Supporting Information for

Toward the Total Synthesis of Goniodomin A, an Actin-Targeting Marine Polyether Macrolide: Convergent Synthesis of the C15–C36 Segment

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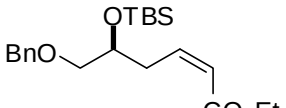
Contents:

General Methods. All reactions sensitive to moisture and/or air were carried out under an atmosphere of argon in dry, freshly distilled solvents under anhydrous conditions using oven-dried glassware, unless otherwise noted. Anhydrous dichloromethane (CH_2Cl_2), DMF, and DMSO were purchased from Kanto Chemical Co. Inc. and used directly without further drying. Anhydrous THF and toluene were purchased from Wako Pure Chemical Industries, Ltd. and further purified by a Glass Contour solvent purification system under an atmosphere of argon immediately prior to use. HMPA was distilled from calcium hydride under reduced pressure. Triethylamine, 2,6-lutidine, and methanol were distilled from calcium hydride under an atmosphere of argon. Tetrakis(triphenylphosphine)palladium(0) was prepared according to the literature procedure (Coulson, D. R. *Inorg. Synth.* **1972**, *13*, 121). All other chemicals were purchased at highest commercial grade and used as supplied. TLC was performed using E. Merck silica gel 60 F_{254} pre-coated plates (0.25-mm thickness). Column chromatography was carried out using Kanto Chemical silica gel 60N (40-100 mesh, spherical, neutral). Flash column chromatography was performed using Fuji Silysia silica gel BW-300 (200-400 mesh). Preparative HPLC was performed on Japan Analytical Industries, Co. Ltd. LC-9201 system. Optical rotations were recorded on a JASCO P-1020 digital polarimeter. IR spectra were recorded on a JASCO FT/IR-4100 spectrometer. ^{1}H and ^{13}C NMR spectra were recorded on a Varian Unity INOVA-500 or INOVA-600 spectrometer. Chemical shift values are reported in δ (ppm) downfield from tetramethylsilane with reference to internal residual solvent [^{1}H NMR, $CHCl_3$ (7.24), C_6HD_5 (7.15); ^{13}C NMR, $CDCl_3$ (77.0), C_6D_6 (128.0)]. Coupling constants (*J*) are reported in Hertz (Hz). The following abbreviations were used to designate the multiplicities: s = singlet; d = doublet; m = multiplet; br = broad. FAB mass spectra were recorded on a JEOL JMS-700 spectrometer and ESI-TOF mass spectra were measured on a Bruker microTOFfocus spectrometer.

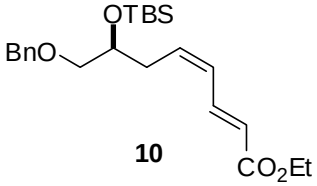
Experimental Procedures



9

(*Z*)-Enoate 9. Ozone was bubbled through a solution of TBS ether **8**[1)] (7.49 g, 24.4 mmol) in CH_2Cl_2 (122 mL) at –78 °C until a pale blue color was persisted. Triphenylphosphine (19.2 g, 73.3 mmol) was added to the solution at –78 °C. The resultant solution was allowed to warm to room temperature and stirred at that temperature overnight. The mixture was concentrated under reduced pressure. Purification by column chromatography (silica gel, EtOAc/hexanes = 1/25–1/20) gave aldehyde **S1**[1a)] (6.95 g, 92%) as a colorless oil: ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.78 (dd, *J* = 2.5, 2.0 Hz, 1H), 7.36–7.24 (m, 5H), 4.51 (d, *J* = 12.5 Hz, 1H), 4.50 (d, *J* = 12.5 Hz, 1H), 4.34 (m, 1H), 3.48 (dd, *J* = 9.0, 4.5 Hz, 1H), 3.37 (dd, *J* = 9.0, 6.0 Hz, 1H), 2.64 (ddd, *J* = 16.0, 5.5, 2.0 Hz, 1H), 2.56 (ddd, *J* = 16.0, 7.0, 2.5 Hz, 1H), 0.84 (s, 9H), 0.04 (s, 6H).

To a solution of ethyl diphenylphosphonoacetate (2.75 g, 8.59 mmol) in THF (72 mL) at 0 °C was added NaH (ca. 60% in mineral oil, 330 mg, 8.25 mmol). The resultant mixture was stirred at that temperature for 20 min and then cooled to –78 °C. To this mixture was added a solution of the above aldehyde **S1** (2.21 g, 7.16 mmol) in THF (4 mL + 1 mL × 2 rinse). The resultant mixture was stirred at –78 °C for 11 h before it was quenched with saturated aqueous NH_4Cl solution. The mixture was diluted with H_2O and the volatiles were removed under reduced pressure. The residue was extracted with EtOAc, and the organic layer was washed with H_2O and brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/40–1/10) gave (*Z*)-enoate **9** (2.15 g, 79%) as a colorless oil, along with a ca. 8:1 mixture of (*E*)- and (*Z*)-isomers (527 mg, 19%). Data for **9**: $[\alpha]_D^{28}$ +4.1 (*c* 3.0, benzene); IR (film) 2954, 2929, 2897, 2856, 1720, 1179, 1096, 835, 777 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34–7.28 (m, 3H), 7.28–7.23 (m, 2H), 6.33 (ddd, *J* = 11.5, 7.5, 7.5 Hz, 1H), 5.81 (ddd, *J* = 11.5, 1.5, 1.5 Hz, 1H), 4.50 (d, *J* = 12.0 Hz, 1H), 4.49 (d, *J* = 12.0 Hz, 1H), 4.14 (q, *J* = 7.0 Hz, 2H), 3.95 (m, 1H), 3.40 (dd, *J* = 9.5, 5.5 Hz, 1H), 3.37 (dd, *J* = 9.5, 5.5 Hz, 1H), 2.96–2.84 (m, 2H), 1.25 (t, *J* = 7.0 Hz, 3H), 0.85 (s, 9H), 0.03 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.3, 146.1, 138.3, 128.3 (× 2), 127.5 (× 2), 127.5, 121.0, 74.4, 73.3, 70.7, 59.8, 34.2, 25.8 (× 3), 18.1, 14.2, –4.5, –4.9; HRMS (ESI) calcd for $C_{21}H_{34}O_4SiNa$ [(M + Na)$^+$] 401.2119, found 401.2126.



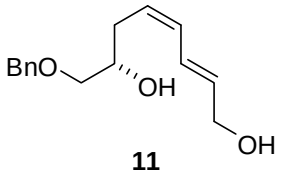
10

Dienoate 10. To a solution of (*Z*)-enoate **9** (25.5 g, 67.3 mmol) in CH_2Cl_2 (670 mL) at –78 °C was

added DIBALH (1.03 M solution in hexane, 137 mL, 141 mmol). The resultant solution was stirred at –78 °C for 40 min before it was quenched with MeOH. Saturated aqueous potassium sodium tartrate solution was added, and the mixture was diluted with EtOAc and stirred at room temperature until the layers became clear. The organic layer was separated, and the aqueous layer was extracted with EtOAc. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by column chromatography (silica gel, EtOAc/hexanes = 1/8) gave allylic alcohol **S2** (21.5 g, 95%) as a colorless oil: $[\alpha]_D^{29}$ +3.9 (*c* 2.0, $CHCl_3$); IR (film) 3388, 2953, 2928, 2886, 2856, 1254, 1104, 1007, 835, 776 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 5.75 (m, 1H), 5.59 (m, 1H), 4.51 (d, *J* = 12.0 Hz, 1H), 4.50 (d, *J* = 12.0 Hz, 1H), 4.12 (brd, *J* = 5.5 Hz, 2H), 3.86 (m, 1H), 3.40 (dd, *J* = 9.5, 4.7 Hz, 1H), 3.36 (dd, *J* = 9.5, 4.7 Hz, 1H), 2.42–2.28 (m, 2H), 1.84 (brs, 1H), 0.86 (s, 9H), 0.03 (s, 3H), 0.03 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 138.1, 130.8, 128.8, 128.4 (× 2), 127.7 (× 2), 127.6, 73.6, 73.4, 70.8, 58.3, 32.6, 25.8 (× 3), 18.1, –4.7 (× 2); HRMS (ESI) calcd for $C_{19}H_{32}O_3SiNa$ [$(M + Na)^+$] 359.2013, found 359.2005.

To a solution of the above allylic alcohol **S2** (10.75 g, 31.90 mmol) in CH_2Cl_2 (160 mL) was added MnO_2 (27.8 g + 27.8 g + 19.5 g, 320 mmol + 320 mmol + 224 mmol) in three portions over a period of 3 h. The resultant mixture was further stirred at room temperature for 1.5 h, at which time TLC analysis showed complete consumption of the starting material. The mixture was filtered through a plug of Celite, and the filtrate was concentrated under reduced pressure. The crude aldehyde was azeotropically dried with benzene twice, and used for the next reaction without purification.

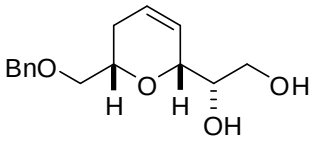
To a solution of ethyl diethylphosphonoacetate (7.96 mL, 40.0 mmol) in THF (107 mL) at 0 °C was added NaH (ca. 60% in mineral oil, 1.53 g, 38.3 mmol). The resultant mixture was stirred at 0 °C for 30 min and cooled to –78 °C. To the mixture was added a solution of the above crude aldehyde in THF (10 mL + 5 mL × 2 rinse). The resultant mixture was allowed to warm to –40 °C, and stirred for 10 h before it was quenched with saturated aqueous NH_4Cl solution. The mixture was diluted with H_2O and concentrated under reduced pressure. The residual aqueous layer was extracted with EtOAc, and the organic layer was washed with H_2O and brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/40–1/10) gave dienoate **10** (12.63 g, 98% for the two steps) as a colorless oil: $[\alpha]_D^{29}$ +14.6 (*c* 1.0, $CHCl_3$); IR (film) 2954, 2928, 2898, 2856, 1715, 1637, 1266, 1173, 1130, 835, 777 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.58 (dd, *J* = 15.5, 12.0 Hz, 1H), 7.38–7.22 (m, 5H), 6.19 (dd, *J* = 12.0, 12.0 Hz, 1H), 5.90 (m, 1H), 5.85 (d, *J* = 15.5 Hz, 1H), 4.49 (d, *J* = 12.5 Hz, 1H), 4.49 (d, *J* = 12.5 Hz, 1H), 4.18 (q, *J* = 7.3 Hz, 2H), 3.91 (m, 1H), 3.39 (dd, *J* = 9.5, 5.5 Hz, 1H), 3.33 (dd, *J* = 9.5, 6.0 Hz, 1H), 2.58–2.47 (m, 2H), 1.27 (t, *J* = 7.3 Hz, 3H), 0.84 (s, 9H), 0.02 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.1, 139.5, 138.2, 136.9, 128.33, 128.31 (× 2), 127.6 (× 2), 127.5, 121.7, 73.9, 73.4, 70.8, 60.2, 33.5, 25.8 (× 3), 18.1, 14.3, –4.6, –4.8; HRMS (ESI) calcd for $C_{23}H_{36}O_4SiNa$ [$(M + Na)^+$] 427.2275, found 427.2259.



11

Diol 11. To a solution of dienoate **10** (2.20 g, 5.43 mmol) in THF (55 mL) at –78 °C was added dropwise DIBALH (1.02 M solution in hexane, 16.0 mL, 16.3 mmol). The resultant solution was allowed to warm to –50 °C and stirred for 30 min before it was quenched with MeOH. Saturated aqueous potassium sodium tartrate solution was added, and the mixture was diluted with EtOAc and stirred at room temperature until the layers became clear. The mixture was concentrated under reduced pressure to remove volatiles, and the residual aqueous layer was extracted with EtOAc. The organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude alcohol was azeotropically dried with benzene twice and used for the next reaction without purification: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 6.51 (ddd, *J* = 15.5, 10.5, 1.3 Hz, 1H), 6.07 (dd, *J* = 11.0, 10.5 Hz, 1H), 5.79 (ddd, *J* = 15.5, 6.0, 6.0 Hz, 1H), 5.50 (ddd, *J* = 11.0, 8.0, 7.5 Hz, 1H), 4.51 (d, *J* = 12.0 Hz, 1H), 4.48 (d, *J* = 12.0 Hz, 1H), 4.14 (m, 2H), 3.87 (ddd, *J* = 11.0, 5.5, 5.5 Hz, 1H), 3.39 (dd, *J* = 9.5, 5.5 Hz, 1H), 3.35 (dd, *J* = 9.5, 6.0, 1H), 2.48–2.35 (m, 2H), 1.28 (dd, *J* = 6.0, 6.0 Hz, 1H), 0.85 (s, 9H), 0.03 (s, 3H), 0.03 (s, 3H).

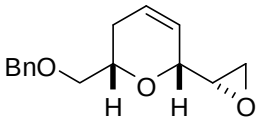
To a solution of the above crude alcohol in THF (18 mL) at 0 °C was added TBAF (1.0 M solution in THF, 8.2 mL, 8.2 mmol). The resultant solution was stirred at room temperature for 13 h before saturated solution of aqueous NH_4Cl was added. The organic layer was concentrated under reduced pressure, and the residual aqueous layer was extracted with EtOAc. The organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/8–1/0) gave diol **11** (1.31 g, 97% for the two steps) as a colorless oil: $[\alpha]_D^{28}$ –3.5 (*c* 1.0, $CHCl_3$); IR (film) 3377, 3027, 2905, 2862, 1454, 1087, 988 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36–7.25 (m, 5H), 6.50 (ddd, *J* = 15.0, 11.0, 1.3 Hz, 1H), 6.11 (dd, *J* = 11.0, 11.0 Hz, 1H), 5.82 (ddd, *J* = 15.0, 5.5, 5.5 Hz, 1H), 5.46 (m, 1H), 4.53 (d, *J* = 12.0 Hz, 1H), 4.52 (d, *J* = 12.0 Hz, 1H), 4.16 (d, *J* = 5.5 Hz, 2H), 3.87 (ddd, *J* = 12.5, 6.5, 3.0 Hz, 1H), 3.50 (dd, *J* = 9.0, 3.0 Hz, 1H), 3.37 (dd, *J* = 9.0, 3.0, 1H), 2.44 (brs, 1H), 2.45–2.34 (m, 2H), 1.70 (brs, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.9, 132.9, 130.3, 128.4 (× 2), 127.8, 127.7 (× 2), 127.2, 126.1, 73.7, 73.4, 70.2, 63.3, 31.7; HRMS (ESI) calcd for $C_{15}H_{20}O_3Na$ [$(M + Na)^+$] 271.1305, found 271.1303.



13

Dihydropyran 13. To a suspension of (+)-diethyl tartrate (2.31 mL, 13.5 mmol) and 4 Å molecular sieves (3.34 g) in CH_2Cl_2 (90 mL) at –40 °C was added dropwise Ti(O*i*-Pr)$_4$ (3.19 mL, 10.8 mmol). The resulting mixture was stirred at –40 °C for 30 min. Cumyl hydroperoxide (80 wt%, 6.63 mL,

35.9 mmol) was added dropwise, and the resultant mixture was stirred at –40 °C for 30 min. To the mixture was added a solution of diol **11** (2.21 g, 8.91 mmol) in CH_2Cl_2 (5 mL + 1 mL × 2 rinse). The resultant mixture was allowed to warm to –25 °C, and stirred for 9 h before it was quenched with tri-*n*-butylphosphine (7.80 mL, 31.3 mmol). Citric acid (3.08g, 16.0 mmol) in acetone/H_2O (9:1, v/v, ca. 30 mL) was added, and the reaction mixture was stirred at room temperature for 1.5 h. The mixture was filtered through a plug of Celite, and the Celite bed was washed successively with CH_2Cl_2, EtOAc, and acetone. The filtrate was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 2/3–1/1) to give dihydropyran **13** (2.07 g, 88%) as a colorless oil: $[\alpha]_D^{27}$ –30.9 (*c* 1.0, $CHCl_3$); IR (film) 3398, 3032, 2865, 1454, 1367, 1186, 1085, 739, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.36–7.25 (m, 5H), 5.92 (m, 1H), 5.68 (m, 1H), 4.55 (d, *J* = 12.5 Hz 1H), 4.54 (d, *J* = 12.5 Hz 1H), 4.32 (brs, 1H), 3.79 (m, 1H), 3.74 (dd, *J* = 11.0, 5.0 Hz, 1H), 3.63 (dd, *J* = 11.0, 4.0 Hz, 1H), 3.61 (m, 1H), 3.52–3.45 (m, 2H), 3.07 (brs, 2H), 2.14 (m, 1H), 1.97 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 137.9, 128.4 (× 2), 127.71, 127.68 (× 2), 126.3, 125.9, 77.1, 73.4, 73.2, 72.9, 72.6, 63.1, 27.3; HRMS (ESI) calcd for $C_{15}H_{20}O_4Na$ [$(M + Na)^+$] 287.1254, found 287.1251.

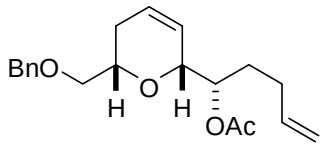


14

Epoxide 14. To a solution of diol **13** (207 mg, 784 μmol), di-*n*-butyltin oxide (4.0 mg, 16 μmol), and *p*-TsCl (157 mg, 823 μmol) in CH_2Cl_2 (7.8 mL) at room temperature was added triethylamine (114 μL, 821 μmol). The resultant solution was stirred at room temperature for 12 h, and additional portions of triethylamine (33.0 μL, 273 μmol) and *p*-TsCl (45.0 mg, 236 μmol) were added. The resultant solution was stirred for 110 min before it was quenched with H_2O. The mixture was extracted with CH_2Cl_2, and the organic layer was washed with brine, dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/3) gave monotosylate **S3** (323 mg, 98%) as a pale yellow oil: $[\alpha]_D^{27}$ –17.4 (*c* 1.0, $CHCl_3$); IR (film) 3419, 2863, 1597, 1454, 1359, 1189, 984 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.81–7.75 (m, 2H), 7.35–7.25 (m, 7H), 5.89 (m, 1H), 5.69 (m, 1H), 4.53 (d, *J* = 12.5 Hz, 1H), 4.51 (d, *J* = 12.5 Hz, 1H), 4.22 (dd, *J* = 10.5, 6.5 Hz, 1H), 4.20 (brs, 1H), 4.07 (dd, *J* = 10.5, 6.5 Hz, 1H), 3.82–3.72 (m, 2H), 3.48 (dd, *J* = 10.5, 6.5 Hz, 1H), 3.41 (dd, *J* = 10.5, 4.3 Hz, 1H), 2.56 (brs, 1H), 2.41 (s, 3H), 2.00 (m, 1H), 1.92 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 144.9, 138.1, 132.7, 129.8 (× 2), 128.4 (× 2), 127.9 (× 2), 127.7, 127.6 (× 2), 126.5, 125.4, 75.1, 73.3, 73.1, 72.7, 71.7, 71.1, 27.4, 21.6; HRMS (ESI) calcd for $C_{22}H_{26}O_6S_1Na$ [$(M + Na)^+$] 441.1342, found 441.1349.

To a solution of the above monotosylate **S3** (323 mg, 771 μmol) in MeOH (2.6 mL) at room temperature was added K_2CO_3 (128 mg, 927 μmol). The resultant solution was stirred at room temperature for 4 h. The mixture was filtered through a plug of Celite, and the filtrate was concentrated under reduced pressure. Purification by flash column chromatography (silica gel,

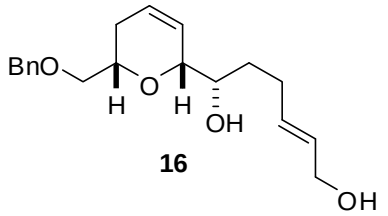
EtOAc/hexanes = 1/5) gave epoxide **14** (156 mg, 82%) as a colorless oil: $[\alpha]_D^{28}$ +10.1 (*c* 1.0, benzene); IR (film) 3033, 2995, 2923, 2895, 2861, 1253, 1091, 740, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 5.92 (m, 1H), 5.76 (m, 1H), 4.60 (d, *J* = 12.0 Hz, 1H), 4.54 (d, *J* = 12.0 Hz, 1H), 3.92 (brs, 1H), 3.81 (ddd, *J* = 10.5, 6.0, 4.0 Hz, 1H), 3.56 (dd, *J* = 10.5, 6.0 Hz, 1H), 3.47 (dd, *J* = 10.5, 4.0 Hz, 1H), 2.95 (ddd, *J* = 6.5, 3.5, 2.0 Hz, 1H), 2.81 (dd, *J* = 5.0, 3.5 Hz, 1H), 2.73 (dd, *J* = 5.0, 2.0 Hz, 1H), 2.09 (m, 1H), 1.95 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 138.1, 128.4 (× 2), 127.7 (× 2), 127.6, 126.2, 125.8, 75.4, 73.4, 72.9, 72.8, 53.4, 46.1, 27.5; HRMS (ESI) calcd for $C_{15}H_{18}O_3Na$ [$(M + Na)^+$] 269.1148, found 269.1148.



15

Acetate 15. To a suspension of CuI (23 mg, 121 μmol) in THF (4.1 mL) at –40 °C was added dropwise allylmagnesium chloride (2.0 M solution in THF, 1.83 mL, 3.66 mmol). The mixture was stirred at –40 °C for 30 min. To the mixture was added dropwise a solution of epoxide **14** (300 mg, 1.22 mmol) in THF (1 mL + 0.5 mL × 2 rinse) via cannula. The resultant solution was stirred at –40 °C for 1.5 h before it was quenched with saturated aqueous NH_4Cl solution. The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude alcohol was used for the next reaction without purification: ^1H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 5.94 (m, 1H), 5.82 (dddd, *J* = 17.0, 10.5, 7.0, 7.0 Hz, 1H), 5.67 (ddd, *J* = 9.5, 1.5, 1.5 Hz, 1H), 5.03 (dd, *J* = 17.0, 1.5 Hz, 1H), 4.95 (brd, *J* = 10.5 Hz, 1H), 4.60 (d, *J* = 12.0 Hz, 1H), 4.55 (d, *J* = 12.0 Hz, 1H), 4.18 (brs, 1H), 3.86 (ddd, *J* = 9.0, 6.5, 3.5 Hz, 1H), 3.74 (ddd, *J* = 9.0, 3.5, 3.5 Hz, 1H), 3.54 (dd, *J* = 10.5, 6.5, 1H), 3.46 (dd, *J* = 10.5, 3.5, 1H), 2.28 (m, 1H), 2.16–2.00 (m, 3H), 1.93 (m, 1H), 1.62–1.52 (m, 2H).

To a solution of the above crude alcohol in CH_2Cl_2 (4.1 mL) at room temperature were added successively triethylamine (678 μL, 4.88 mmol), acetic anhydride (345 μL, 3.65 mmol), and DMAP (30.0 mg, 246 μmol). The resultant solution was stirred at room temperature for 2.5 h before it was concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/8) gave acetate **15** (376 mg, 93% for the two steps) as a colorless oil: $[\alpha]_D^{27}$ –33.9 (*c* 1.0, $CHCl_3$); IR (film) 3064, 3033, 2921, 2858, 1740, 1373, 1236, 1095 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.36–7.24 (m, 5H), 5.89 (m, 1H), 5.78 (dddd, *J* = 17.0, 10.3, 6.5, 6.5 Hz, 1H), 5.59 (ddd, *J* = 10.5, 1.5, 1.5 Hz, 1H), 4.99 (dd, *J* = 17.0, 1.5 Hz, 1H), 4.95 (dd, *J* = 10.3, 1.5 Hz, 1H), 4.89 (ddd, *J* = 9.0, 3.9, 3.8 Hz, 1H), 4.60 (d, *J* = 12.0 Hz, 1H), 4.57 (d, *J* = 12.0 Hz, 1H), 4.28 (brs, 1H), 3.79 (m, 1H), 3.56 (dd, *J* = 10.7, 6.5 Hz, 1H), 3.46 (dd, *J* = 10.7, 4.0 Hz, 1H), 2.16–1.90 (m, 4H), 2.06 (s, 3H), 1.83–1.66 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 138.4, 137.9, 128.3 (× 2), 127.6 (× 2), 127.5, 126.2, 126.1, 114.9, 75.6, 75.0, 73.3, 73.1, 72.9, 29.7, 28.3, 27.7, 21.2; HRMS (ESI) calcd for $C_{20}H_{26}O_4Na$ [$(M + Na)^+$] 353.1723, found 353.1725.



16

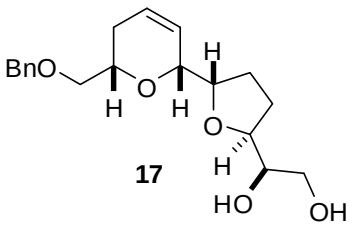
Allylic Alcohol 16. To a solution of acetate **15** (4.21 g, 12.8 mmol) and $(DHQD)_2PHAL$ (298 mg, 383 μmol) in *t*-BuOH/H_2O (1:1, v/v, 64 mL) at 0 °C were added AD-mix β (17.9 g) and OsO_4 (39.3 mM solution in *t*-BuOH, 3.25 mL, 128 μmol). The resultant mixture was stirred at 0 °C for 21 h, and an additional portion of OsO_4 (39.3 mM solution in *t*-BuOH, 1.63 mL, 64.1 μmol) was added. The mixture was stirred at 0 °C for 4 h before it was quenched with saturated aqueous $Na_2S_2O_3$ solution The mixture was extracted with EtOAc, and the organic layer was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/5–5/1) gave diol **S4** (2.71 g, dr = ca. 4:1 by ^1H NMR) as a colorless oil, along with recovered **15** (1.48 g). To a solution of the recovered **15** (1.48 g, 4.38 mmol) and $(DHQD)_2PHAL$ (137 mg, 176 μmol) in *t*-BuOH/H_2O (1:1, v/v, 14.6 mL) at 0 °C were added AD-mix β (6.13 g) and OsO_4 (39.3 mM solution in *t*-BuOH, 1.67 mL, 65.6 μmol). After the mixture was stirred at 0 °C for 11 h, *t*-butyl methyl ether (3.8 mL) was added and the mixture was stirred for 7 h. To the mixture was added an additional amount of OsO_4 (39.3 mM solution in *t*-BuOH, 1.67 mL, 65.6 μmol). The resultant mixture was stirred at 0 °C for 17 h and then room temperature for 10 h before it was quenched with saturated aqueous $Na_2S_2O_3$ solution. The mixture was extracted with EtOAc, and the organic layer was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/5–5/1) gave diol **S4** (886 mg, dr = ca. 4:1, total 3.60 g, 77%) as a colorless oil: $[\alpha]_D^{28}$ –21.7 (*c* 1.0, $CHCl_3$); IR (film) 3421, 2927, 2863, 1734, 1374, 1244, 1092 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$, major isomer) δ 7.35–7.24 (m, 5H), 5.88 (m, 1H), 5.59 (ddd, *J* = 10.5, 1.0, 1.0 Hz, 1H), 4.85 (ddd, *J* = 9.0, 4.4 Hz, 4.2 Hz, 1H), 4.58 (d, *J* = 12.0 Hz, 1H), 4.54 (d, *J* = 12.0 Hz, 1H), 4.25 (brs, 1H), 3.79 (ddd, *J* = 10.5, 7.5, 4.0 Hz, 1H), 3.63 (brs, 1H), 3.58–3.52 (m, 2H), 3.45 (dd, *J* = 10.0, 4.0 Hz, 1H), 3.35 (dd, *J* = 10.5, 7.5 Hz, 1H), 2.84 (brs, 1H), 2.49 (brs, 1H), 2.05 (s, 3H), 2.13 (m, 1H), 1.92 (m, 1H), 1.81 (m, 1H), 1.73 (m, 1H), 1.48 (m, 1H), 1.37 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$, major isomer) δ 170.9, 138.1, 128.3 (× 2), 127.7 (× 2), 127.6, 126.1, 126.0, 75.5, 75.3, 73.3, 73.0, 72.8, 71.9, 66.6, 28.7, 27.5, 25.3, 21.2; HRMS (ESI) calcd for $C_{20}H_{28}O_6Na$ $[(M + Na)^+]$ 387.1778, found 387.1780.

To a solution of the above diol **S4** (2.67 g, 7.34 mmol) in CH_2Cl_2 (70 mL) at 0 °C was added $NaIO_4$ on SiO_2[2)] (17.7 g, ca. 12.1 mmol). The resultant mixture was allowed to warm to room temperature and stirred for 40 min. The mixture was filtered through sintered glass funnel, and the filtrate was concentrated under reduced pressure. The crude aldehyde was azeotropically dried with benzene and used immediately in the next reaction without purification.

To a solution of the above aldehyde in THF (37 mL) at –40 °C was added ethyl (triphenylphosphoranylidene)acetate (5.11 g, 14.7 mmol). The resultant solution was stirred at –40 °C for 50 min and allowed to warm to room temperature. The mixture was stirred at room

temperature for 13 h before it was concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/7–1/1) gave enoate **S5** (2.83 g, 96% for the two steps, E/Z >20:1) as a colorless oil: $[\alpha]_D^{26}$ –16.0 (*c* 1.0, $CHCl_3$); IR (film) 2927, 2900, 2859, 1737, 1717, 1653, 1369, 1236, 1094, 1044 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 6.92 (ddd, *J* = 15.5, 7.0, 7.0 Hz, 1H), 5.89 (m, 1H), 5.79 (d, *J* = 15.5 Hz, 1H), 5.57 (m, 1H), 4.85 (ddd, *J* = 8.5, 4.0, 4.0 Hz, 1H), 4.60 (d, *J* = 12.0 Hz, 1H), 5.56 (d, *J* = 12.0 Hz, 1H), 4.27 (brs, 1H), 4.15 (q, *J* = 7.0 Hz, 2H), 3.78 (m, 1H), 3.55 (dd, *J* = 10.0, 6.5 Hz, 1H), 3.46 (dd, *J* = 10.0, 4.5 Hz, 1H), 2.30–2.14 (m, 2H), 2.06 (s, 3H), 2.06–1.86 (m, 2H), 1.85–1.74 (m, 2H), 1.26 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 166.6, 148.2, 138.3, 128.3 (× 2), 127.6 (× 2), 127.5, 126.4, 125.9, 121.6, 75.4, 74.9, 73.3, 73.1, 72.8, 60.2, 28.3, 27.6, 27.5, 21.1, 14.2; HRMS (ESI) calcd for $C_{23}H_{30}O_6Na$ $[(M + Na)^+]$ 425.1935, found 425.1928.

