–7.20 (m, 3 H), 7.06 (d, *J* = 7.7 Hz, 2 H), 6.91 (d, *J* = 9.1 Hz, 2 H), 4.26–4.19 (m, 1 H), 3.80 (s, 3 H), 3.53 (td, *J* = 9.5, 5.7 Hz, 1 H), 3.38 (td, *J* = 9.5, 5.8 Hz, 1 H), 2.81 (dd, *J* = 13.6, 4.4 Hz, 1 H), 2.21–2.08 (m, 2 H), 2.07–1.91 (m, 3 H), 1.68–1.53 (m, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.4, 137.4, 130.9, 130.4, 129.1, 128.6, 126.6, 114.3, 61.8, 60.2, 55.4, 46.5, 40.4, 32.6, 31.3, 21.3; IR (film) 1506, 1337, 1248, 1158 cm^{-1}. MS (ESI) 373.1589 (373.1580 calcd for $C_{20}H_{24}N_2O_3S$, M + H$^+$).

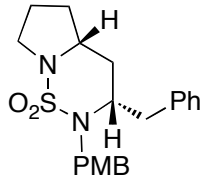


(±)-(3*S,4a*R**)-3-Benzyl-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (S4).** General procedure B was employed for the coupling of **S1** (60 mg, 0.2 mmol) and phenyl triflate (65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 44 mg (58%) of the title compound as a white solid and as a 7:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 50–53 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.41 (d, *J* = 9.1 Hz, 2 H), 7.37 (d, *J* = 8.4 Hz, 2 H), 7.29–7.22 (m, 3 H), 7.05 (d, *J* = 7.7 Hz, 2 H), 4.25 (m, 1 H), 3.81 (ddt, *J* = 11.2, 6.6, 4.2 Hz, 1 H), 3.53 (td, *J* = 9.5, 5.8 Hz, 1 H), 3.43–3.35 (m, 1 H), 2.78 (dd, *J* = 13.6, 4.5 Hz, 1 H), 2.21 (dd, *J* = 13.3, 9.8 Hz, 1 H), 2.18–2.10 (m, 1 H), 2.08–1.87 (m, 2 H), 1.69–1.52 (m, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 136.9, 136.6, 134.3, 131.2, 129.4, 129.0, 128.6, 126.8, 61.8, 60.2, 46.6, 40.4, 32.6, 31.3, 21.4; IR (film) 1486, 1338, 1159 cm^{-1}. MS (ESI) 377.1089 (377.1085 calcd for $C_{19}H_{21}ClN_2O_2S$, M + H$^+$).

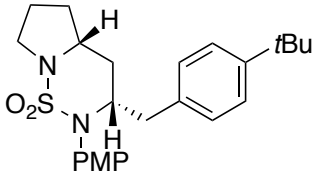


(±)-(3*S,4a*R**)-2,3-Dibenzylhexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (S5).** General procedure A was employed for the coupling of **S2** (56 mg, 0.2 mmol) and phenyl triflate (65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 61 mg (86%) of the title compound as a white solid and as a 3:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 113–116 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.42 (d, *J* = 7.0 Hz, 2 H), 7.34–7.18 (m, 6 H), 7.07 (d, *J* = 7.0 Hz, 2 H), 4.59 (d, *J* = 16.2 Hz, 1 H), 4.15 (d, *J* = 16.1 Hz, 1 H), 4.15–4.09 (m, 1 H), 3.48 (m, 1 H), 3.26 (m, 2 H), 2.92 (dd, *J* = 13.4, 4.6 Hz, 1 H), 2.54 (dd, *J* = 13.4, 10.5 Hz, 1 H), 2.07–2.01 (m, 1 H), 1.98–1.90 (m, 1 H), 1.82 (m, 1 H), 1.71–1.49 (m, 3 H);

^{13}C NMR (175 MHz, $CDCl_3$) δ 138.5, 137.4, 129.2, 128.5, 128.4, 127.7, 127.2, 126.7, 61.6, 60.8, 49.6, 45.8, 40.6, 31.6, 30.7, 21.1; IR (film) 1333, 1155 cm^{-1}. MS (ESI) 357.1632 (357.1631 calcd for $C_{20}H_{24}N_2O_2S$, M + H$^+$).

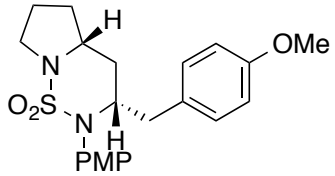


(±)-(3*S,4a*R**)-3-Benzyl-2-(4-methoxybenzyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (S6).** General procedure A was employed for the coupling of **S3** (62 mg, 0.2 mmol) and phenyl triflate (65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 63 mg (82%) of the title compound as a red-brown oil and as a 3:1 mixture of diastereomers as determined by ^{1}H NMR analysis. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.32 (d, *J* = 8.4 Hz, 2 H), 7.26–7.15 (m, 3 H), 7.08 (d, *J* = 7.0 Hz, 2 H), 6.85 (d, *J* = 8.4 Hz, 2 H), 4.51 (d, *J* = 15.9 Hz, 1 H), 4.08 (d, *J* = 16.1 Hz, 1 H), 4.11–4.03 (m, 1 H), 3.80 (s, 3 H), 3.48–3.42 (m, 1 H), 3.27–3.21 (m, 2 H), 2.92 (dd, *J* = 13.3, 4.9 Hz, 1 H), 2.55 (dd, *J* = 13.4, 10.3 Hz, 1 H), 2.06–1.98 (m, 1 H), 1.96–1.85 (m, 1 H), 1.82–1.76 (m, 1 H), 1.70–1.46 (m, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 158.8, 137.5, 130.4, 129.1, 129.1, 128.5, 126.6, 113.7, 61.3, 60.7, 55.2, 49.3, 45.9, 40.7, 31.6, 30.9, 21.3; IR (film) 1332, 1245, 1155 cm^{-1}. MS (ESI) 387.1725 (387.1737 calcd for $C_{21}H_{26}N_2O_3S$, M + H$^+$).

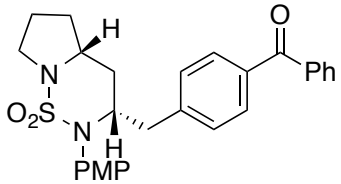


(±)-(3*S,4a*R**)-3-[4-(*tert*-Butyl)benzyl]-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10b).** General procedure B was employed for the coupling of **9a** (59 mg, 0.2 mmol) and 4-(*tert*-butyl)phenyl triflate (113 mg, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 62 mg (72%) of the title compound as a white solid and as a 7:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 61–63 °C. Data are for the major isomer.

^{1}H NMR (700 MHz, $CDCl_3$) δ 7.39 (d, *J* = 9.1 Hz, 2 H), 7.27 (d, *J* = 7.7 Hz, 2 H), 6.98 (d, *J* = 8.4 Hz, 2 H), 6.90 (d, *J* = 9.1 Hz, 2 H), 4.25–4.19 (m, 1 H), 3.81 (s, 3 H), 3.80–3.76 (m, 1 H), 3.54–3.49 (m, 1 H), 3.41–3.34 (m, 1 H), 2.77 (dd, *J* = 13.7, 4.3 Hz, 1 H), 2.14–2.09 (m, 2 H), 2.07–1.87 (m, 2 H), 1.70–1.52 (m, 3 H), 1.29 (s, 9 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.4, 149.5, 134.2, 130.9, 130.4, 128.7, 125.4, 114.3, 61.8, 60.2, 55.4, 46.5, 39.9, 37.4, 34.4, 32.6, 31.3, 21.3; IR (film) 1506, 1338, 1247, 1158 cm^{-1}. MS (ESI) 429.2215 (429.2215 calcd for $C_{24}H_{32}N_2O_3S$, M + H$^+$).

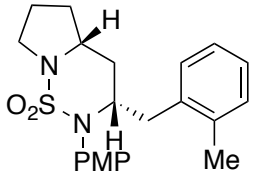


(±)-(3*S,4a*R**)-3-(4-Methoxybenzyl)-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10c).** General procedure B was employed for the coupling of **9a** (59 mg, 0.2 mmol) and 4-methoxyphenyl triflate (72 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 52 mg (65%) of the title compound as a white solid and as a 7:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 48–51 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.38 (d, *J* = 8.4 Hz, 2 H), 6.97 (d, *J* = 8.4 Hz, 2 H), 6.91 (d, *J* = 9.1 Hz, 2 H), 6.80 (d, *J* = 8.4 Hz, 2 H), 4.20–4.14 (m, 1 H), 3.85 (s, 3 H), 3.80 (s, 3 H), 3.80–3.73 (m, 1 H), 3.56–3.46 (m, 1 H), 3.37 (td, *J* = 9.4, 5.7 Hz, 1 H), 2.74 (dd, *J* = 13.7, 4.4 Hz, 1 H), 2.15–2.08 (m, 2 H), 2.04–1.91 (m, 2 H), 1.64–1.50 (m, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.4, 158.3, 130.9, 130.4, 130.0, 129.3, 114.3, 113.9, 61.9, 60.3, 55.4, 55.2, 46.5, 39.5, 32.5, 31.3, 21.3; IR (film) 1507, 1338, 1247, 1158 cm^{-1}. MS (ESI) 403.1679 (403.1686 calcd for $C_{21}H_{26}N_2O_4S$, M + H$^+$).

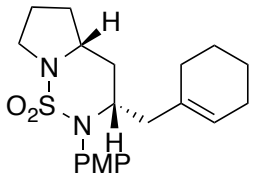


(±)-(3*S,4a*R**)-{4-{[2-(4-Methoxyphenyl)-1,1-dioxidohexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazin-3-yl]methyl}phenyl}(phenyl)methanone (10d).** General procedure B was

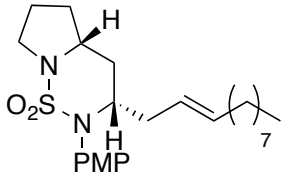
employed for the coupling of **9a** (59 mg, 0.2 mmol) and 4-benzoylphenyl triflate (132 mg, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). The diastereoselectivity of the reaction was judged to be 5:1 dr as determined by ^{1}H NMR analysis prior to flash chromatography. This procedure afforded 62 mg (65%) of the title compound as a white solid and as a 8:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 58–61 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.7 Hz, 2 H), 7.72 (d, *J* = 8.4 Hz, 2 H), 7.59 (t, *J* = 7.5 Hz, 1 H), 7.49 (t, *J* = 7.6 Hz, 2 H), 7.38 (d, *J* = 8.8 Hz, 2 H), 7.18 (d, *J* = 7.9 Hz, 2 H), 6.91 (d, *J* = 8.7 Hz, 2 H), 4.33–4.28 (m, 1 H), 3.79 (s, 3 H), 3.79–3.77 (m, 1 H), 3.54 (td, *J* = 9.4, 5.7 Hz, 1 H), 3.39 (td, *J* = 9.3, 5.8 Hz, 1 H), 2.87 (dd, *J* = 13.7, 4.8 Hz, 1 H), 2.33 (dd, *J* = 13.7, 9.8 Hz, 1 H), 2.19–2.12 (m, 1 H), 2.01–1.95 (m, 2 H), 1.68–1.62 (m, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 196.2, 159.5, 142.4, 137.5, 136.1, 132.5, 130.9, 130.4, 130.2, 130.0, 129.0, 128.3, 114.4, 61.5, 60.1, 55.4, 46.5, 40.4, 32.9, 31.4, 21.3; IR (film) 1654, 1605, 1506, 1339, 1278, 1249, 1157 cm^{-1}. MS (ESI) 477.1847 (477.1843 calcd for $C_{27}H_{28}N_2O_4S$, M + H$^+$).



(±)-(3*S,4a*R**)-2-(4-Methoxyphenyl)-3-(2-methylbenzyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10e).** General procedure B was employed for the coupling of **9a** (59 mg, 0.2 mmol) and 2-tolyl triflate (96 mg, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 65 mg (84%) of the title compound as a white solid and as a 5:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 39–43 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.41 (d, *J* = 9.1 Hz, 2 H), 7.12–7.10 (m, 3 H), 7.05–7.02 (m, 1 H), 6.91 (d, *J* = 9.1 Hz, 2 H), 4.24–4.17 (m, 1 H), 3.82 (s, 3 H), 3.81–3.74 (m, 1 H), 3.55 (td, *J* = 9.4, 5.7 Hz, 1 H), 3.43–3.36 (m, 1 H), 2.75 (dd, *J* = 13.8, 4.4 Hz, 1 H), 2.22 (dd, *J* = 13.8, 10.5 Hz, 1 H), 2.18 (s, 3 H), 2.13 (ddt, *J* = 12.6, 9.6, 6.5 Hz, 1 H), 2.09–1.95 (m, 2 H), 1.67–1.60 (m, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.4, 136.3, 135.5, 130.9, 130.5, 130.4, 130.1, 126.8, 125.9, 114.3, 60.4, 60.2, 55.4, 46.5, 37.9, 32.7, 31.3, 21.3, 19.6; IR (film) 1506, 1338, 1248, 1157 cm^{-1}. MS (ESI) 387.1745 (387.1737 calcd for $C_{21}H_{26}N_2O_3S$, M + H$^+$).

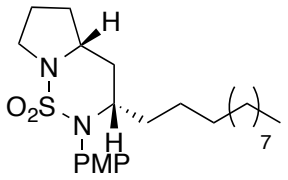


(±)-(3*S,4a*R**)-3-(Cyclohex-1-en-1-ylmethyl)-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10f).** General procedure B was employed for the coupling of **9a** (59 mg, 0.2 mmol) and 1-cyclohexenyl triflate (63 μL, 0.6 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 55 mg (73%) of the title compound as a pale yellow oil and as a 6:1 mixture of diastereomers as determined by ^{1}H NMR analysis. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.32 (d, *J* = 8.4 Hz, 2 H), 6.87 (d, *J* = 9.1 Hz, 2 H), 5.33 (s, 1 H), 4.13–4.07 (m, 1 H), 3.87–3.82 (m, 1 H), 3.79 (m, 3 H), 3.51 (td, *J* = 9.4, 5.6 Hz, 1 H), 3.36 (td, *J* = 9.4, 5.8 Hz, 1 H), 2.20 (ddt, *J* = 12.7, 9.7, 6.5 Hz, 1 H), 2.08–1.42 (m, 15 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.2, 133.1, 131.0, 130.4, 124.9, 114.0, 60.4, 58.5, 55.4, 46.4, 42.8, 33.0, 31.4, 28.2, 25.2, 22.8, 22.2, 21.3; IR (film) 1506, 1337, 1248, 1156 cm^{-1}. MS (ESI) 377.1903 (377.1893 calcd for $C_{20}H_{28}N_2O_3S$, M + H$^+$).

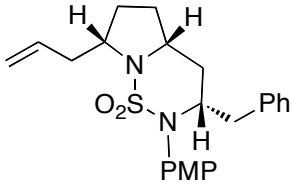


(±)-(*E*,3*S,4a*R**)-2-(4-Methoxyphenyl)-3-(undec-2-en-1-yl)-hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10g).** General procedure B was employed for the coupling of **9a** (15 mg, 0.05 mmol) and 1-decenyl triflate (29 μL, 0.15 mmol, 5:1 mixture of *E*/*Z* isomers), using a catalyst composed of $Pd(OAc)_2$ (0.45 mg, 0.002 mmol), and CPhos (2.2 mg, 0.005 mmol). The crude diastereoselectivity of the reaction could not be precisely determined directly due to the formation of a complex mixture of diastereomers and *E*/*Z* isomers. However, the crude diastereoselectivity was estimated to be between 5:1 and 10:1 dr as determined by ^{1}H NMR analysis prior to flash chromatography. Following flash chromatography, this procedure afforded 10 mg (46%) of the title compound as a pale yellow oil and as a 10:1 mixture of diastereomers as determined by ^{1}H NMR analysis following hydrogenation of the olefin (see below for details). Data are for the major isomer. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 (d, *J* = 9.0 Hz, 2 H), 6.88 (d, *J*

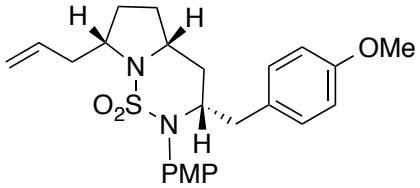
= 9.1 Hz, 2 H), 5.46–5.41 (m, 1 H), 5.26–5.20 (m, 1 H), 4.01–3.90 (m, 2 H), 3.80 (s, 3 H), 3.52 (td, *J* = 9.4, 6.0 Hz, 1 H), 3.40 (td, *J* = 9.4, 5.8 Hz, 1 H), 2.20 (ddt, *J* = 12.8, 9.8, 6.7 Hz, 1 H), 2.10–1.91 (m, 3 H), 1.88–1.78 (m, 3 H), 1.73–1.54 (m, 2 H), 1.33–1.26 (m, 13 H), 0.88 (t, *J* = 7.0 Hz, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.3, 133.3, 130.9, 130.2, 123.8, 114.2, 60.4, 60.0, 55.4, 46.6, 32.8, 31.9, 31.5, 31.4, 29.7, 29.4, 29.4, 29.3, 27.4, 22.7, 21.4, 14.1; IR (film) 2922, 1507, 1349, 1248, 1161 cm^{-1}. MS (ESI) 435.2678 (435.2676 calcd for $C_{24}H_{38}N_2O_3S$, M + H$^+$).



(±)-(3*S,4a*R**)-2-(4-Methoxyphenyl)-3-undecylhexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (S7).** A flask equipped with a stirbar was charged with **10g** (10 mg, 0.023 mmol) and methanol (2 mL). Pd/C (10 mg) was added to the solution and the flask was capped with a rubber septum. The flask was briefly flushed with hydrogen and then a hydrogen-filled balloon attached to a needle (via an adaptor) was connected to the flask through the septum. The mixture was stirred at rt until the starting material had been consumed as judged by ESI$^+$ MS analysis (ca. 1 hr). The crude product was then filtered through a plug of celite to remove the Pd/C and washed with methanol (5 mL). The crude material was concentrated *in vacuo* and required no further purification. This procedure afforded 9 mg (90%) of the title compound as a clear colorless oil and as a 10:1 mixture of diastereomers as determined by ^{1}H NMR analysis. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.32 (d, *J* = 8.4 Hz, 2 H), 6.87 (d, *J* = 9.1 Hz, 2 H), 4.00–3.94 (m, 1 H), 3.88–3.78 (m, 1 H), 3.80 (s, 3 H), 3.50 (td, *J* = 9.4, 5.6 Hz, 1 H), 3.35 (td, *J* = 9.4, 5.9 Hz, 1 H), 2.21 (ddt, *J* = 12.5, 9.6, 6.3 Hz, 1 H), 2.07–1.92 (m, 2 H), 1.81 (dt, *J* = 13.9, 3.2 Hz, 1 H), 1.73–1.57 (m, 2 H), 1.35–1.04 (m, 20 H), 0.88 (t, *J* = 7.2 Hz, 3 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.2, 131.0, 130.4, 114.1, 60.7, 60.4, 55.4, 46.4, 33.4, 33.1, 31.9, 31.5, 29.6, 29.6, 29.4, 29.4, 29.3, 29.3, 25.4, 22.7, 21.2, 14.1; IR (film) 1507, 1345, 1248, 1161 cm^{-1}. MS (ESI) 437.2836 (437.2832 calcd for $C_{24}H_{40}N_2O_3S$, M + H$^+$).

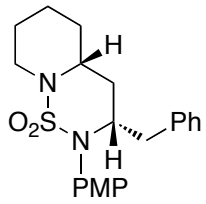


(±)-(3*S,4a*R**,7*S**)-7-Allyl-3-benzyl-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10h).** General procedure B was employed for the coupling of **9b** (67 mg, 0.2 mmol) and phenyl triflate (65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). The diastereoselectivity of the reaction was judged to be 12:1 dr as determined by ^{1}H NMR analysis prior to flash chromatography. This procedure afforded 51 mg (62%) of the title compound as a pale yellow oil and as a 20:1 mixture of diastereomers as determined by ^{1}H NMR analysis. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.4 Hz, 2 H), 7.26–7.19 (m, 3 H), 7.09 (d, *J* = 7.0 Hz, 2 H), 6.88 (d, *J* = 9.1 Hz, 2 H), 5.78 (ddt, *J* = 15.8, 11.2, 7.1 Hz, 1 H), 5.10–5.04 (m, 2 H), 4.41 (tdd, *J* = 9.9, 5.3, 2.6 Hz, 1 H), 3.82 (s, 3 H), 3.77–3.72 (m, 1 H), 3.44 (tdd, *J* = 11.3, 5.0, 3.0 Hz, 1 H), 2.82 (dd, *J* = 13.8, 5.3 Hz, 1 H), 2.64–2.58 (m, 1 H), 2.37 (dt, *J* = 14.0, 7.8 Hz, 1 H), 2.11 (dd, *J* = 13.8, 10.0 Hz, 1 H), 2.01–1.94 (m, 1 H), 1.90 (ddt, *J* = 13.0, 10.2, 8.9 Hz, 1 H), 1.78–1.68 (m, 2 H), 1.68–1.53 (m, 2 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.4, 137.3, 134.4, 131.4, 130.5, 129.1, 128.5, 126.7, 117.7, 114.0, 62.8, 61.7, 57.8, 55.4, 40.0, 39.8, 32.9, 30.5, 26.8; IR (film) 1506, 1344, 1249, 1155 cm^{-1}. MS (ESI) 413.1895 (413.1893 calcd for $C_{23}H_{28}N_2O_3S$, M + H$^+$).