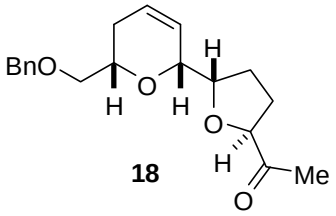
To a solution of the above enoate **S5** (19.8 mg, 49.3 μmol) in CH_2Cl_2 at –78 °C was added dropwise DIBALH (1.02 M solution in hexane, 217 μL, 221 μmol). The resultant solution was stirred at –78 °C for 20 min before it was quenched with saturated aqueous potassium sodium tartrate solution. The mixture was diluted with EtOAc and stirred at room temperature until the layers became clear. The mixture was extracted with EtOAc, washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification of by flash column chromatography (silica gel, EtOAc/hexanes = 1/2–2/1) gave allylic alcohol **16** (15.4 mg, 98%) as a colorless oil: $[\alpha]_D^{28}$ –4.5 (*c* 1.0, $CHCl_3$); IR (film) 3397, 3033, 2911, 2859, 1450, 1362, 1183, 1088, 1006, 967, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 5.91 (m, 1H), 5.71–5.60 (m, 3H), 4.58 (d, *J* = 12.5 Hz, 1H), 4.54 (d, *J* = 12.5 Hz, 1H), 4.16 (brs, 1H), 4.03 (m, *J* = 5.0 Hz, 2H), 3.84 (m, 1H), 3.70 (m, 1H), 3.53 (dd, *J* = 10.0, 6.5 Hz, 1H), 3.46 (dd, *J* = 10.0, 4.0 Hz, 1H), 2.46 (brs, 1H), 2.27 (m, 1H), 2.11 (m, 1H), 2.04 (m, 1H), 1.91 (m, 1H), 1.83 (brs, 1H), 1.61–1.47 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 138.0, 132.4, 129.5, 128.4 (× 2), 127.7 (× 2), 127.6, 126.4, 125.6, 77.8, 73.3, 73.0, 72.9, 72.6, 63.5, 31.2, 28.6, 27.6; HRMS (ESI) calcd for $C_{19}H_{26}O_4Na$ $[(M + Na)^+]$ 341.1723, found 341.1728.



17

Diol 17. To a suspension of (–)-diethyl tartrate (freshly distilled, 39.0 μL, 228 μmol) and 4 Å molecular sieves (50.0 mg) in CH_2Cl_2 (1 mL) at –20 °C was added dropwise Ti(O*i*-Pr)$_4$ (50.0 μL, 169 μmol). The resulting mixture was stirred at –20 °C for 35 min. TBHP (5.68 M solution in isooctane, 100 μL, 568 μmol) was added dropwise, and the resultant mixture was stirred at –20 °C for 45 min. To the mixture was added dropwise a solution of allylic alcohol **16** (41.8 mg, 131 μmol) in CH_2Cl_2 (1 mL + 0.5 mL × 3 rinse) via cannula. The resultant mixture was allowed to warm to –15 °C and stirred for 20 h. Citric acid (61.0 mg, 318 μmol) in acetone/H_2O (9:1, v/v, ca. 1 mL)

was added, and the resultant mixture was stirred at room temperature for 0.5 h. The mixture was filtered through a plug of Celite, and the Celite bed was washed successively with CH_2Cl_2, EtOAc, and acetone. The filtrate was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 2/3–3/2–3/1) gave diol **17** (38.7 mg, 88%, dr >10:1) as a colorless oil: $[\alpha]_D^{28}$ –17.2 (*c* 1.0, $CHCl_3$); IR (film) 3398, 3028, 2869, 1454, 1362, 1067, 737, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.36–7.24 (m, 5H), 5.86 (m, 1H), 5.70 (ddd, *J* = 10.5, 1.3, 1.3 Hz, 1H), 4.58 (d, *J* = 12.0 Hz, 1H), 4.56 (d, *J* = 12.0 Hz, 1H), 4.15 (brs, 1H), 4.00–3.91 (m, 2H), 3.80 (m, 1H), 3.73–3.63 (m, 2H), 3.59 (dd, *J* = 12.0, 6.5 Hz, 1H), 3.54 (dd, *J* = 10.3, 4.0 Hz, 1H), 3.46 (dd, *J* = 10.3, 4.5 Hz, 1H), 2.59 (brs, 2H), 2.09–1.85 (m, 5H), 1.81 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 138.3, 128.3 (× 2), 127.61 (× 2), 127.58, 126.9, 125.4, 81.3, 80.6, 76.8, 73.3, 73.1, 73.06, 72.97, 63.8, 27.7, 27.2, 27.1; HRMS (ESI) calcd for $C_{19}H_{26}O_5Na$ [$(M + Na)^+$] 357.1673, found 357.1659.



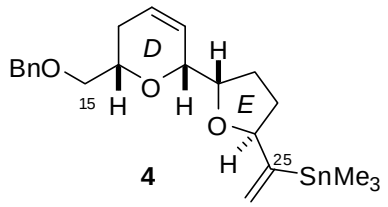
18

Methyl Ketone 18. To a solution of diol **17** (112.6 mg, 337 μmol) in CH_2Cl_2 at 0 °C was added $NaIO_4$ on SiO_2 (673 mg, ca. 460 μmol). The resultant mixture was allowed to warm to room temperature and stirred for 60 min. An additional portion of $NaIO_4$ on SiO_2 (135 mg, ca. 92.0 μmol) was added, and the stirring was continued for 20 min. The mixture was filtered through sintered glass funnel, and the filtrate was concentrated under reduced pressure. The crude aldehyde was used immediately in the next reaction without purification.

To a solution of the above aldehyde in MeOH (1.7 mL) at 0 °C were added Ohira–Bestmann reagent (76.0 μL, 507 μmol) and K_2CO_3 (116 mg, 841 μmol). The resultant solution was stirred at 0 °C for 1.5 h before it was diluted with diethyl ether. The mixture was extracted with diethyl ether, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/20) gave terminal alkyne **S6** (95.0 mg, 95%) as a colorless oil: $[\alpha]_D^{26}$ –21.4 (*c* 0.5, $CHCl_3$); IR (film) 3289, 3032, 2889, 2862, 1093, 1062, 737, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.35–7.24 (m, 5H), 5.87 (m, 1H), 5.72 (m, 1H), 4.70 (ddd, *J* = 6.5, 4.5, 1.8 Hz, 1H), 4.59 (d, *J* = 12.0 Hz, 1H), 4.55 (d, *J* = 12.0 Hz, 1H), 4.14 (m, 1H), 4.06 (ddd, *J* = 7.5, 5.5, 5.5 Hz, 1H), 3.80 (m, 1H), 3.55 (dd, *J* = 10.3, 5.8 Hz, 1H), 3.46 (dd, *J* = 10.3, 4.3 Hz, 1H), 2.40 (d, *J* = 1.8 Hz, 1H), 2.17 (m, 1H), 2.13–2.00 (m, 2H), 1.95–1.90 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 138.4, 128.4 (× 2), 127.60 (× 2), 127.55, 127.1, 125.5, 83.7, 81.0, 76.6, 73.3, 73.0, 72.9, 72.5, 68.5, 33.2, 27.8, 26.5; HRMS (ESI) calcd for $C_{19}H_{22}O_3Na$ [$(M + Na)^+$] 321.1461, found 321.1450.

To a solution of the above alkyne **S6** (46.3 mg, 155 μmol) in THF/H_2O (2:1, v/v, 1.5 mL) at 0 °C was added saturated solution of $HgSO_4$ in 1% aqueous H_2SO_4 (683 μL). The resultant mixture

was allowed to warm to room temperature and stirred for 4 h before it was quenched with saturated aqueous $NaHCO_3$ solution at 0 °C. The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/5) gave methyl ketone **18** (46.1 mg, 94%) as a colorless oil: $[\alpha]_D^{26}$ –43.3 (*c* 1.0, $CHCl_3$); IR (film) 3032, 2889, 2862, 1715, 1454, 1355, 1186, 1077, 738, 698 cm^{-1}; ^1H NMR (500 MHz, C_6D_6) δ 7.32–7.27 (m, 2H), 7.21–7.16 (m, 2H), 7.10 (m, 1H), 5.77 (ddd, *J* = 10.0, 1.5, 1.5 Hz, 1H), 5.67 (m, 1H), 4.40 (d, *J* = 15.0 Hz, 1H), 4.37 (d, *J* = 15.0 Hz, 1H), 4.22 (dd, *J* = 7.0, 7.0 Hz, 1H), 4.04 (brs, 1H), 3.90 (dd, *J* = 12.5, 6.3 Hz, 1H), 3.71 (m, 1H), 3.44 (dd, *J* = 10.3, 5.5 Hz, 1H), 3.30 (dd, *J* = 10.3, 4.8 Hz, 1H), 1.94 (m, 1H), 1.87 (s, 3H), 1.84 (m, 1H), 1.80–1.57 (m, 4H); ^{13}C NMR (125 MHz, C_6D_6) δ 208.9, 139.2, 128.5 (× 2), 127.9, 127.69 (× 2), 127.67, 125.4, 84.5, 82.6, 77.3, 73.33, 73.30, 73.28, 28.9, 28.2, 27.5, 25.3; HRMS (ESI) calcd for $C_{19}H_{24}O_4Na$ [$(M + Na)^+$] 339.1567, found 339.1558.

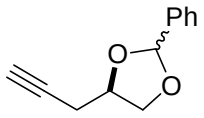


4

Vinyl Stannane 4. To a solution of KHMDS (0.5 M solution in toluene, 1.51 mL, 753 μmol) in THF (4.6 mL) at –78 °C was added dropwise a solution of methyl ketone **18** (226 mg, 708 μmol) in THF (1 mL + 0.5 mL × 2 rinse) via cannula. The resultant solution was allowed to warm to –40 °C. After being stirred for 15 min, the solution was cooled to –78 °C, and a solution of $PhNTf_2$ (282 mg, 790 μmol) in THF (0.57 mL) was added via cannula. The resultant solution was allowed to warm to –20 °C. After being stirred at that temperature for 20 min, the solution was cooled to –78 °C and quenched with saturated aqueous NH_4Cl solution. The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, hexanes then EtOAc/hexanes = 1/10) gave vinyl triflate **S7** (251 mg, 79%) as a colorless oil: $[\alpha]_D^{27}$ –12.9 (*c* 1.0, benzene); IR (film) 3033, 2894, 2861, 1670, 1419, 1212, 1142, 1079, 933 cm^{-1}; ^1H NMR (500 MHz, C_6D_6) δ 7.32–7.26 (m, 2H), 7.21–7.16 (m, 2H), 7.10 (m, 1H), 5.69–5.60 (m, 2H), 4.80 (d, *J* = 3.0 Hz, 1H), 4.68 (d, *J* = 3.0 Hz, 1H), 4.38 (d, *J* = 12.5 Hz, 1H), 4.37 (d, *J* = 12.5 Hz, 1H), 4.35 (m, 1H), 4.03 (m, 1H), 3.93 (dd, *J* = 12.0, 6.0 Hz, 1H), 3.69 (m, 1H), 3.43 (dd, *J* = 10.5, 6.0 Hz, 1H), 3.29 (dd, *J* = 10.5, 4.5 Hz, 1H), 1.91 (m, 1H), 1.80–1.70 (m, 3H), 1.67 (m, 1H), 1.55 (m, 1H); ^{13}C NMR (125 MHz, C_6D_6) δ 155.9, 139.1, 128.5 (× 2), 128.3, 127.7 (× 2), 127.6, 125.5, 119.1 (q, $J_{C\text{-}F}$ = 320 Hz), 103.7, 82.4, 77.7, 77.2, 73.34, 73.30, 73.2, 30.0, 28.1, 27.0; HRMS (ESI) calcd for $C_{20}H_{23}F_3O_6SNa$ [$(M + Na)^+$] 471.1060, found 471.1047.

To a solution of the above vinyl triflate **S7** (34.7 mg, 77.5 μmol) in THF (1.48 mL) at room temperature were added successively LiCl (32.8 mg, 774 μmol), tetrakis(triphenylphosphine)palladium (8.9 mg, 7.7 μmol), and hexamethylditin (48.1 μmol, 232

μmol). After being stirred at room temperature for 1 h, the solution was warmed to 70 °C and stirred for 3 h. The mixture was cooled to room temperature, diluted with diethyl ether, and filtered through a plug of Celite. The filtrate was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, hexanes then EtOAc/hexanes = 1/20–1/10) gave vinyl stannane **4** (32.4 mg, 90%) as a colorless oil: $[\alpha]_D^{28}$ –18.6 (*c* 1.0, benzene); IR (film) 3033, 2975, 2934, 2908, 2893, 2860, 1456, 1185, 1093, 1061, 917, 767, 696, 526 cm^{-1}; ^1H NMR (500 MHz, C_6D_6) δ 7.34–7.29 (m, 2H), 7.23–7.16 (m, 2H), 7.11 (m, 1H), 5.97 (ddd, *J* = 10.5, 1.3, 1.3 Hz, 1H), 5.76 (m, 1H), 5.69 (m, 1H), 5.29 (m, 1H), 4.59 (m, 1H), 4.43 (d, *J* = 12.2 Hz, 1H), 4.40 (d, *J* = 12.2 Hz, 1H), 4.07 (brs, 1H), 3.98 (dd, *J* = 14.2, 6.8 Hz, 1H), 3.76 (m, 1H), 3.49 (dd, *J* = 9.8, 5.9 Hz, 1H), 3.34 (dd, *J* = 9.8, 4.4 Hz, 1H), 2.03–1.89 (m, 3H), 1.83 (m, 1H), 1.72 (m, 1H), 1.49 (dddd, *J* = 9.3, 9.3, 9.3, 9.3 Hz, 1H), 0.24 (s, 9H); ^{13}C NMR (125 MHz, C_6D_6) δ 159.0, 139.3, 128.7, 128.5 (× 2), 127.7 (× 2), 127.6, 125.0, 122.4, 85.9, 81.6, 78.1, 73.43, 73.41, 73.3, 34.0, 29.2, 28.3, –8.7 (× 3); HRMS (ESI) calcd for $C_{22}H_{32}O_3SnNa$ [$(M + Na)^+$] 487.1270, found 487.1280.



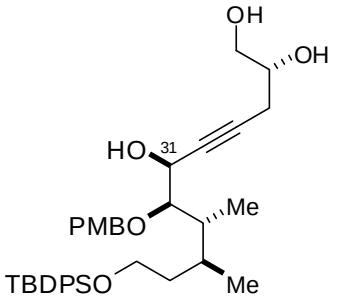
6

Alkyne 6. To a solution of trimethylsilylacetylene (2.00 mL, 14.2 mmol) in THF (25 mL) at –78 °C was added *n*-BuLi (2.69 M solution in hexane, 5.10 mL, 13.7 mmol). After being stirred at –78 °C for 20 min, $BF_3 \cdot OEt_2$ (1.69 mL, 13.7 mmol) was added. The mixture was stirred for 40 min, and a solution of (*S*)-glycidol (351 mg, 4.74 mmol) in THF (1 mL + 0.5 mL × 2 rinse) was added dropwise via cannula. The resultant solution was warmed to 0 °C and stirred for further 20 min before it was quenched with saturated aqueous $NaHCO_3$ solution. The organic layer was concentrated under reduced pressure, and the residue was extracted with EtOAc, washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure to give a crude diol (776 mg), which was used in the next reaction without purification: ^1H NMR (500 MHz, $CDCl_3$) δ 3.85 (m, 1H), 3.72 (dd, *J* = 11.5, 3.5 Hz, 1H), 3.57 (dd, *J* = 11.5, 6.5 Hz, 1H), 2.47 (dd, *J* = 16.5, 6.5, 1H), 2.44 (dd, *J* = 16.5, 6.5, 1H), 2.09 (brs, 2H), 0.13 (s, 9H).

To a solution of the above diol (776 mg) in CH_2Cl_2 (15.6 mL) were added benzaldehyde dimethylacetal (1.42 mL, 9.47 mmol) and CSA (55.0 mg, 237 μmol). The resultant solution was stirred at room temperature for 3 h before it was quenched with triethylamine. The mixture was concentrated under reduced pressure to give a crude acetal, which was used in the next reaction without purification.

To a solution of the above crude acetal in MeOH (9.4 mL) was added K_2CO_3 (1.55 g, 11.2 mmol). The resultant solution was stirred at room temperature for 1 h. The mixture was diluted with EtOAc, and the organic layer was washed with H_2O and brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, hexanes then diethyl ether/hexanes = 1/6) gave alkyne **6** (741 mg, 81% for the three steps based on

^{1}H NMR analysis, dr = ca. 1.2:1) as a colorless oil, which was contaminated with benzaldehyde. This mixture was used in the next reaction without further purification. Analytical sample was further purified by preparative HPLC and reported as a ca. 1.1:1 mixture of diastereomers: $[\alpha]_D^{26}$ –51.1 (*c* 1.0, $CHCl_3$); IR (film) 3290, 3035, 2881, 1478, 1401, 1220, 1091, 1070, 1026, 971, 759, 698 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52–7.42 (m, 4.35H), 7.40–7.34 (m, 6.38H), 5.98 (s, 1.0H), 5.80 (s, 1.09H), 4.44–4.35 (m, 2.20H), 4.30 (dd, *J* = 8.5, 6.5 Hz, 1.14H), 4.15 (dd, *J* = 8.0, 7.0 Hz, 1.27H), 4.00 (dd, *J* = 8.0, 5.0 Hz, 1.23H), 3.88 (dd, *J* = 8.5, 7.0 Hz, 1.15H), 2.66–2.59 (m, 2.55H), 2.59–2.50 (m, 2.47H), 2.20–2.00 (m, 1.95H); ^{13}C NMR (125 MHz, $CDCl_3$) δ; 137.7, 137.1, 129.5, 129.2, 128.4 (× 2), 128.3 (× 2), 126.7(× 2), 126.4 (× 2), 104.6, 103.9, 79.6, 79.4, 74.6, 74.0, 70.6, 70.3, 69.9, 69.6, 23.9, 23.2; HRMS (ESI) calcd for $C_{12}H_{12}O_2Na$ [$(M + Na)^+$] 211.0730, found 211.0722.

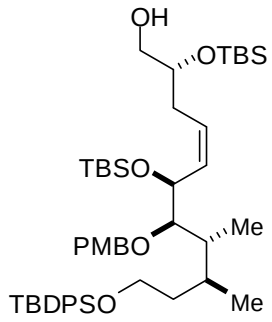


19

Triol 19. To a suspension of $Zn(OTf)_2$ (755 mg, 2.08 mmol), which was dried under vacuum (2 mmHg) at 60–80 °C for 20 min prior to use, and (+)-*N*-methylephedrine (406 mg, 2.27 mmol) in toluene (1 mL) was treated with triethylamine (316 μL, 2.27 mmol). The resulting mixture was stirred at room temperature for 2 h 40 min, and a solution of alkyne **6** (356 mg, ca. 1.89 mmol) in toluene (0.5 mL) was added dropwise via cannula. After being stirred for 45 min, a solution of aldehyde **7**[3)] (453 mg, 873 μmol) in toluene (300 μL + 200 μL × 2 rinse) was added dropwise via cannula. The resultant mixture was stirred at room temperature for 12 h before it was quenched with saturated aqueous NH_4Cl solution. The mixture was extracted with diethyl ether, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/10–1/3.5) gave a propargylic alcohol (561 mg) as a mixture of diastereomers, which contained some byproducts. The mixture was used in the next reaction without further purification: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68–7.62 (m, 8.8H), 7.47–7.44 (m, 3.1H), 7.43–7.31 (m, 22H), 7.25–7.21 (m, 4.3H), 6.83–6.78 (m, 4.3H), 5.95 (s, 0.1H), 5.92 (s, 1.0H), 5.81 (s, 0.1H), 5.75 (s, 1.2H), 4.70–4.66 (m, 2.1H), 4.57–4.53 (m, 2.2H), 4.47–4.42 (m, 2.2H), 4.37–4.27 (m, 2.2H), 4.22 (dd, *J* = 8.5, 6.0 Hz, 1.0H), 4.06 (dd, *J* = 8.5, 6.5 Hz, 1.2H), 3.95 (dd *J* = 8.5, 5.0 Hz, 1.2H), 3.82 (dd, *J* = 8.5, 7.0 Hz, 1.0H), 3.76 (s, 3.6H), 3.75 (s, 3.0H), 3.73–3.62 (m, 4.7H), 3.42–3.36 (m, 2.2H), 2.74–2.58 (m, 2.9H), 2.58–2.46 (m, 2.4H), 2.29–2.22 (m, 1.9H), 2.21–2.12 (m, 2.4H), 1.86–1.76 (m, 2.4H), 1.60–1.51 (m, 2.4H), 1.50–1.41 (m, 2.4H), 1.02 (s, 21.1H), 0.78–0.68 (m, 13.5H).

To a solution of the above propargylic alcohol (561 mg) in EtOH (7.9 mL) at room temperature

was added PPTS (80.0 mg, 319 μmol). The resultant solution was stirred at room temperature for 4.5 h before it was quenched with triethylamine (221 μL, 1.59 mmol). The mixture was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 2/3–2/1) to give triol **19** (441 mg, 82% for the two steps) as a colorless oil: $[\alpha]_D^{28}$ +29.3 (*c* 1.0, $CHCl_3$); IR (film) 3386, 2961, 2931, 2861, 1514, 1248, 1111, 1087, 1036, 703 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.68–7.62 (m, 4H), 7.42–7.32 (m, 6H), 7.26–7.21 (m, 2H), 6.84–6.80 (m, 2H), 4.69 (d, *J* = 11.0 Hz, 1H), 4.56 (d, *J* = 11.0 Hz, 1H) 4.43 (brd, *J* = 5.5 Hz, 1H), 3.76 (s, 3H), 3.76–3.64 (m, 3H), 3.61 (brd, *J* = 12.5 Hz, 1H), 3.48 (dd, *J* = 11.5, 6.0 Hz, 1H), 3.40 (dd, *J* = 10.0, 3.3 Hz, 1H), 2.59 (brs, 1H), 2.45–2.80 (m, 2H), 2.25 (d, *J* = 8.5, 1H), 2.16 (m, 1H), 1.92 (brs, 1H), 1.78 (m, 1H), 1.55 (m, 1H), 1.46 (m, 1H), 1.02 (s, 9H), 0.74 (d, *J* = 7.5 Hz, 3H), 0.71 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.3, 135.6 (× 2), 135.5 (× 2), 134.00, 133.97, 130.5, 129.54 (× 2), 129.51 (× 2), 127.6 (× 4), 113.9 (× 2), 84.1, 82.8, 80.9, 74.7, 70.1, 65.4, 64.9, 62.5, 55.2, 39.3, 38.3, 28.2, 26.8 (× 3), 23.9, 19.2, 13.8, 10.0; HRMS (ESI) calcd for $C_{37}H_{50}O_6SiNa$ $[(M + Na)^+]$ 641.3269, found 641.3270.



20

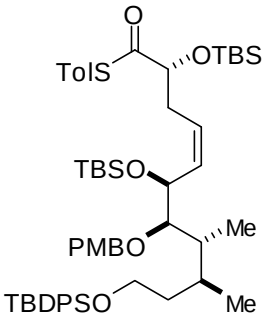
Primary Alcohol 20. To a solution of triol **19** (124 mg, 200 μmol) in EtOAc (1 mL) were added quinoline (6.1 μL, 50 μmol) and $Pd/CaCO_3$ poisoned with Pb (12.4 mg). The resultant mixture was stirred vigorously under an atmosphere of hydrogen at room temperature for 13 h before it was filtered through a plug of Celite. The filtrate was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 1/1–2/1) to give (*Z*)-alkene **S8** (117 mg, 94%) as a colorless oil: $[\alpha]_D^{28}$ –7.5 (*c* 1.0, $CHCl_3$); IR (film) 3377, 2958, 2931, 2857, 1514, 1248, 1111, 1091, 1037, 703 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.68–7.63 (m, 4H), 7.43–7.37 (m, 2H), 7.37–7.32 (m, 4H), 7.26–7.21 (m, 2H), 6.84–6.80 (m, 2H), 5.83 (dd, *J* = 10, 10.0 Hz, 1H), 5.59 (ddd, *J* = 10.0, 10.0, 6.5 Hz, 1H), 4.62 (d, *J* = 11.5 Hz, 1H) 4.57 (d, *J* = 11.5 Hz, 1H), 4.51 (dd, *J* = 8.5, 3.0 Hz, 1H), 3.76 (s, 3H), 3.75–3.62 (m, 3H), 3.61–3.48 (m, 2H), 3.45 (dd, *J* = 8.5, 3.3 Hz, 1H), 2.62 (brs, 3H), 2.48 (ddd, *J* = 14.0, 9.5, 7.0 Hz, 1H), 2.24 (m, 1H), 2.16 (m, 1H), 1.59 (m, 1H), 1.51 (m, 1H), 1.44 (m, 1H), 1.01 (s, 9H), 0.76 (d, *J* = 8.0 Hz, 3H), 0.67 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.1, 135.6 (× 2), 135.5 (× 2), 134.00, 133.98, 130.8, 130.7, 129.50, 129.49, 129.35 (× 2), 129.2, 127.6 (× 4), 113.8 (× 2), 84.3, 74.8, 71.0, 68.1, 64.9, 62.5, 55.2, 38.7, 38.3, 31.9, 28.3, 26.8 (× 3), 19.1, 14.0, 10.2; HRMS (ESI) calcd for $C_{37}H_{52}O_6SiNa$ $[(M + Na)^+]$ 643.3425, found 643.3434.

To a solution of the above (*Z*)-alkene **S8** (70.8 mg, 114 μmol) in 1,2-dichloroethane (290 μL) at 0 °C were added triethylamine (47.6 μL, 343 μmol), TrCl (41.2 mg, 148 μmol), and DMAP (1.4 mg, 11 μmol), and the resultant solution was stirred at room temperature for 1.5 h. The reaction mixture was diluted with 1,2-dichloroethane (850 μL) and stirred at 50 °C for 10 h. Additional portions of triethylamine (111 μL, 799 μmol) and TrCl (41.2 mg, 148 μmol) were added, and the stirring was continued at 50 °C for further 17 h. The mixture was cooled to room temperature, quenched with H_2O, and neutralized with 5 % aqueous citric acid (pH = ca. 7). The mixture was extracted with CH_2Cl_2, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/10–1/7–1/5) gave trityl ether **S9** (89.0 mg, 90%) as a colorless viscous oil: $[\alpha]_D^{28}$ +16.0 (*c* 1.0, $CHCl_3$); IR (film) 3410, 3068, 2957, 2930, 2858, 1513, 1248, 1110, 1089, 1035, 763, 745, 703, 505 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.67–7.62 (m, 4H), 7.44–7.39 (m, 6H), 7.39–7.32 (m, 6H), 7.31–7.25 (m, 6H), 7.25–7.19 (m, 5H), 6.82–6.78 (m, 2H), 5.77 (t, *J* = 9.5 Hz, 1H), 5.50 (m, 1H), 4.62 (d, *J* = 11.0 Hz, 1H) 4.57 (d, *J* = 11.0 Hz, 1H), 4.44 (dd, *J* = 9.0, 2.5 Hz, 1H), 3.84 (q, *J* = 5.5 Hz, 1H), 3.75 (s, 3H), 3.71–3.60 (m, 2H), 3.41 (dd, *J* = 8.5, 3.0 Hz, 1H), 3.15–3.07 (m, 2H), 2.51 (brs, 2H), 2.40 (ddd, *J* = 14.0, 8.5, 5.0 Hz, 1H), 2.24 (ddd, *J* = 14.0, 6.0, 6.0 Hz, 1H), 2.15 (m, 1H), 1.57–1.38 (m, 3H), 1.01 (s, 9H), 0.73 (d, *J* = 7.0 Hz, 3H), 0.64 (d, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.0, 143.8 (× 3), 135.6 (× 4), 134.1, 134.0, 131.1, 131.0, 129.47, 129.46, 129.3 (× 2), 128.7, 128.6 (× 6), 127.9 (× 6), 127.6 (× 4), 127.1 (× 3), 113.7 (× 2), 86.8, 84.3, 74.6, 70.0, 68.4, 66.8, 62.5, 55.2, 38.7, 38.4, 31.6, 28.2, 26.8 (× 3), 19.1, 13.9, 10.3; HRMS (ESI) calcd for $C_{56}H_{66}O_6SiNa$ $[(M + Na)^+]$ 885.4521, found 885.4543.

To a solution of the above trityl ether **S9** (71.9 mg, 83.3 μmol) and 2,6-lutidine (49.0 μL, 421 μmol) in CH_2Cl_2 (1 mL) at 0 °C was added TBSOTf (46.0 μL, 201 μmol). The resultant solution was allowed to warm to room temperature and stirred for 1 h before it was quenched with saturated aqueous NH_4Cl solution. The mixture was extracted with $CHCl_3$, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/80–1/40) gave bis-TBS ether **S10** (82.9 mg, 91%) as a colorless oil: $[\alpha]_D^{26}$ +21.6 (*c* 1.0, $CHCl_3$); IR (film) 2955, 2929, 2885, 2856, 1514, 1249, 1111, 1087, 834, 775, 703 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.67–7.62 (m, 4H), 7.47–7.41 (m, 6H), 7.40–7.31 (m, 6H), 7.30–7.24 (m, 6H), 7.24–7.18 (m, 5H), 6.80–6.76 (m, 2H), 5.62 (dd, *J* = 9.0, 9.0 Hz, 1H), 5.49 (ddd, *J* = 11.5, 9.0, 6.0 Hz, 1H), 4.90 (d, *J* = 10.5 Hz, 1H), 4.62 (brd, *J* = 9.5 Hz, 1H), 4.41 (d, *J* = 10.5 Hz, 1H), 3.79 (m, 1H), 3.75 (s, 3H), 3.70–3.57 (m, 2H), 3.28 (dd, *J* = 9.5, 1.3 Hz, 1H), 3.07 (dd, *J* = 8.5, 5.0 Hz, 1H), 2.98 (dd, *J* = 8.5, 6.0 Hz, 1H), 2.60 (m, 1H), 2.16–2.06 (m, 2H), 1.52–1.38 (m, 3H), 1.01 (s, 9H), 0.89 (s, 9H), 0.83 (s, 9H), 0.74 (d, *J* = 7.0 Hz, 3H), 0.64 (d, *J* = 6.5 Hz, 3H), 0.07 (s, 3H), 0.03 (s, 3H), –0.01 (s, 3H), –0.07 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.8, 144.1 (× 3), 135.5 (× 4), 134.14, 134.11, 131.7, 130.8, 129.42, 129.40, 129.3 (× 2), 128.7 (× 6), 127.7 (× 6), 127.55 (× 2), 127.54 (× 2), 127.0, 126.9 (× 3), 113.5 (× 2), 86.5, 86.4, 74.3, 71.6, 70.9, 67.8, 62.9, 55.2, 38.6, 38.3, 34.1, 28.1, 26.9 (× 3), 25.9 (× 3), 25.8 (× 3), 19.1, 18.1, 18.0, 13.4, 10.9, –4.1, –4.4, –4.6, –4.8; HRMS (ESI) calcd for $C_{68}H_{94}O_6Si_3Na$ [(M +

Na)$^+$] 1113.6250, found 1113.6277.

To a solution of the above bis-TBS ether **S10** (80.7 mg, 73.9 μmol) in CH_2Cl_2/MeOH (3:1, v/v 400 μL) at 0 °C was added $ZnBr_2$ (167 mg, 742 μmol). The resultant solution was stirred at 0 °C for 1 h. An additional portion of $ZnBr_2$ (83.0 mg, 369 μmol) was added, and the mixture was stirred at 0 °C for 3 h before it was quenched with saturated aqueous $NaHCO_3$ solution The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/40–1/20) gave primary alcohol **20** (59.2 mg, 94%) as a colorless oil: $[\alpha]_D^{26}$ +5.1 (*c* 1.0, $CHCl_3$); IR (film) 3472, 2955, 2929, 2885, 2857, 1514, 1250, 1110, 1091, 1038, 836, 776, 702 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.67–7.62 (m, 4H), 7.42–7.38 (m, 2H), 7.38–7.33 (m, 4H), 7.25–7.22 (m, 2H), 6.82–6.78 (m, 2H), 5.65 (dd, *J* = 11.0, 9.5 Hz, 1H), 5.49 (ddd, *J* = 11.0, 7.0, 7.0 Hz, 1H), 4.82 (d, *J* = 11.5 Hz, 1H), 4.58 (dd, *J* = 9.5, 3.3 Hz, 1H), 4.43 (d, *J* = 11.5 Hz, 1H), 3.76 (s, 3H), 3.74 (m, 1H), 3.70–3.59 (m, 2H), 3.44 (ddd, *J* = 11.5, 6.0, 6.0 Hz, 1H), 3.36 (ddd, *J* = 11.5, 6.0, 6.0 Hz, 1H), 3.27 (dd, *J* = 8.5, 3.3 Hz, 1H), 2.34–2.23 (m, 2H), 2.10 (m, 1H), 2.04 (brdd, *J* = 6.0, 6.0 Hz, 1H), 1.56–1.40 (m, 3H), 1.02 (s, 9H), 0.89 (s, 9H), 0.88 (s, 9H), 0.77 (d, *J* = 7.0 Hz, 3H), 0.71 (d, *J* = 6.5 Hz, 3H), 0.06 (s, 3H), 0.06 (s, 6H), 0.04 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.9, 135.5 (× 4), 134.12, 134.09, 132.1, 131.3, 129.42, 129.41, 129.35 (× 2), 127.9, 127.55 (× 2), 127.53 (× 2), 113.5 (× 2), 86.4, 74.4, 72.3, 70.4, 65.6, 62.9, 55.2, 38.7, 38.4, 32.7, 28.2, 26.9 (× 3), 25.9 (× 3), 25.8 (× 3), 19.1, 18.04, 18.02, 13.8, 11.1, –4.1, –4.5, –4.6, –4.7; HRMS (ESI) calcd for $C_{49}H_{80}O_6Si3Na$ [(M + Na)$^+$] 871.5155, found 871.5172.



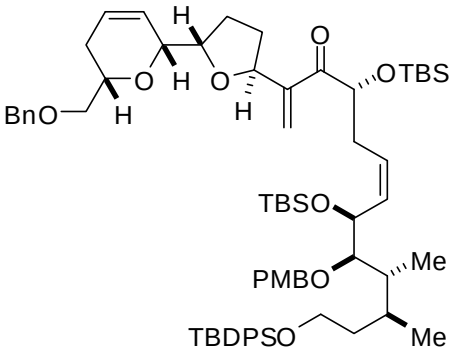
5

Thiol Ester 5. To a solution of primary alcohol **20** (60.1 mg, 70.8 μmol) in DMSO (700 μL) at room temperature was added IBX (50.6 mg, 177 μmol). The resultant solution was stirred at room temperature for 3 h 20 min before THF (350 μL) was added. The mixture was stirred for further 1 h. The reaction mixture was quenched with a mixture of saturated aqueous $NaHCO_3$ solution and saturated aqueous $Na_2S_2O_3$ solution (1:1, v/v). The mixture was extracted with diethyl ether, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes 1/40–1/20) gave an aldehyde (54.3 mg, 91%) as a colorless oil, which was used in the next reaction immediately without further purification.

To a solution of the above aldehyde (54.3 mg, 64.1 μmol), 2-methyl-2-butene (68.0 μL, 643

μmol), and NaH_2PO_4 (15.4 mg, 128 μmol) in *t*-BuOH/H_2O (5:1, v/v, 1.28 mL) at 0 °C was added $NaClO_2$ (17.4 mg, 193 μmol). The resultant mixture was stirred at 0 °C for 1 h before it was quenched with saturated aqueous NH_4Cl solution. The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude acid was azeotropically dried with benzene and used immediately in the next reaction without purification.

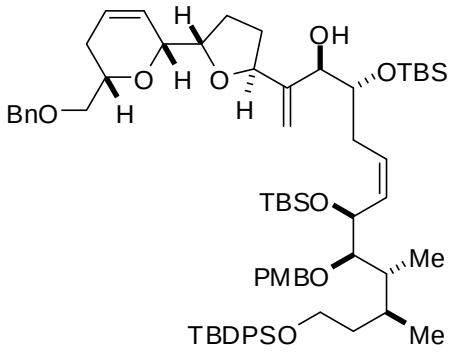
To a solution of the above crude acid, *i*-Pr_2NEt (16.7 μL, 96.1 μmol), and *p*-tolylthiol (9.6 mg, 77 μmol) in CH_2Cl_2 (1 mL) at 0 °C was added PyBOP® (40.0 mg, 76.9 μmol). The resultant solution was allowed to warm to room temperature and stirred for 10 h. The reaction mixture was diluted with EtOAc and washed with saturated aqueous $NaHCO_3$ solution. The aqueous layer was extracted with EtOAc, and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/80–1/40) gave thiol ester **5** (48.0 mg, 77%) as a colorless oil: $[\alpha]_D^{26}$ +59.5 (*c* 1.0, $CHCl_3$); IR (film) 2955, 2929, 2894, 2857, 1700, 1514, 1250, 1111, 835, 777, 702 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.67–7.62 (m, 4H), 7.42–7.36 (m, 2H), 7.36–7.31 (m, 4H), 7.26–7.20 (m, 4H), 7.20–7.16 (m, 2H), 6.81–6.76 (m, 2H), 5.73 (dd, *J* = 11.0, 9.5 Hz, 1H), 5.61 (m, 1H), 4.88 (d, *J* = 11.5 Hz, 1H), 4.57 (dd, *J* = 9.0, 1.5 Hz, 1H), 4.40 (d, *J* = 11.5 Hz, 1H), 4.26 (dd, *J* = 7.5, 4.5 Hz, 1H), 3.75 (s, 3H), 3.69–3.59 (m, 2H), 3.25 (dd, *J* = 9.0, 1.5 Hz, 1H), 2.57 (m, 1H), 2.45 (m, 1H), 2.33 (s, 3H), 2.11 (m, 1H), 1.52–1.37 (m, 3H), 1.01 (s, 9H), 0.98 (s, 9H), 0.88 (s, 9H), 0.71 (d, *J* = 8.0 Hz, 3H), 0.67 (d, *J* = 7.0 Hz, 3H), 0.18 (s, 3H), 0.11 (s, 3H), 0.04 (s. 3H), 0.02 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 203.0, 158.8, 139.4, 135.6 (× 4), 134.6 (× 2), 134.15, 134.11, 132.2, 131.6, 123.0 (× 2), 129.43, 129.41, 129.3 (× 2), 127.6 (× 4), 124.6, 124.3, 113.5 (× 2), 86.2, 78.2, 74.3, 70.7, 62.9, 55.2, 38.5, 38.3, 34.6, 28.1, 26.9 (× 3), 25.9 (× 3), 25.8 (× 3), 21.3, 19.1, 18.2, 18.0, 13.5, 10.9, –4.2, –4.6, –4.80, –4.82; HRMS (ESI) calcd for $C_{56}H_{84}O_6SSi_3Na$ $[(M + Na)^+]$ 991.5189, found 991.5217.



3

Enone 3. To a suspension of vinyl stannane **4** (2.6 mg, 5.6 μmol), thiol ester **5** (5.0 mg, 5.2 μmol), copper(I) diphenylphosphinate (2.9 mg, 10 μmol), triethylphosphite (0.71 μL, 4.2 μmol), and $Pd_2(dba)_3$ (1.0 mg, 1.1 μmol) in hexane (347 μL) was added THF (173 μL). The resulting ocherous suspension was stirred at room temperature for 4 h before it was diluted with diethyl ether.

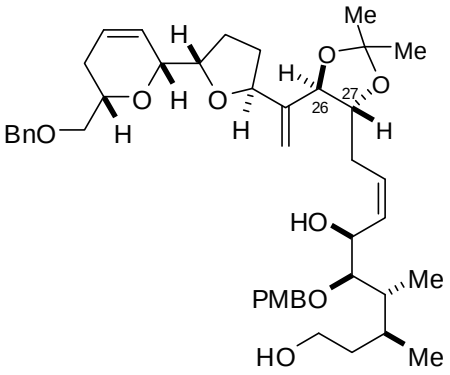
Insoluble materials were filtered off, and the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 1/30–1/20–1/15–1/10) to give enone **3** (4.0 mg, 68%) as a pale yellow oil: $[\alpha]_D^{27}$ +8.7 (*c* 1.0, $CHCl_3$); IR (film) 3032, 2954, 2929, 2893, 2856, 1683, 1514, 1471, 1250, 1091, 1038, 836, 777, 701 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.66–7.61 (m, 4H), 7.41–7.36 (m, 2H), 7.36–7.29 (m, 8H), 7.28–7.24 (m, 1H), 7.23–7.19 (m, 2H), 6.80–6.76 (m, 2H), 6.20 (s, 1H), 6.12 (s, 1H), 5.87 (m, 1H), 5.79 (brd, *J* = 10.0 Hz, 1H), 5.67 (dd, *J* = 11.5, 9.5 Hz, 1H), 5.49 (ddd, *J* = 11.5, 7.5, 7.5 Hz, 1H), 4.86 (d, *J* = 11.0 Hz, 1H), 4.81 (dd, *J* = 6.7, 6.7 Hz, 1H), 4.60 (d, *J* = 12.5 Hz, 1H), 4.58 (m, 1H), 4.57 (d, *J* = 12.5 Hz, 1H), 4.53 (d, *J* = 10.5 Hz, 1H), 4.39 (d, *J* = 11.0 Hz, 1H), 4.13 (brs, 1H), 4.01 (dd, *J* = 13.0, 6.5 Hz, 1H), 3.81 (m, 1H), 3.74 (s, 3H), 3.66–3.55 (m, 2H), 3.56 (dd, *J* = 10.5, 6.0 Hz, 1H), 3.47 (dd, *J* = 10.5, 4.5 Hz, 1H), 3.25 (dd, *J* = 9.0, 1.5 Hz, 1H), 2.49 (m, 1H), 2.38 (m, 1H), 2.30 (m, 1H), 2.12–2.01 (m, 2H), 2.01–1.88 (m, 3H), 1.52–1.36 (m, 4H), 1.00 (s, 9H), 0.87 (s, 9H), 0.86 (s, 9H), 0.69 (d, *J* = 7.0 Hz, 3H), 0.65 (d, *J* = 7.0 Hz, 3H), 0.04 (s, 3H), 0.01 (s, 3H), –0.01 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 200.8, 158.8, 147.5, 138.4, 135.5 (× 4), 134.14, 134.11, 131.9, 131.6, 129.42, 129.41, 129.2 (× 2), 128.3 (× 2), 127.6 (× 2), 127.55 (× 2), 127.54 (× 3), 127.4, 125.6, 125.3, 123.7, 113.5 (× 2), 86.2, 81.4, 77.5, 76.8, 75.6, 74.3, 73.4, 73.04, 73.01, 70.8, 62.9, 55.2, 38.5, 38.4, 34.5, 32.6, 28.1, 27.9, 27.2, 26.9 (× 3), 25.9 (× 3), 25.8 (× 3), 19.1, 18.2, 18.0, 13.4, 10.9, –4.1, –4.57, –4.58, –5.0; HRMS (ESI) calcd for $C_{68}H_{100}O_9Si_3Na$ $[(M + Na)^+]$ 1167.6567, found 1167.6544.



2

Alcohol 2. To a solution of enone **3** (3.2 mg, 2.8 μmol) in EtOH (500 μL) was added $CeCl_3 \cdot 7H_2O$ (10.4 mg, 27.9 μmol). The resultant solution was stirred at room temperature for 45 min. The solution was cooled to –40 °C and treated with $NaBH_4$ (0.5 mg, 13 μmol). The resultant mixture was stirred at –40 °C for 30 min before it was quenched with saturated aqueous NH_4Cl solution. The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash column chromatography (silica gel, EtOAc/hexanes = 1/10) gave alcohol **2** (2.1 mg, 66%) as a colorless oil: $[\alpha]_D^{28}$ +10.4 (*c* 0.3, $CHCl_3$); IR (film) 3478, 3066, 3039, 2954, 2928, 2985, 2856, 1249, 1090, 836, 776, 702 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.65–7.61 (m, 4H), 7.40–7.35 (m, 2H), 7.35–7.29 (m, 8H), 7.28–7.24 (m, 1H), 7.23–7.20 (m, 2H), 6.80–6.76 (m, 2H) , 5.84 (m, 1H), 5.80 (brd, *J* = 10.5

Hz, 1H), 5.65 (dd, *J* = 10.0, 10.0 Hz, 1H), 5.42 (ddd, *J* = 11.5, 8.5, 5.0 Hz, 1H), 5.20 (s, 1H), 5.07 (s, 1H), 4.87 (d, *J* = 11.0 Hz, 1H), 4.60 (brd, *J* = 12.5 Hz, 1H), 4.59 (d, *J* = 12.0 Hz, 1H), 4.55 (d, *J* = 12.0 Hz, 1H), 4.42 (dd, *J* = 6.5, 6.5 Hz, 1H), 4.39 (d, *J* = 11.0 Hz, 1H), 4.06 (brs, 1H), 3.93 (dd, *J* = 13.0, 6.5 Hz, 1H), 3.89 (m, 1H), 3.82–3.76 (m, 2H), 3.74 (s, 3H), 3.67–3.57 (m, 2H), 3.54 (dd, *J* = 10.0, 6.0 Hz, 1H), 3.46 (dd, *J* = 10.0, 4.0 Hz, 1H), 3.24 (dd, *J* = 9.0, 2.0 Hz, 1H), 2.75 (d, *J* = 8.5 Hz, 1H), 2.51 (m, 1H), 2.16–1.98 (m, 4H), 1.98–1.86 (m, 2H), 1.71 (dddd, *J* = 12.5, 8.0, 8.0, 8.0 Hz, 1H), 1.52–1.38 (m, 4H), 1.00 (s, 9H), 0.87 (s, 9H), 0.85 (s, 9H), 0.72 (d, *J* = 7.0 Hz, 3H), 0.65 (d, *J* = 7.0 Hz, 3H), 0.05 (s, 3H), 0.03 (s, 3H), 0.02 (s, 3H), 0.01 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.8, 149.5, 138.4, 135.5 (× 4), 134.2, 134.1, 132.6, 131.6, 129.42, 129.41, 129.3 (× 2), 128.4 (× 2), 127.8, 127.59 (× 2), 127.55 (× 3), 127.54 (× 2), 125.8, 125.0, 113.5 (× 2), 110.2, 86.6, 81.0, 79.6, 77.2, 74.1, 73.39, 73.37, 73.26, 73.1, 73.0, 70.9, 62.9, 55.2, 38.6, 38.3, 33.3, 31.5, 28.1, 27.9, 27.5, 26.9 (× 3), 25.92 (× 3), 25.87 (× 3), 19.2, 18.2, 18.0, 13.4, 10.9, –4.3 (× 2), –4.4, –4.7; HRMS (ESI) calcd for $C_{68}H_{102}O_9Si_3Na$ [$(M + Na)^+$] 1169.6724, found 1169.6726.



21

Acetonide 21. To a solution of alcohol **2** (2.1 mg, 1.8 μmol) in THF (300 μL) at 0 °C was added TBAF (1.0 M solution in THF, 8.2 μL, 8.2 μmol). The resultant solution was stirred at room temperature for 1 h and then warmed to 50 °C and stirred for 23 h. The solution was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 2/1–1/0) to give a tetraol, which was used in the next reaction without further purification: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34–7.31 (m, 4H), 7.29–7.24 (m, 3H), 7.86–7.82 (m, 2H), 5.92–5.85 (m, 2H), 5.79 (brd, *J* = 10.0 Hz, 1H), 5.63 (ddd, *J* = 10.5, 10.5, 6.0 Hz, 1H), 5.19 (s, 1H), 5.19 (s, 1H), 4.72 (d, *J* = 11.0 Hz, 1H), 4.61–4.51 (m, 5H), 4.17 (brs, 1H), 4.06–3.99 (m, 2H), 3.85–3.77 (m, 2H), 3.77 (s, 3H), 3.66 (ddd, *J* = 11.0, 6.5, 6.5 Hz, 1H), 3.59 (ddd, *J* = 11.0, 6.5, 6.5 Hz, 1H), 3.54 (dd, *J* = 10.0, 6.0 Hz, 1H), 3.49–3.44 (m, 2H), 2.56 (ddd, *J* = 14.0, 10.0, 4.0 Hz, 1H), 2.23 (ddd, *J* = 14.0, 12.5, 6.0 Hz, 1H), 2.16–2.08 (m, 2H), 2.06–1.99 (m, 2H), 1.99–1.83 (m, 3H), 1.59 (m, 1H), 1.57 (brs, 4H), 1.47–1.42 (m, 2H), 0.79 (d, *J* = 6.5 Hz, 3H), 0.73 (d, *J* = 7.5 Hz, 3H).

To a solution of the above tetraol in CH_2Cl_2 (500 μL) at 0 °C were added 2,2-dimethoxypropane (4.4 μL, 36 μmol) and a catalytic amount of CSA. The resultant solution was stirred at room temperature for 2.5 h before it was quenched with saturated aqueous $NaHCO_3$

solution. The mixture was extracted with EtOAc, and the organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude acetonide was contaminated with the corresponding 2-methoxy-2-propyl ether, and thus used in the next reaction without purification.

To a solution of the above mixture in EtOH (500 μL) at 0 °C was added a catalytic amount of PPTS (ca. 0.3 mg). The resultant solution was stirred at room temperature for 15 min before it was quenched with triethylamine (excess). The mixture was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel, EtOAc/hexanes = 3/2) to give acetonide **21** (1.2 mg, 91% for the three steps) as a colorless oil: $[\alpha]_D^{28}$ +4.9 (*c* 0.1, $CHCl_3$); IR (film) 3446, 2955, 2922, 2855, 1514, 1456, 1377, 1248, 1059 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.34–7.29 (m, 3H), 7.28–7.24 (m, 4H), 6.86–6.82 (m, 2H), 5.91 (dd, *J* = 10.5, 9.0Hz, 1H), 5.86 (m, 1H), 5.76 (ddd, *J* = 10.5, 1.5Hz, 1.5 Hz, 1H), 5.68 (ddd, *J* = 11.5, 7.5, 7.5 Hz, 1H), 5.31 (s, 1H), 5.25 (s, 1H), 4.73 (d, *J* = 11.0 Hz, 1H), 4.59 (d, *J* = 12.0 Hz, 1H), 4.55 (d, *J* = 12.0 Hz, 1H), 4.54 (d, *J* = 11.0 Hz, 1H), 4.52–4.47 (m, 2H), 4.14 (brs, 1H), 4.10 (d, *J* = 9.0 Hz, 1H), 4.00 (dd, *J* = 13.0, 6.5 Hz, 1H), 3.92 (ddd, *J* = 9.0, 6.5, 4.0 Hz, 1H), 3.80 (m, 1H), 3.77 (s, 3H), 3.65 (ddd, *J* = 11.0, 7.0, 6.5 Hz, 1H), 3.58 (ddd, *J* = 11.0, 7.0, 6.5 Hz, 1H), 3.55 (dd, *J* = 10.5, 6.0 Hz, 1H), 3.46 (dd, *J* = 10.5, 5.0 Hz, 1H), 3.45 (dd, *J* = 4.0, 2.0 Hz, 1H), 2.72 (brs, 2H), 2.62 (ddd, *J* = 14.0, 8.5, 3.0 Hz, 1H), 2.35 (ddd, *J* = 14.0, 6.5, 6.5 Hz, 1H), 2.18–1.90 (m, 6H), 1.77 (dddd, *J* = 11.5, 7.5, 7.0, 6.5 Hz, 1H), 1.59 (m, 1H), 1.47–1.43 (m, 2H), 1.40 (s, 3H), 1.37 (s, 3H), 0.79 (d, *J* = 6.5 Hz, 3H), 0.74 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.1, 146.5, 134.9, 131.9, 131.2, 129.4 (× 2), 128.45, 128.37 (× 2), 127.61 (× 2), 127.57, 127.4, 125.3, 113.7 (× 2), 112.2, 108.4, 84.5, 81.2, 80.3, 80.2, 79.6, 77.2, 74.7, 73.4, 73.04, 72.97, 68.3, 61.1, 55.3, 38.3, 37.6, 32.0, 29.4, 27.80, 27.76, 27.11, 27.09, 26.9, 14.6, 10.5; HRMS (ESI) calcd for $C_{43}H_{60}O_9Na$ $[(M + Na)^+]$ 743.4130, found 743.4149.

References

1) (a) Ramachandran, P. V.; Prabhudas, B.; Chandra, J. S.; Reddy, M. V. R. *J. Org. Chem.* **2004**, *69*, 6294–6304. (b) Huang, H.; Mao, C.; Jan, S.-T.; Uckun, F. M. *Tetrahedron Lett.* **2000**, *41*, 1699–1702. (c) Bonini, C.; Chiummiento, L.; Pullez, M.; Solladie, G.; Colobert, F. *J. Org. Chem.* **2004**, *69*, 5015–5022.
2) Zhong, Y-L.; Shing, T. K. M. *J. Org. Chem.* **1997**, *62*, 2622–2624.
3) Takeda, Y.; Shi, J.; Oikawa, M.; Sasaki, M. *Org. Lett.* **2008**, *10*, 1013–1016.

Stereochemical Assignment of Compound 4

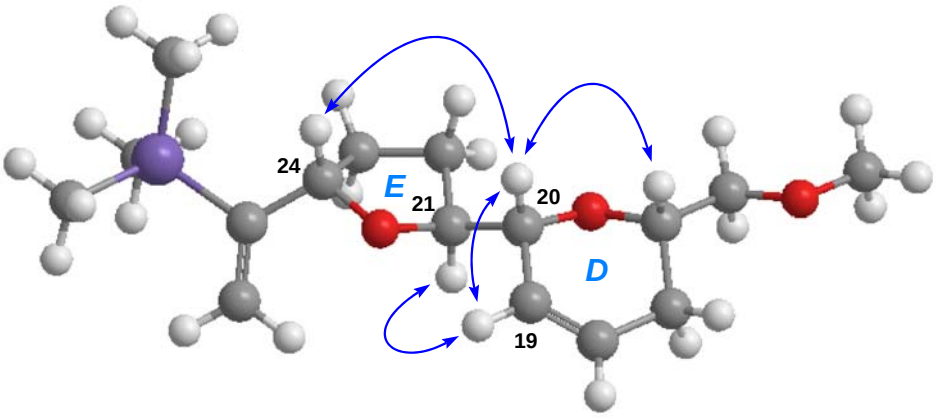


Figure S1. The double-ended arrows indicate the selected key NOEs. No NOE was observed between 21-H and 24-H. For clarity, the benzyl group was replaced with a methyl group.

*Matsumori, N.; Kaneno, D.; Murata, M.; Nakamura, H.; Tachibana, K. *J. Org. Chem.* **1999**, *64*, 866–876.

STANDARD PROTON PARAMETERS

Pulse Sequence: s2pul

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INOVA-500 "varian"

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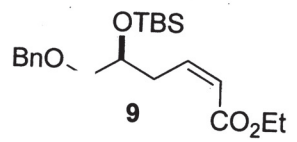

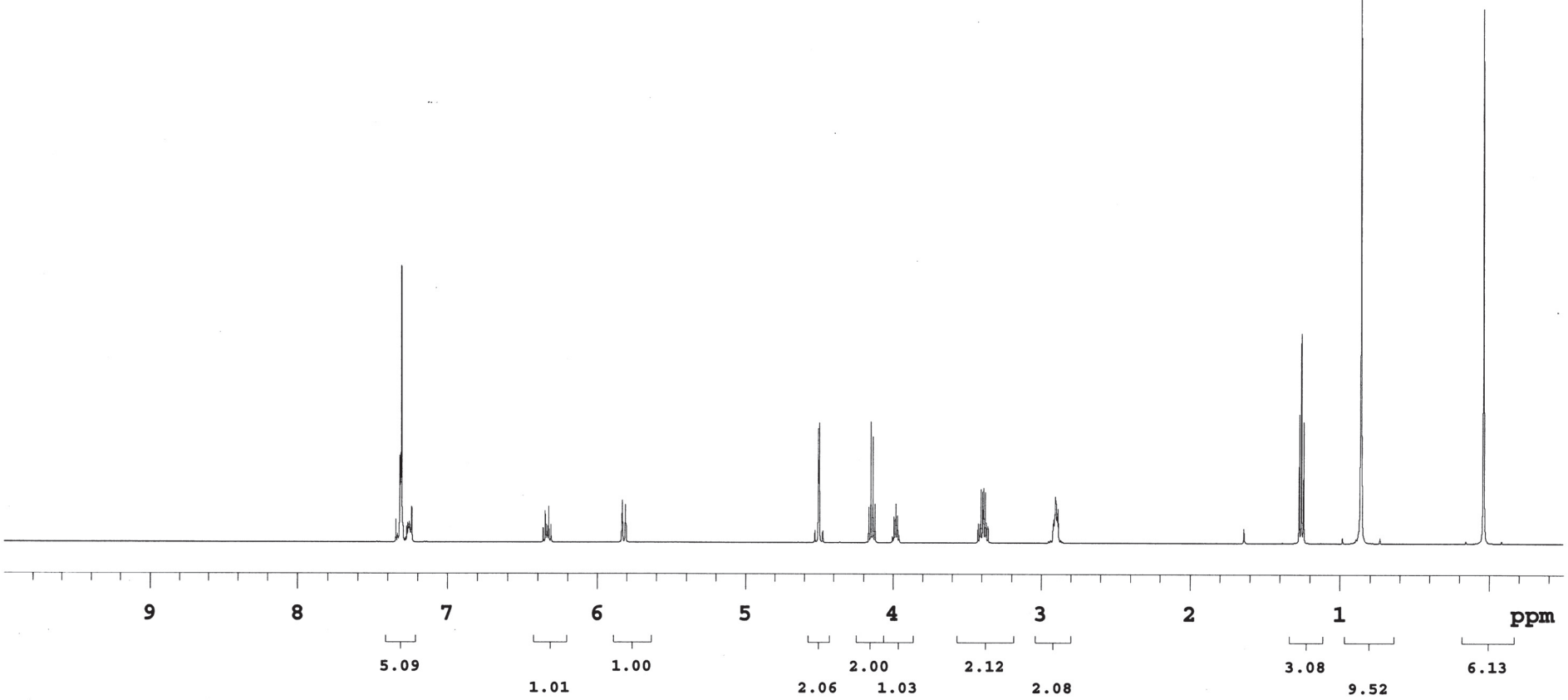

STANDARD CARBON PARAMETERS

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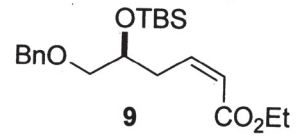