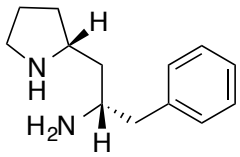
(±)-(3*S,4a*R**,7*S**)-7-Allyl-3-(4-methoxybenzyl)-2-(4-methoxyphenyl)hexahydro-2*H*-pyrrolo[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (10i).** General procedure B was employed for the coupling of **9b** (67 mg, 0.2 mmol) and 4-methoxyphenyl triflate (72 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). The diastereoselectivity of the reaction was judged to be 13:1 dr as determined by ^{1}H NMR analysis prior to flash chromatography. This procedure afforded 57 mg (64%) of the title compound as a white solid and as a >20:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp =

44–46 °C. Data are for the major isomer. ^{1}H NMR (700 MHz, $CDCl_3$) δ 7.39 (d, *J* = 8.6 Hz, 2 H), 7.00 (d, *J* = 8.6 Hz, 2 H), 6.88 (d, *J* = 9.1 Hz, 2 H), 6.81 (d, *J* = 8.4 Hz, 2 H), 5.82–7.73 (m, 1 H), 5.10–5.04 (m, 2 H), 4.39–4.35 (m, 1 H), 3.82 (s, 3 H), 3.78 (s, 3 H), 3.77–3.72 (m, 1 H), 3.46–3.39 (m, 1 H), 2.76 (dd, *J* = 13.9, 5.3 Hz, 1 H), 2.61 (dd, *J* = 14.4, 6.0 Hz, 1 H), 2.37 (dt, *J* = 15.0, 7.9 Hz, 1 H), 2.04 (dd, *J* = 13.9, 10.0 Hz, 1 H), 2.01–1.88 (m, 2 H), 1.78–1.68 (m, 2 H), 1.62–1.53 (m, 2 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.5, 158.4, 134.4, 131.5, 130.6, 130.0, 129.3, 117.7, 114.0, 113.9, 62.9, 61.9, 57.9, 55.4, 55.2, 39.8, 39.1, 32.9, 30.5, 26.8; IR (film) 1507, 1345, 1247, 1156 cm^{-1}. MS (ESI) 443.1993 (443.1999 calcd for $C_{24}H_{30}N_2O_4S$, M + H$^+$).



(±)-(3*S,4a*R**)-3-Benzyl-2-(4-methoxyphenyl)octahydropyrido[1,2-*b*][1,2,6]thiadiazine-1,1-dioxide (14).** General procedure B was employed for the coupling of **9c** (62 mg, 0.2 mmol) and phenyl triflate (65 μL, 0.4 mmol), using a catalyst composed of $Pd(OAc)_2$ (1.8 mg, 0.008 mmol), and CPhos (8.7 mg, 0.02 mmol). This procedure afforded 65 mg (84%) of the title compound as a white solid and as a 5:1 mixture of diastereomers as determined by ^{1}H NMR analysis: mp = 46–49 °C. Data are for the major isomer. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41 (d, *J* = 8.5 Hz, 2 H), 7.28–7.20 (m, 3 H), 7.07 (d, *J* = 7.5 Hz, 2 H), 6.91 (d, *J* = 9.0 Hz, 2 H), 4.41–4.37 (m, 1 H), 3.82 (s, 3 H), 3.59–3.43 (m, 2 H), 2.97–2.88 (m, 1 H), 2.79 (dd, *J* = 13.6, 4.8 Hz, 1 H), 2.13 (dd, *J* = 13.7, 10.1 Hz, 1 H), 1.89–1.65 (m, 4 H), 1.58–1.36 (m, 4 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 159.4, 137.2, 131.2, 130.0, 129.1, 128.5, 126.7, 114.2, 60.4, 57.1, 55.4, 44.3, 40.3, 32.1, 31.9, 24.9, 21.9; IR (film) 1507, 1338, 1250, 1156 cm^{-1}. MS (ESI) 387.1737 (387.1737 calcd for $C_{21}H_{26}N_2O_3S$, M + H$^+$).

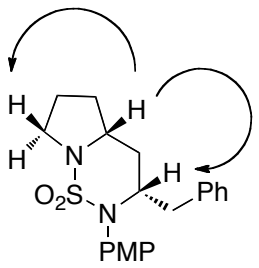
Cleavage of Sulfamide Bridge and Deprotection of 10a

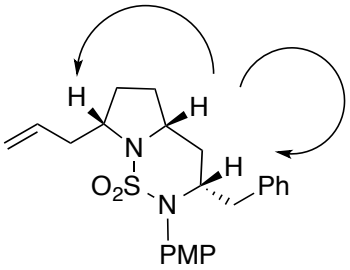


(±)-(*S*,R)-1-Phenyl-3-(pyrrolidin-2-yl)propan-2-amine (15).** The title compound was prepared via the following two-step one-pot procedure. The first step was carried out according to the published work by Snyder and Heckert.[6] A flask equipped with a stirbar and reflux condenser was charged with **10a** (66 mg, 0.18 mmol). Hydrobromic acid (48%, 4 mL) was slowly added to the flask and the reaction was heated to 120 ^{O}C and stirred until the starting material had been completely consumed (ca. 2 h) as judged by MS ESI+ analysis (297.1 m/z, M + H^+). The mixture was cooled to rt, CH_3CN (2 mL) was added, followed by a solution of ceric ammonium nitrate (494 mg, 0.9 mmol) in H_2O (2 mL) and then stirred overnight (ca. 8 hr) at rt. Dichloromethane (8 mL) was added to the solution, the mixture was transferred to a separatory funnel and the layers were separated. The aqueous layer was carefully basified with NH_4OH to pH > 12 and extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were washed with Na_2SO_3 (1 x 10 mL) and brine (1 x 10 mL). The organic layer was dried over anhydrous sodium sulfate, filtered, and concentrated *in vacuo*. This procedure afforded 27 mg (75%) of the title compound as a yellow brown oil and as a 7:1 mixture of diastereomers as determined by ^{1}H NMR analysis. Data are for the major isomer. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.30 (t, *J* = 8.0 Hz, 2 H), 7.22 (t, *J* = 8.0 Hz, 1 H), 7.17 (d, *J* = 7.5 Hz, 2 H), 3.37–3.33 (m, 1 H), 3.15–3.12 (m, 1 H), 3.06–2.97 (m, 2 H), 2.86 (s, br, 3 H), 2.79 (dd, *J* = 13.3, 4.9 Hz, 1 H), 2.54 (dd, *J* = 13.3, 8.2 Hz, 1 H), 2.02–1.97 (m, 1 H), 1.83–1.77 (m, 2 H), 1.70–1.66 (m, 1 H), 1.48–1.43 (m, 1 H), 1.37–1.32 (m, 1 H); ^{13}C NMR (175 MHz, $CDCl_3$) δ 138.7, 129.3, 128.5, 126.4, 58.5, 52.4, 45.8, 45.7, 41.7, 32.1, 24.6; IR (film) 3360, 2929 cm^{-1}. MS (ESI) 205.1700 (205.1699 calcd for $C_{13}H_{20}N_2$, M + H^+).

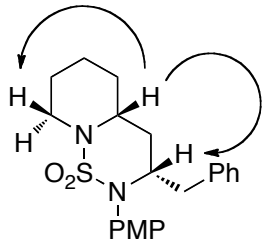
Assignment of Stereochemistry

The relative stereochemistry of compound **10a** and **10h** was assigned on the basis of 1D NOESY experiments. Significant nOe relationships are shown below. The stereochemistry of all other 5-6 bicyclic sulfamide products was assigned based on analogy to **10a** and **10h**.

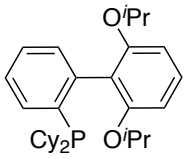




The relative stereochemistry of compound **14** was assigned on the basis of observed 1D NOESY experiments. Significant nOe relationships are shown below.



Structures of Ligands Named in Table 1



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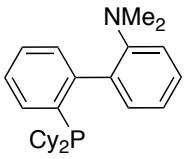
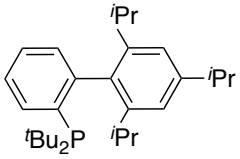
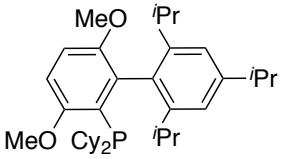


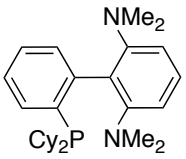
DavePhos



tBuXPhos



BrettPhos



CPhos

References

[1] Coldham, I.; Leonori, D. *J. Org. Chem*, **2010**, *75*, 4069.

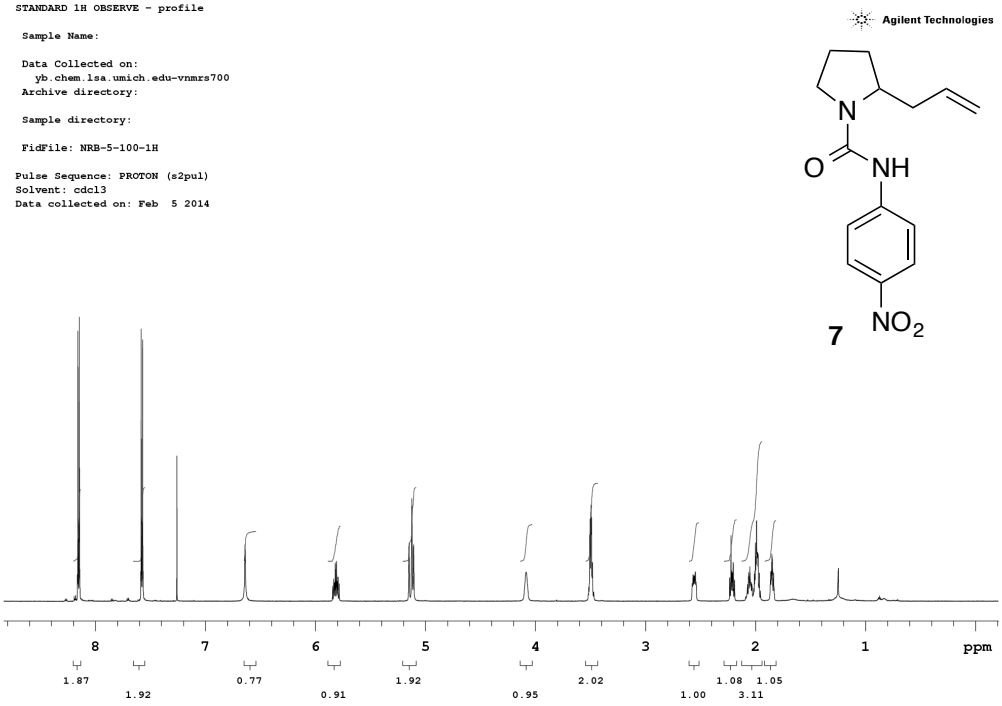
[2] Babij, N. R.; Wolfe, J. P. *Angew. Chem. Int. Ed.* **2013**, *52*, 9247.

[3] Fornwald, R. M.; Fritz, J. A.; Wolfe, J. P. *Chem. Eur. J.* **2014**, Accepted for publication, DOI: 10.1002/chem.201402258R1.

[4] Borghese, A.; Antoine, L.; Van Hoeck, J. P.; Mockel, A.; Merschaert, A.; *Org. Proc. Res. Dev.* **2006**, *10*, 770.

[5] Frantz, D. E.; Weaver, D. G.; Carey, J. P.; Kress, M. H.; Dolling, U. H. *Org. Lett.* **2002**, *4*, 4717.