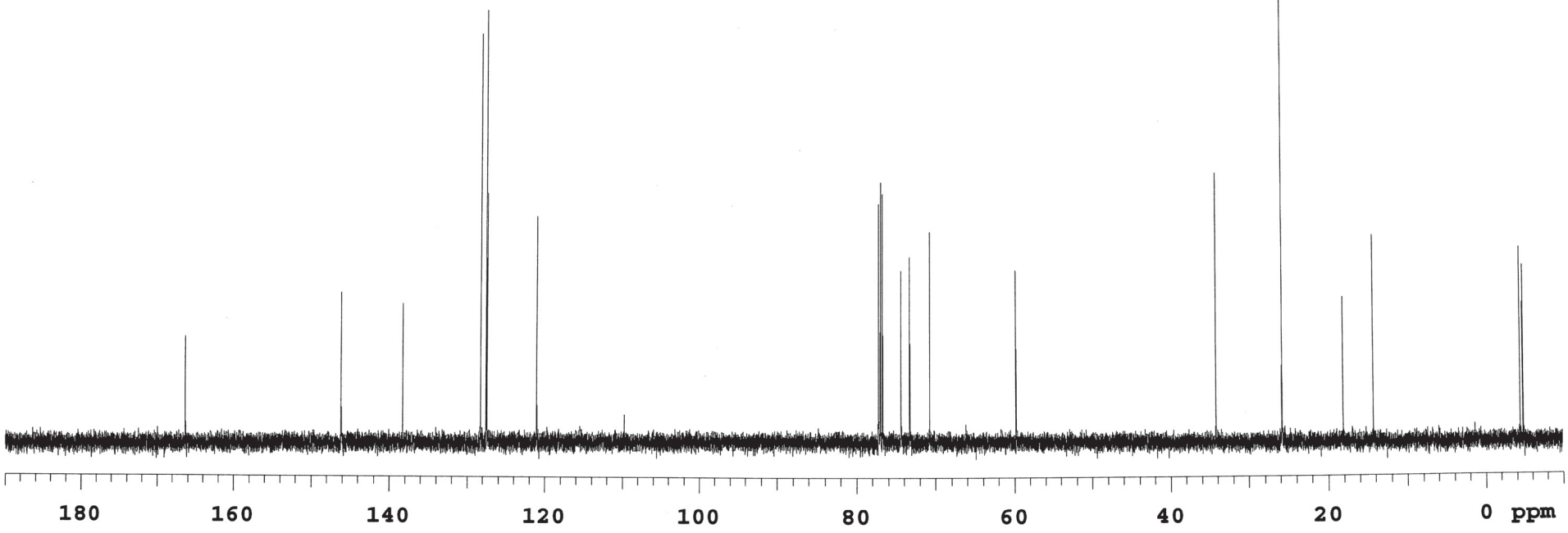

STANDARD PROTON PARAMETERS

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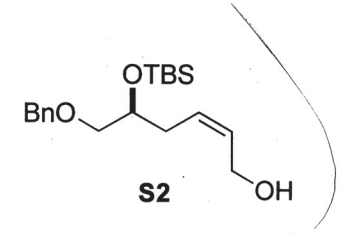
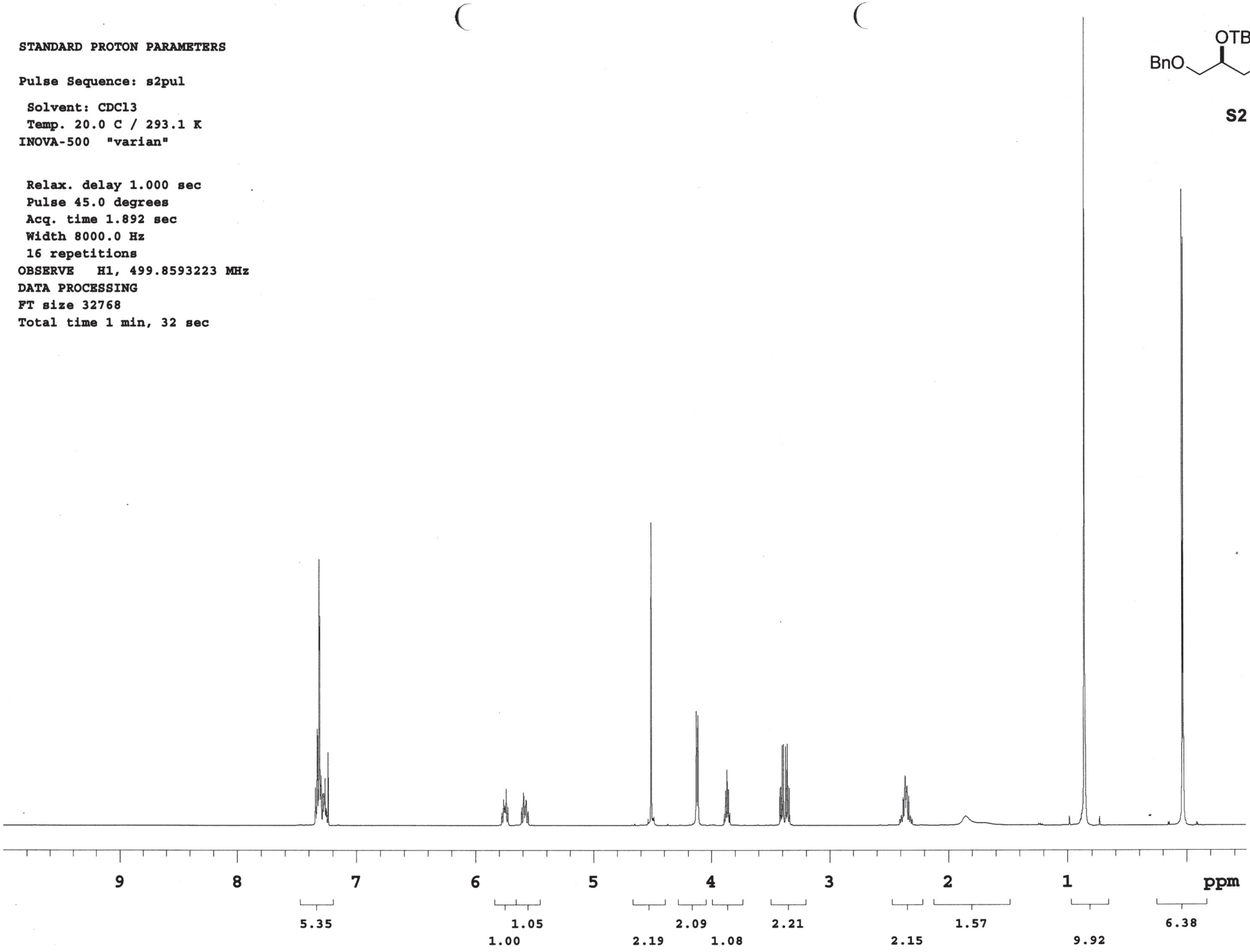


S2



STANDARD CARBON PARAMETERS

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User: 1-14-87
INOVA-500 "varian"

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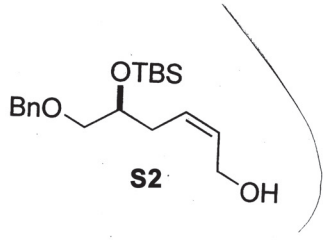
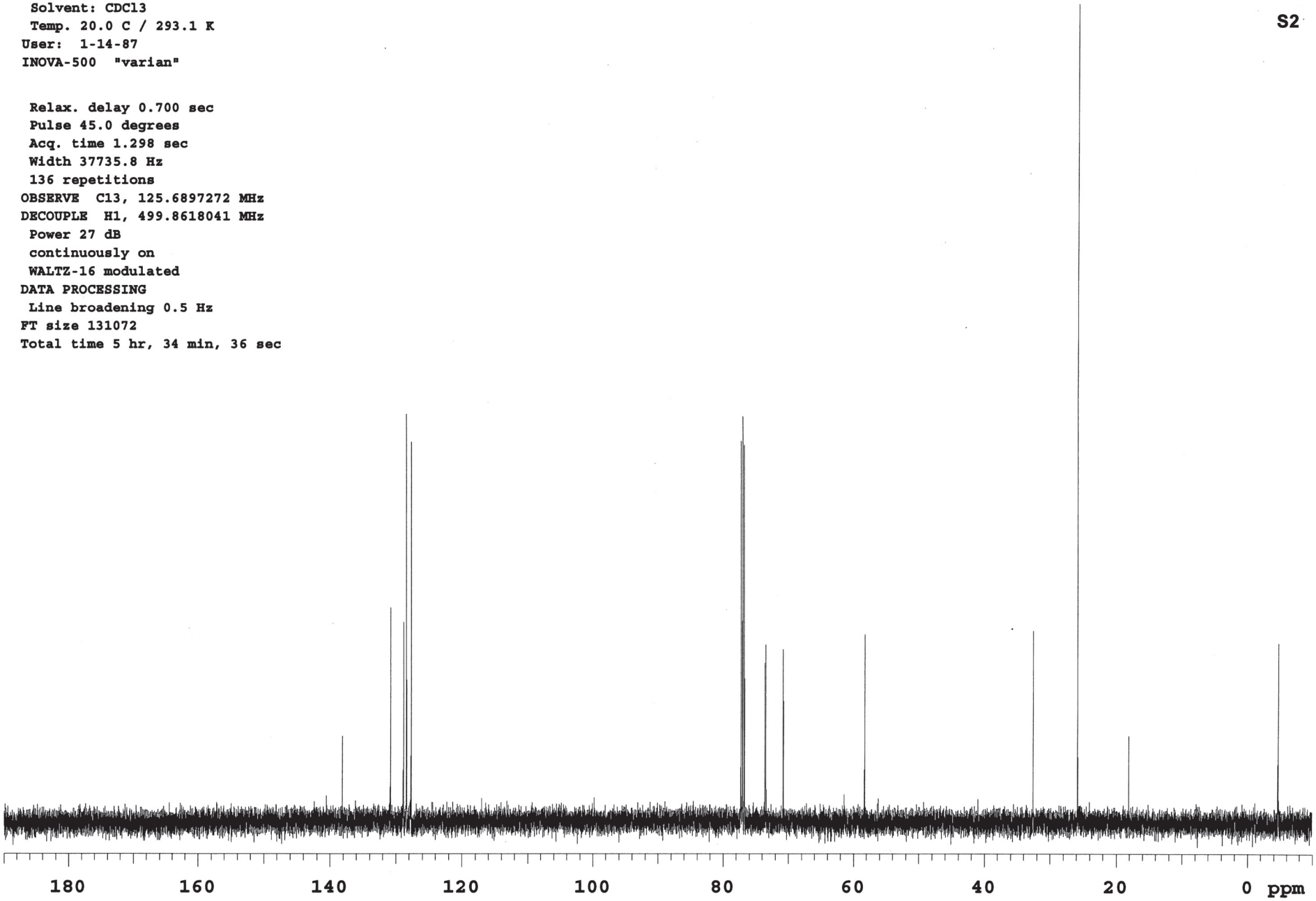
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
136 repetitions
OBSERVE C13, 125.6897272 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



S2



STANDARD PROTON PARAMETERS

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INOVA-500 "varian"

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Pulse 45.0 degrees
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DATA PROCESSING
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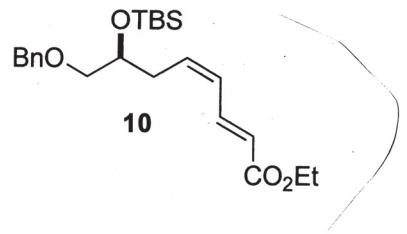
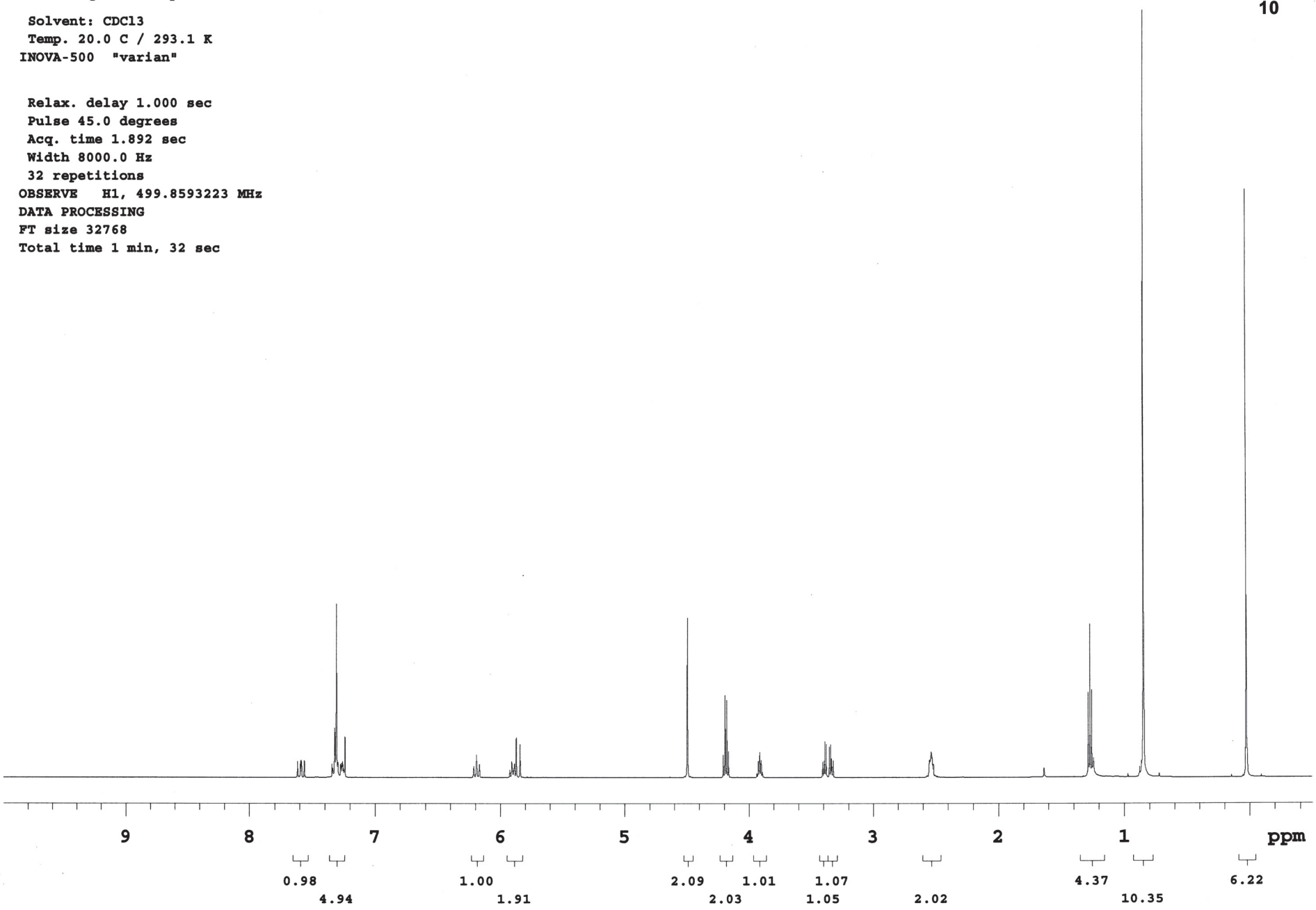
Total time 1 min, 32 sec



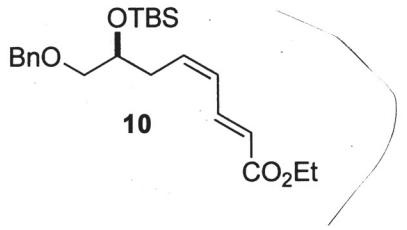


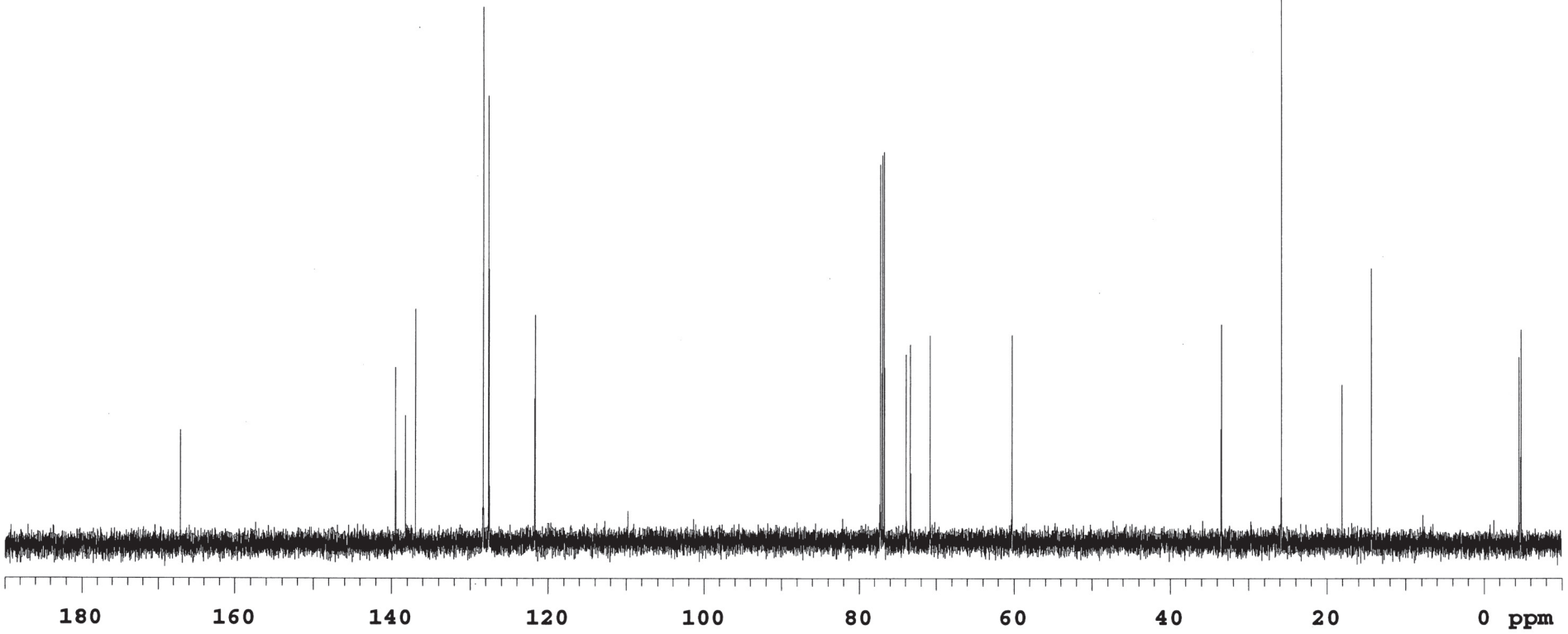
STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
144 repetitions
OBSERVE C13, 125.6897277 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



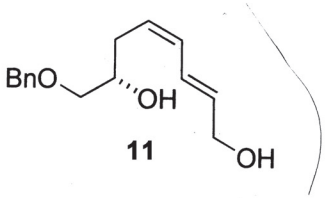


STANDARD PROTON PARAMETERS

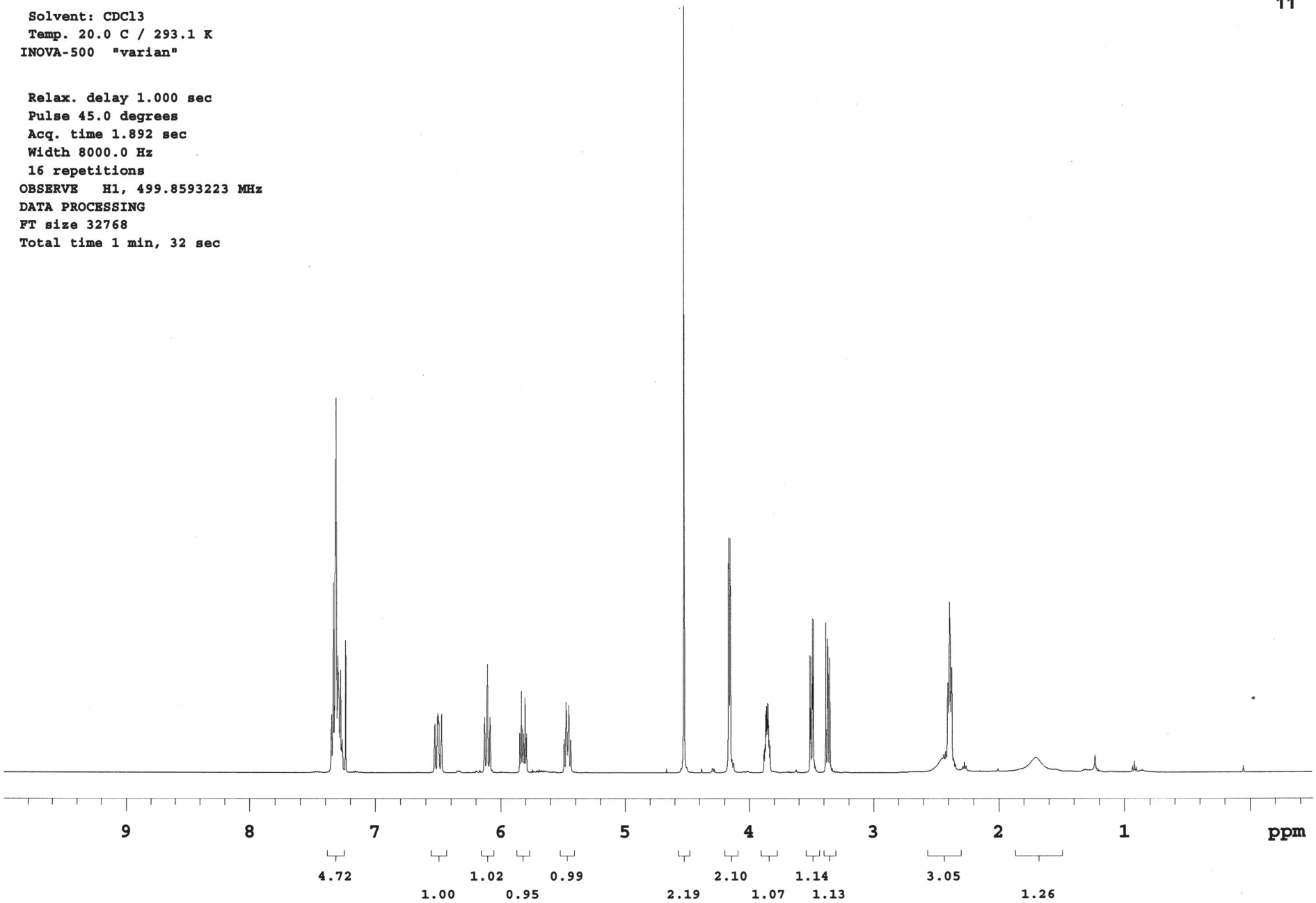
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
16 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



11

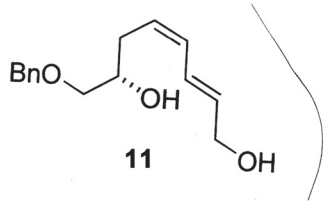


STANDARD CARBON PARAMETERS

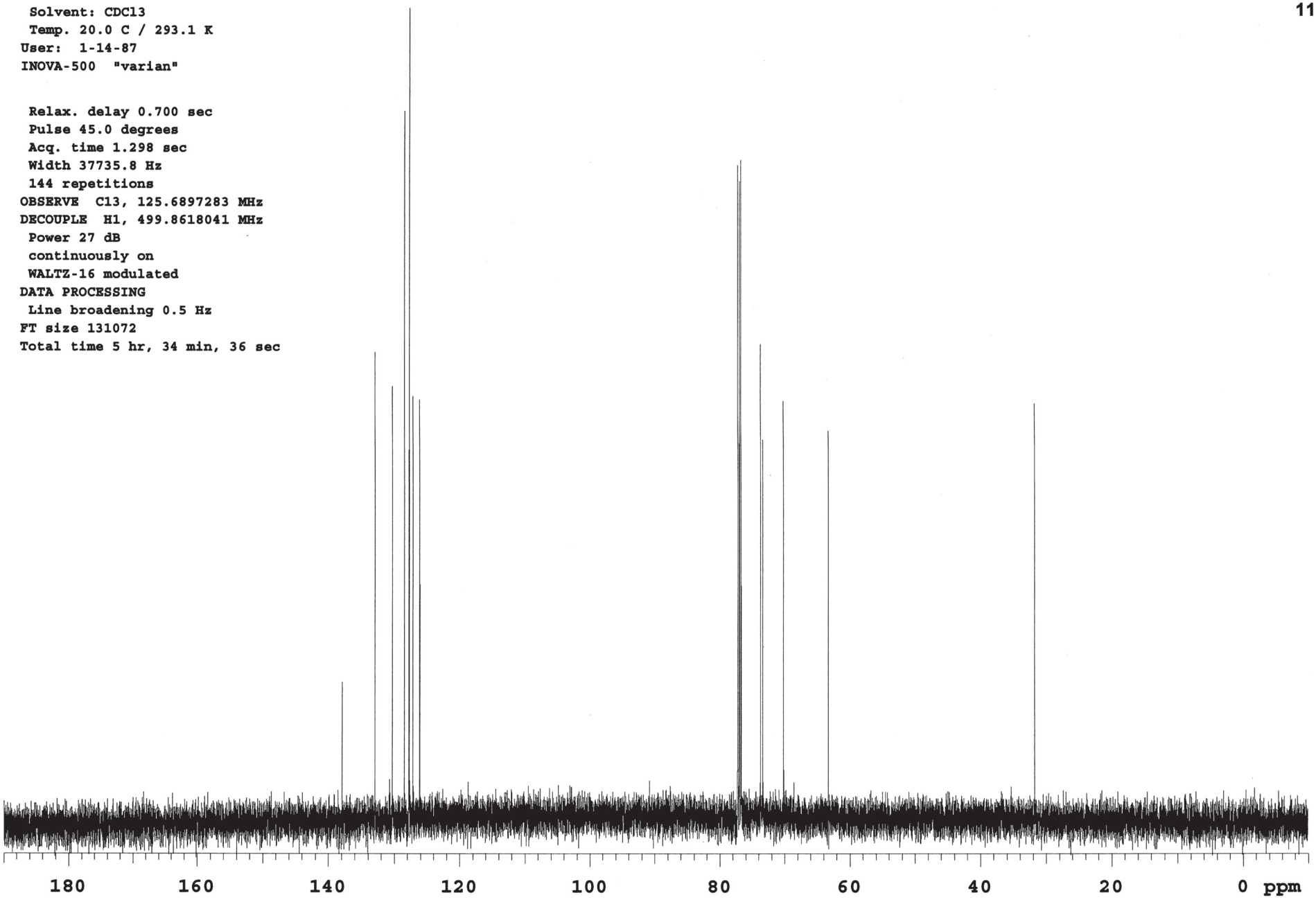
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
144 repetitions
OBSERVE C13, 125.6897283 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



11

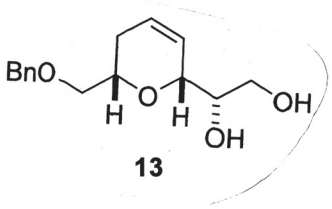


STANDARD PROTON PARAMETERS

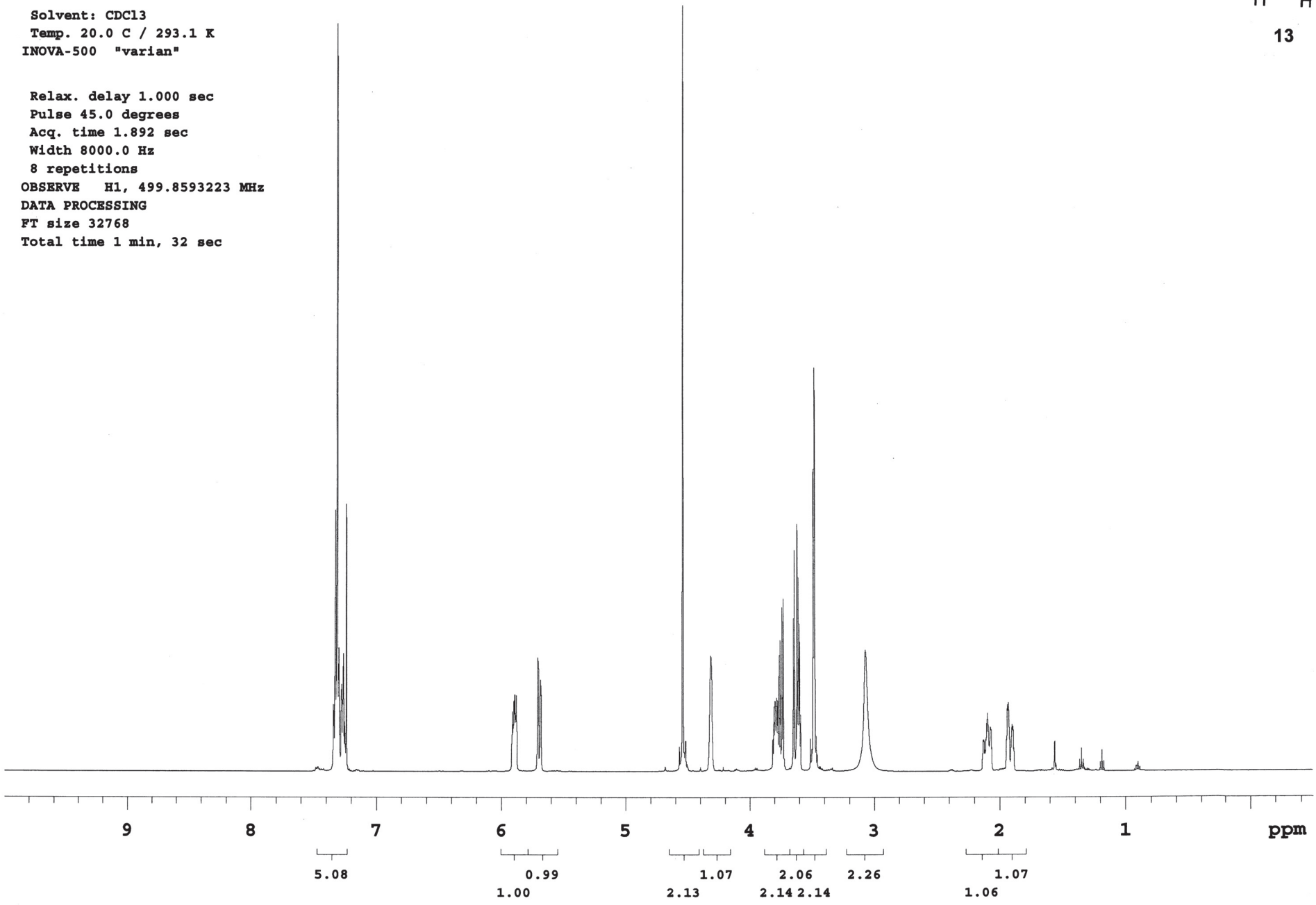
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
8 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