[6] Snyder, H. R.; Heckert, R. E. *J. Am. Chem. Soc.* **1952**, *74*, 2006.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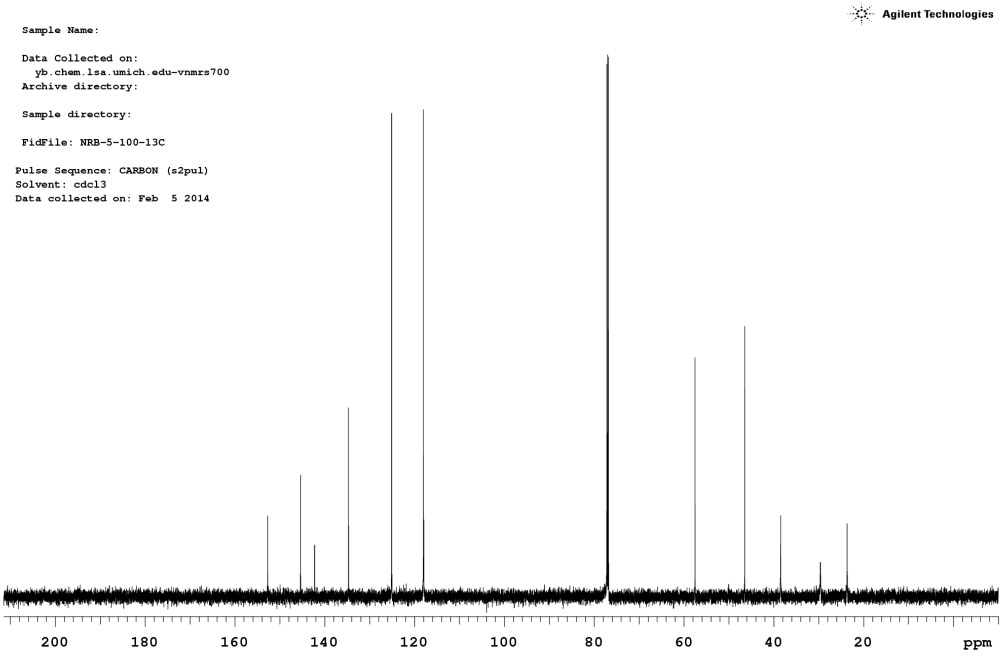
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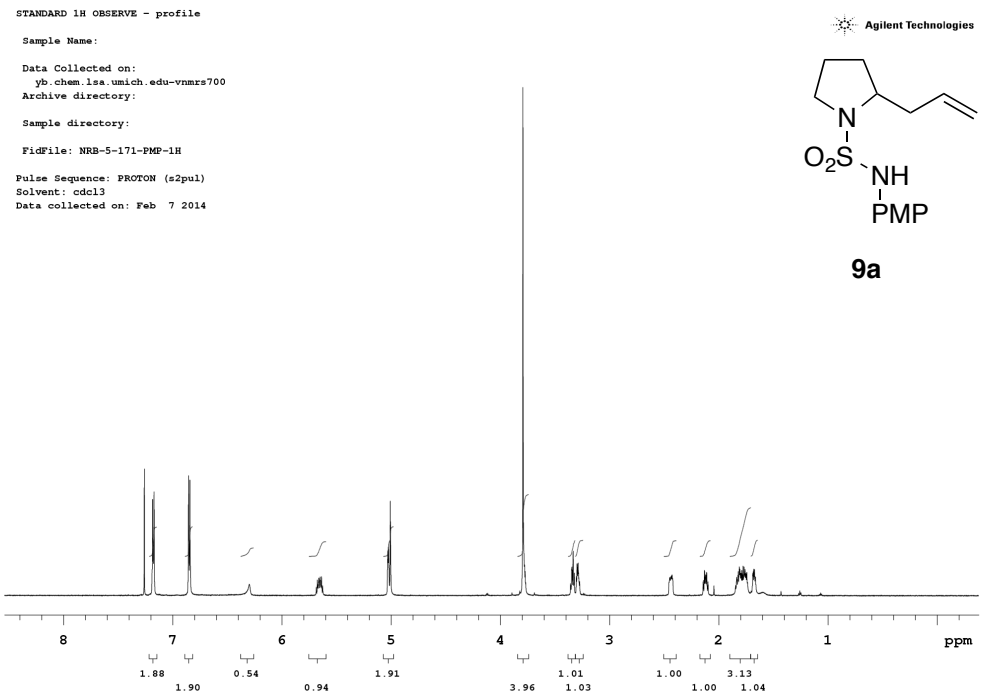
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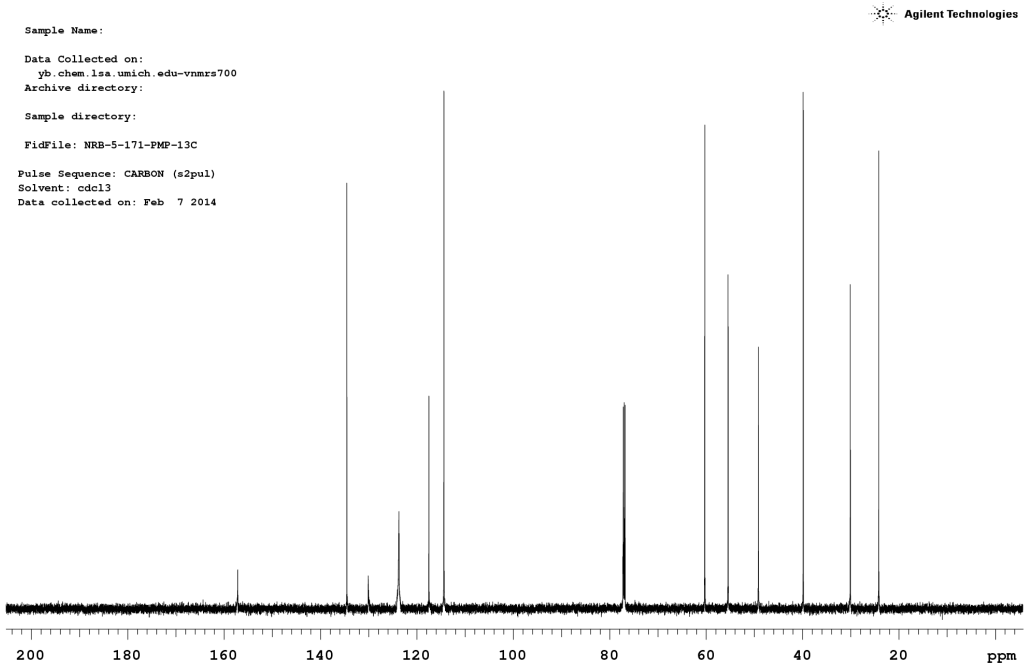
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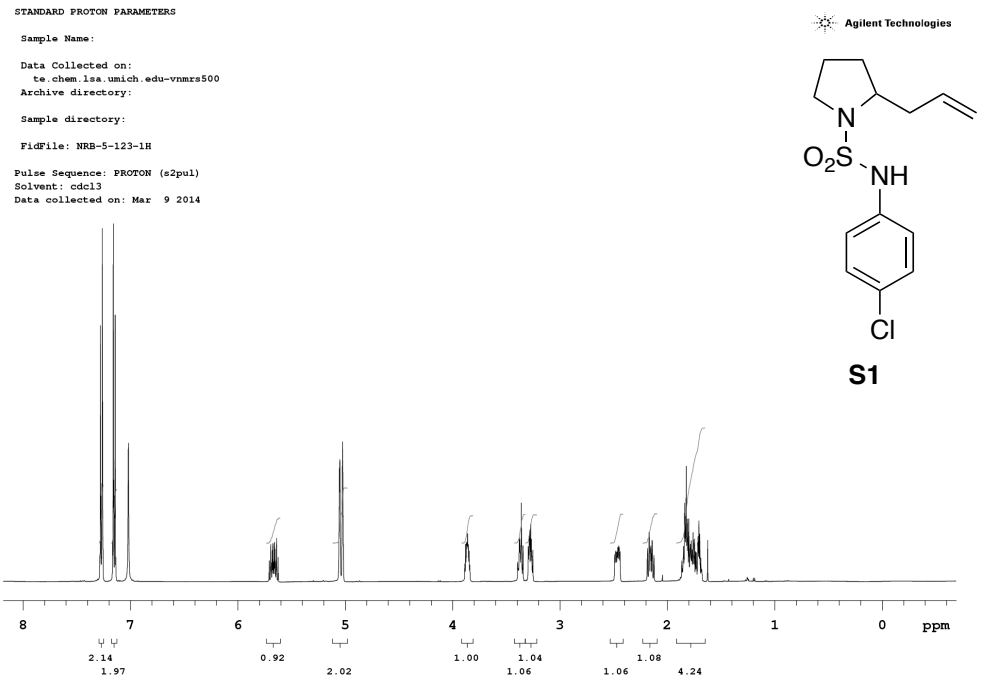
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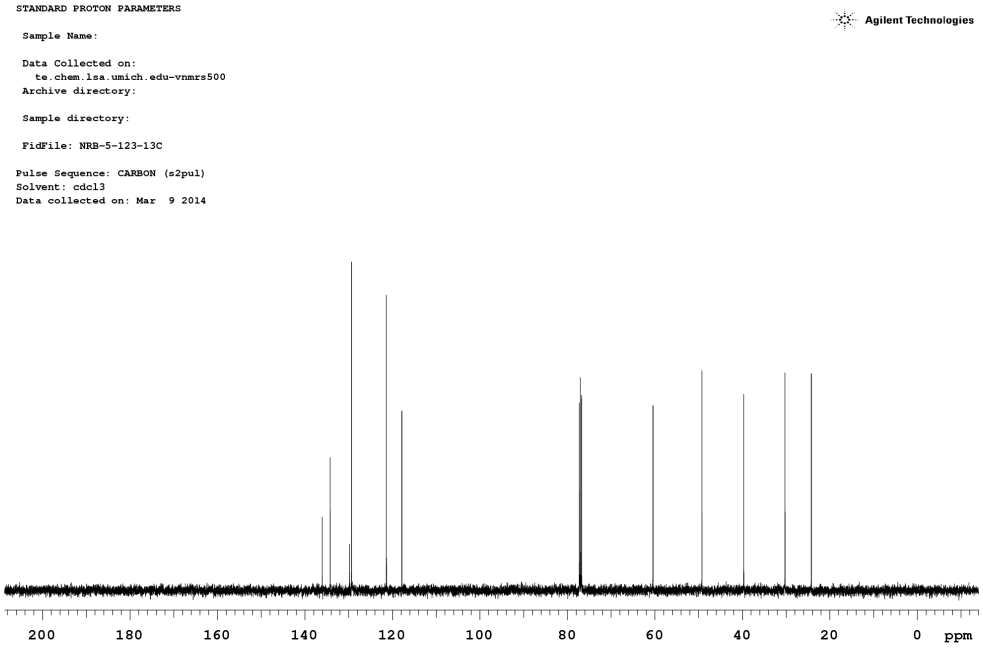
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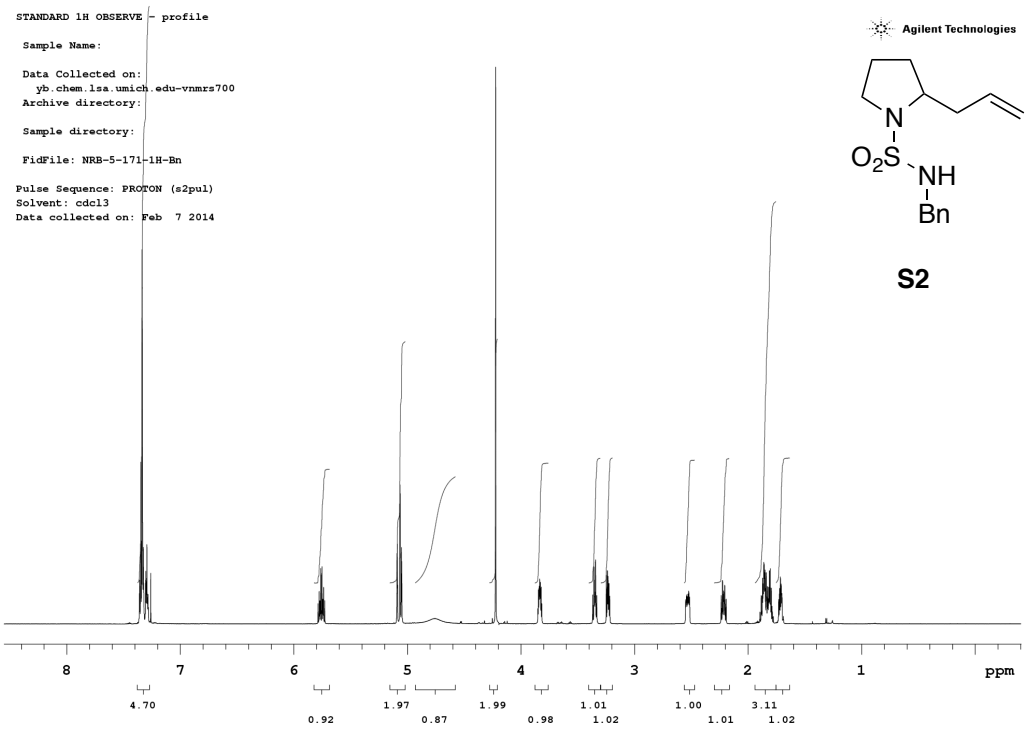
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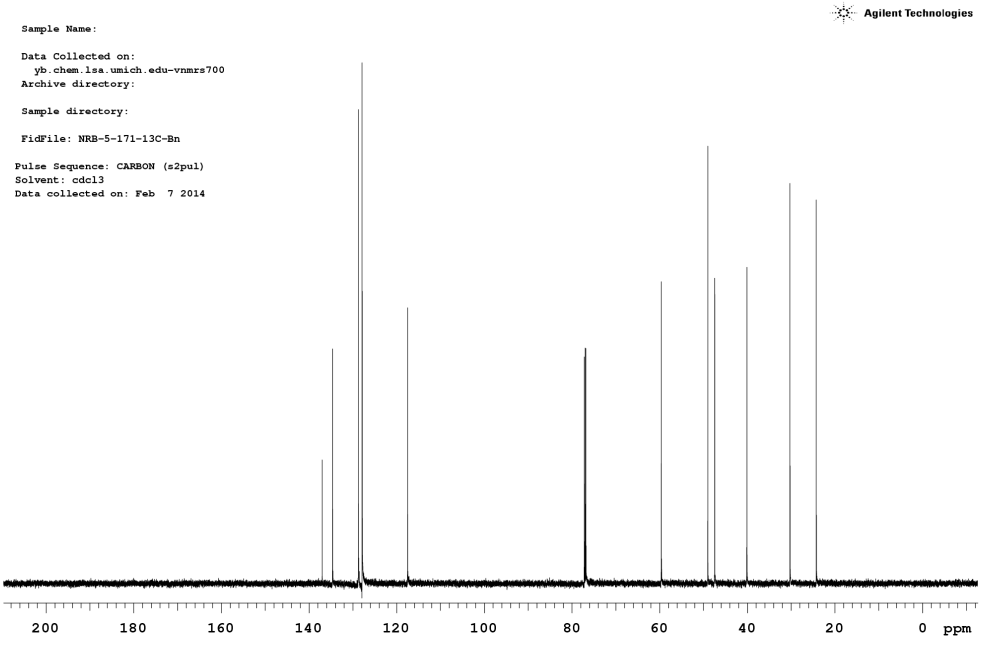
S2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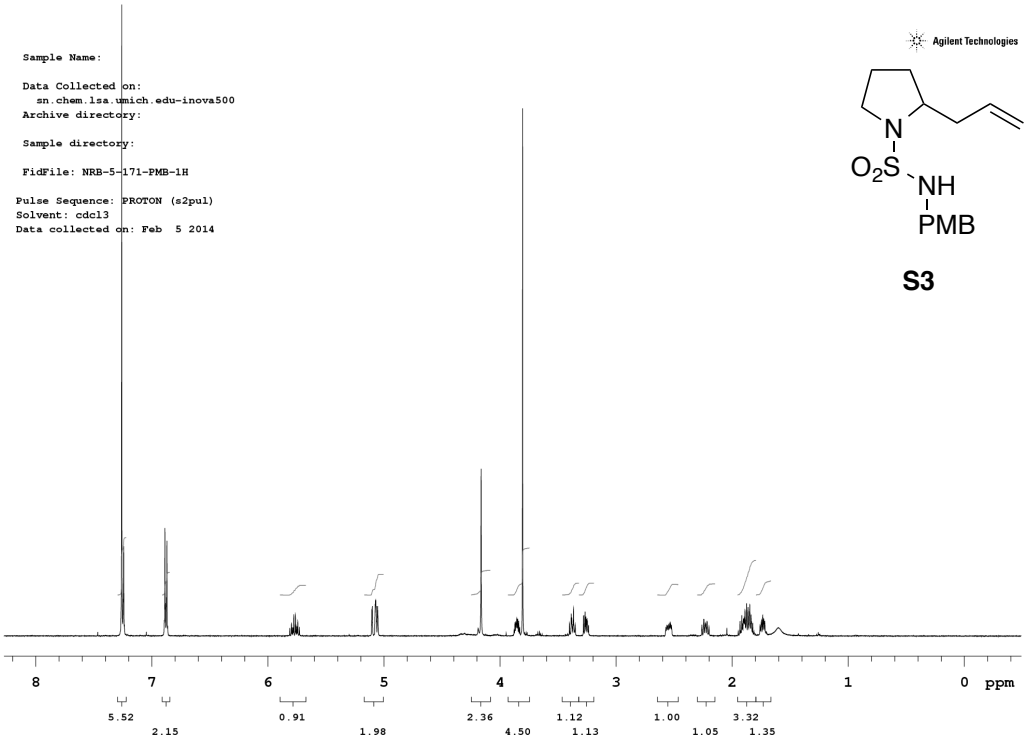
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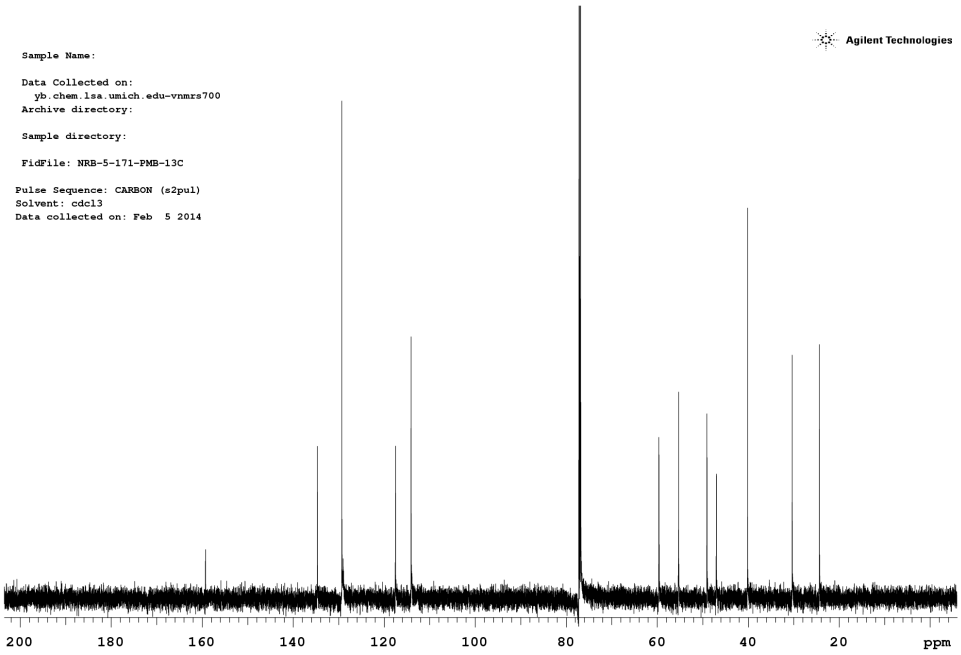
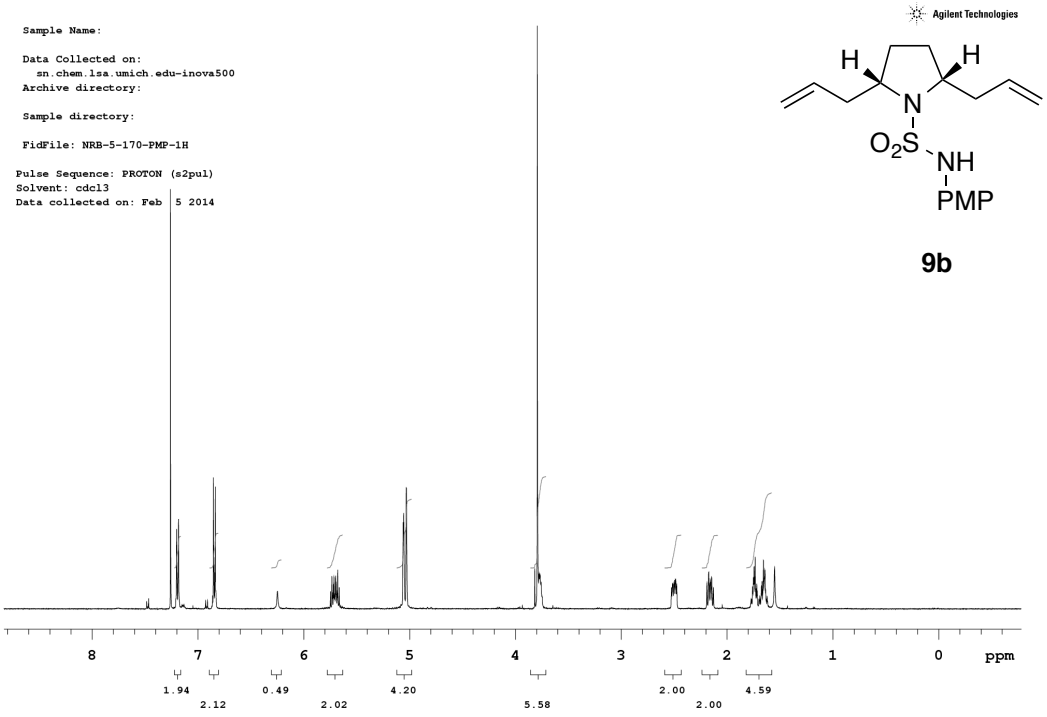
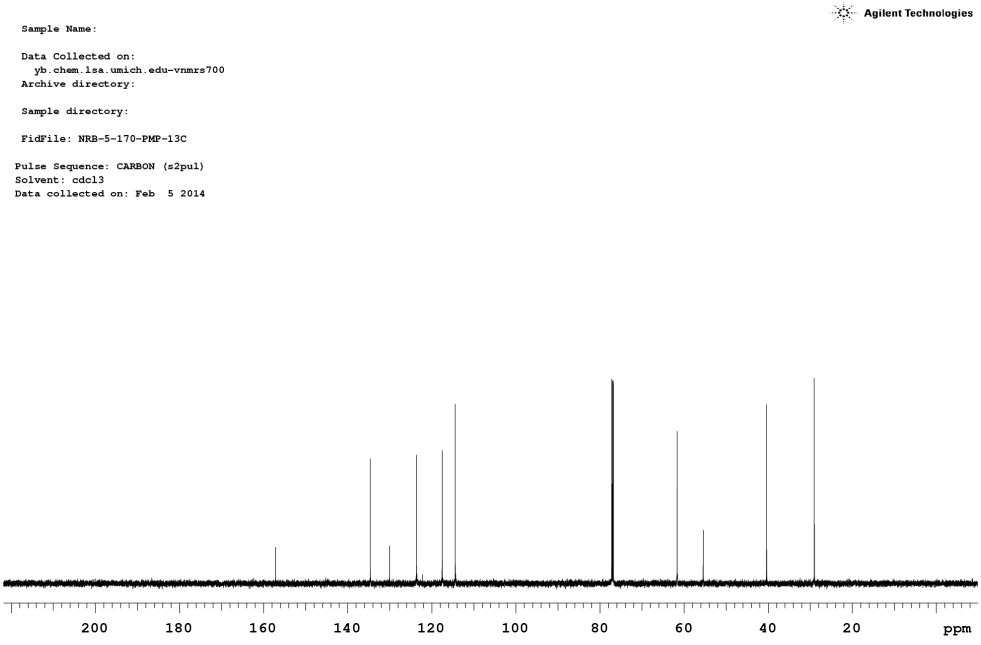
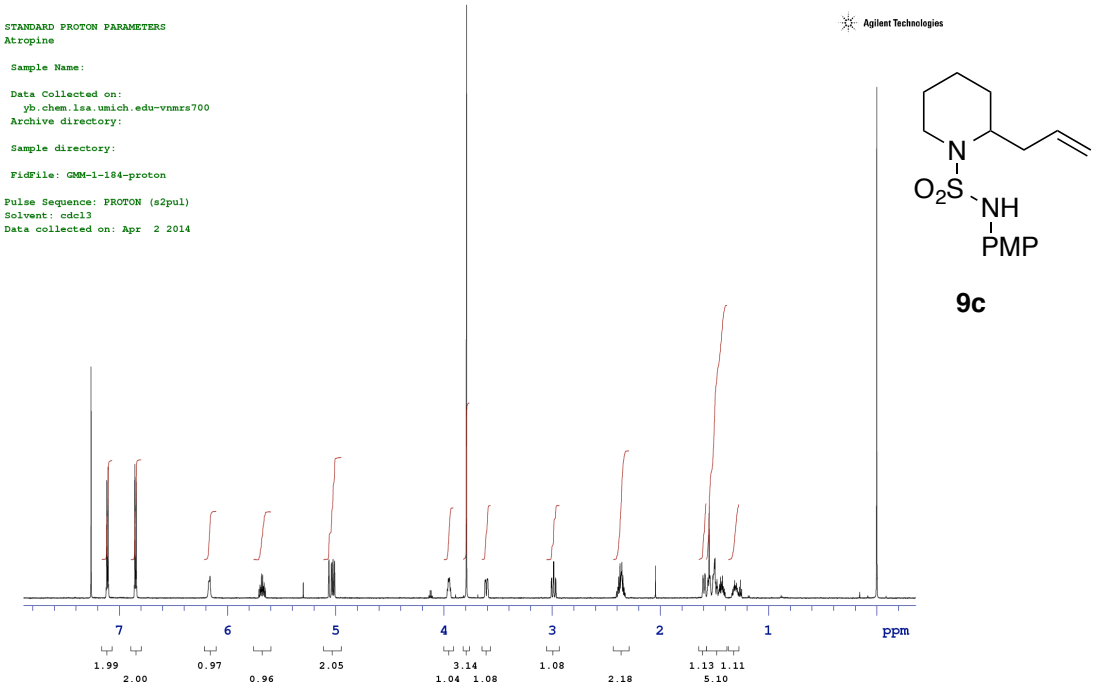
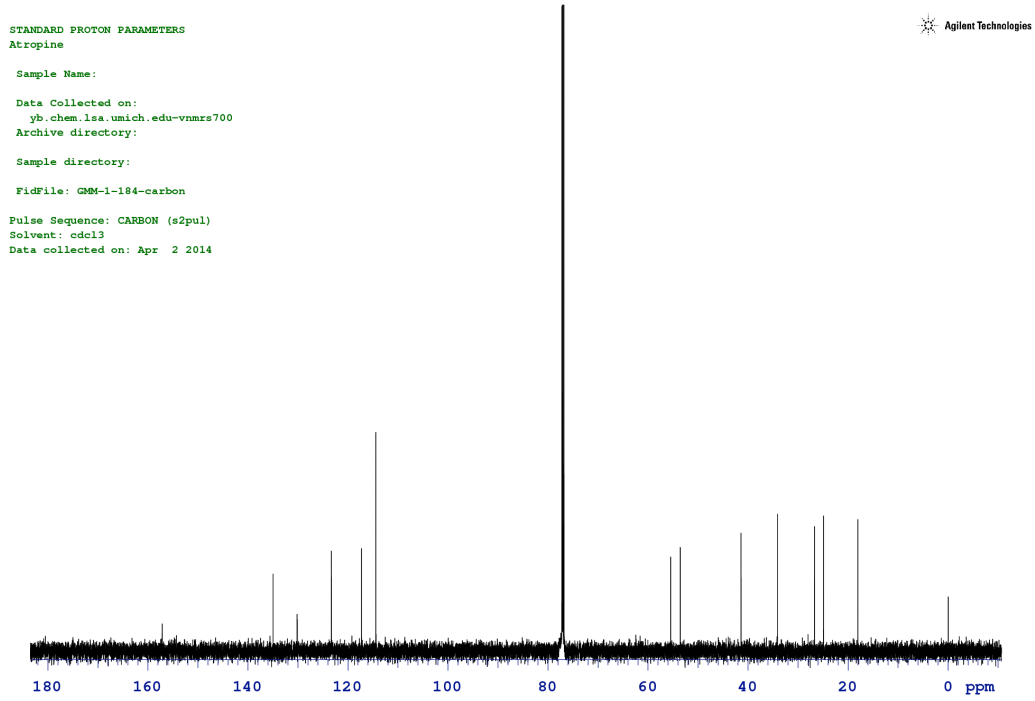
S3

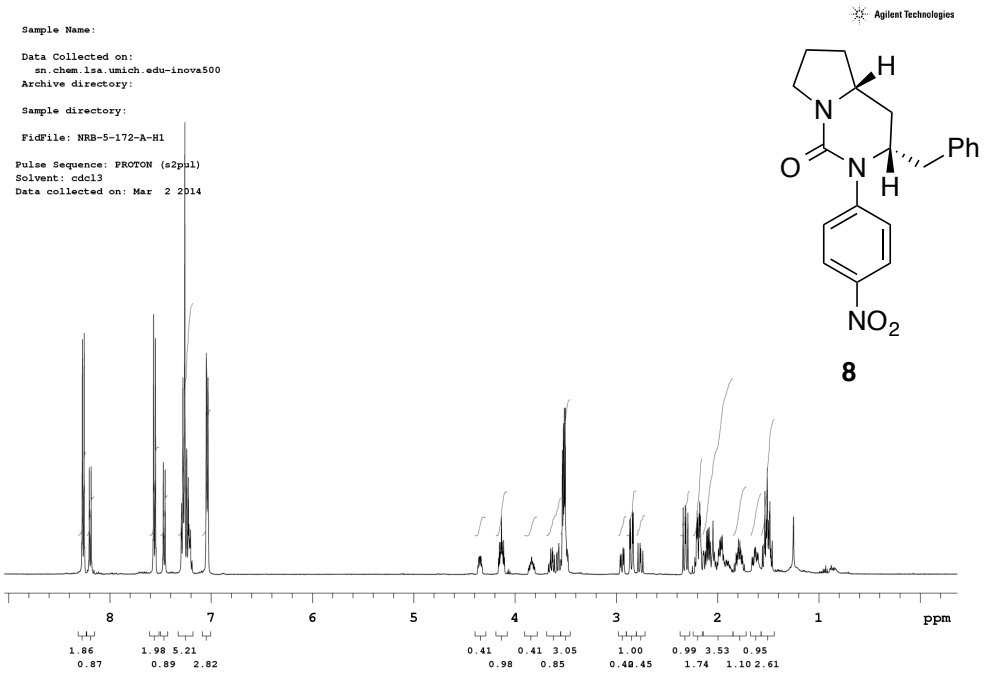

Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-5-171-PMB-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Feb 5 2014
Agilent Technologies
200 180 160 140 120 100 80 60 40 20 ppm

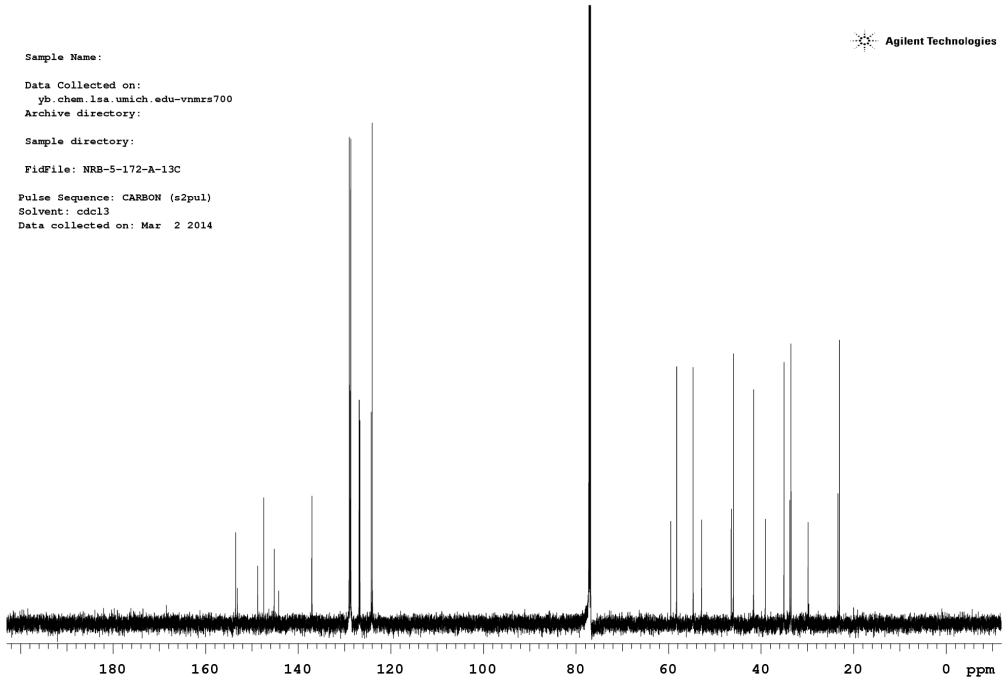

Agilent Technologies
Sample Name:
Data Collected on:
sn.chem.lsa.umich.edu-inova500
Archive directory:
Sample directory:
FidFile: NRB-5-170-PMP-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Feb 5 2014
H
H
N
O2S
NH
PMP
9b
8
7
6
5
4
3
2
1
0
ppm
1.94
2.12
0.49
2.02
4.20
5.58
2.00
2.00
4.59

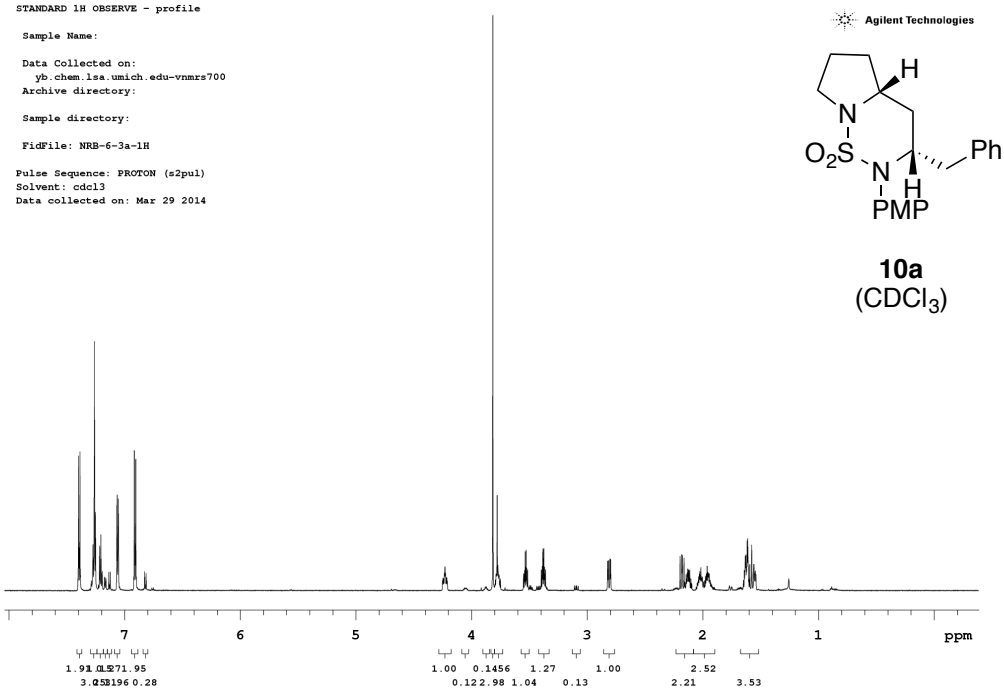

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-5-170-PMP-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Feb 5 2014
200
180
160
140
120
100
80
60
40
20
ppm

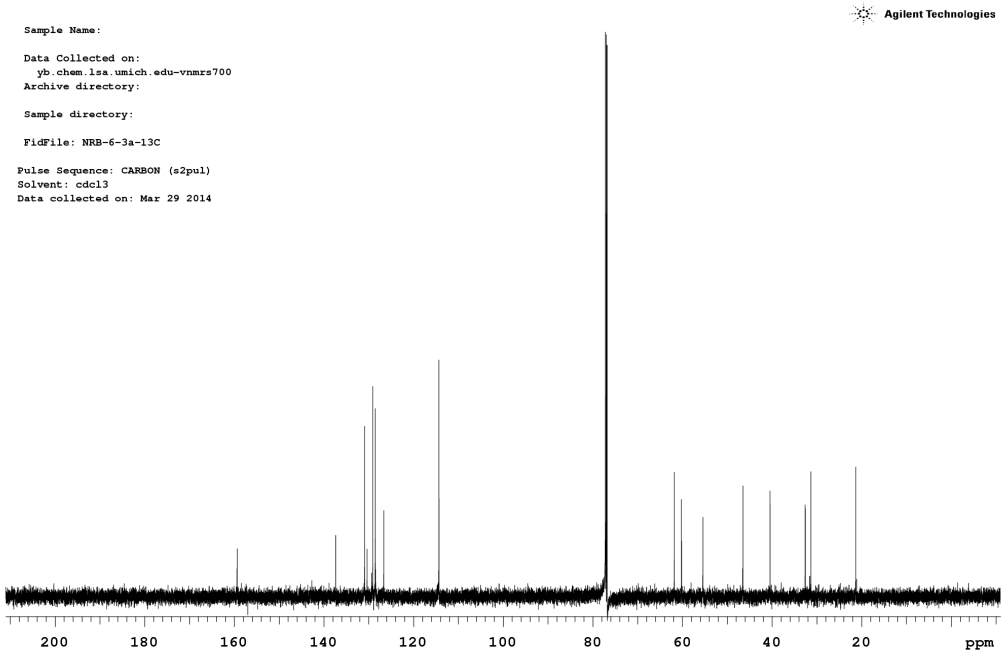

STANDARD PROTON PARAMETERS
Atropine
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: GMM-1-184-proton
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 2 2014
Agilent Technologies
N
O2S
NH
PMP
9c
7
6
5
4
3
2
1
ppm
1.99
2.00
0.97
0.96
2.05
3.14
1.04
1.08
1.08
2.18
1.13
1.11
5.10

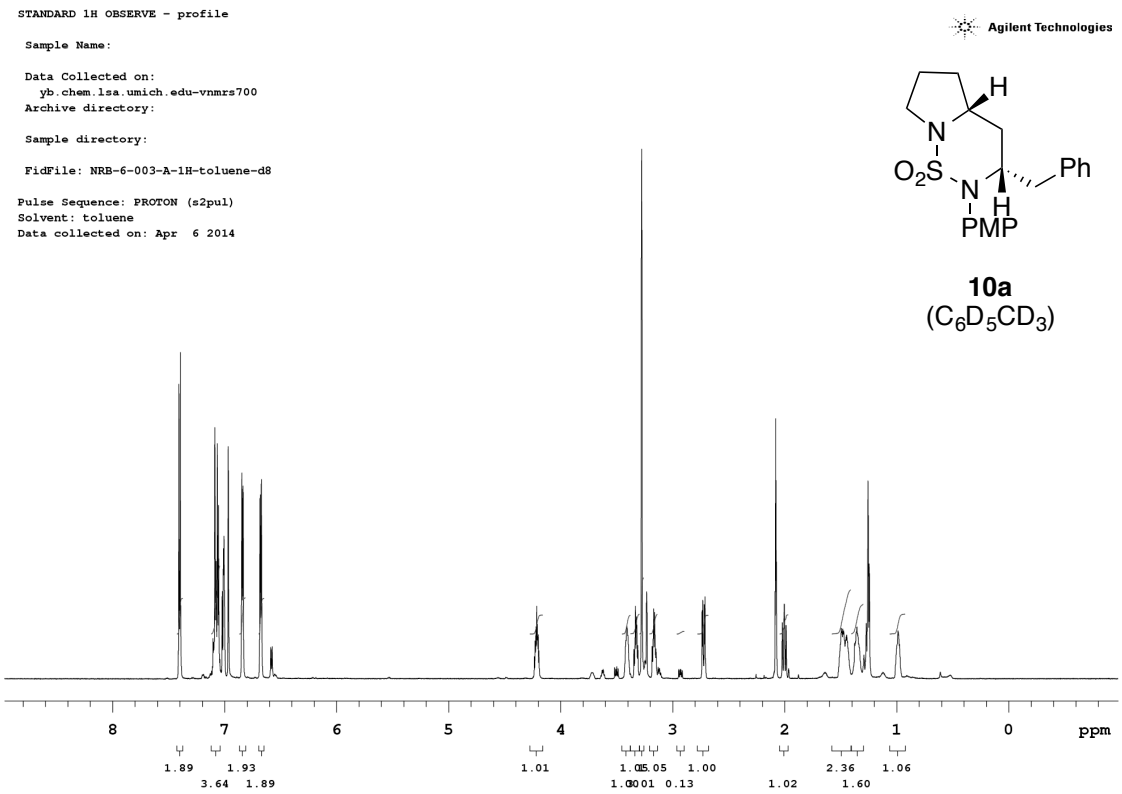

STANDARD PROTON PARAMETERS
Atropine
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: GMM-1-184-carbon
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 2 2014
Agilent Technologies
180
160
140
120
100
80
60
40
20
0 ppm

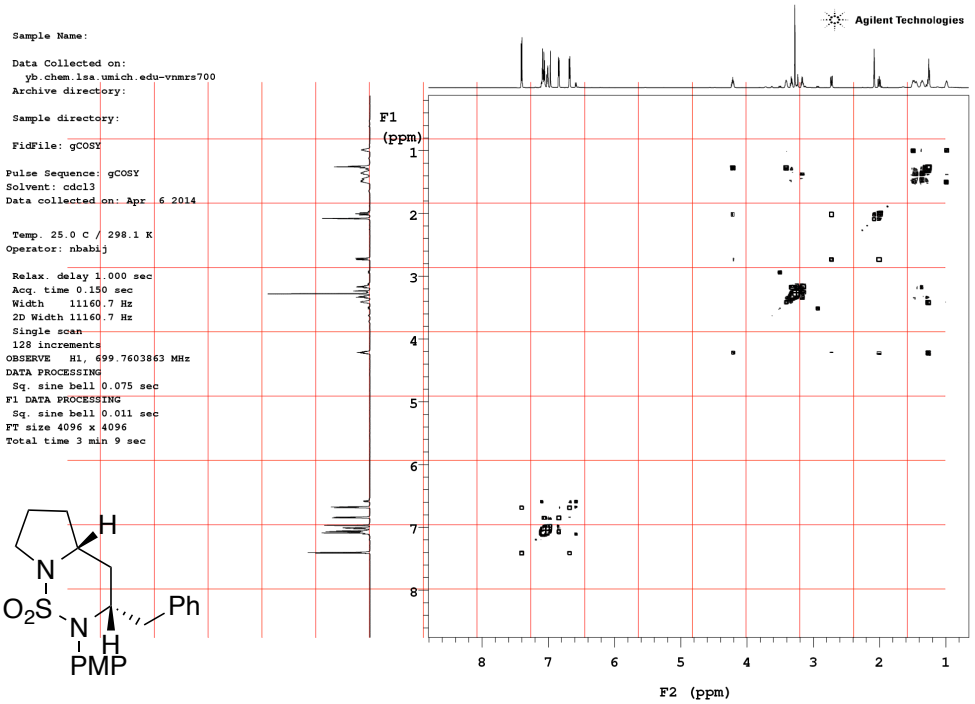

Agilent Technologies
Sample Name:
Data Collected on:
sn.chem.lsa.umich.edu-inova500
Archive directory:
Sample directory:
FidFile: NRB-5-172-A-H1
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014
H
N
O
N
H
Ph
NO2
8
8
7
6
5
4
3
2
1
ppm
1.86
0.87
1.98
0.89
5.21
2.82
0.41
0.98
0.41
0.85
3.05
1.00
0.45
0.99
1.74
3.53
1.10
0.95
2.61


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-5-172-A-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014
180
160
140
120
100
80
60
40
20
0
ppm

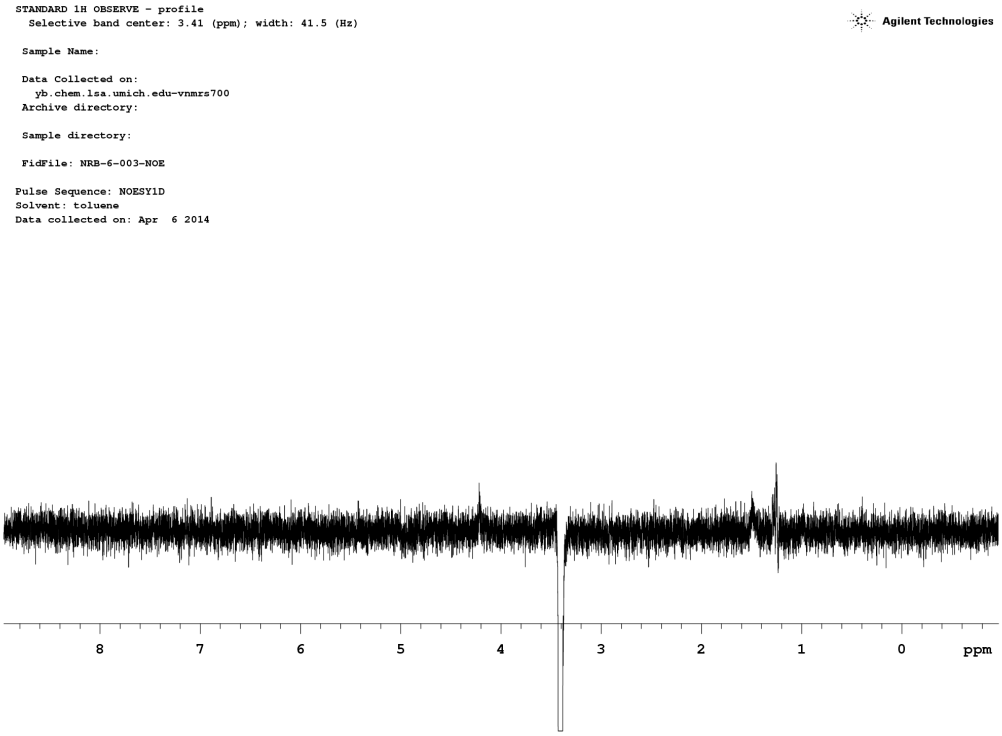

STANDARD 1H OBSERVE - profile
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-3a-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
Agilent Technologies
H
N
O2S
N
H
Ph
PMP
10a
(CDCl3)
7
6
5
4
3
2
1
ppm
1.00 0.14 56 1.27 1.00 2.52
0.12 2.98 1.04 0.13 2.21 3.53

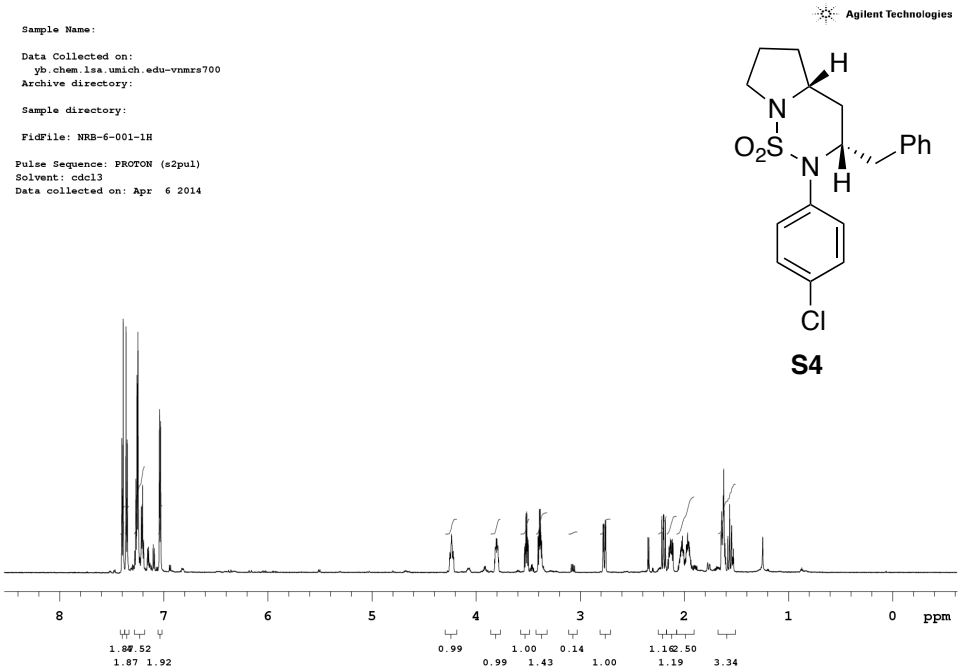

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-3a-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
200
180
160
140
120
100
80
60
40
20
ppm

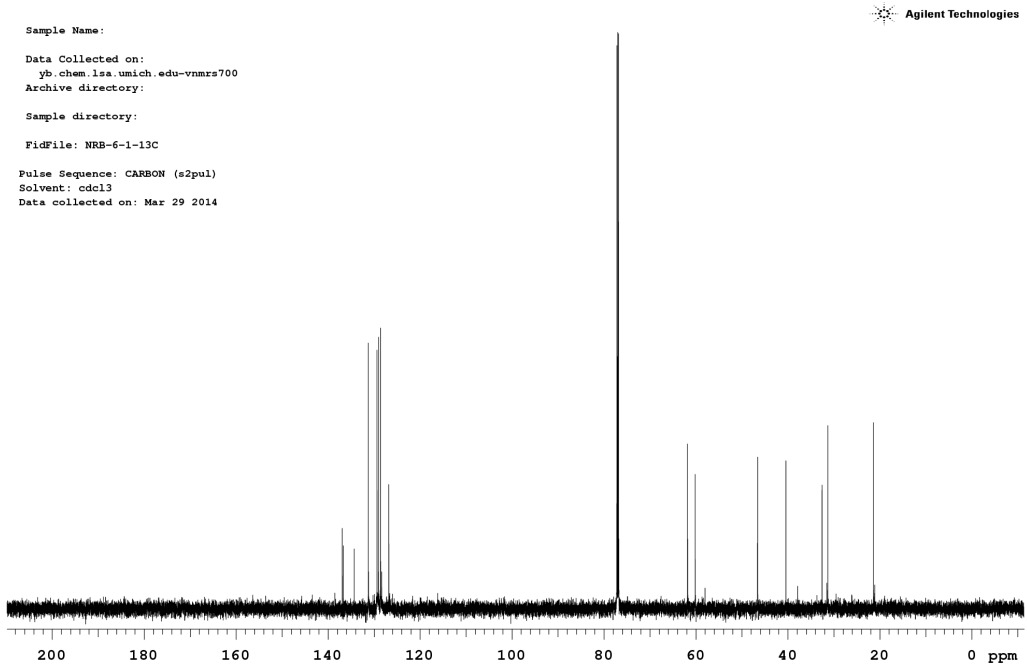

STANDARD 1H OBSERVE - profile
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-003-A-1H-toluene-d8
Pulse Sequence: PROTON (s2pul)
Solvent: toluene
Data collected on: Apr 6 2014
Agilent Technologies
H
N
O2S
N
H
PMP
Ph
10a
(C6D5CD3)
8
7
6
5
4
3
2
1
0
ppm
1.89
1.93
3.64
1.89
1.01
1.05
1.00
0.13
1.02
2.36
1.60
1.06