13

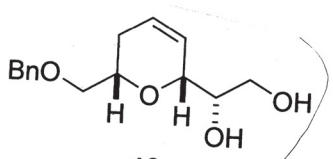


STANDARD CARBON PARAMETERS

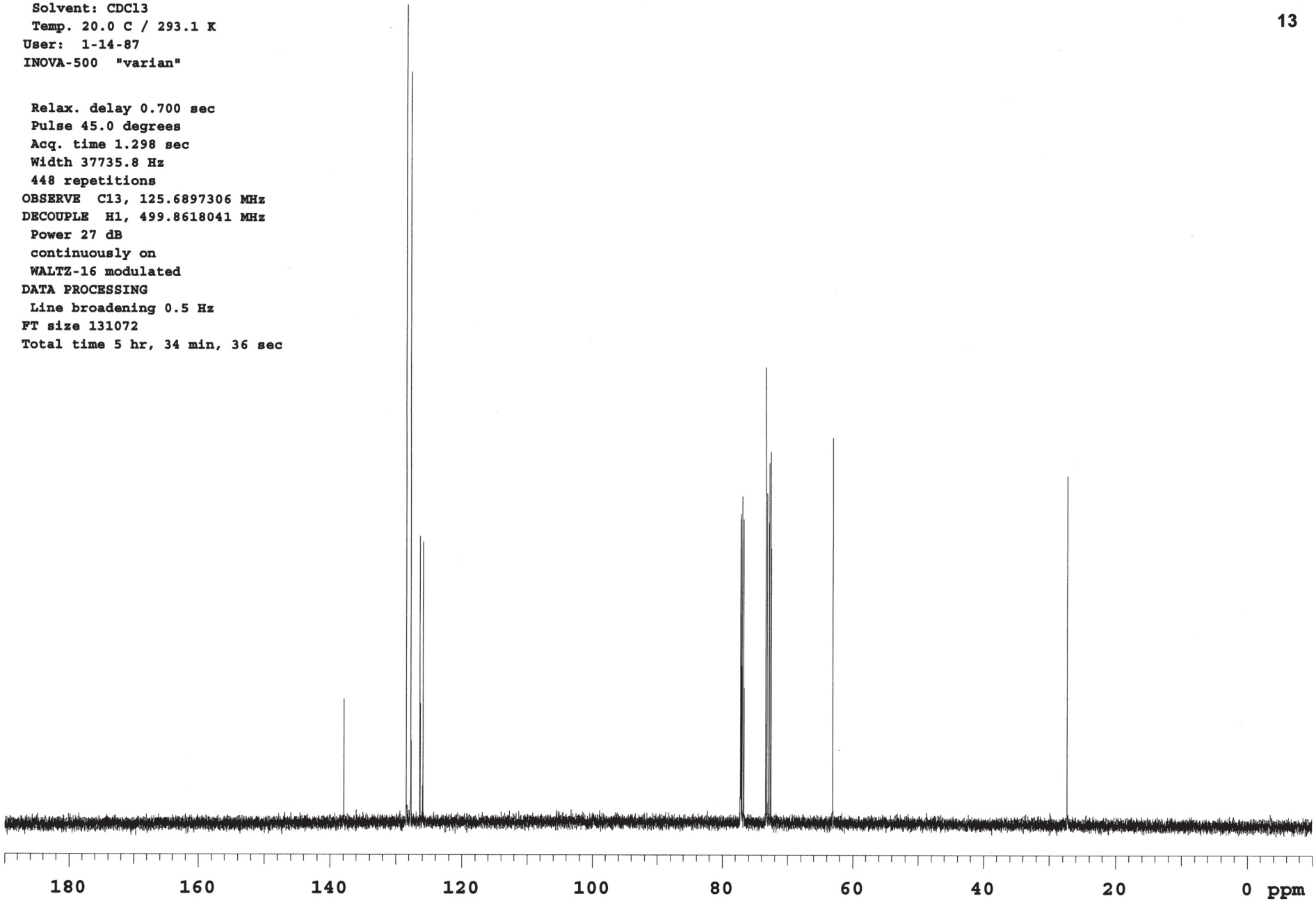
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
448 repetitions
OBSERVE C13, 125.6897306 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



13

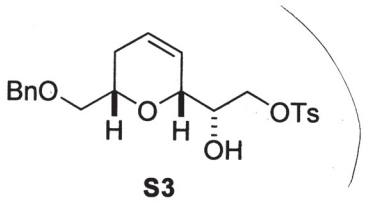


STANDARD PROTON PARAMETERS

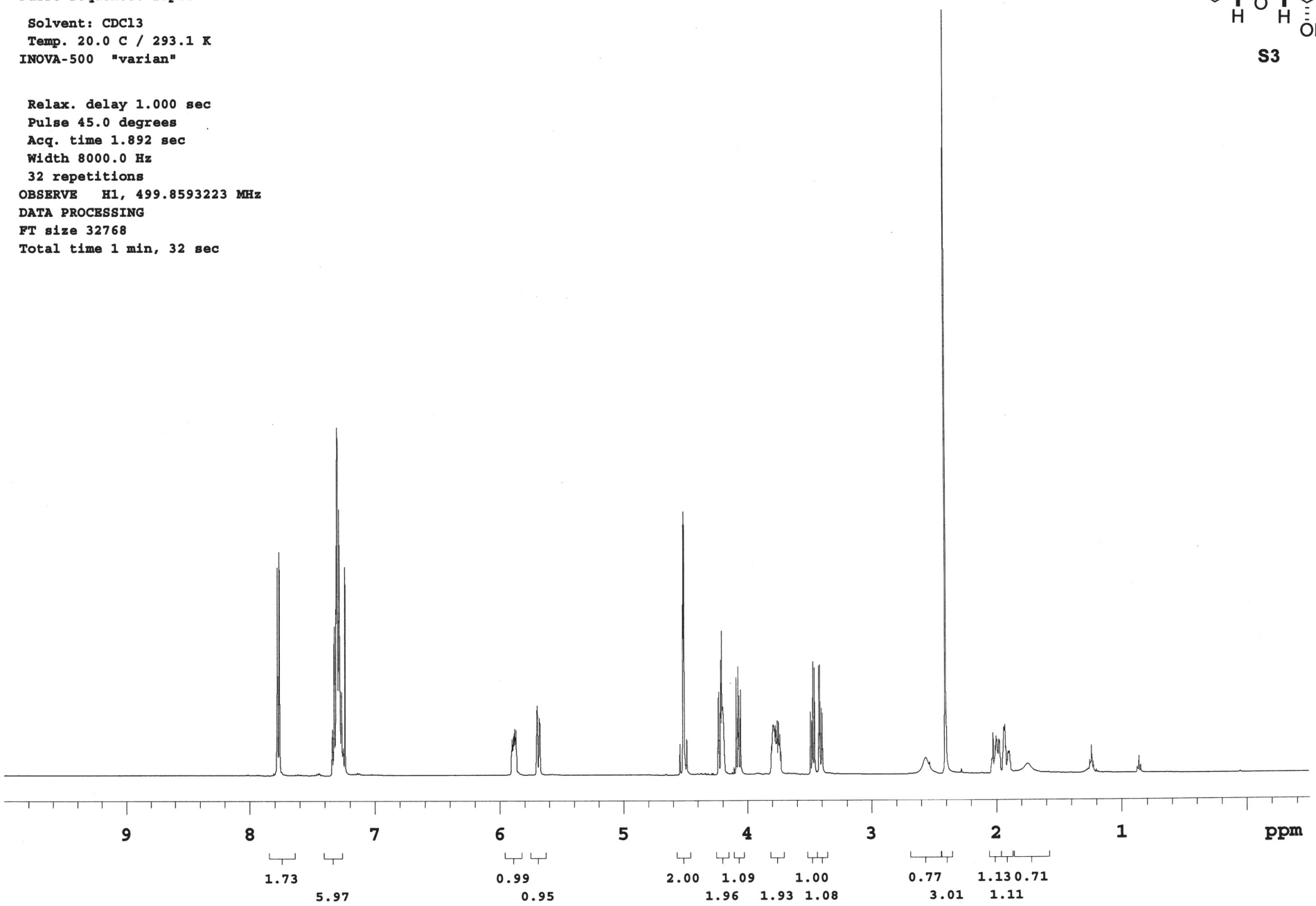
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S3

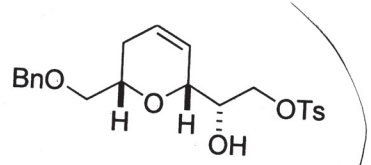


STANDARD CARBON PARAMETERS

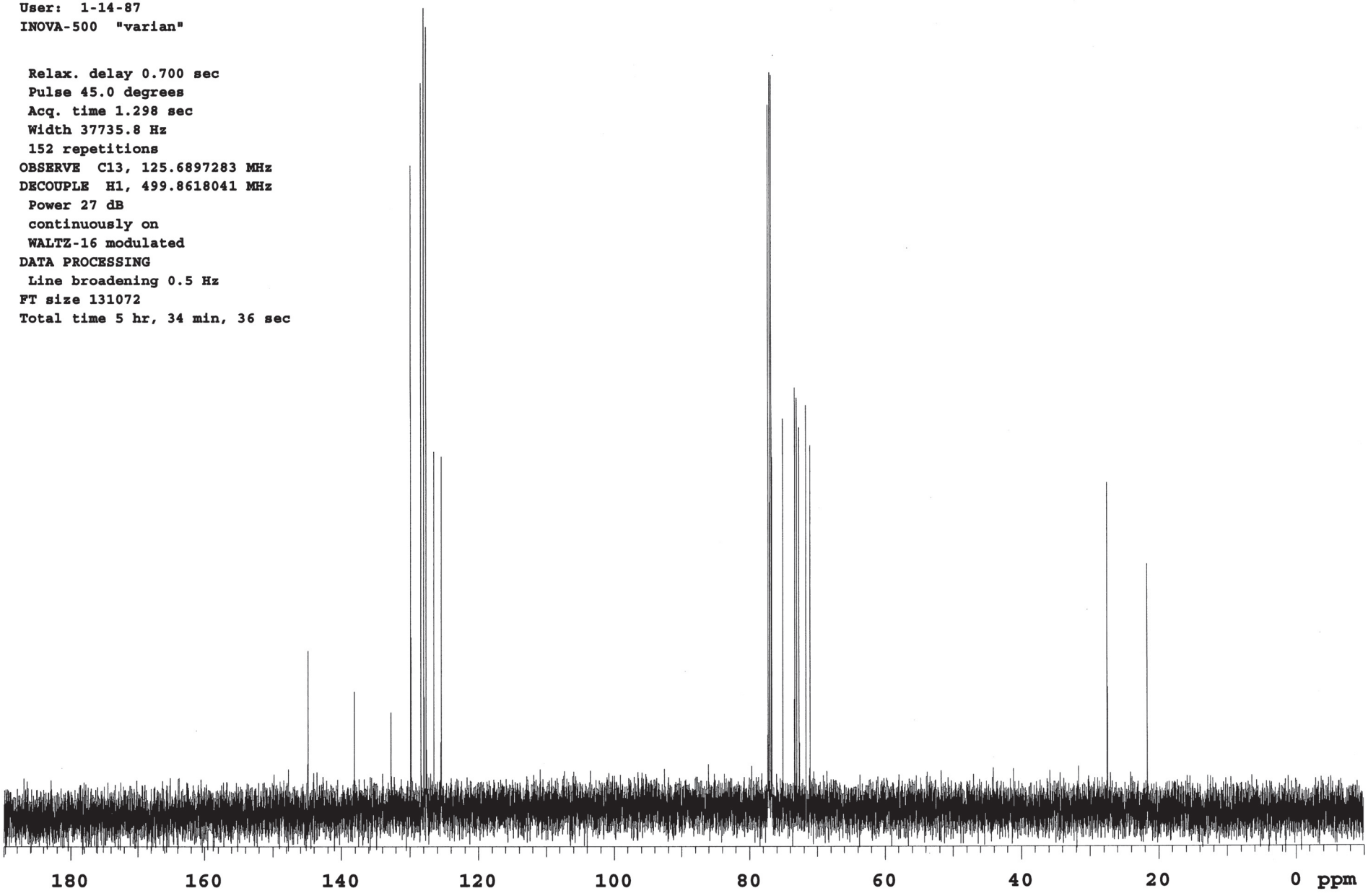
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
152 repetitions
OBSERVE C13, 125.6897283 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



S3

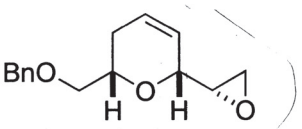


STANDARD PROTON PARAMETERS

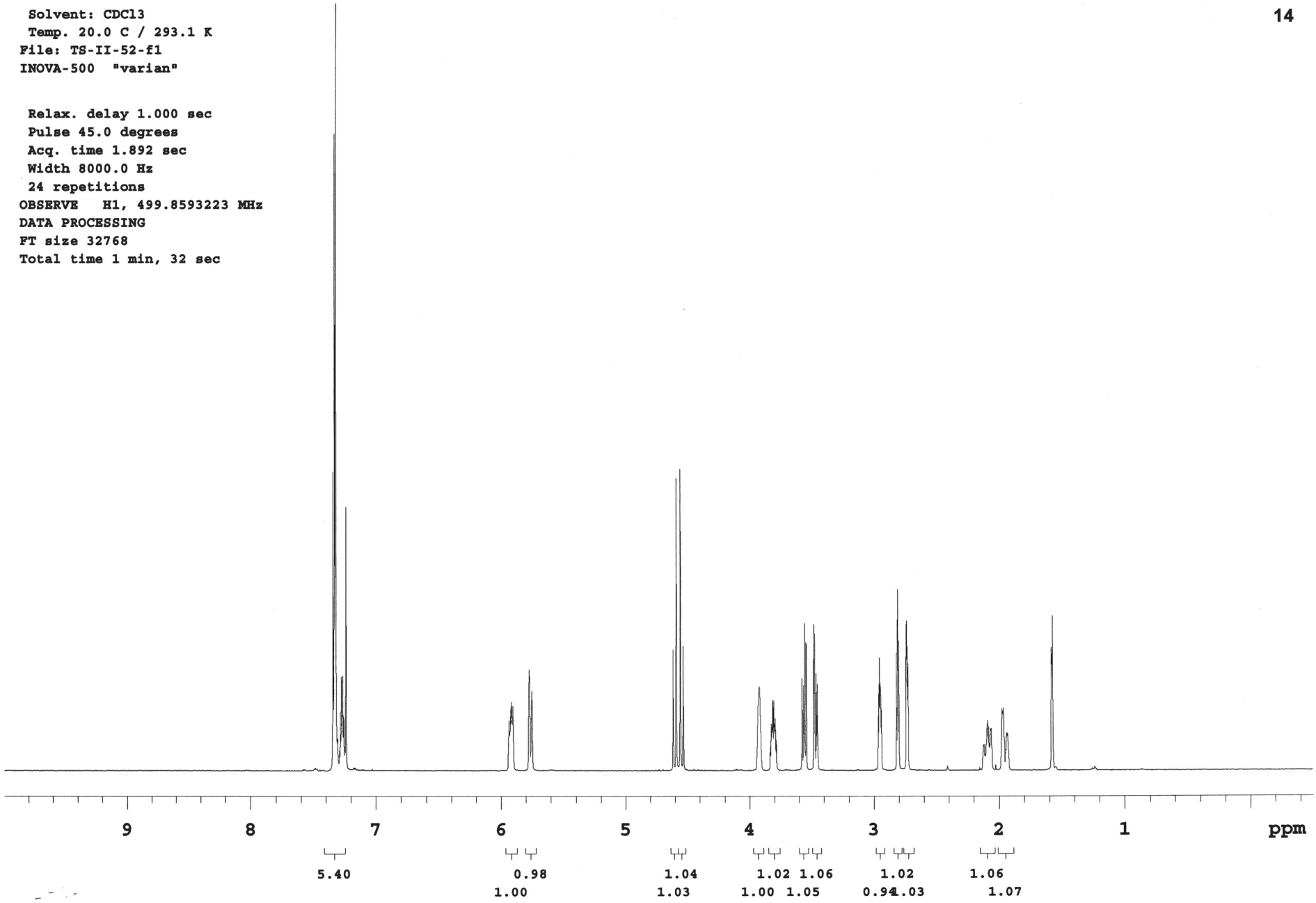
Pulse Sequence: s2pul

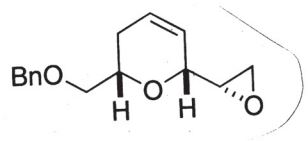
Solvent: CDCl3
Temp. 20.0 C / 293.1 K
File: TS-II-52-f1
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
24 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



14





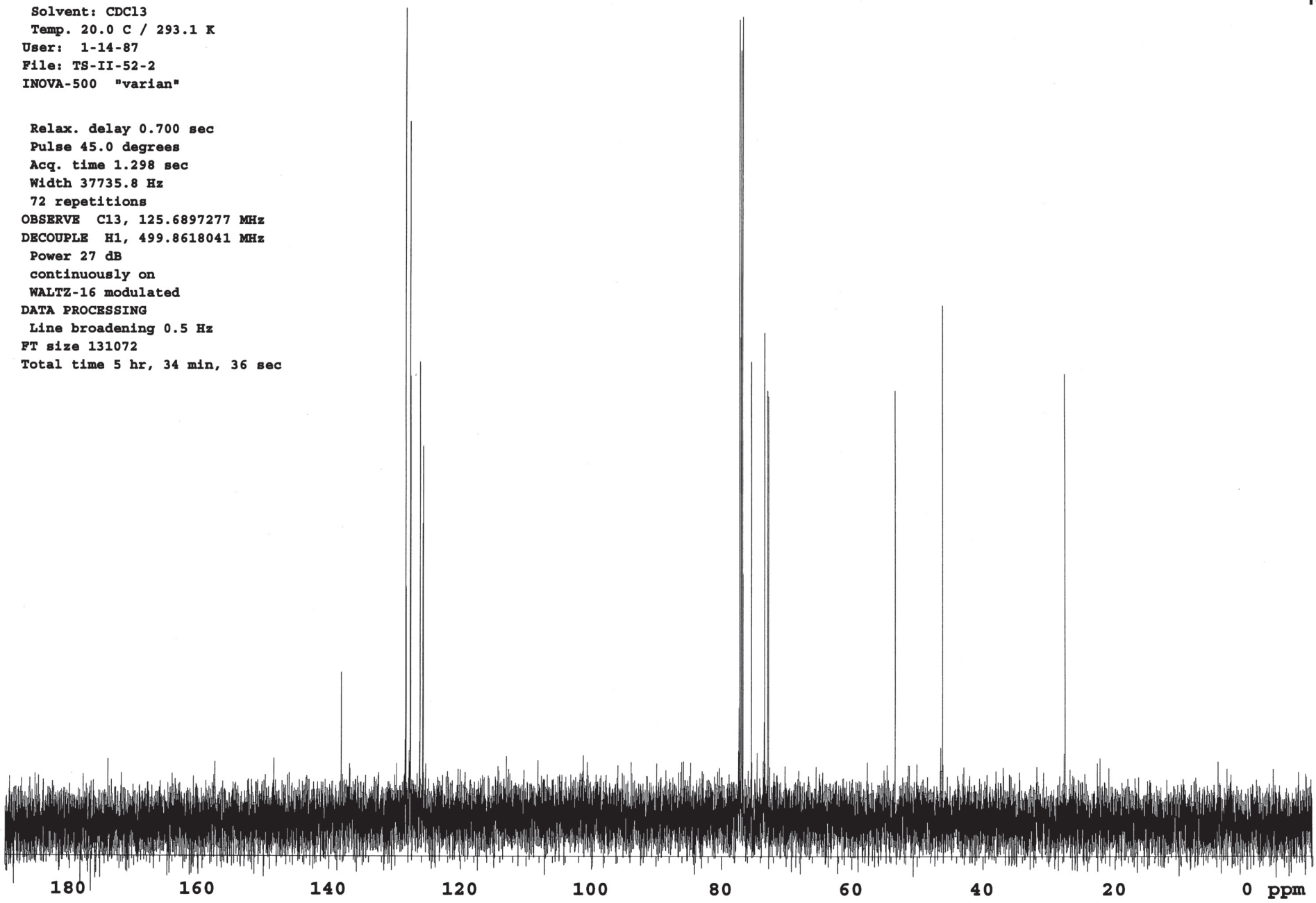
14

STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
File: TS-II-52-2
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
72 repetitions
OBSERVE C13, 125.6897277 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec

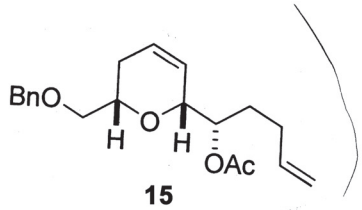


STANDARD PROTON PARAMETERS

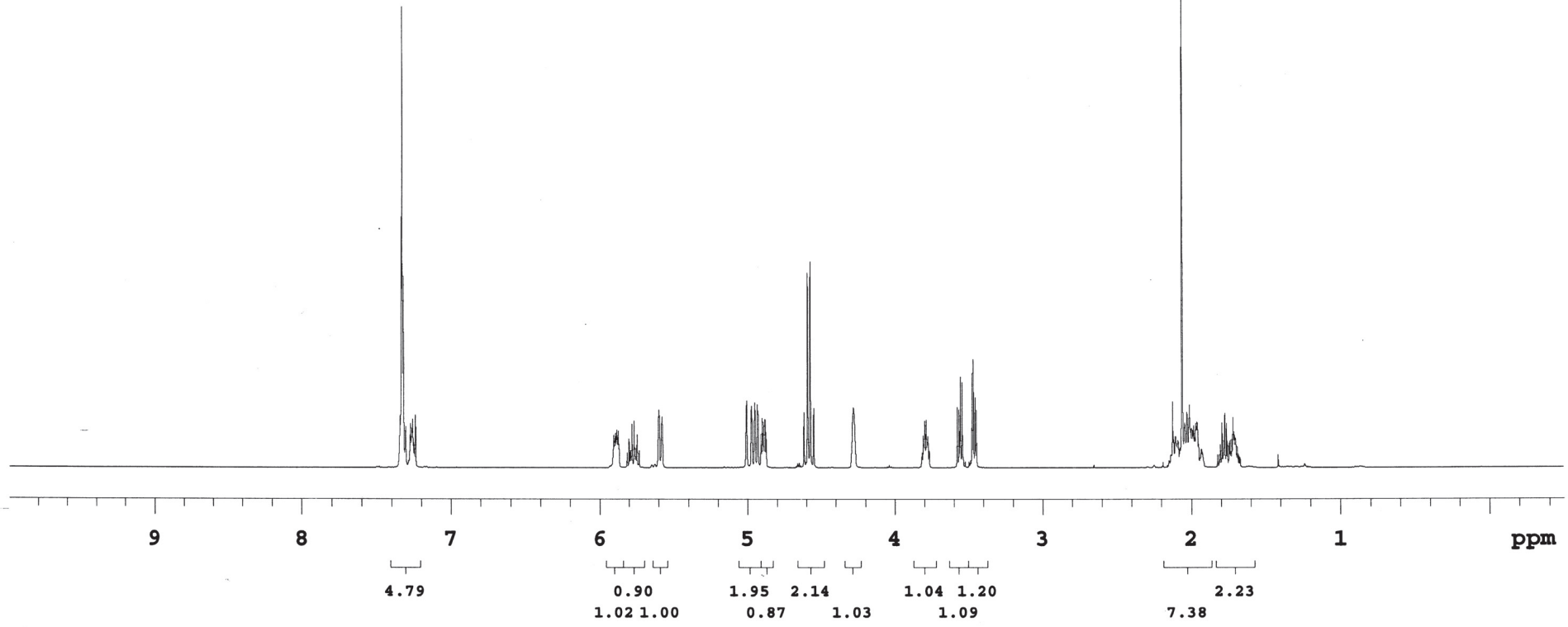
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
12 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



15

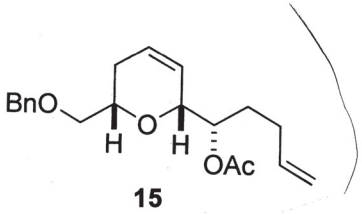


STANDARD CARBON PARAMETERS

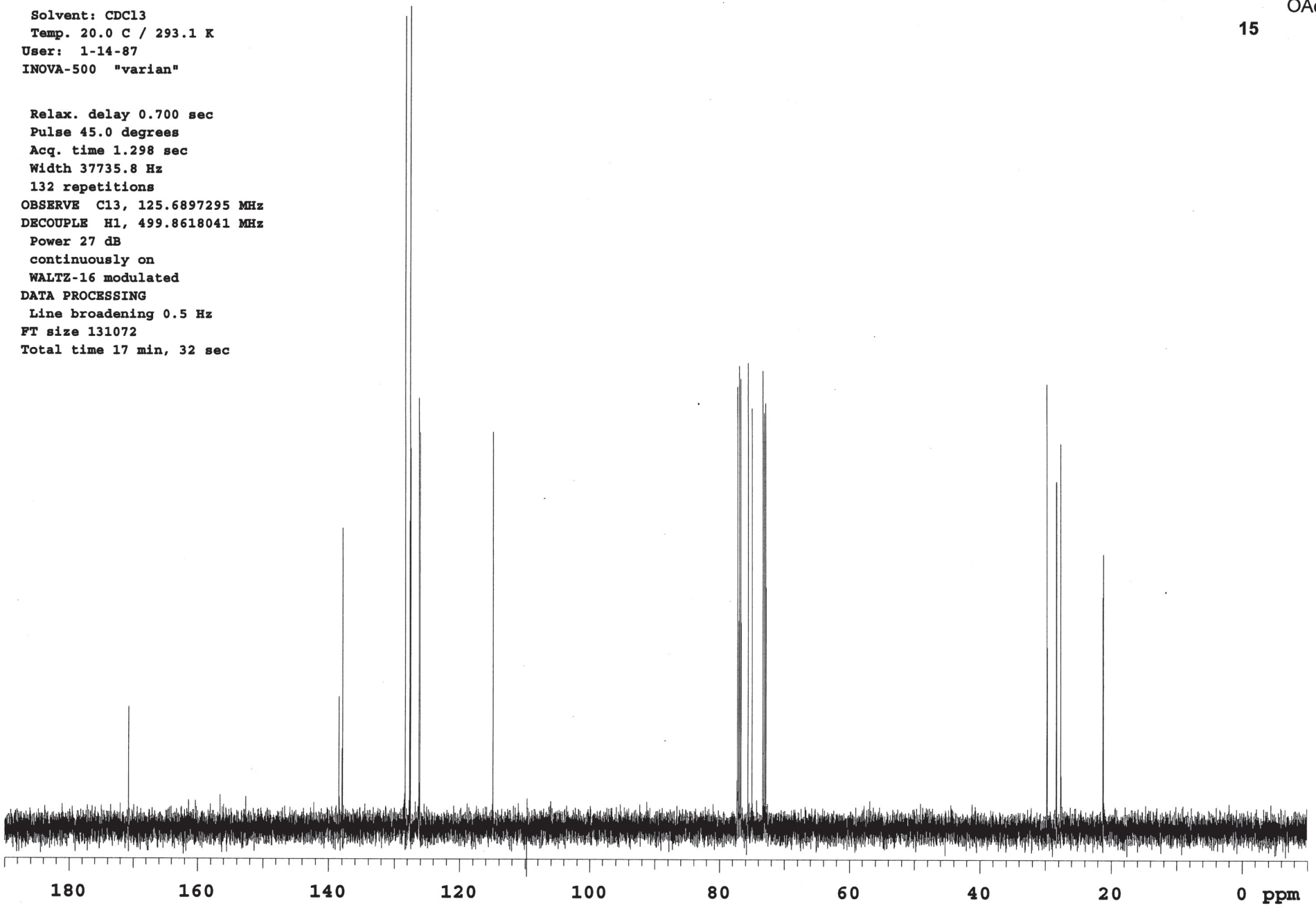
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
132 repetitions
OBSERVE C13, 125.6897295 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 17 min, 32 sec



15

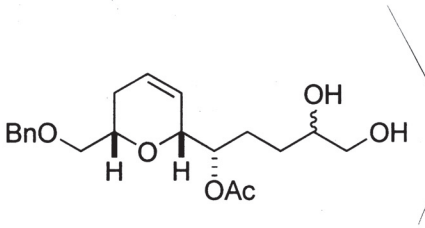


STANDARD PROTON PARAMETERS

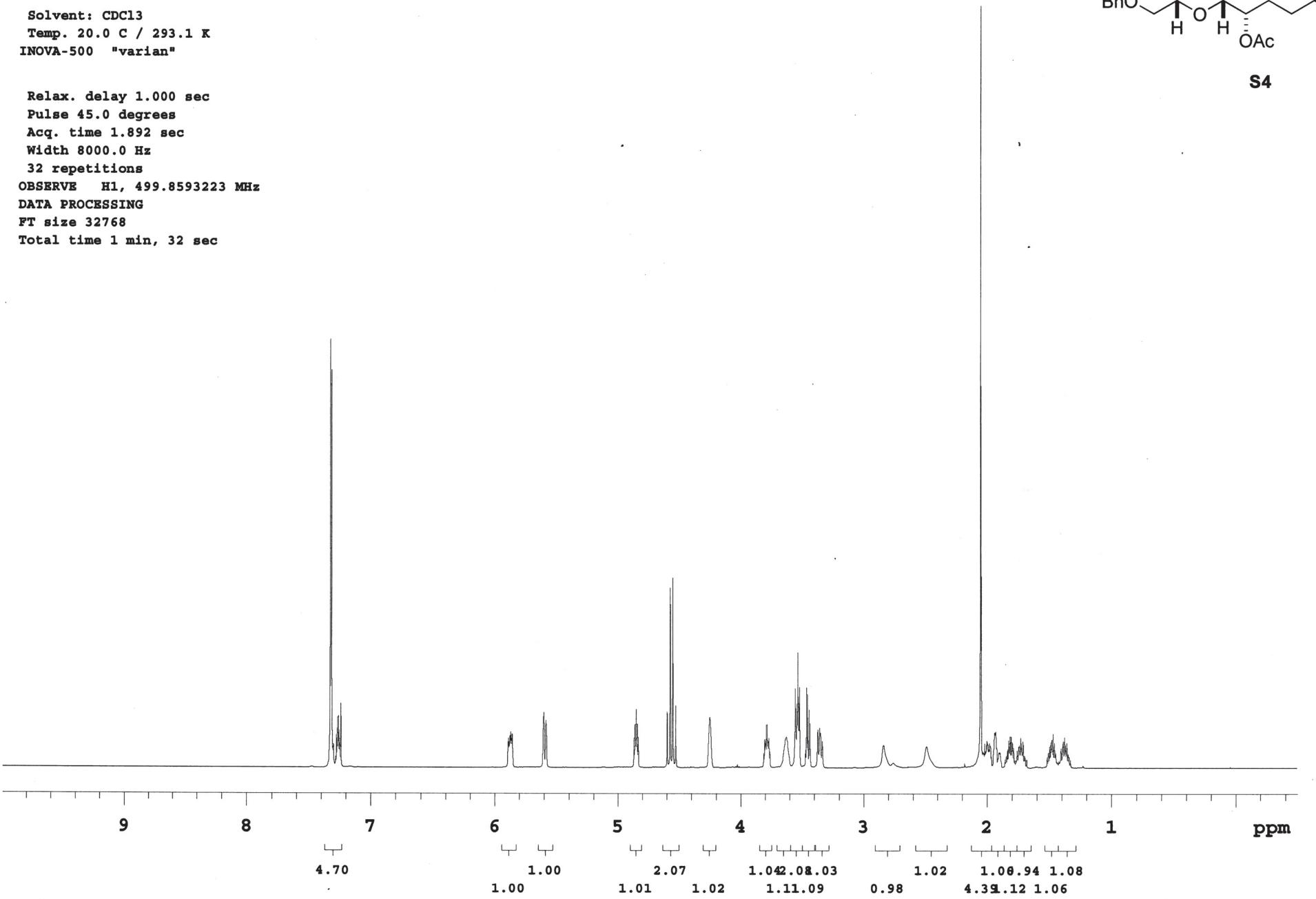
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S4