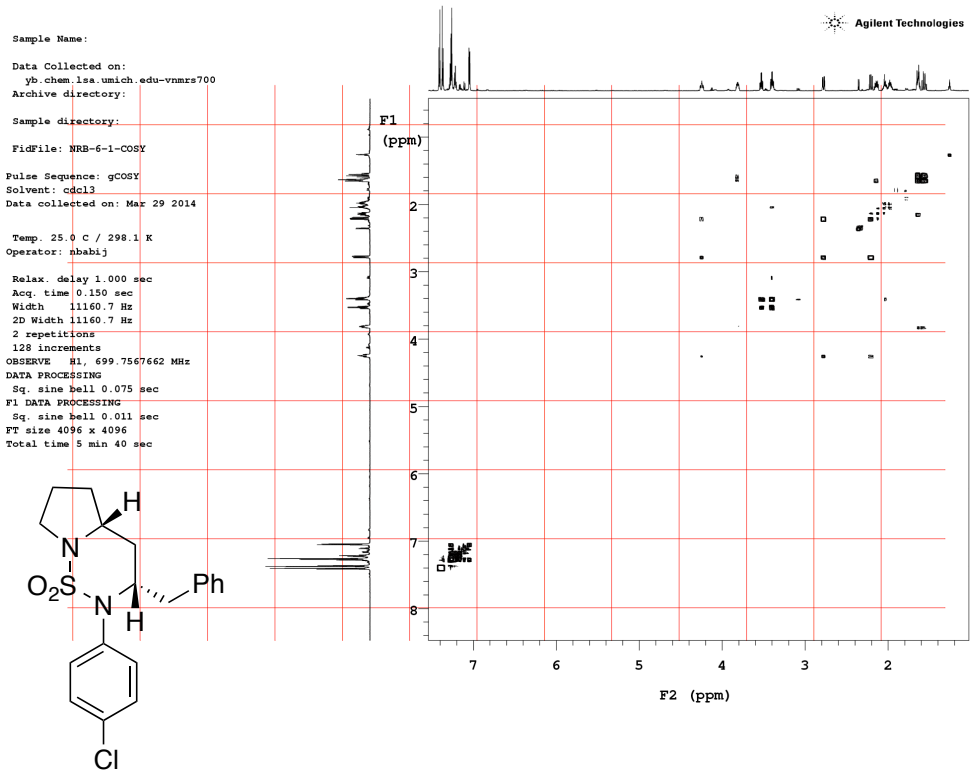

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: gCOSY
Pulse Sequence: gCOSY
Solvent: cdcl3
Data collected on: Apr 6 2014
Temp. 25.0 C / 298.1 K
Operator: nbabij
Relax. delay 1.000 sec
Acq. time 0.150 sec
Width 11160.7 Hz
2D Width 11160.7 Hz
Single scan
128 increments
OBSERVE H1, 699.7603863 MHz
DATA PROCESSING
Sq. sine bell 0.075 sec
F1 DATA PROCESSING
Sq. sine bell 0.011 sec
FT size 4096 x 4096
Total time 3 min 9 sec
F1
(ppm)
F2 (ppm)
H
N
O2S
N
H
Ph
PMP

10a
($C_6D_5CD_3$)

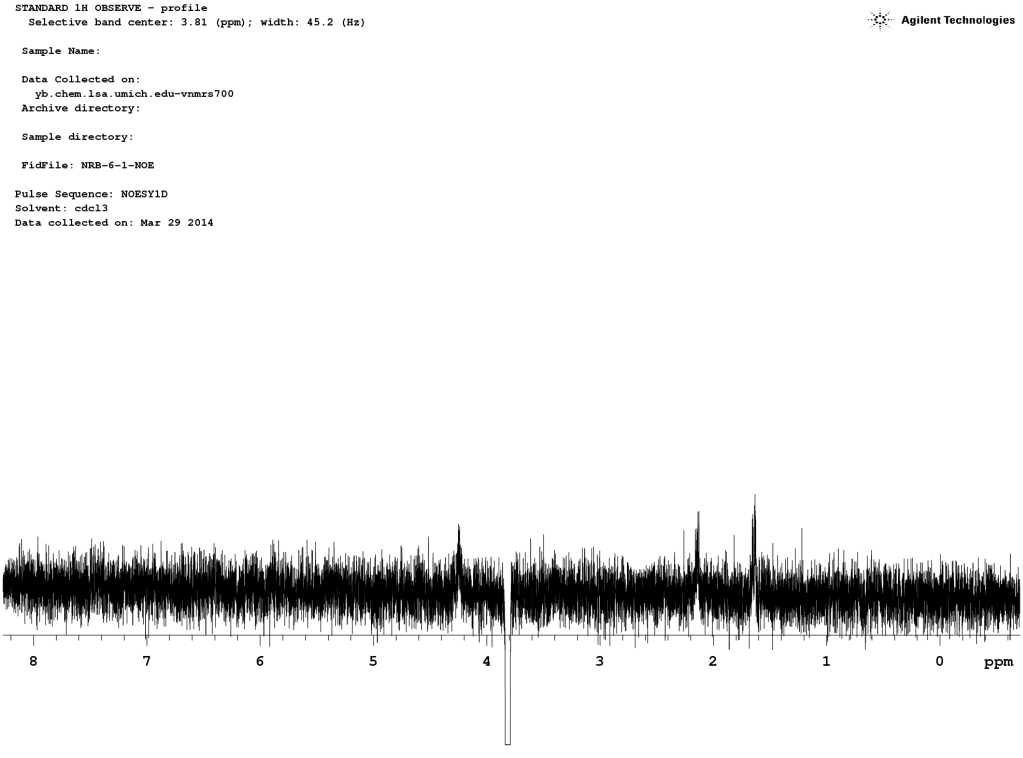

STANDARD 1H OBSERVE - profile
Selective band center: 3.41 (ppm); width: 41.5 (Hz)
Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-003-NOE
Pulse Sequence: NOESY1D
Solvent: toluene
Data collected on: Apr 6 2014
ppm


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-001-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 6 2014
H
N
O2S
N
H
Ph
Cl
S4
8
7
6
5
4
3
2
1
0
ppm
1.87
7.52
1.92
0.99
0.99
1.00
1.43
0.14
1.00
1.16
2.50
1.19
3.34


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-1-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
200
180
160
140
120
100
80
60
40
20
0
ppm


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-1-COSY
Pulse Sequence: gCOSY
Solvent: cdcl3
Data collected on: Mar 29 2014
Temp. 25.0 C / 298.1 K
Operator: nbabij
Relax. delay 1.000 sec
Acq. time 0.150 sec
Width 11160.7 Hz
2D Width 11160.7 Hz
2 repetitions
128 increments
OBSERVE H1, 699.7567662 MHz
DATA PROCESSING
Sq. sine bell 0.075 sec
F1 DATA PROCESSING
Sq. sine bell 0.011 sec
FT size 4096 x 4096
Total time 5 min 40 sec
F1 (ppm)
F2 (ppm)
H
N
O2S
N
H
Ph
Cl

S4


STANDARD 1H OBSERVE - profile
Selective band center: 3.81 (ppm); width: 45.2 (Hz)
Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-1-NOE
Pulse Sequence: NOESY1D
Solvent: cdcl3
Data collected on: Mar 29 2014
ppm

STANDARD 1H OBSERVE - profile

Sample Name:

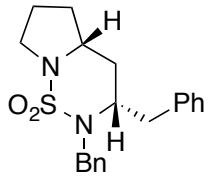
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:

Sample directory:

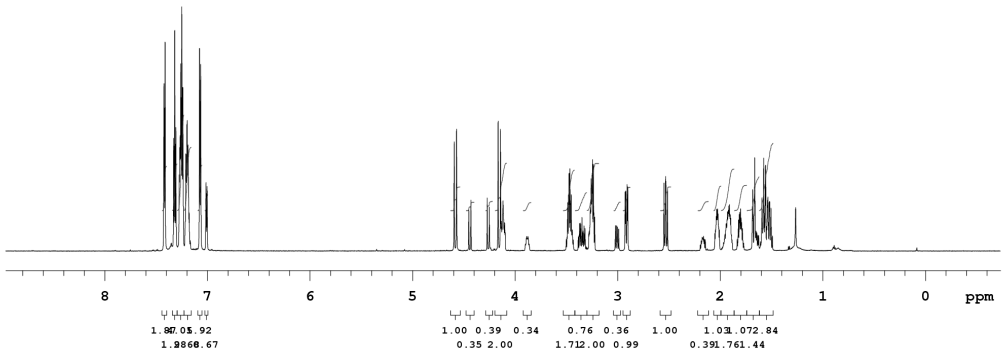
FidFile: NRB-5-180-Bn-1H

Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014

Agilent Technologies



S5



Agilent Technologies

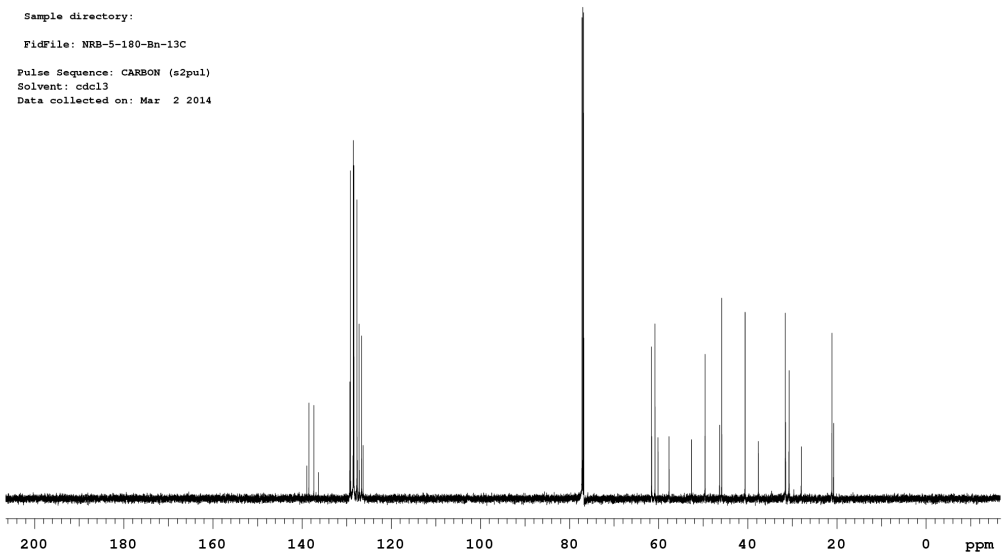
Sample Name:

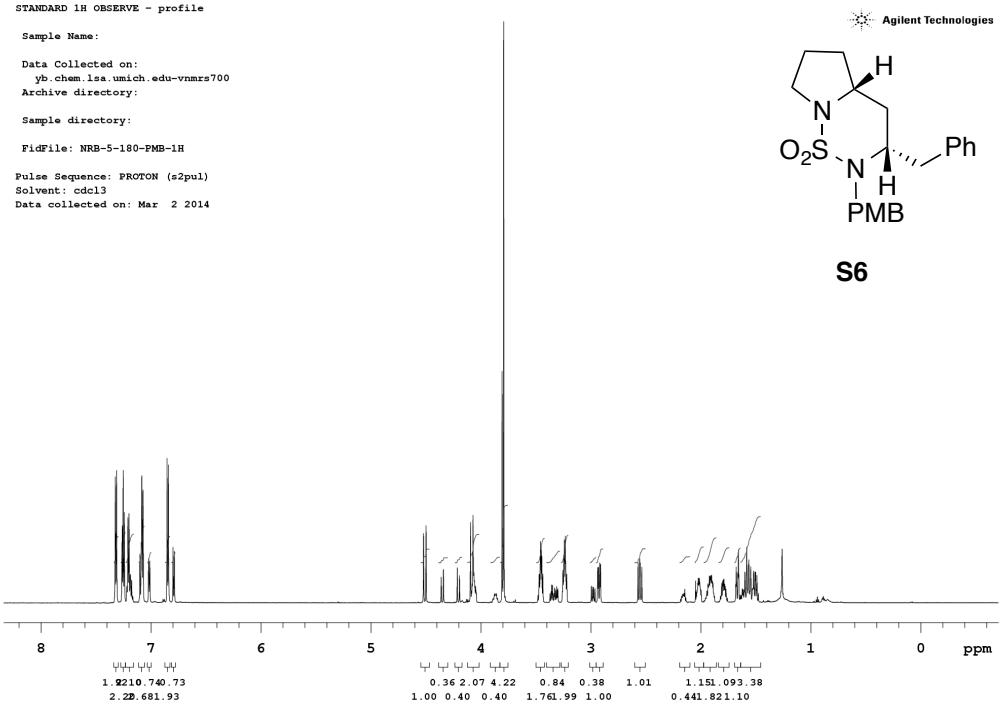
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:

Sample directory:

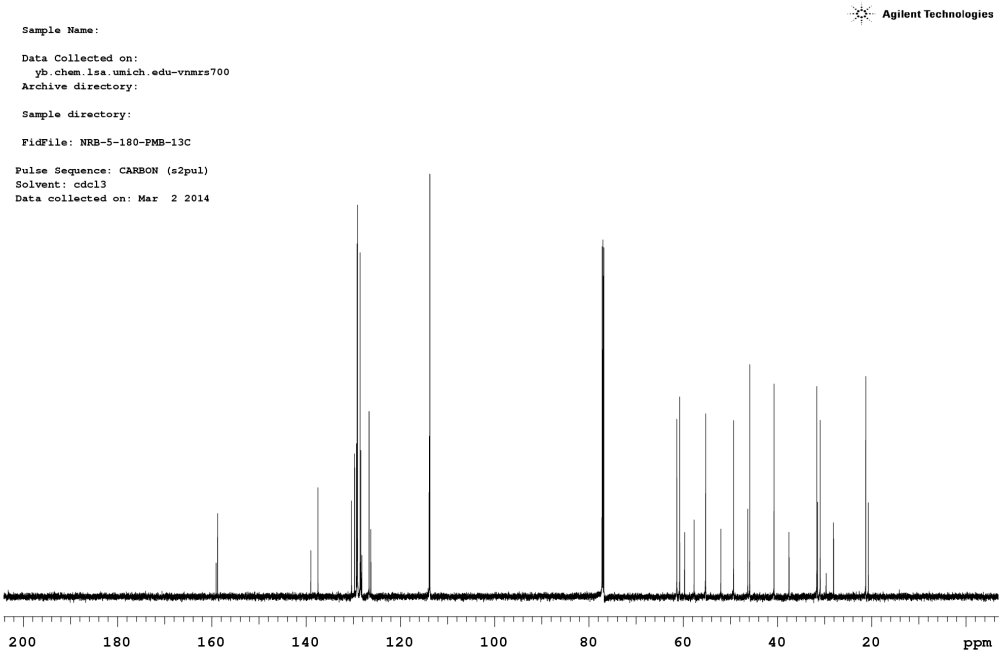
FidFile: NRB-5-180-Bn-13C

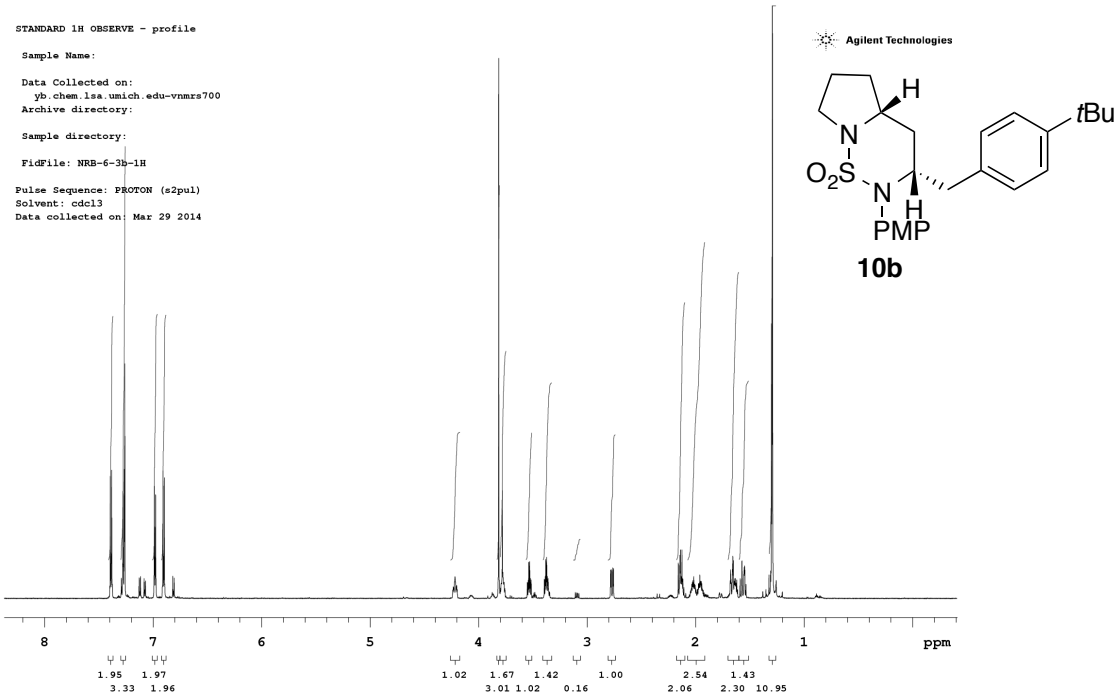
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014

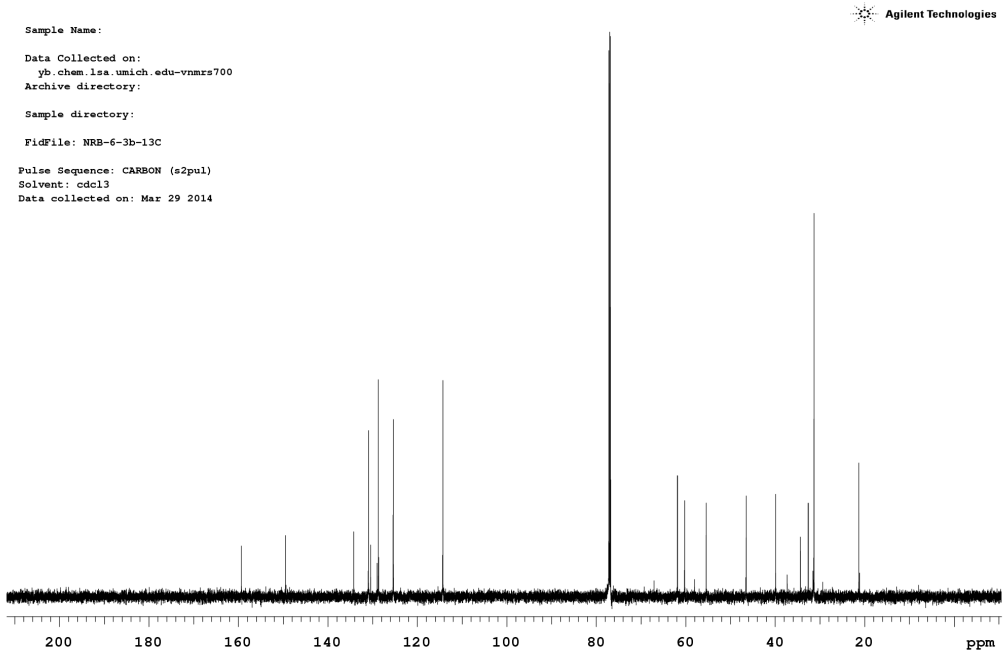


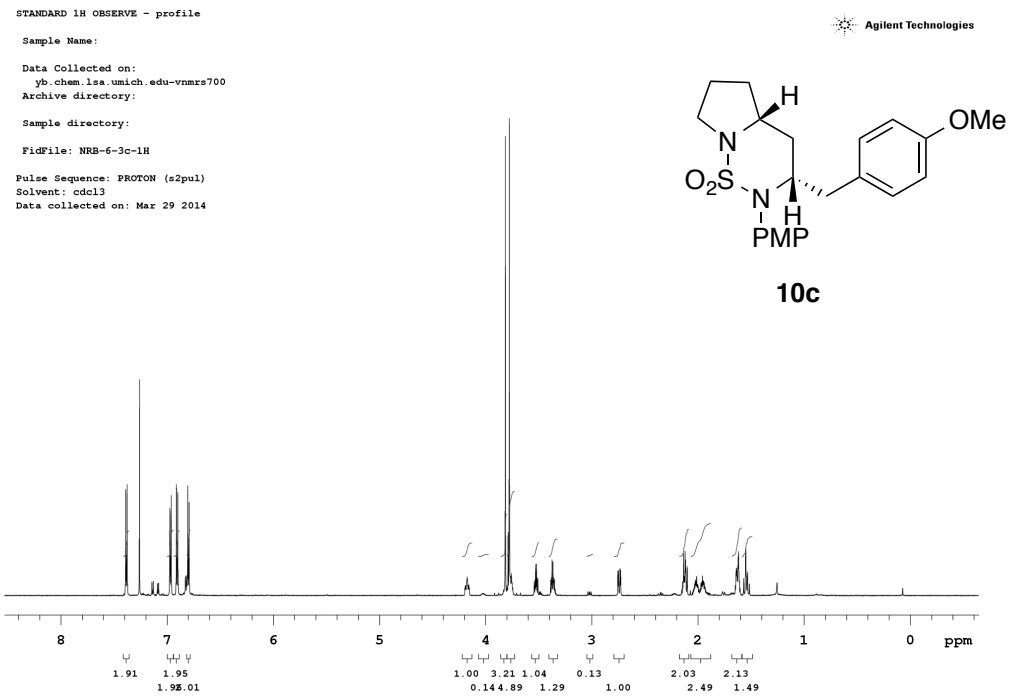

STANDARD 1H OBSERVE - profile
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-5-180-PMB-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014
Agilent Technologies
H
N
O2S
N
H
Ph
PMB
8
7
6
5
4
3
2
1
0
ppm
1.92 1.0 0.74 0.73
2.22 2.68 1.93
0.36 2.07 4.22 0.84 0.38 1.01 1.15 1.09 3.38
1.00 0.40 0.40 1.76 1.99 1.00 0.44 1.82 1.10

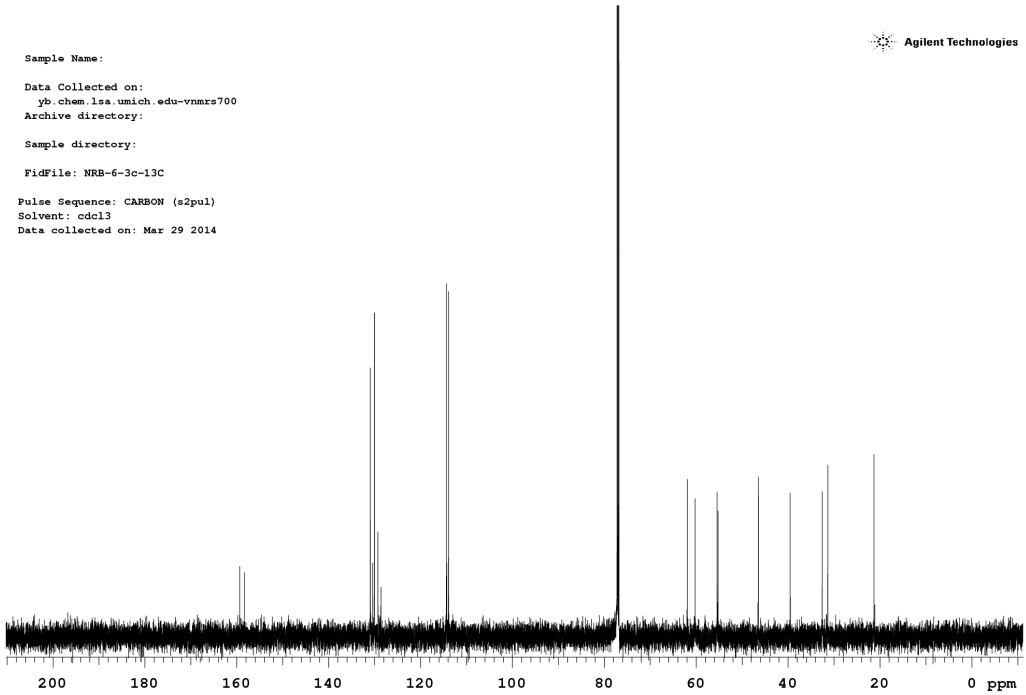
S6

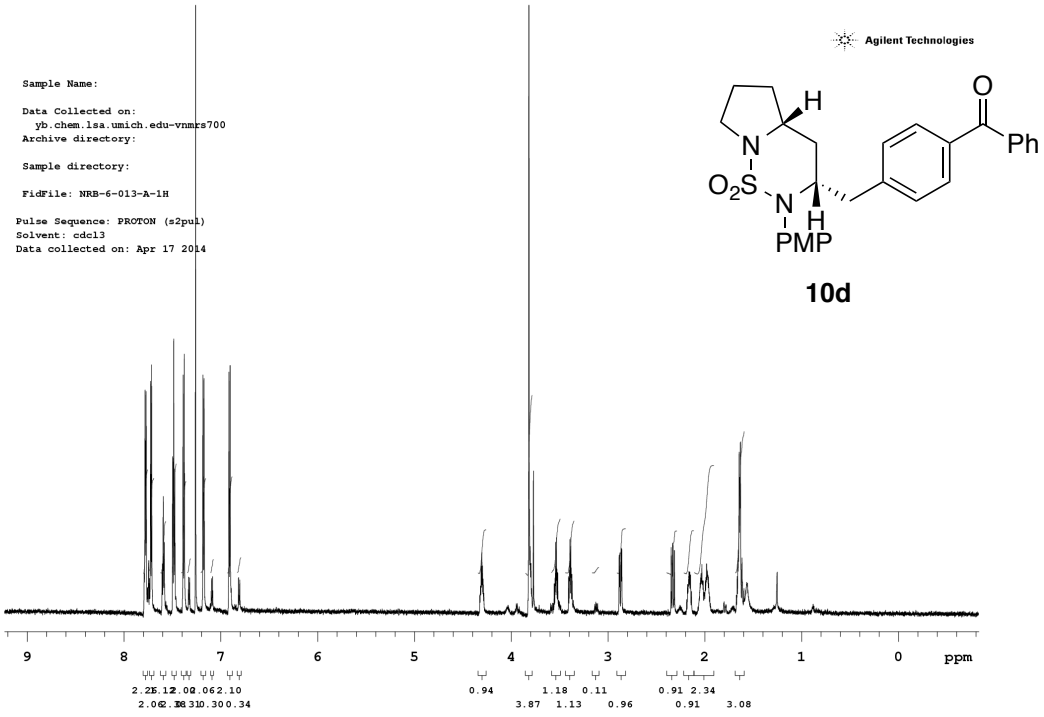

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-5-180-PMB-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014
200
180
160
140
120
100
80
60
40
20
ppm

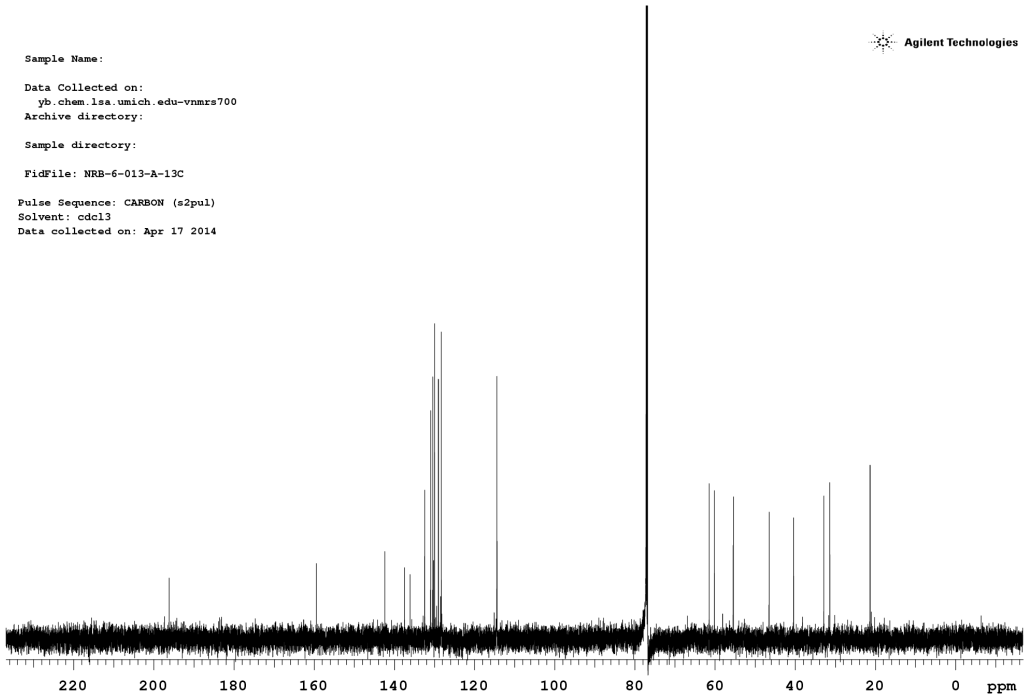

STANDARD 1H OBSERVE - profile
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-3b-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
Agilent Technologies
H
N
O2S
N
H
PMP
tBu
10b
8
7
6
5
4
3
2
1
ppm
1.95 1.97
3.33 1.96
1.02 1.67 1.42 1.00
3.01 1.02 0.16
2.54 1.43
2.06 2.30 10.95

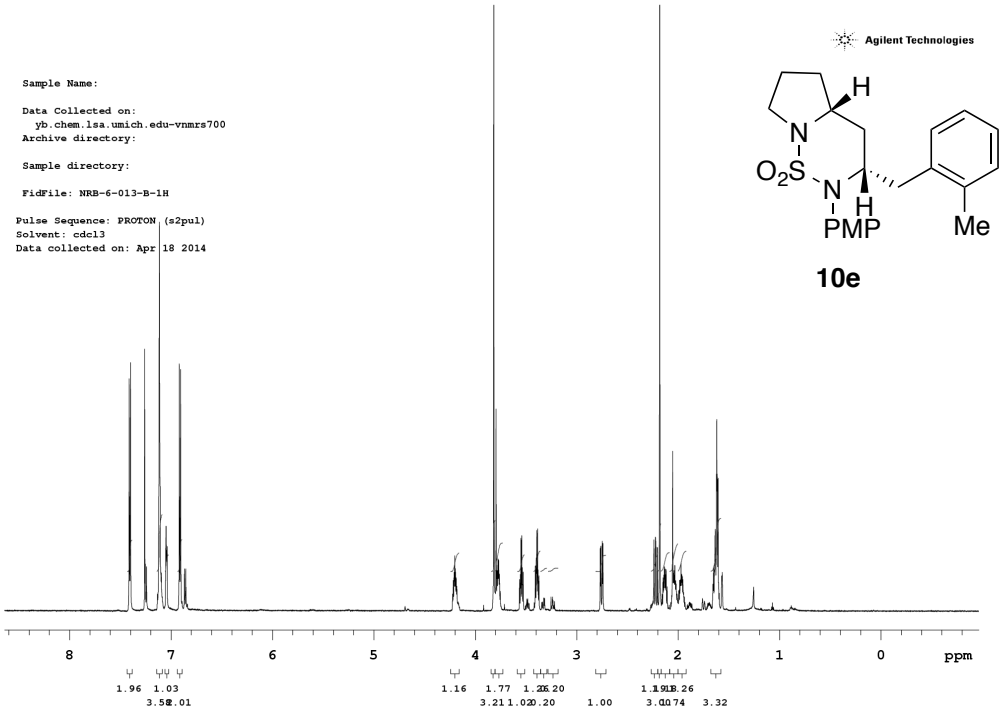

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-3b-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
200
180
160
140
120
100
80
60
40
20
ppm

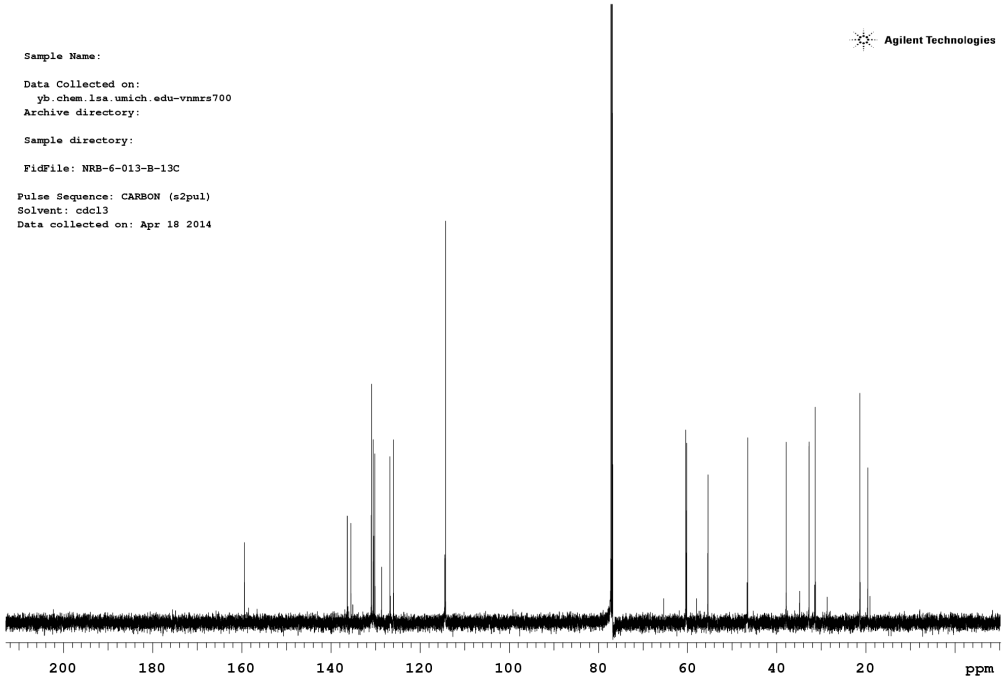

STANDARD 1H OBSERVE - profile
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-3c-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
Agilent Technologies
H
N
O2S
N
H
PMP
OMe
10c
8
7
6
5
4
3
2
1
0
ppm
1.91
1.95
1.95
1.01
1.00
3.21
1.04
0.13
0.14
4.89
1.29
1.00
2.03
2.13
2.49
1.49

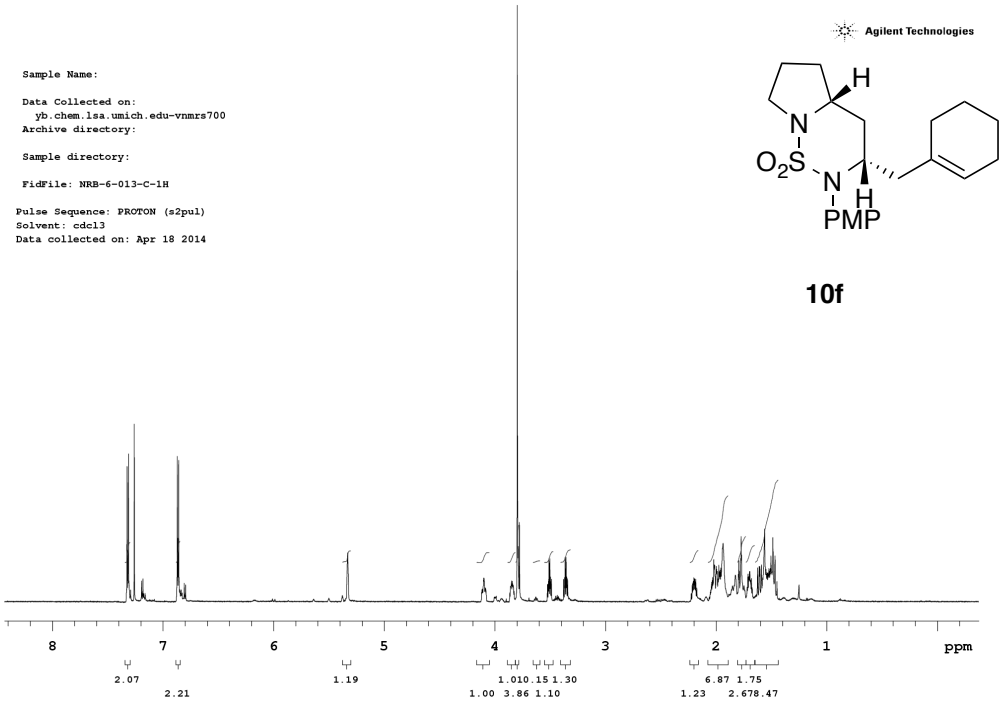

Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-3c-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
Agilent Technologies
200
180
160
140
120
100
80
60
40
20
0
ppm


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-013-A-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 17 2014
H
N
O2S
N
H
PMP
O
Ph
10d
9
8
7
6
5
4
3
2
1
0
ppm
2.25 5.12 2.02 2.06 2.10
2.06 2.38 1.31 0.30 0.34
0.94
3.87
1.18
1.13
0.11
0.96
0.91 2.34
0.91
3.08

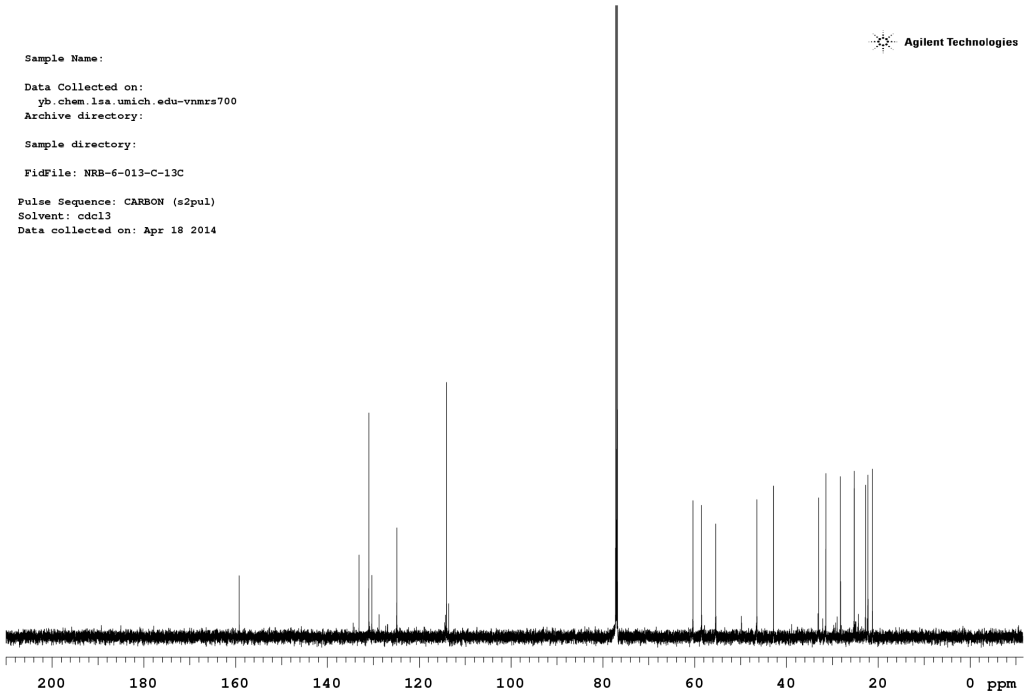

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-013-A-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 17 2014
220
200
180
160
140
120
100
80
60
40
20
0
ppm

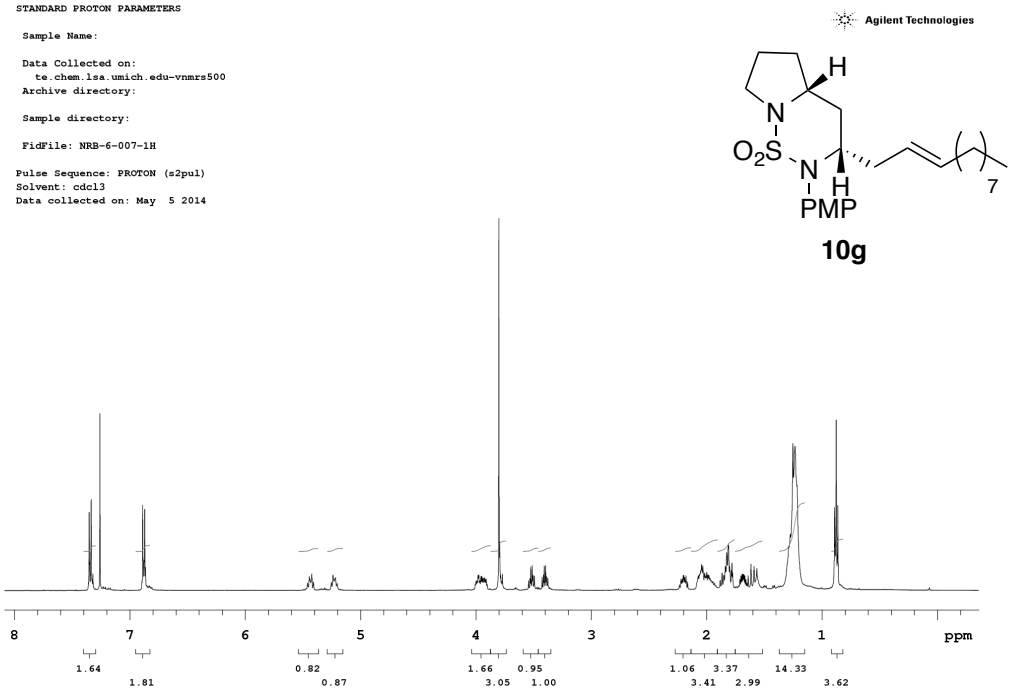

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-013-B-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 18 2014
H
N
O2S
N
H
PMP
Me
10e
8
7
6
5
4
3
2
1
0
ppm
1.96
1.03
1.16
1.77
3.21
1.02
1.00
3.32