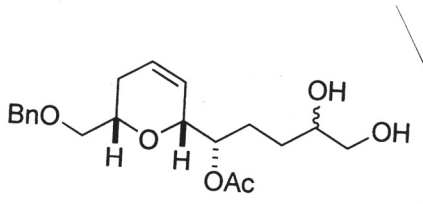


STANDARD CARBON PARAMETERS

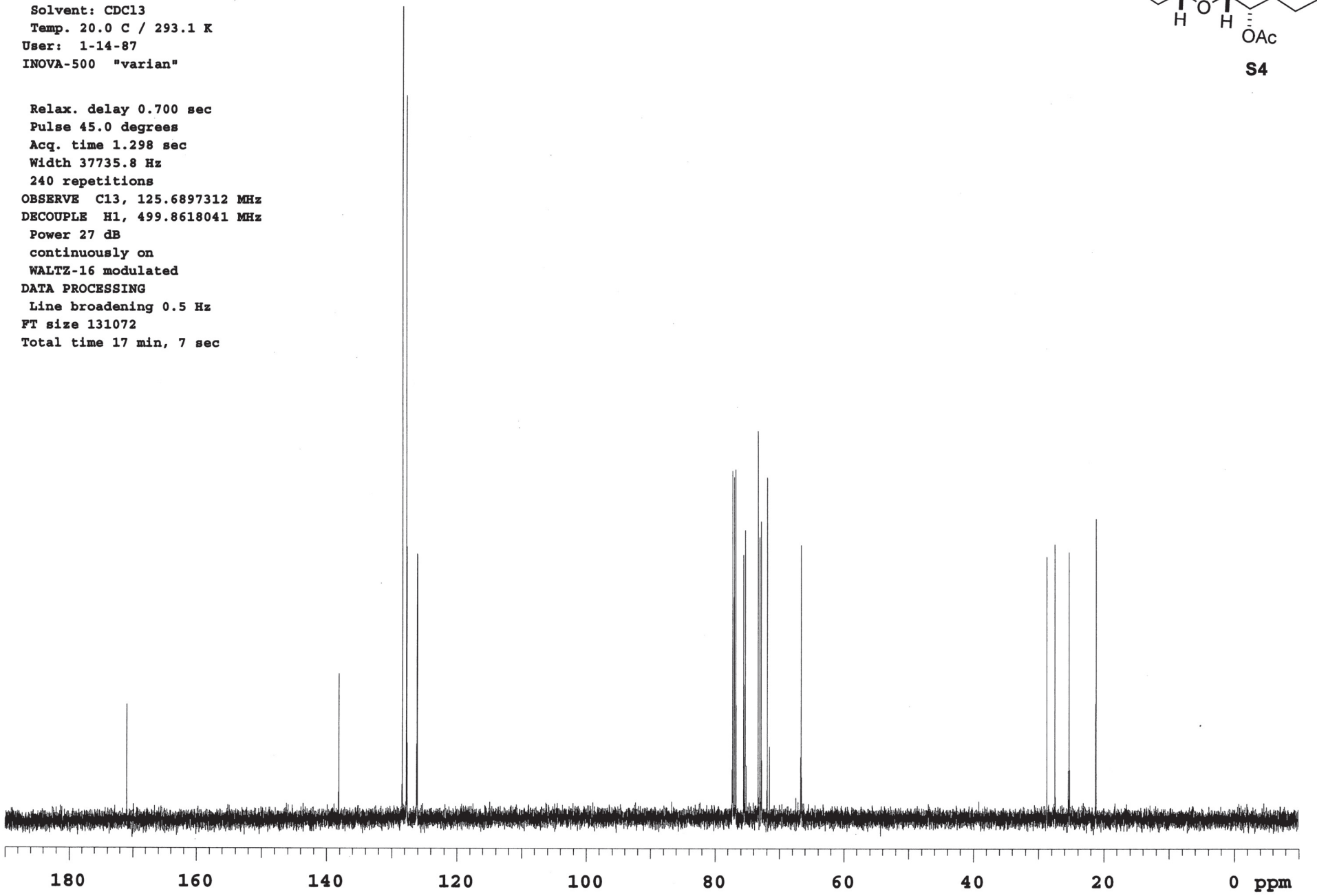
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
240 repetitions
OBSERVE C13, 125.6897312 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 17 min, 7 sec



S4

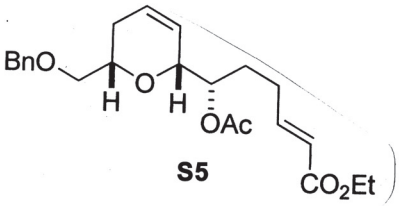


STANDARD PROTON PARAMETERS

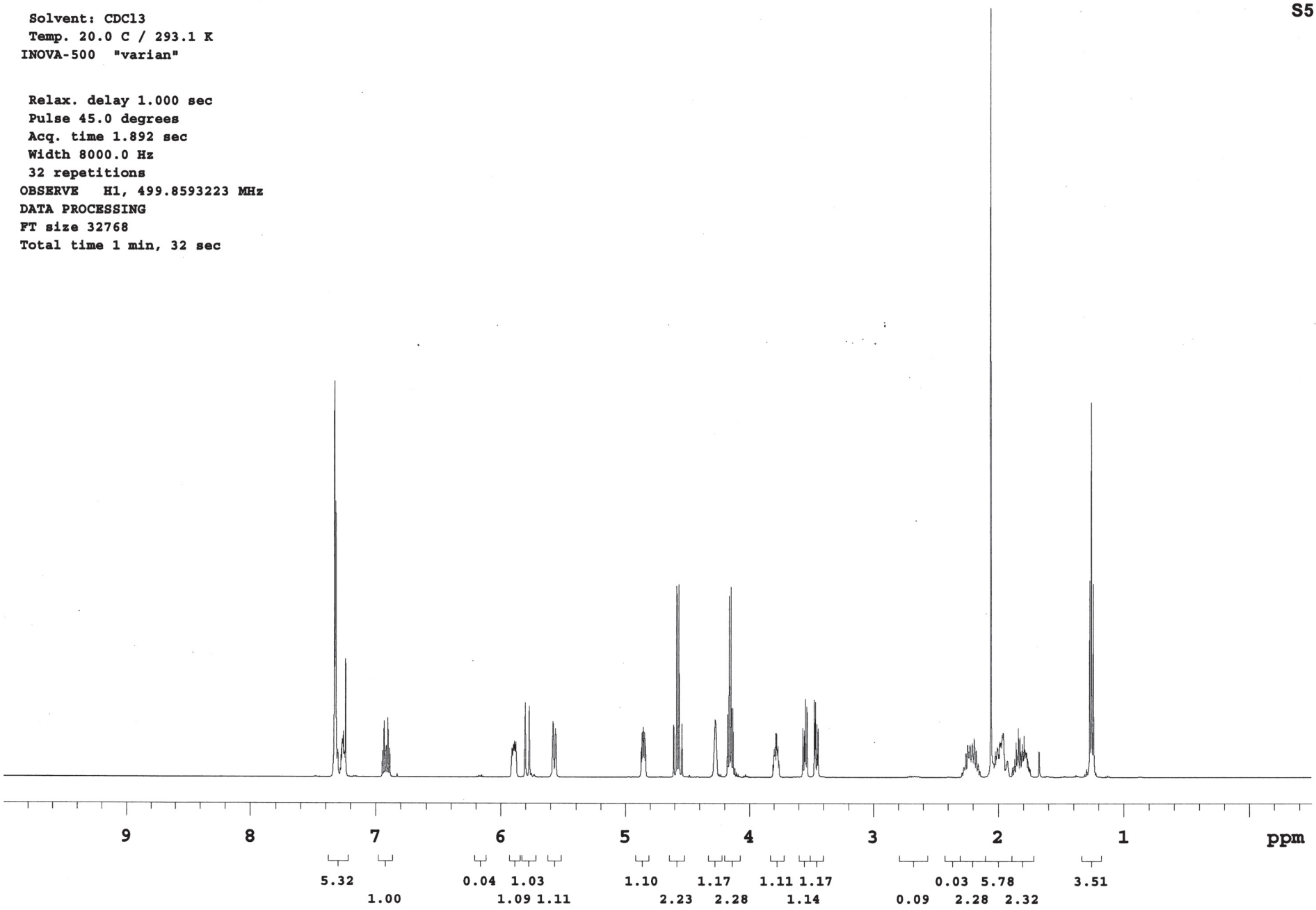
Pulse Sequence: s2pul

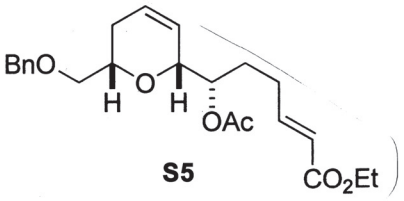
Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S5





S5

STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
244 repetitions
OBSERVE C13, 125.6897277 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 17 min, 7 sec

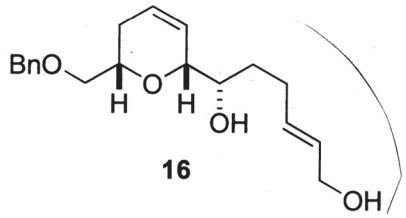
180 160 140 120 100 80 60 40 20 0 ppm

STANDARD PROTON PARAMETERS

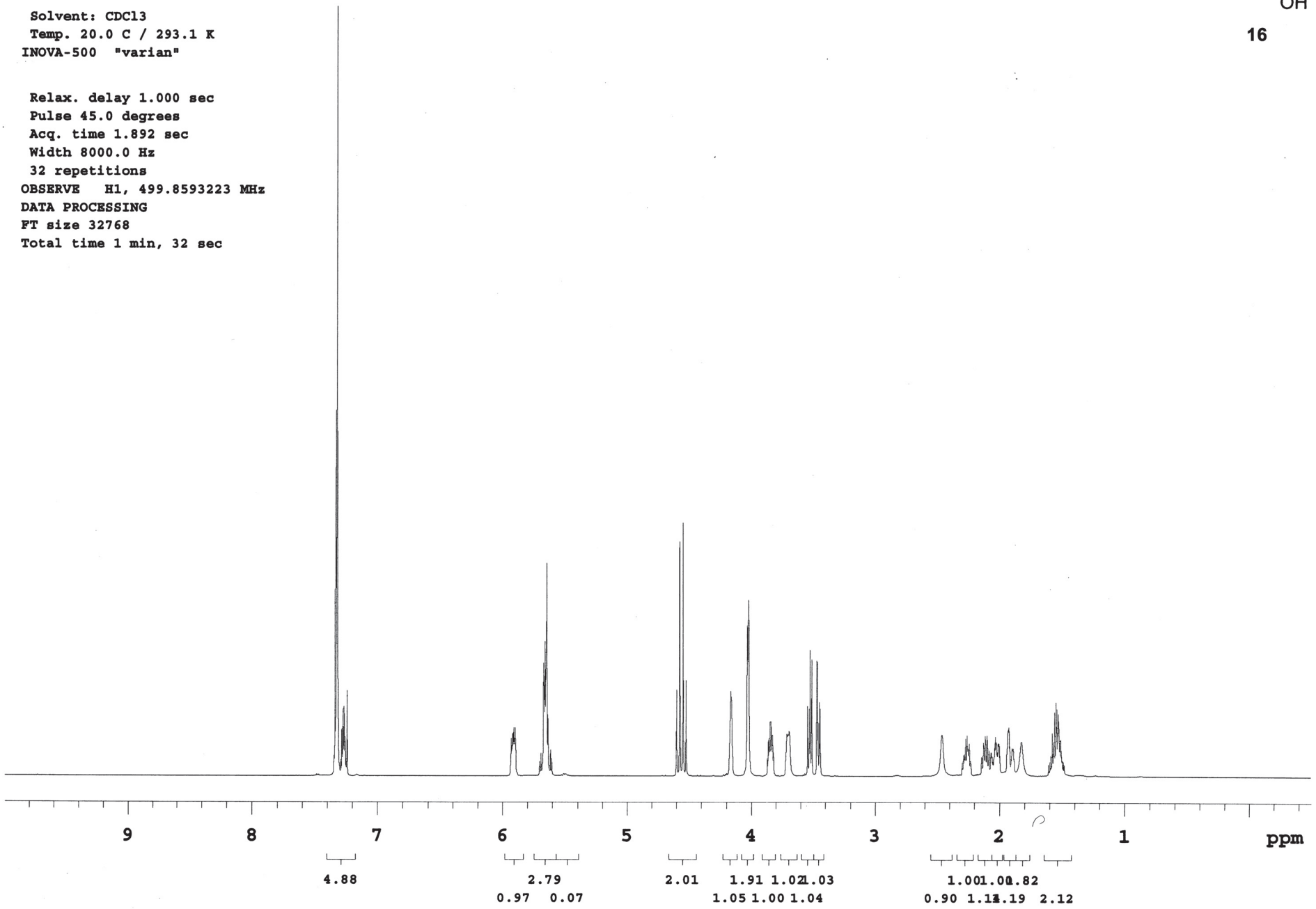
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



16

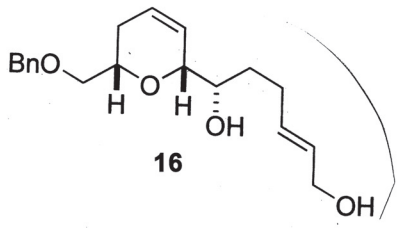


STANDARD CARBON PARAMETERS

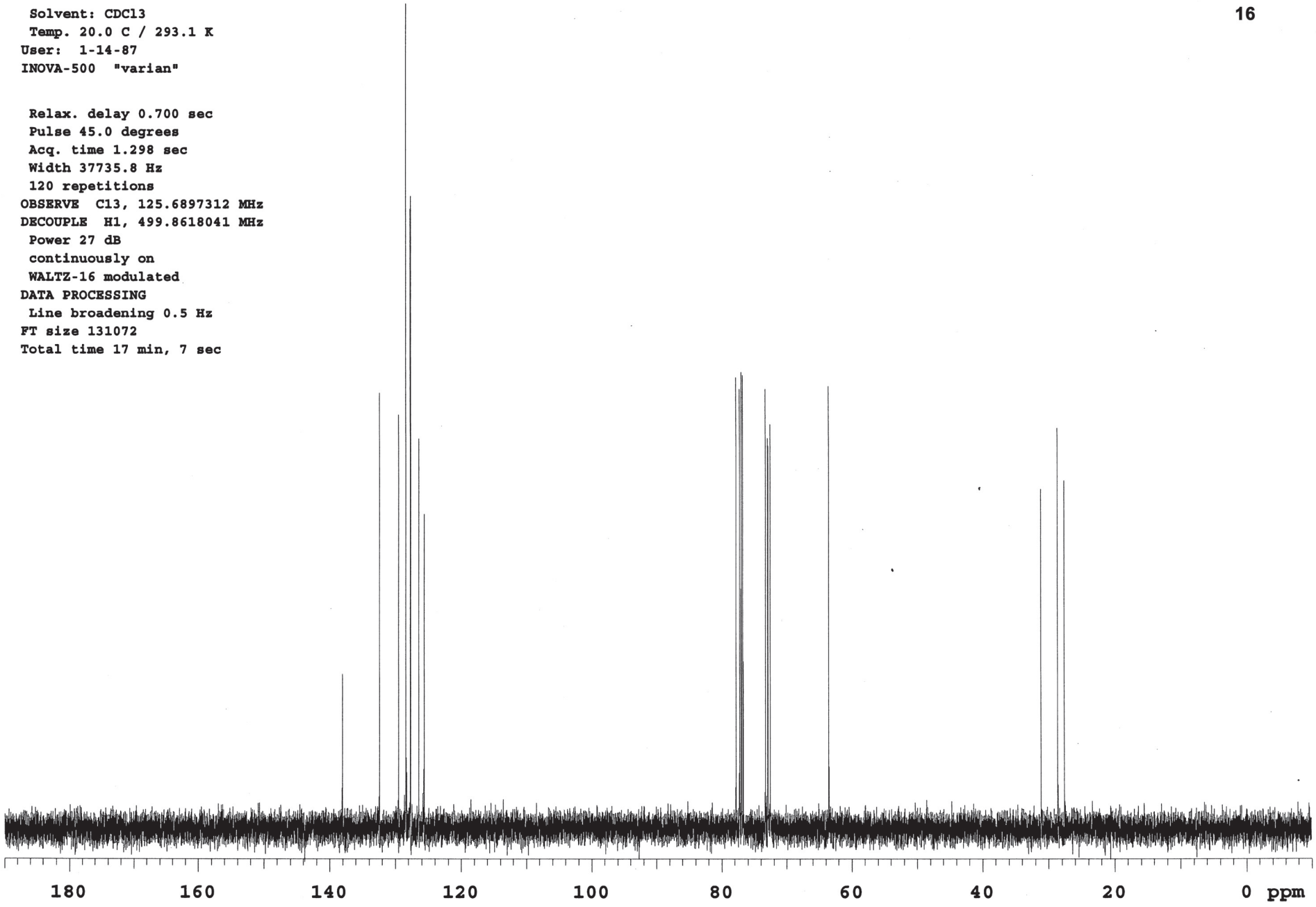
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
120 repetitions
OBSERVE C13, 125.6897312 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 17 min, 7 sec



16

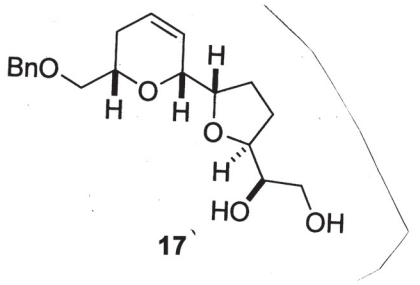


STANDARD PROTON PARAMETERS

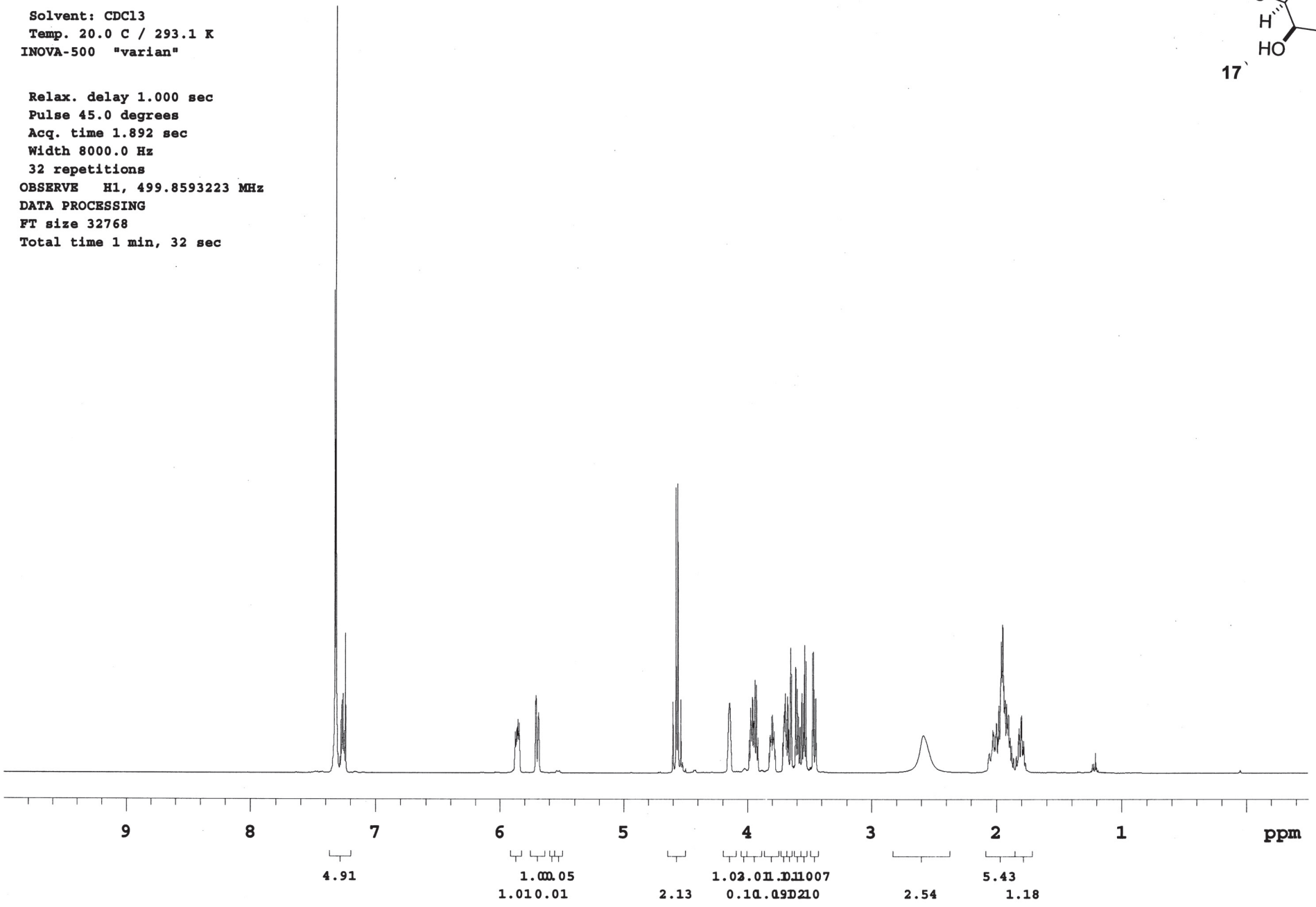
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



17

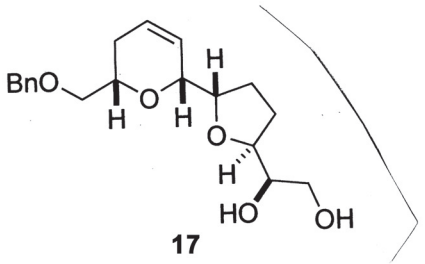


STANDARD CARBON PARAMETERS

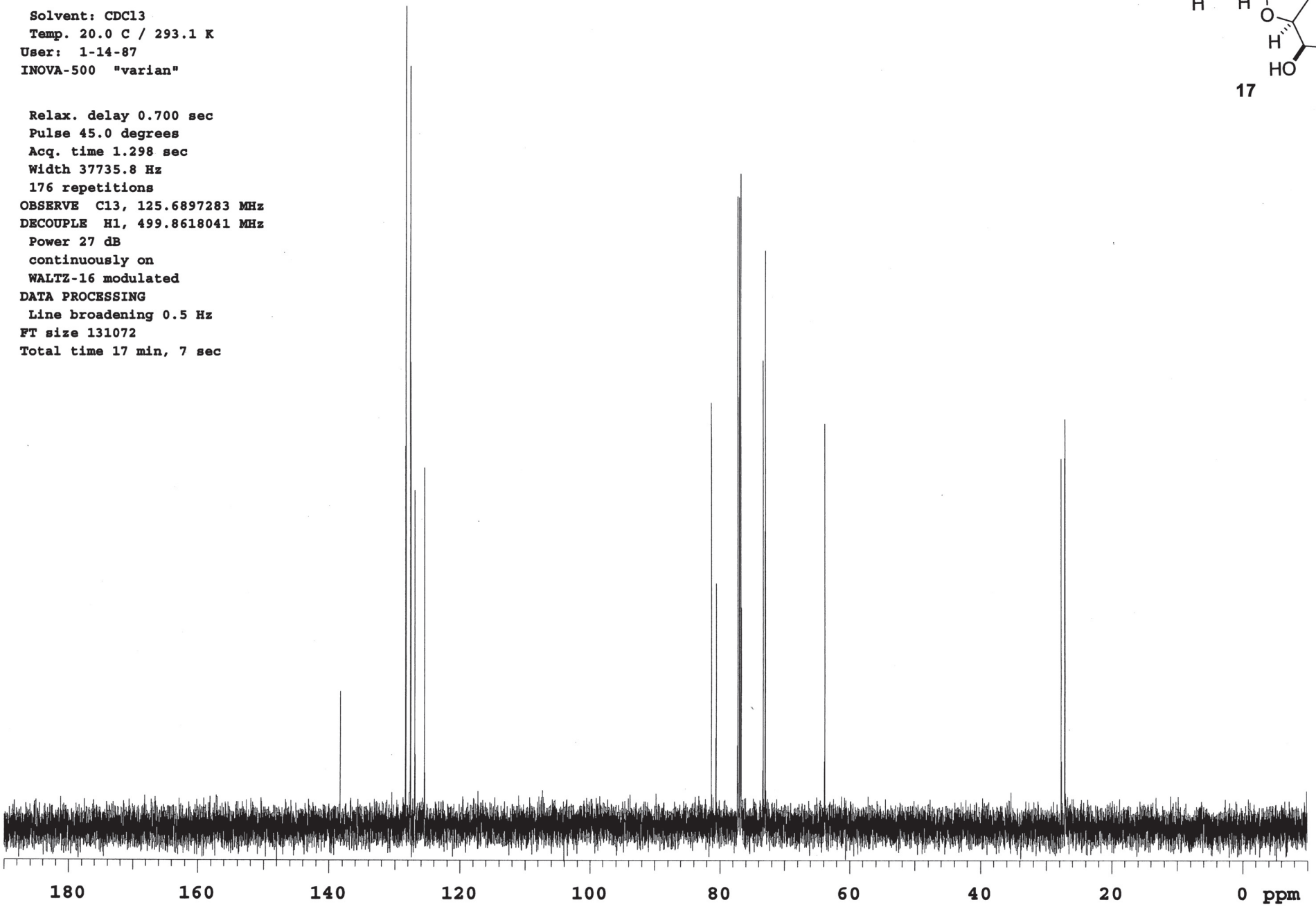
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
176 repetitions
OBSERVE C13, 125.6897283 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 17 min, 7 sec



17

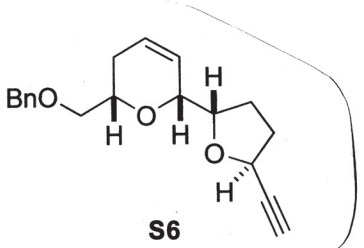


STANDARD PROTON PARAMETERS

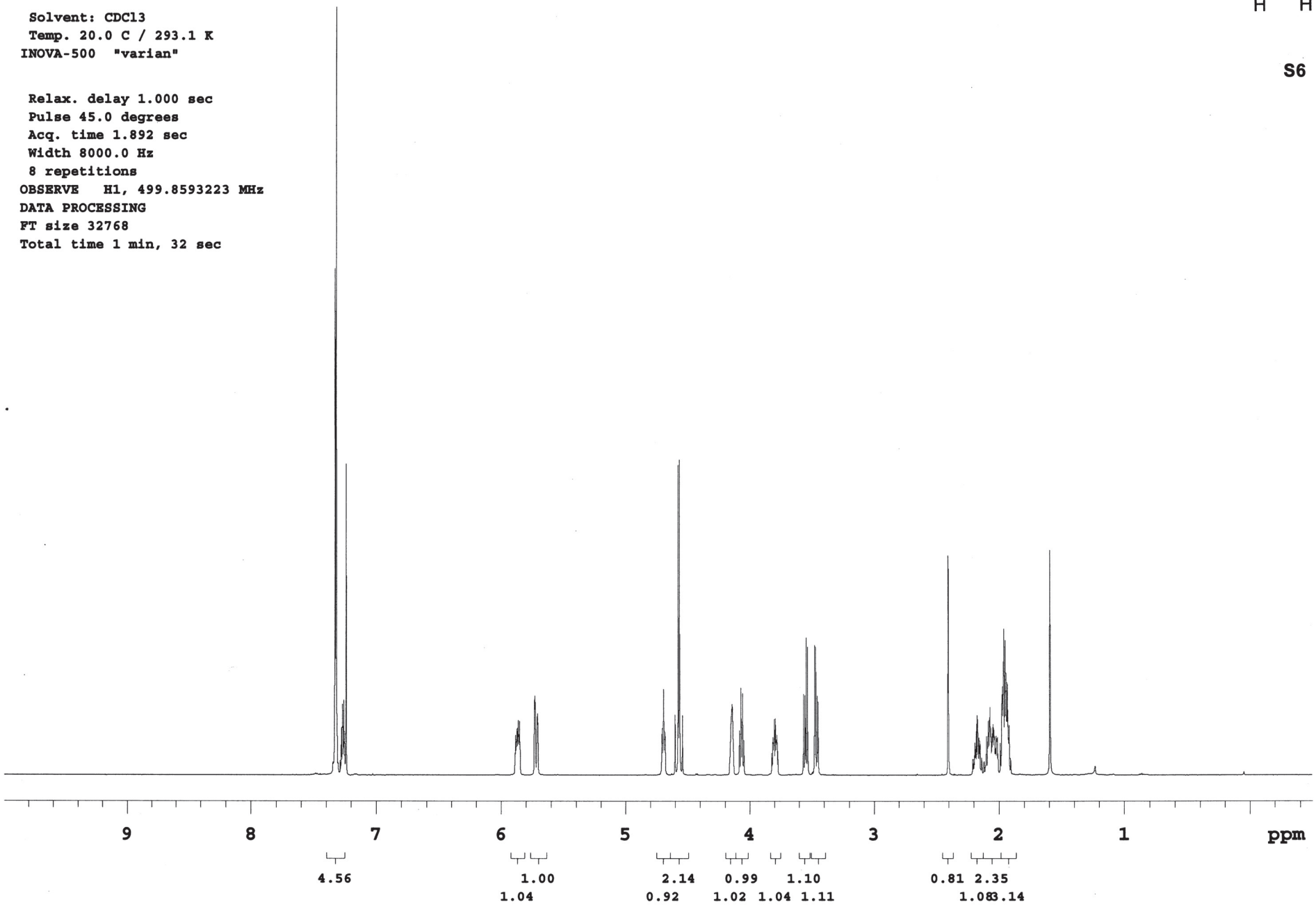
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
8 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S6