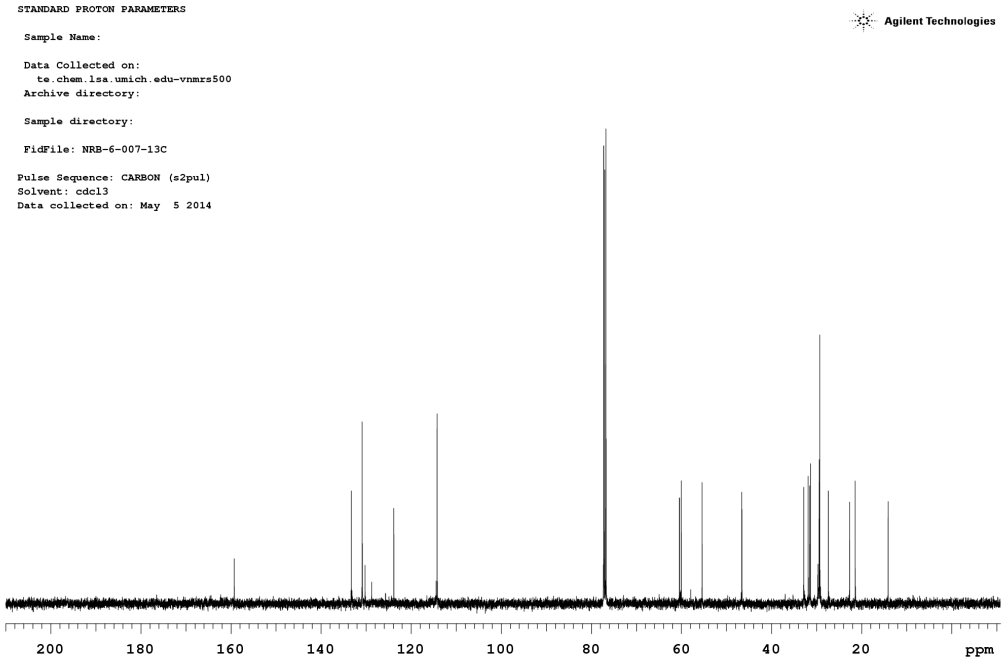

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-013-B-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 18 2014
200
180
160
140
120
100
80
60
40
20
ppm

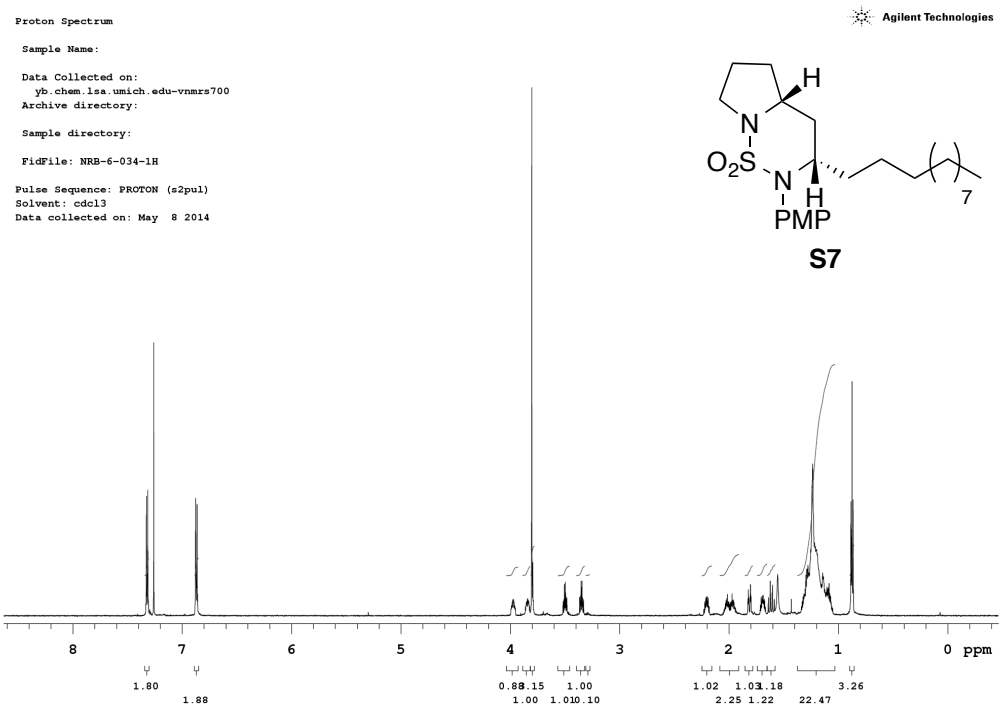

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-013-C-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 18 2014
H
N
O2S
N
H
PMP
8
7
6
5
4
3
2
1
ppm
2.07
2.21
1.19
1.00
3.86
1.10
1.01
0.15
1.30
1.23
6.87
1.75
2.67
8.47

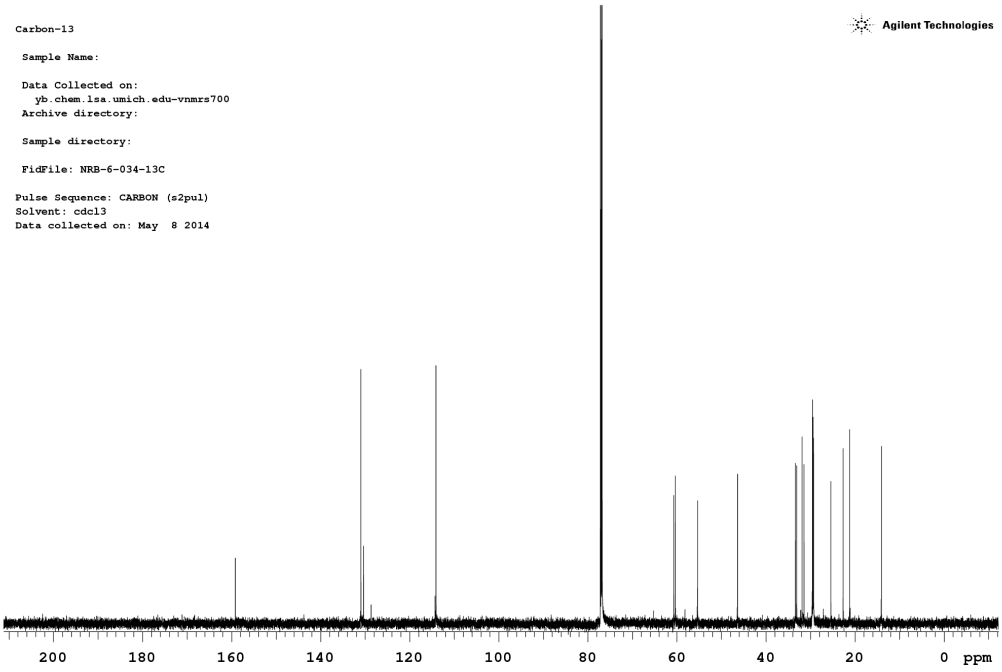
10f

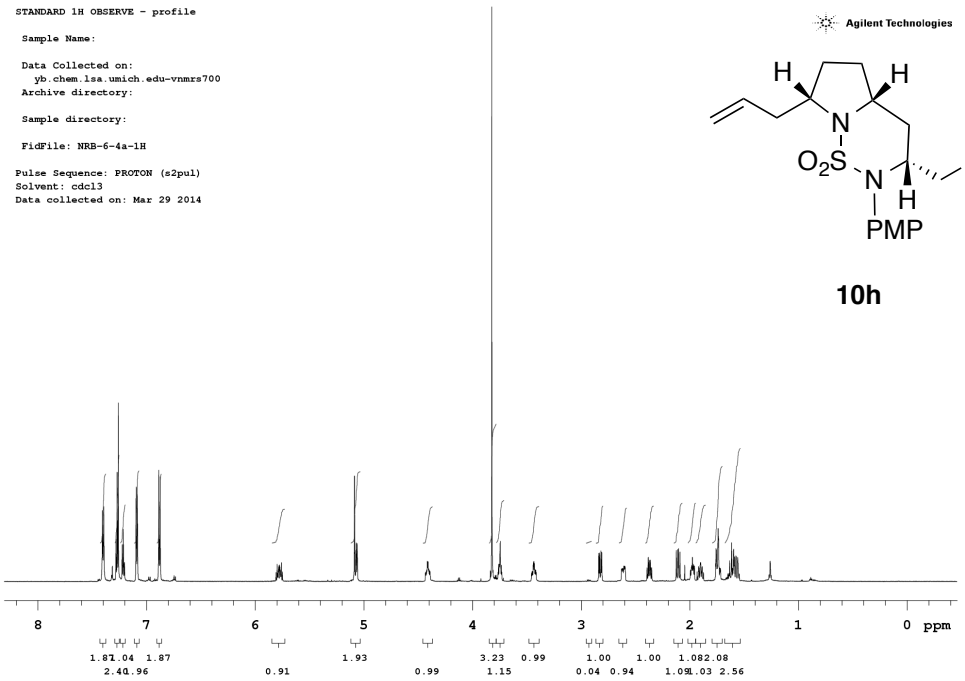

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-013-C-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 18 2014
200
180
160
140
120
100
80
60
40
20
0
ppm

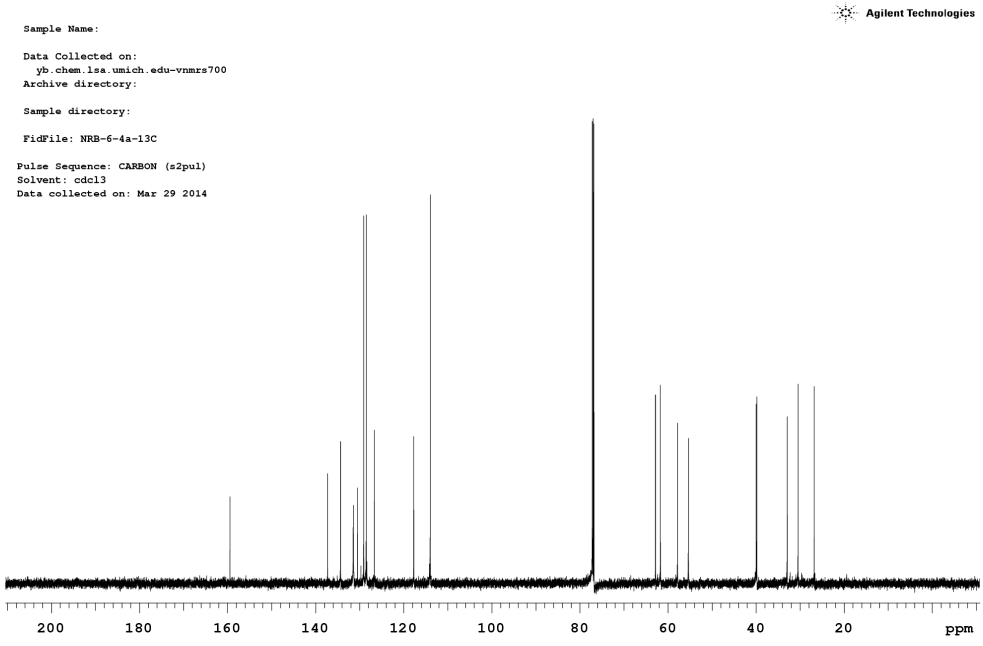

STANDARD PROTON PARAMETERS
Sample Name:
Data Collected on:
te.chem.lsa.umich.edu-vnmrs500
Archive directory:
Sample directory:
FidFile: NRB-6-007-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: May 5 2014
Agilent Technologies
H
N
O2S
N
H
PMP
7
10g
8
7
6
5
4
3
2
1
ppm
1.64
1.81
0.82
0.87
1.66
3.05
0.95
1.00
1.06
3.41
3.37
2.99
14.33
3.62

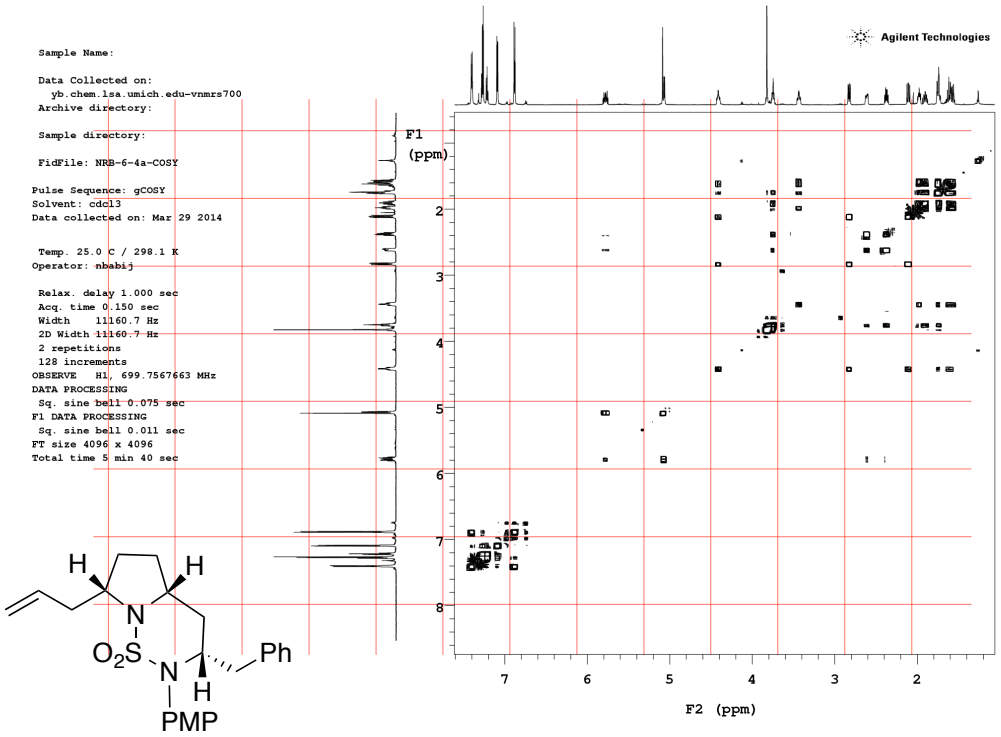

STANDARD PROTON PARAMETERS
Sample Name:
Data Collected on:
te.chem.lsa.umich.edu-vnmrs500
Archive directory:
Sample directory:
FidFile: NRB-6-007-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: May 5 2014
Agilent Technologies
200
180
160
140
120
100
80
60
40
20
ppm


Proton Spectrum
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-034-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: May 8 2014
Agilent Technologies
H
N
O2S
N
H
PMP
7
S7
8
7
6
5
4
3
2
1
0 ppm
1.80
1.88
0.88
3.15
1.00
1.00
1.01
0.10
1.02
2.25
1.03
1.22
1.18
22.47
3.26

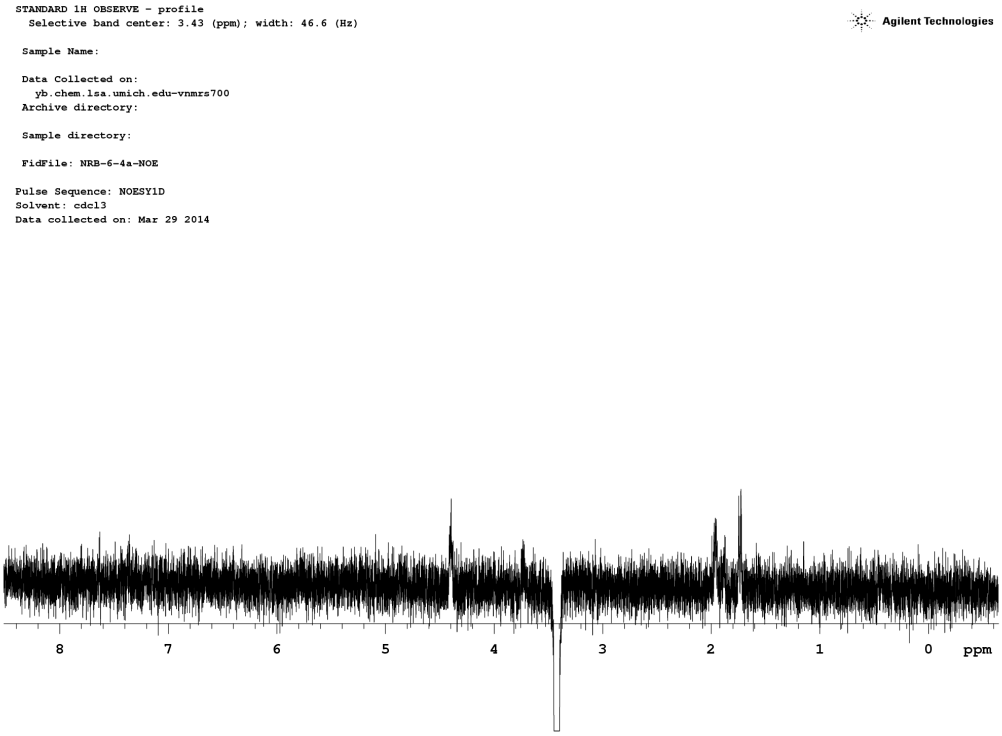

Carbon-13
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-034-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: May 8 2014
Agilent Technologies
200
180
160
140
120
100
80
60
40
20
0 ppm

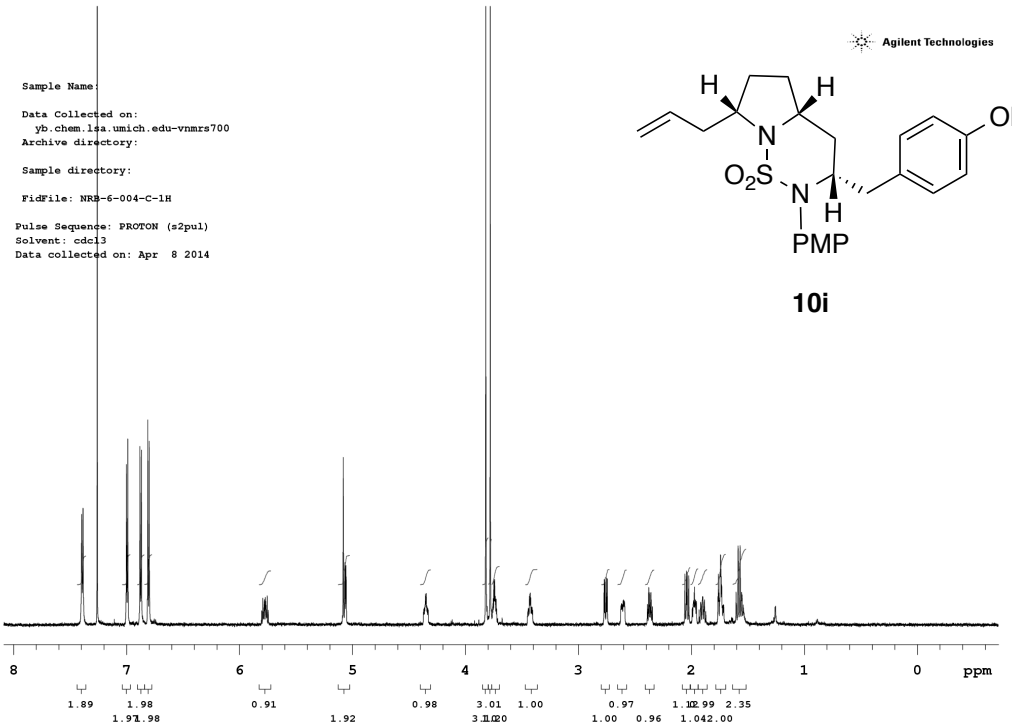

STANDARD 1H OBSERVE - profile
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-4a-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
Agilent Technologies
H
H
N
O2S
N
H
Ph
PMP
10h
8
7
6
5
4
3
2
1
0 ppm
1.87 1.04 1.87
2.40 0.96
0.91
1.93
0.99
3.23 0.99
1.15
1.00 1.00
0.04 0.94
1.08 2.08
1.09 1.03 2.56