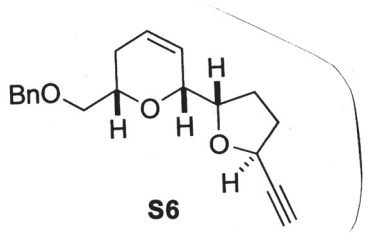


STANDARD CARBON PARAMETERS

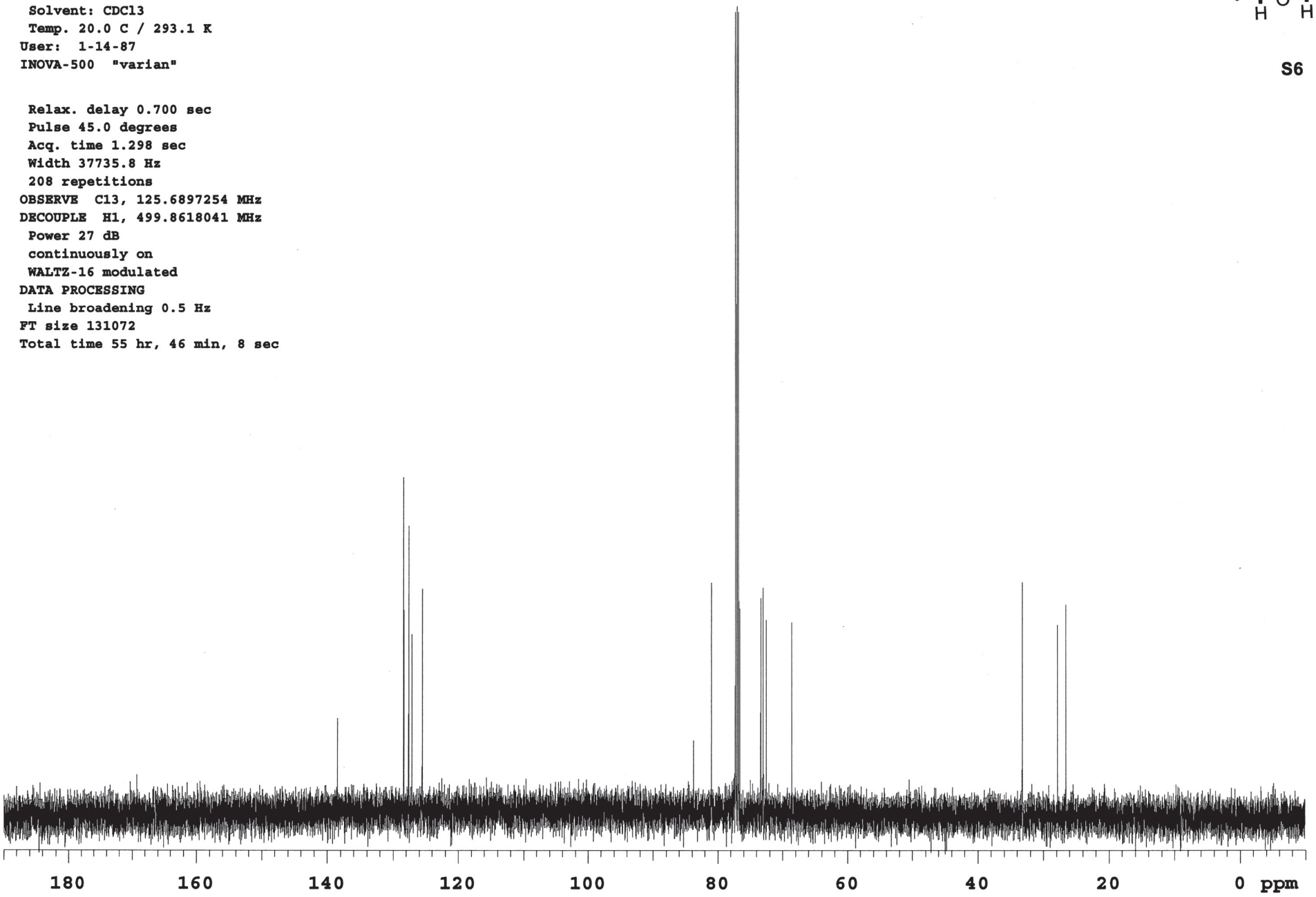
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
208 repetitions
OBSERVE C13, 125.6897254 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



S6

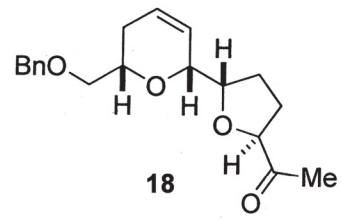


STANDARD PROTON PARAMETERS

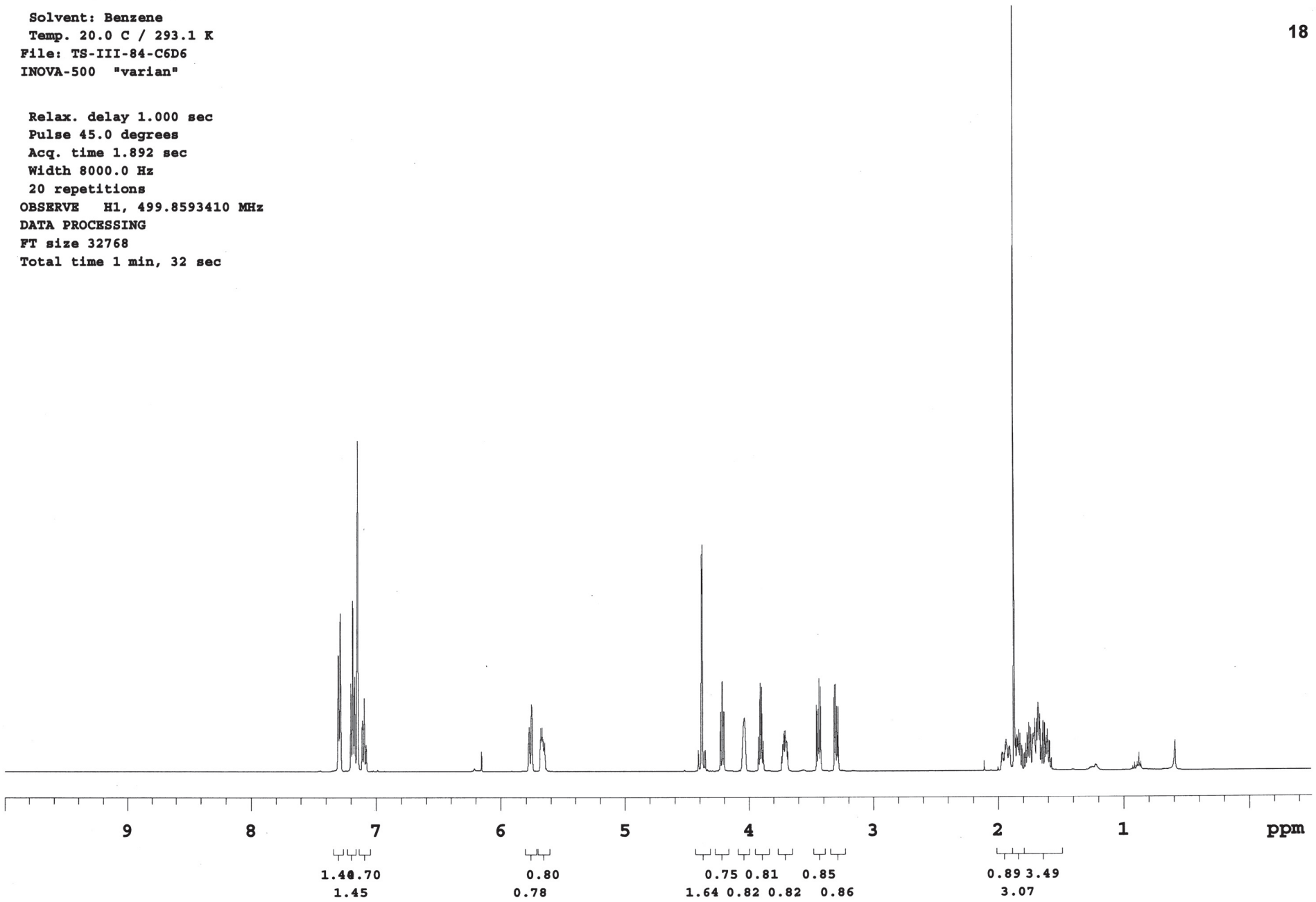
Pulse Sequence: s2pul

Solvent: Benzene
Temp. 20.0 C / 293.1 K
File: TS-III-84-C6D6
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
20 repetitions
OBSERVE H1, 499.8593410 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



18

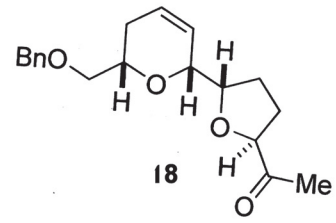


STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: Benzene
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
456 repetitions
OBSERVE C13, 125.6896933 MHz
DECOUPLE H1, 499.8618491 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



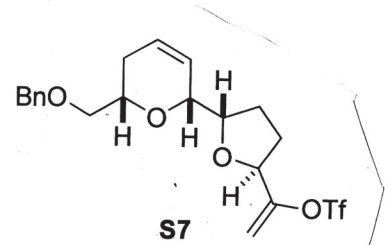
18

STANDARD PROTON PARAMETERS

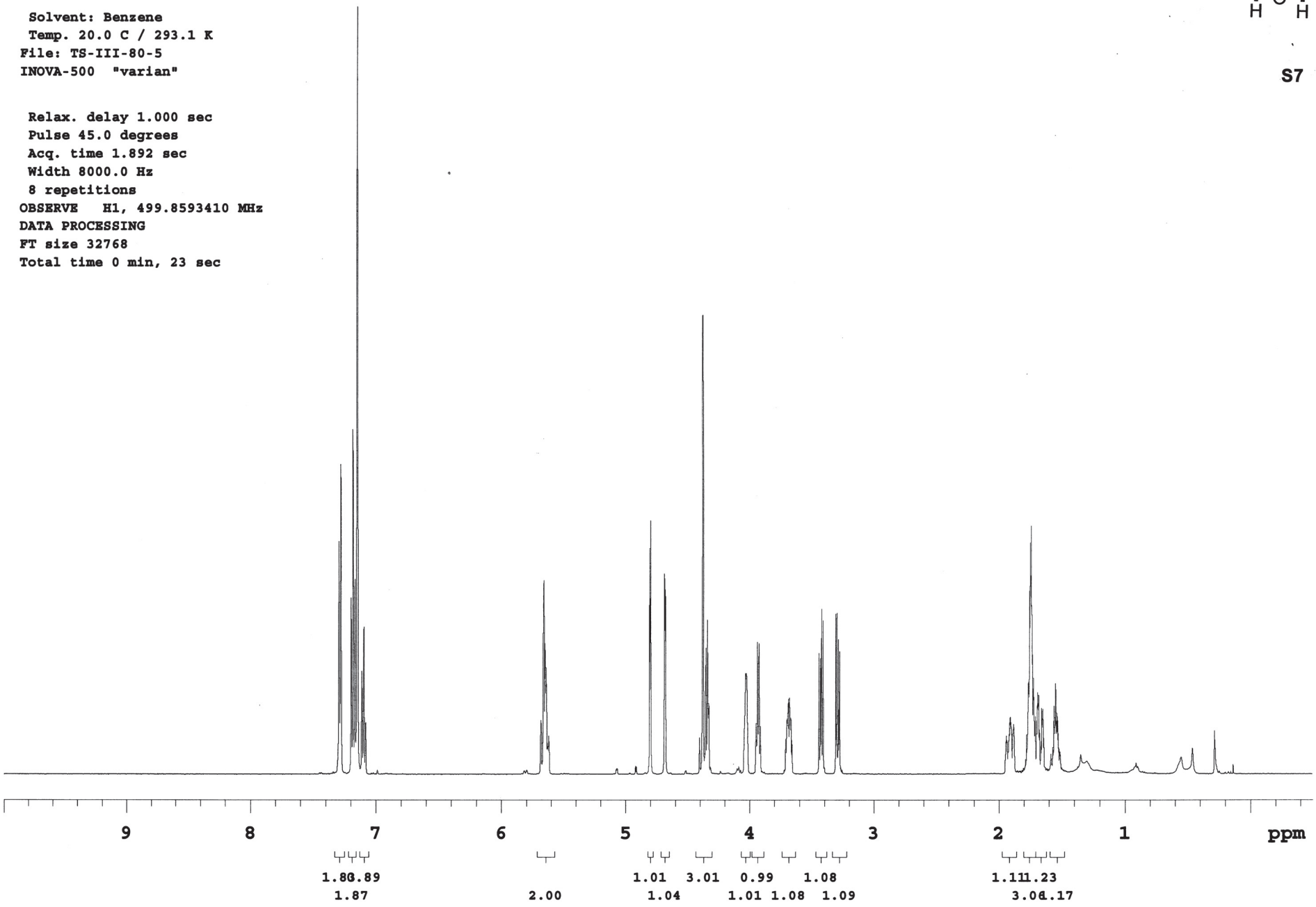
Pulse Sequence: s2pul

Solvent: Benzene
Temp. 20.0 C / 293.1 K
File: TS-III-80-5
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
8 repetitions
OBSERVE H1, 499.8593410 MHz
DATA PROCESSING
FT size 32768
Total time 0 min, 23 sec



S7

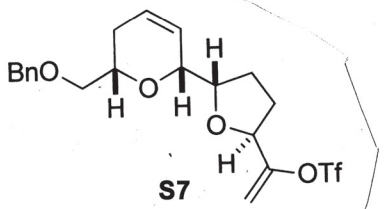


STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: Benzene
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
1888 repetitions
OBSERVE C13, 125.6896927 MHz
DECOUPLE H1, 499.8618491 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



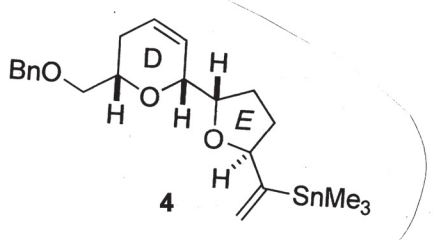
S7

STANDARD PROTON PARAMETERS

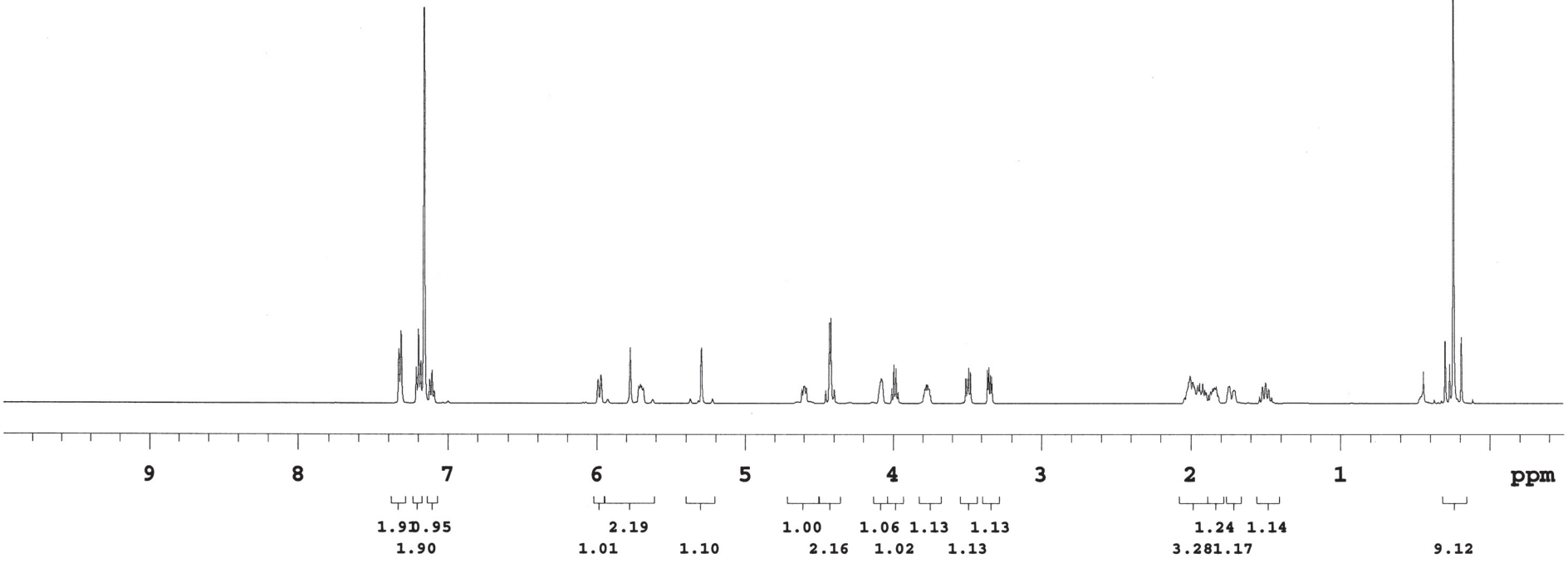
Pulse Sequence: s2pul

Solvent: Benzene
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593360 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



4

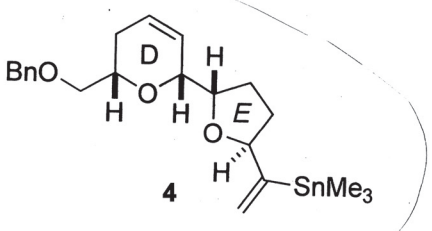


STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: Benzene
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
224 repetitions
OBSERVE C13, 125.6896933 MHz
DECOUPLE H1, 499.8618491 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



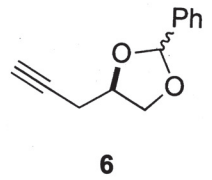
4

STANDARD PROTON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593218 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



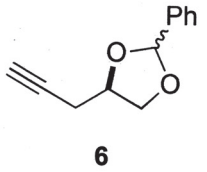
6

STANDARD CARBON PARAMETERS

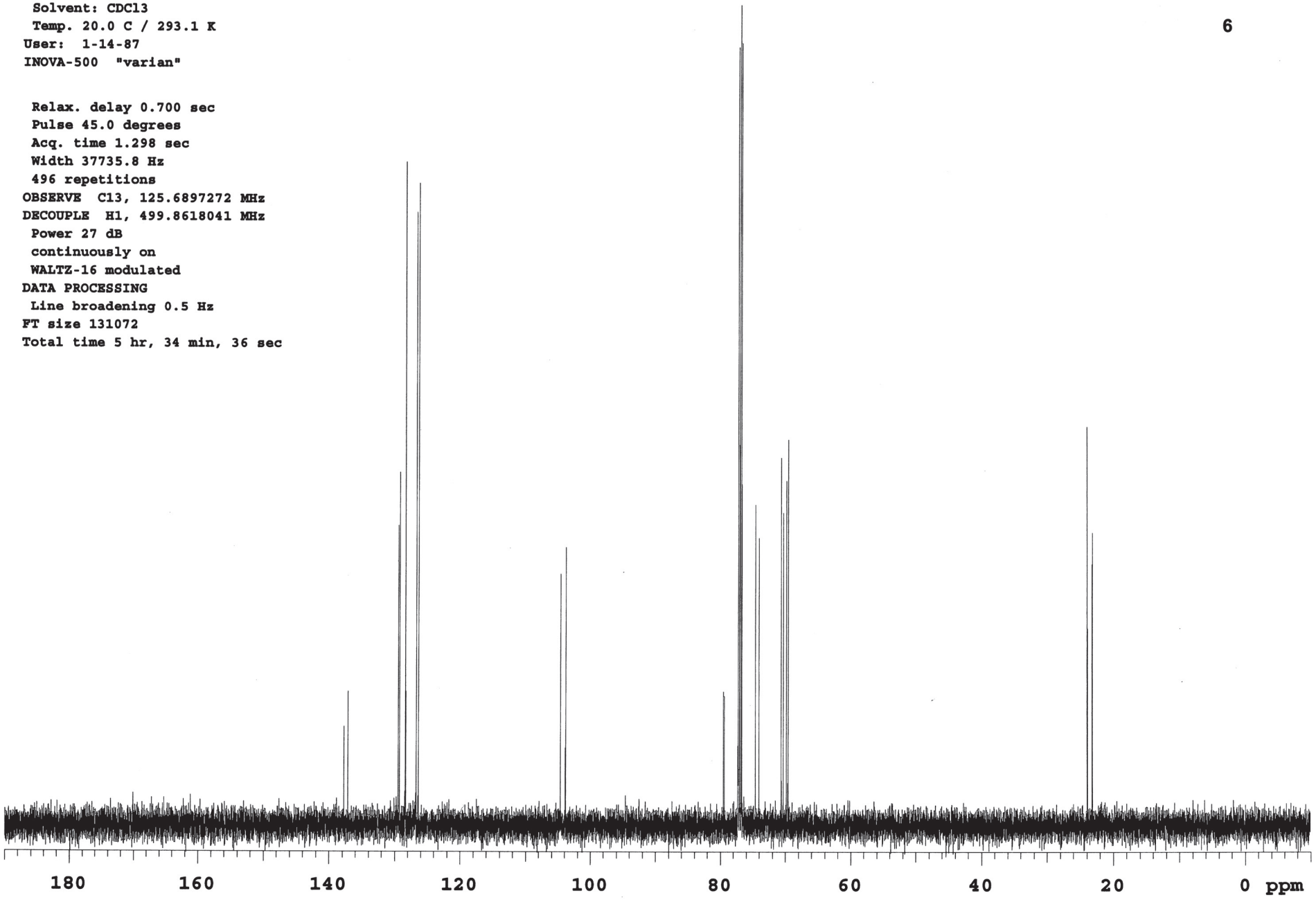
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
496 repetitions
OBSERVE C13, 125.6897272 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



6

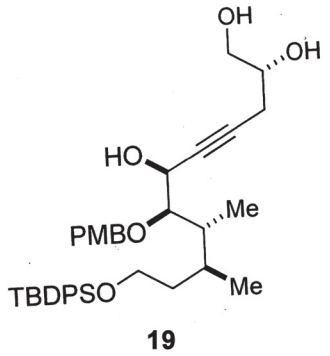


STANDARD PROTON PARAMETERS

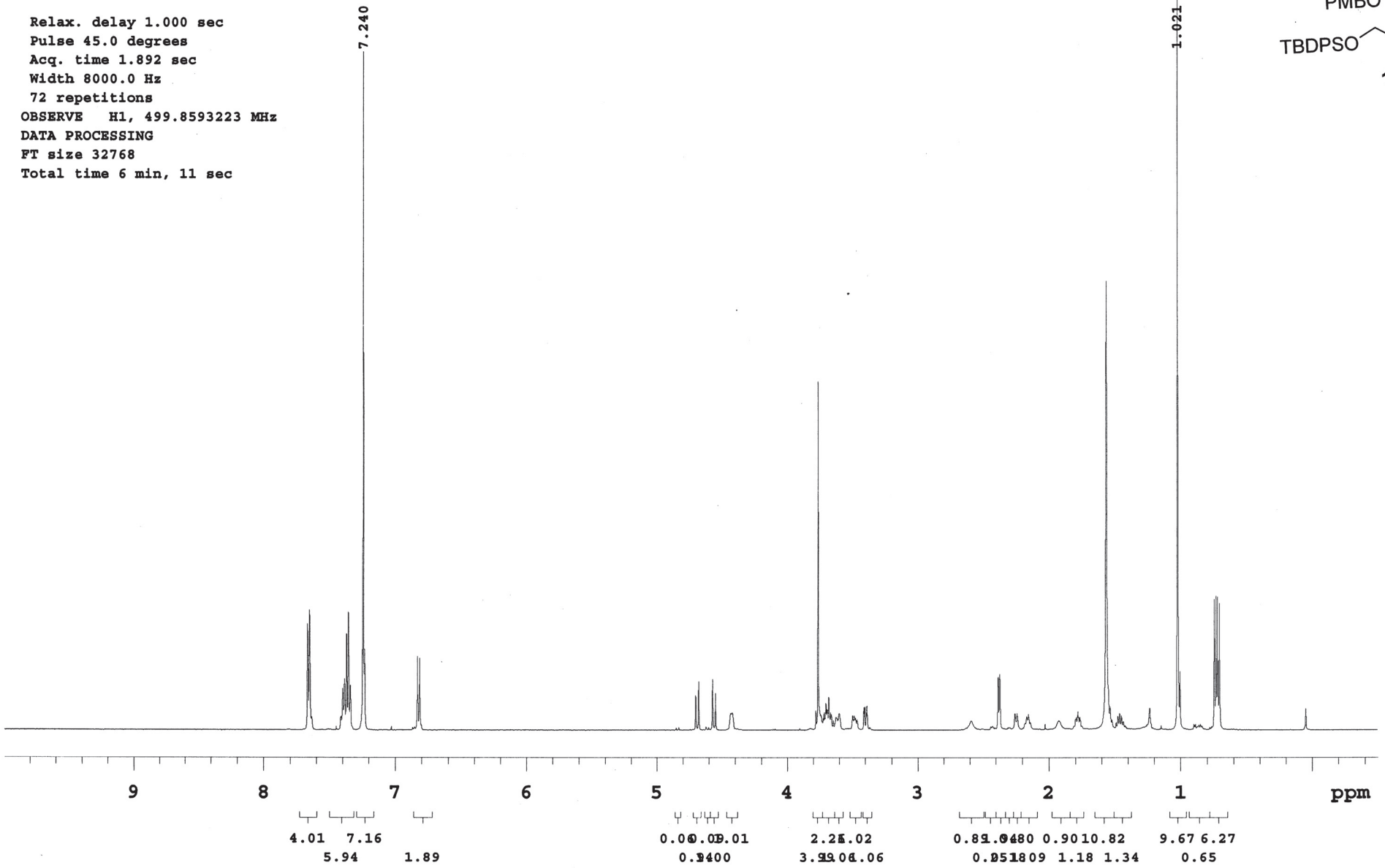
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
72 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 6 min, 11 sec



19

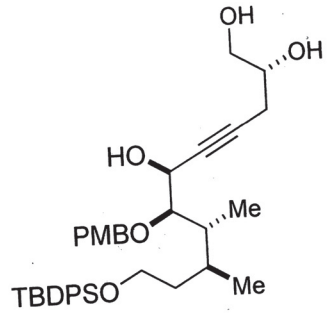


STANDARD CARBON PARAMETERS

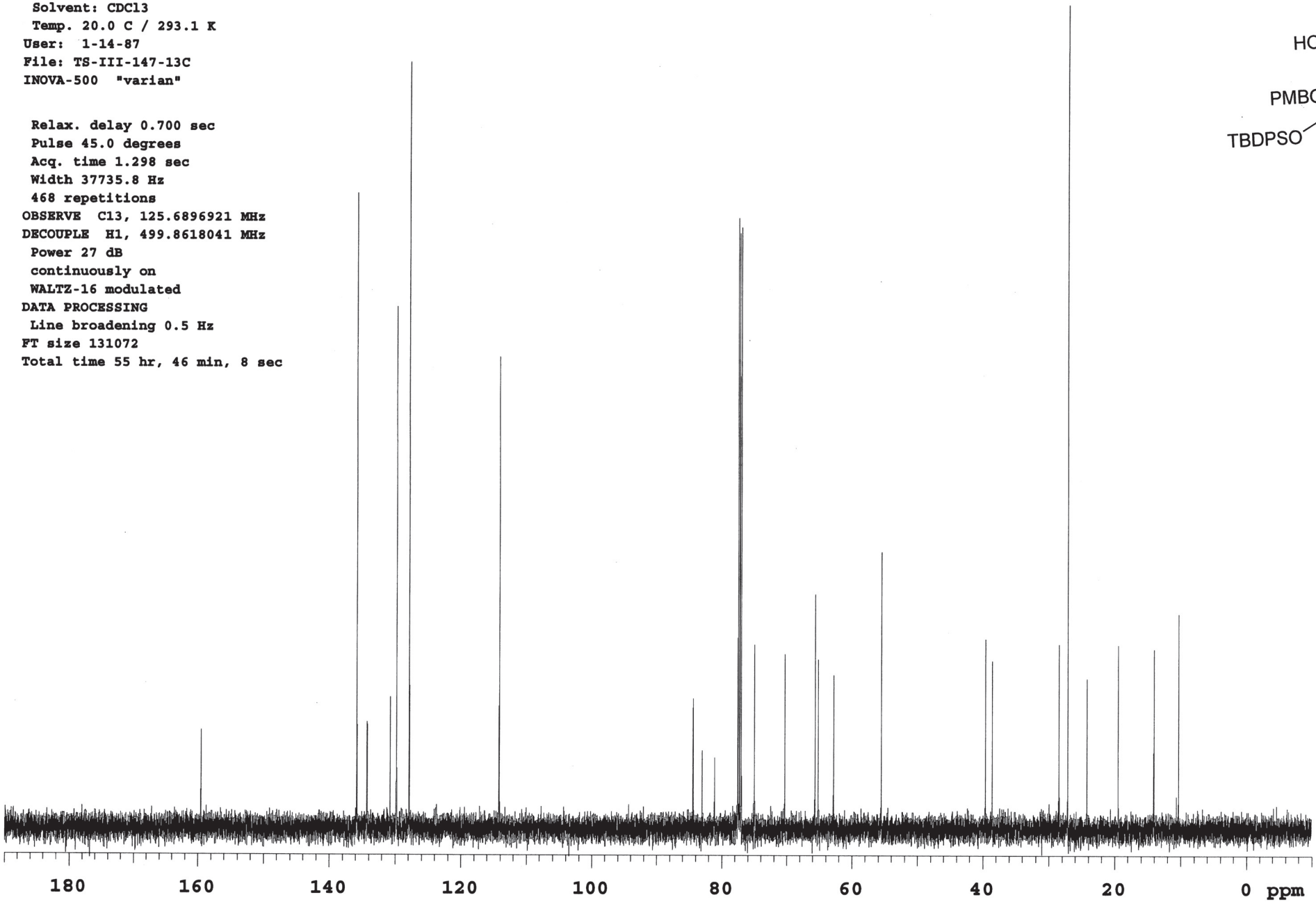
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
File: TS-III-147-13C
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
468 repetitions
OBSERVE C13, 125.6896921 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