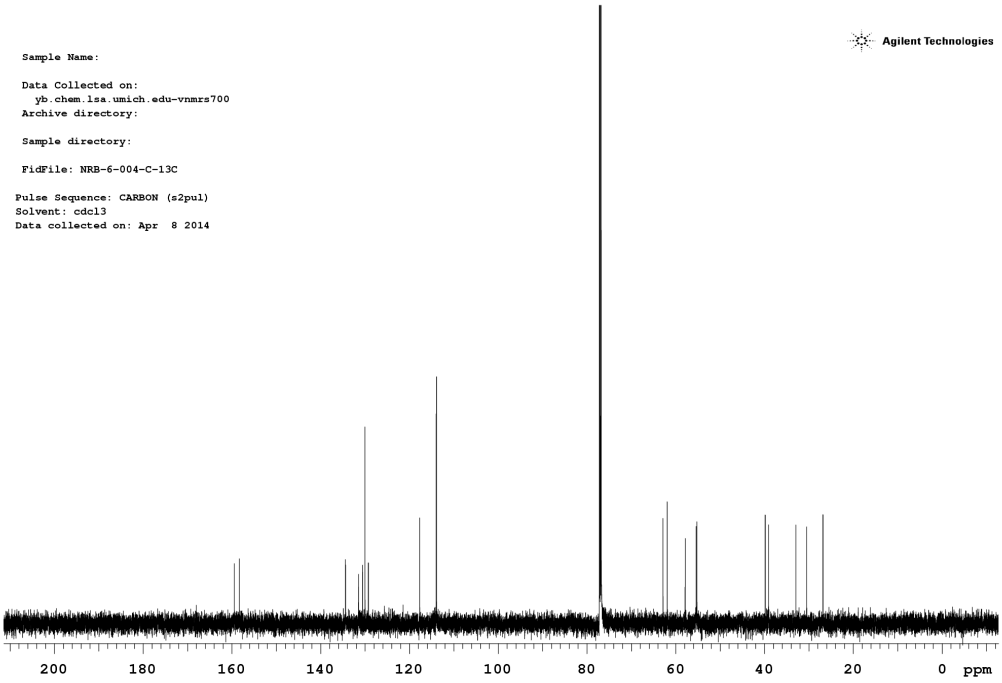

Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-4a-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 29 2014
200
180
160
140
120
100
80
60
40
20
ppm

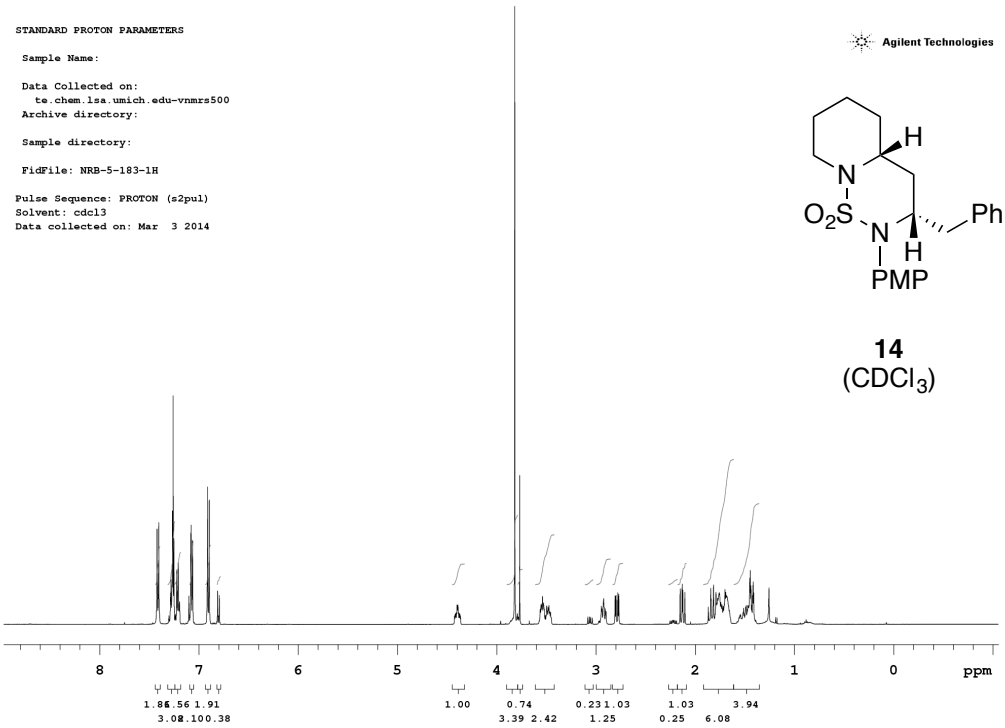

Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-4a-COSY
Pulse Sequence: gCOSY
Solvent: cdcl3
Data collected on: Mar 29 2014
Temp. 25.0 C / 298.1 K
Operator: nbabij
Relax. delay 1.000 sec
Acq. time 0.150 sec
Width 11160.7 Hz
2D Width 11160.7 Hz
2 repetitions
128 increments
OBSERVE H1, 699.7567663 MHz
DATA PROCESSING
Sq. sine bell 0.075 sec
F1 DATA PROCESSING
Sq. sine bell 0.011 sec
FT size 4096 x 4096
Total time 5 min 40 sec
Agilent Technologies
F1 (ppm)
F2 (ppm)
H
H
N
O2S
N
H
Ph
PMP

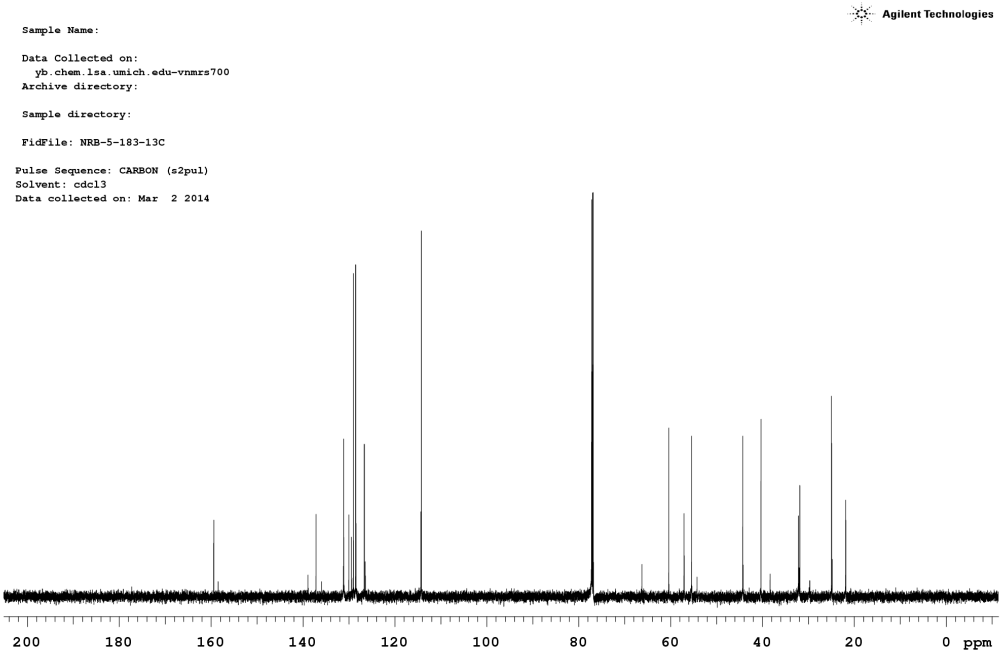
10h

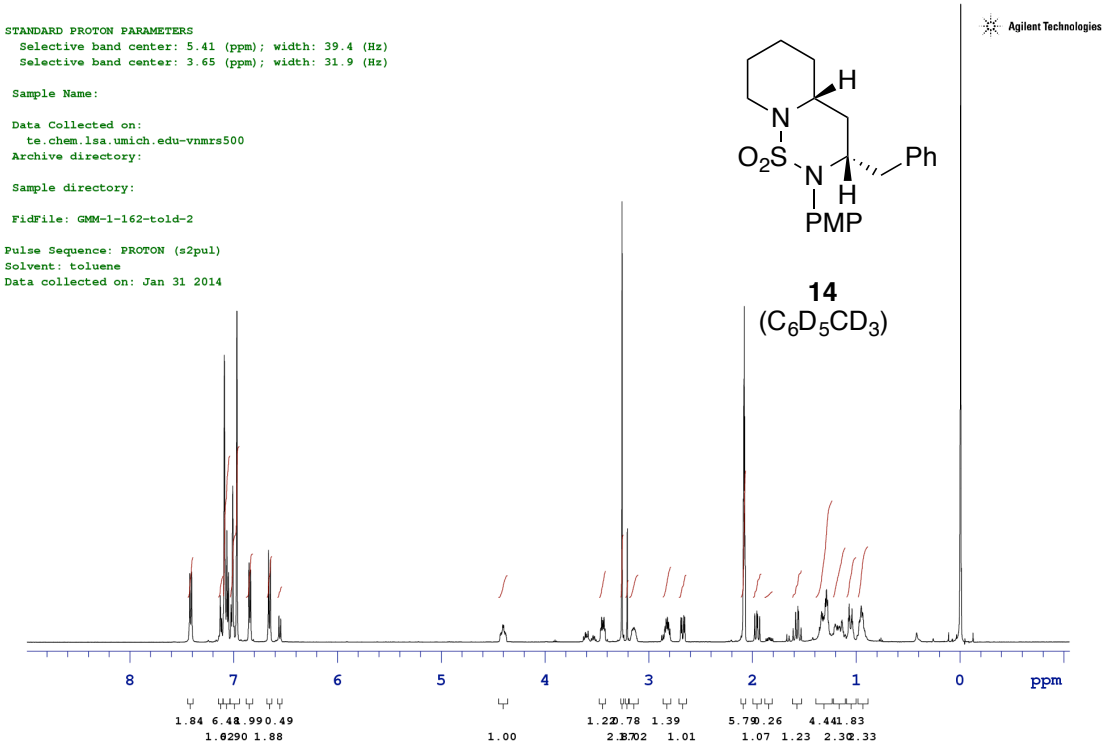

STANDARD 1H OBSERVE - profile
Selective band center: 3.43 (ppm); width: 46.6 (Hz)
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-4a-NOE
Pulse Sequence: NOESY1D
Solvent: cdcl3
Data collected on: Mar 29 2014
Agilent Technologies
ppm


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-004-C-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 8 2014
H
H
N
O2S
N
H
PMP
OMe
10i
8
7
6
5
4
3
2
1
0
ppm
1.89
1.98
1.97
1.98
0.91
1.92
0.98
3.01
1.00
0.97
1.00
0.96
1.04
2.00
2.35


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-004-C-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Apr 8 2014
200
180
160
140
120
100
80
60
40
20
0
ppm


STANDARD PROTON PARAMETERS
Sample Name:
Data Collected on:
te.chem.lsa.umich.edu-vnmrs500
Archive directory:
Sample directory:
FidFile: NRB-5-183-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Mar 3 2014
Agilent Technologies
H
N
O2S
N
H
Ph
PMP
14
(CDCl3)
8
7
6
5
4
3
2
1
0
ppm
1.86 1.56 1.91
3.08 2.10 0.38
1.00
0.74
3.39 2.42
0.23 1.03
1.25
1.03
0.25
3.94
6.08


Agilent Technologies
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-5-183-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: Mar 2 2014
200
180
160
140
120
100
80
60
40
20
0
ppm


STANDARD PROTON PARAMETERS
Selective band center: 5.41 (ppm); width: 39.4 (Hz)
Selective band center: 3.65 (ppm); width: 31.9 (Hz)
Sample Name:
Data Collected on:
te.chem.lsa.umich.edu-vnmrs500
Archive directory:
Sample directory:
FidFile: GMM-1-162-told-2
Pulse Sequence: PROTON (s2pul)
Solvent: toluene
Data collected on: Jan 31 2014
Agilent Technologies
H
N
O2S
N
H
Ph
PMP
14
(C6D5CD3)
8
7
6
5
4
3
2
1
0
ppm
1.84 6.48 1.99 0.49
1.62 9.90 1.88
1.00
1.22 0.78 1.39
2.87 1.01
5.75 0.26
1.07 1.23
4.44 1.83
2.30 2.33

STANDARD PROTON PARAMETERS
Selective band center: 5.41 (ppm); width: 39.4 (Hz)
Selective band center: 3.65 (ppm); width: 31.9 (Hz)

Sample Name:

Data Collected on:
te.chem.lsa.umich.edu-vnmrs500
Archive directory:

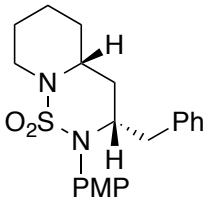
Sample directory:

FidFile: GMM-1-162-told-cosy

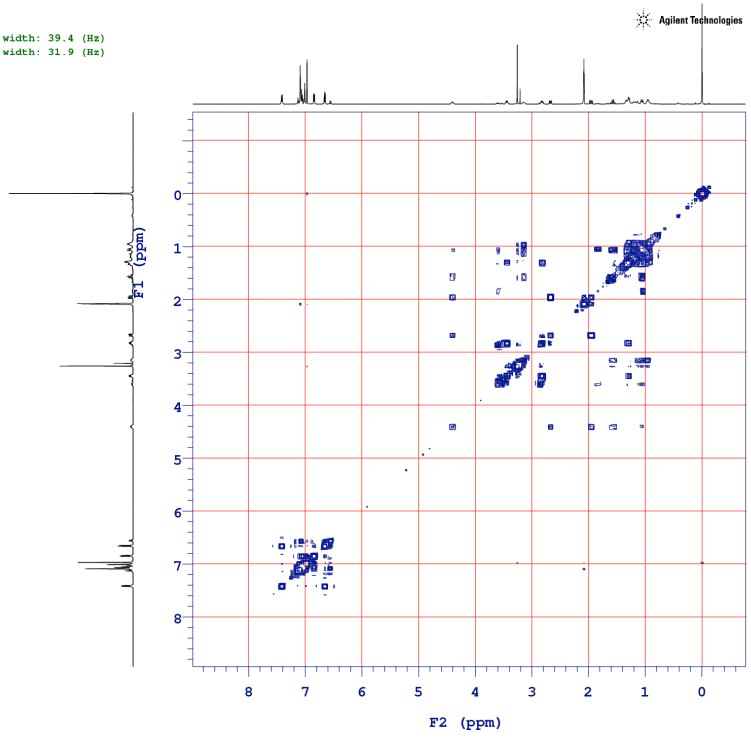
Pulse Sequence: gCOSY
Solvent: toluene
Data collected on: Jan 31 2014

Temp. 23.0 C / 296.1 K
Operator: gmckenna

Relax. delay 1.000 sec
Acq. time 0.150 sec
Width 8012.8 Hz
2D Width 8012.8 Hz
2 repetitions
128 increments
OBSERVE H1, 500.0820753 MHz
DATA PROCESSING
Sq. sine bell 0.075 sec
F1 DATA PROCESSING
Sq. sine bell 0.016 sec
FT size 4096 x 4096
Total time 5 min 41 sec



14
$(C_6D_5CD_3)$



STANDARD PROTON PARAMETERS
Selective band center: 5.41 (ppm); width: 39.4 (Hz)
Selective band center: 3.65 (ppm); width: 31.9 (Hz)
Selective band center: 8.16 (ppm); width: 42.3 (Hz)

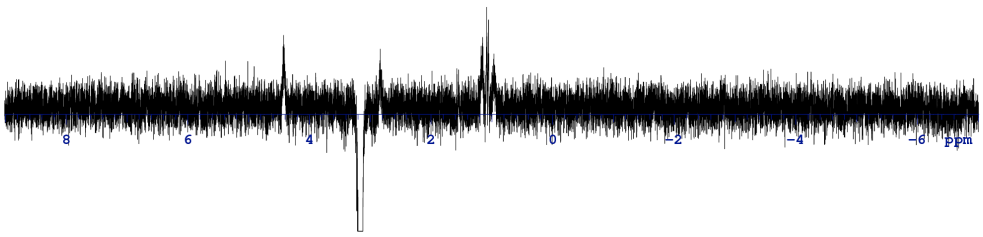
Sample Name:

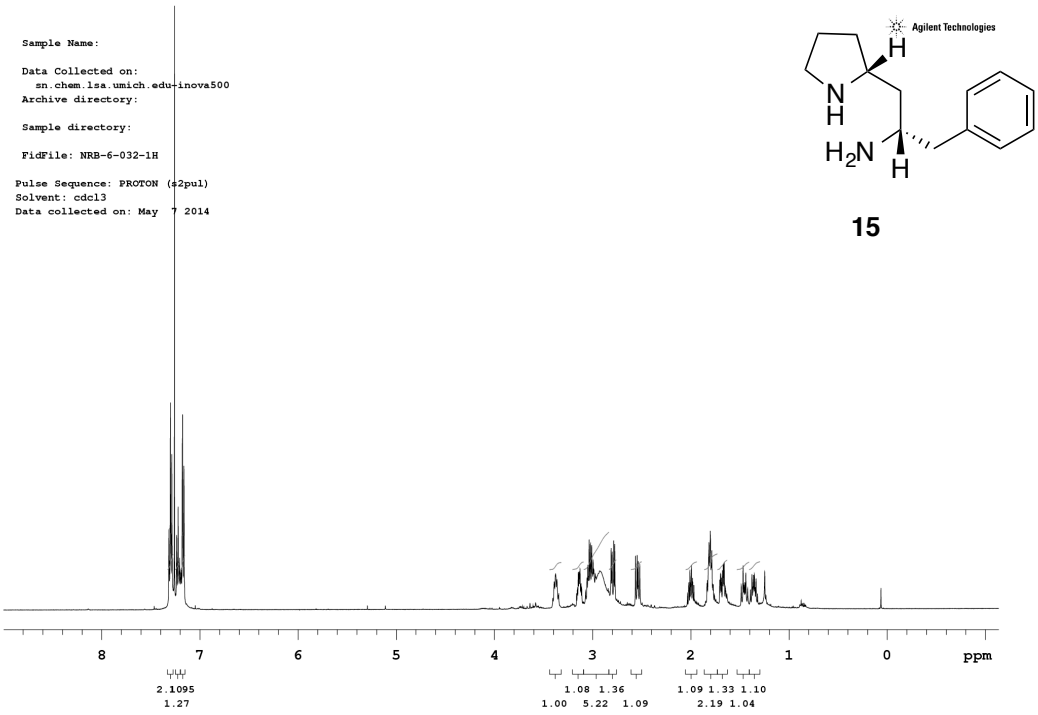
Data Collected on:
te.chem.lsa.umich.edu-vnmrs500
Archive directory:

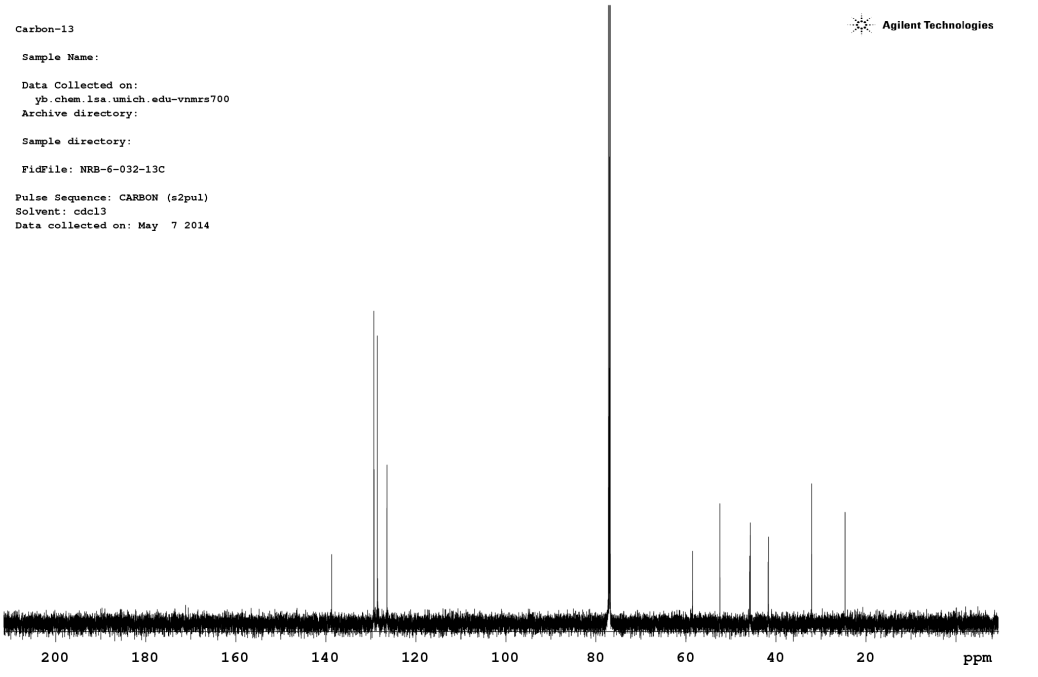
Sample directory:

FidFile: GMM-1-162-noe8.1

Pulse Sequence: NOESY1D
Solvent: toluene
Data collected on: Jan 31 2014




Sample Name:
Data Collected on:
sn.chem.lsa.umich.edu-inova500
Archive directory:
Sample directory:
FidFile: NRB-6-032-1H
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: May 7 2014
Agilent Technologies
H
N
H
H2N
H
15
8
7
6
5
4
3
2
1
0
ppm
2.1095
1.27
1.08 1.36
1.00 5.22 1.09
1.09 1.33 1.10
2.19 1.04


Carbon-13
Sample Name:
Data Collected on:
yb.chem.lsa.umich.edu-vnmrs700
Archive directory:
Sample directory:
FidFile: NRB-6-032-13C
Pulse Sequence: CARBON (s2pul)
Solvent: cdcl3
Data collected on: May 7 2014
Agilent Technologies
200
180
160
140
120
100
80
60
40
20
ppm