19

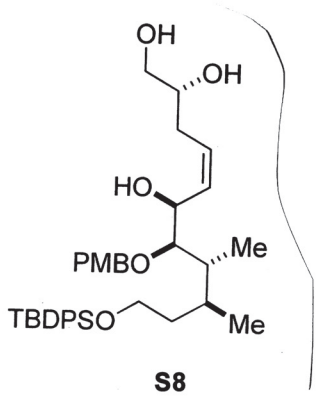


STANDARD PROTON PARAMETERS

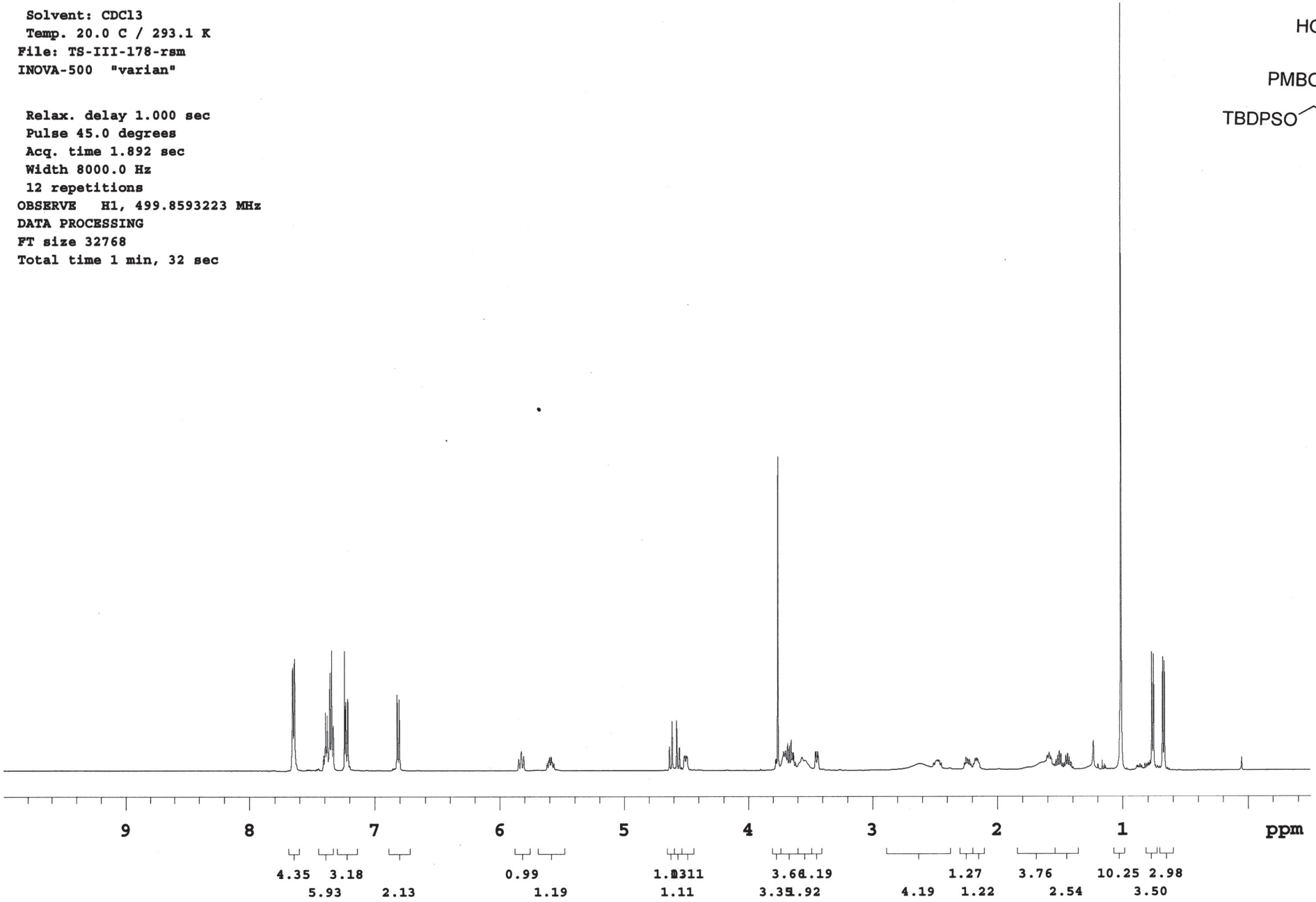
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
File: TS-III-178-rsm
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
12 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S8

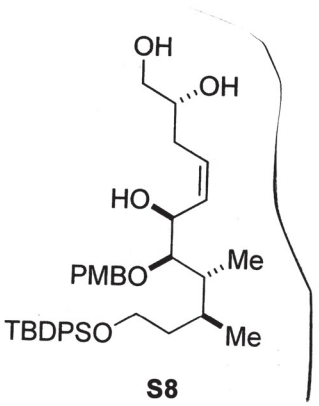


STANDARD CARBON PARAMETERS

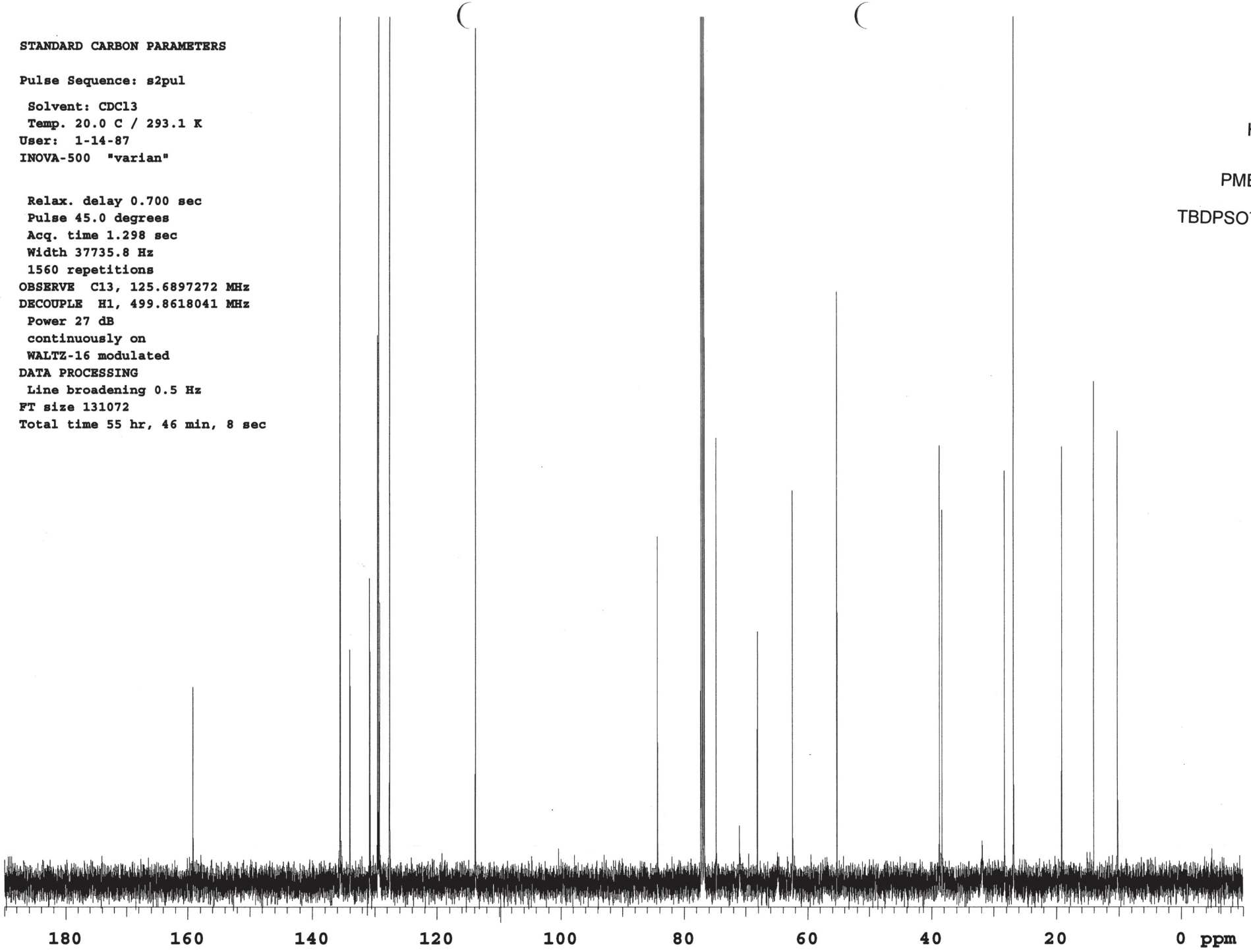
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
1560 repetitions
OBSERVE C13, 125.6897272 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



S8

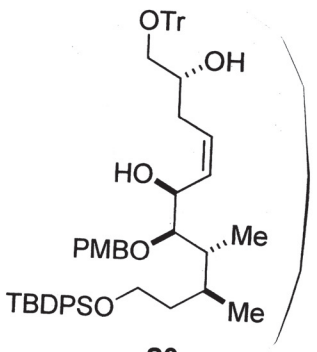


STANDARD PROTON PARAMETERS

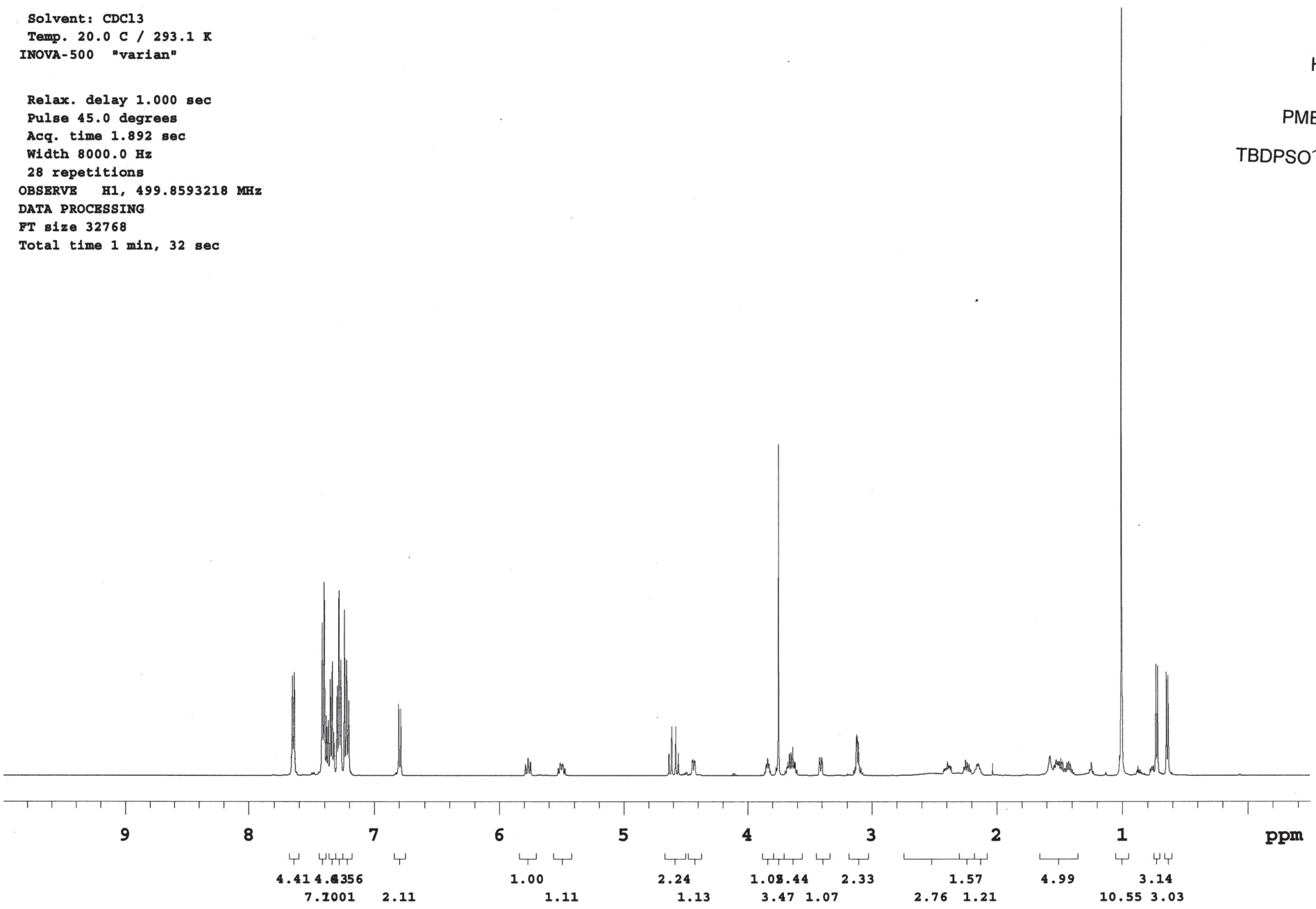
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
28 repetitions
OBSERVE H1, 499.8593218 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S9

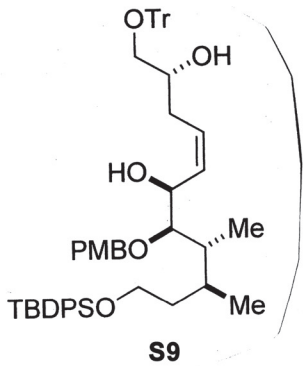


STANDARD CARBON PARAMETERS

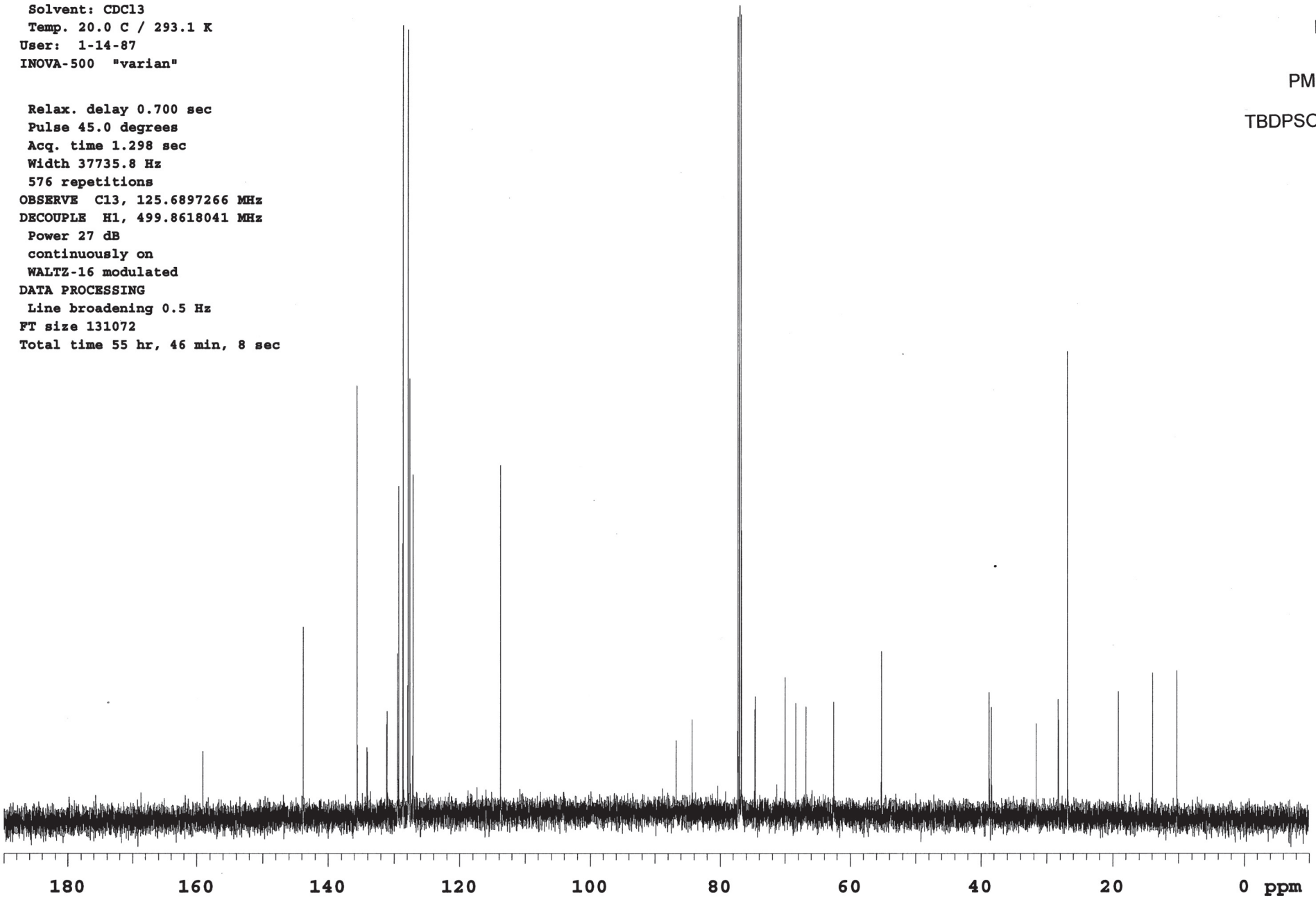
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
576 repetitions
OBSERVE C13, 125.6897266 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



S9

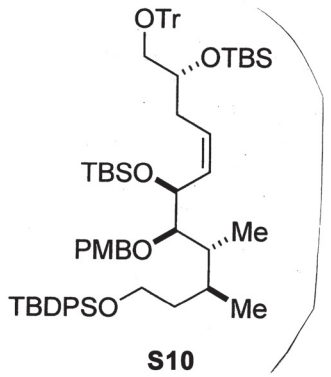


STANDARD PROTON PARAMETERS

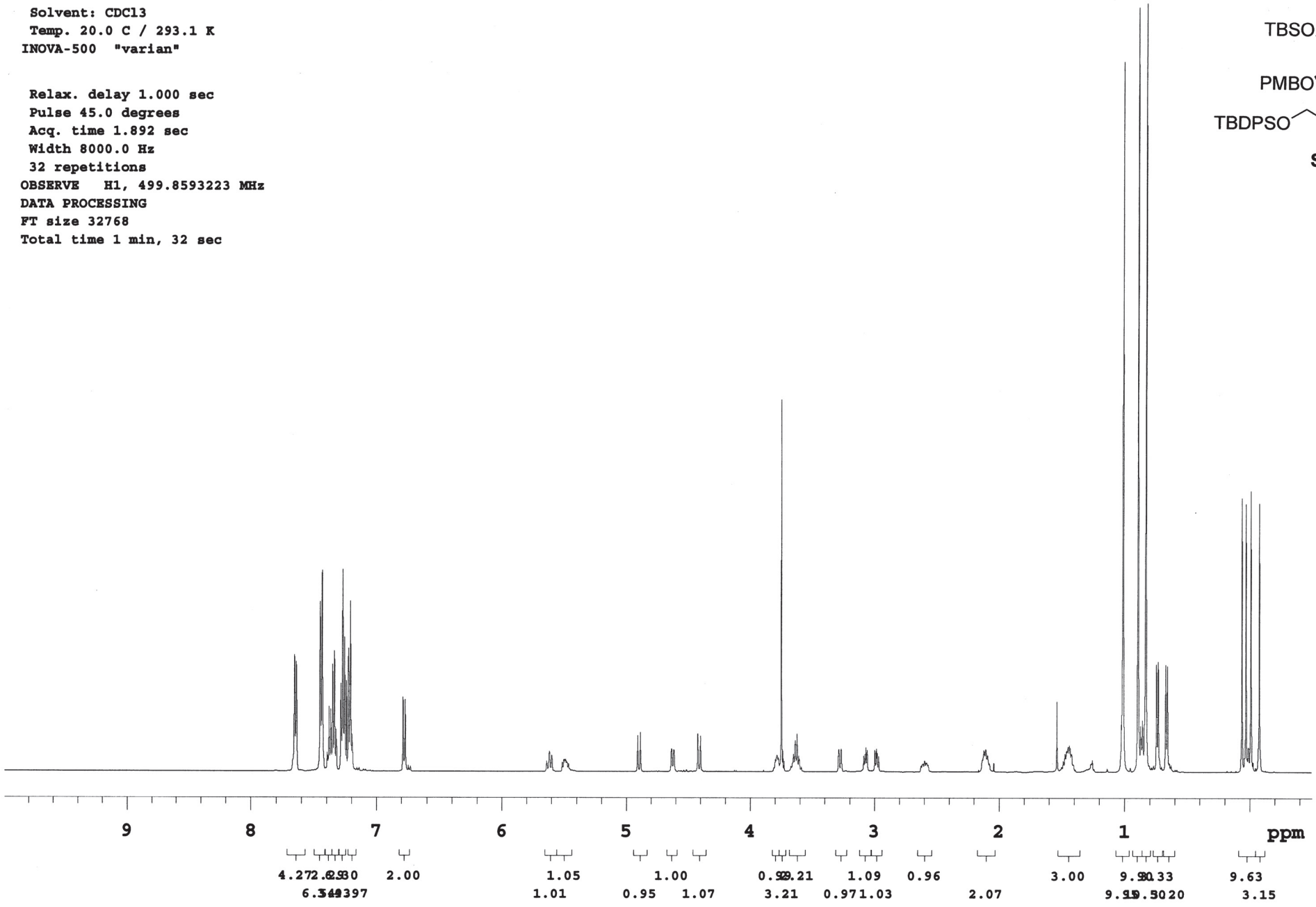
Pulse Sequence: s2pul

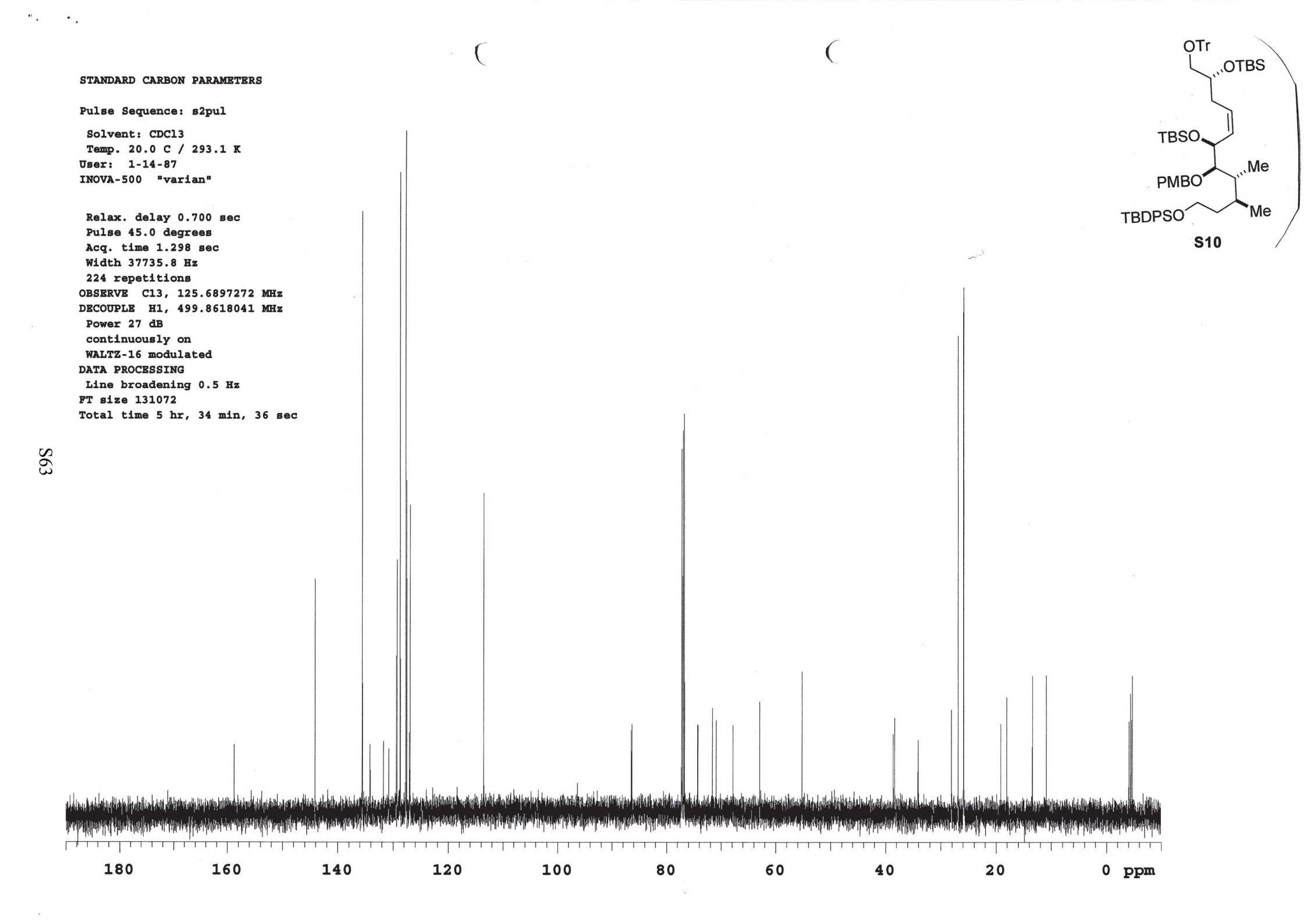
Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
32 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



S10



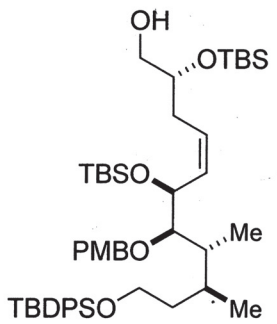

STANDARD CARBON PARAMETERS
Pulse Sequence: s2pul
Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"
Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
224 repetitions
OBSERVE C13, 125.6897272 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec
OTr
OTBS
TBSO
Me
PMBO
Me
TBDPSO
S10
180
160
140
120
100
80
60
40
20
0 ppm

STANDARD PROTON PARAMETERS

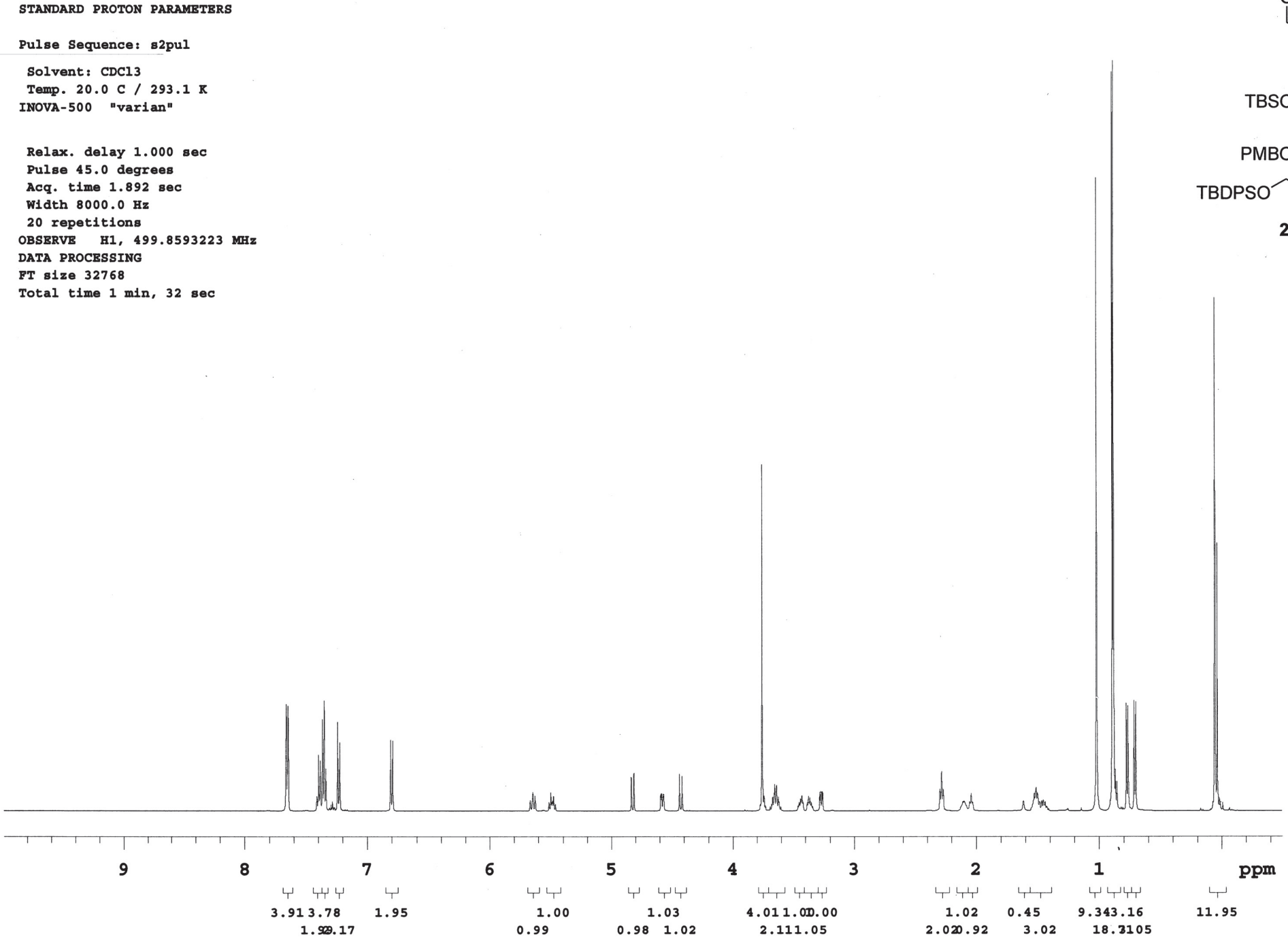
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
20 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



20

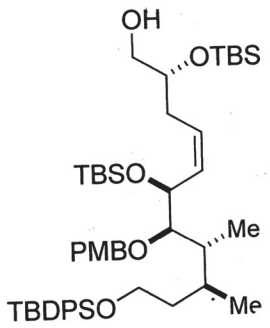


STANDARD CARBON PARAMETERS

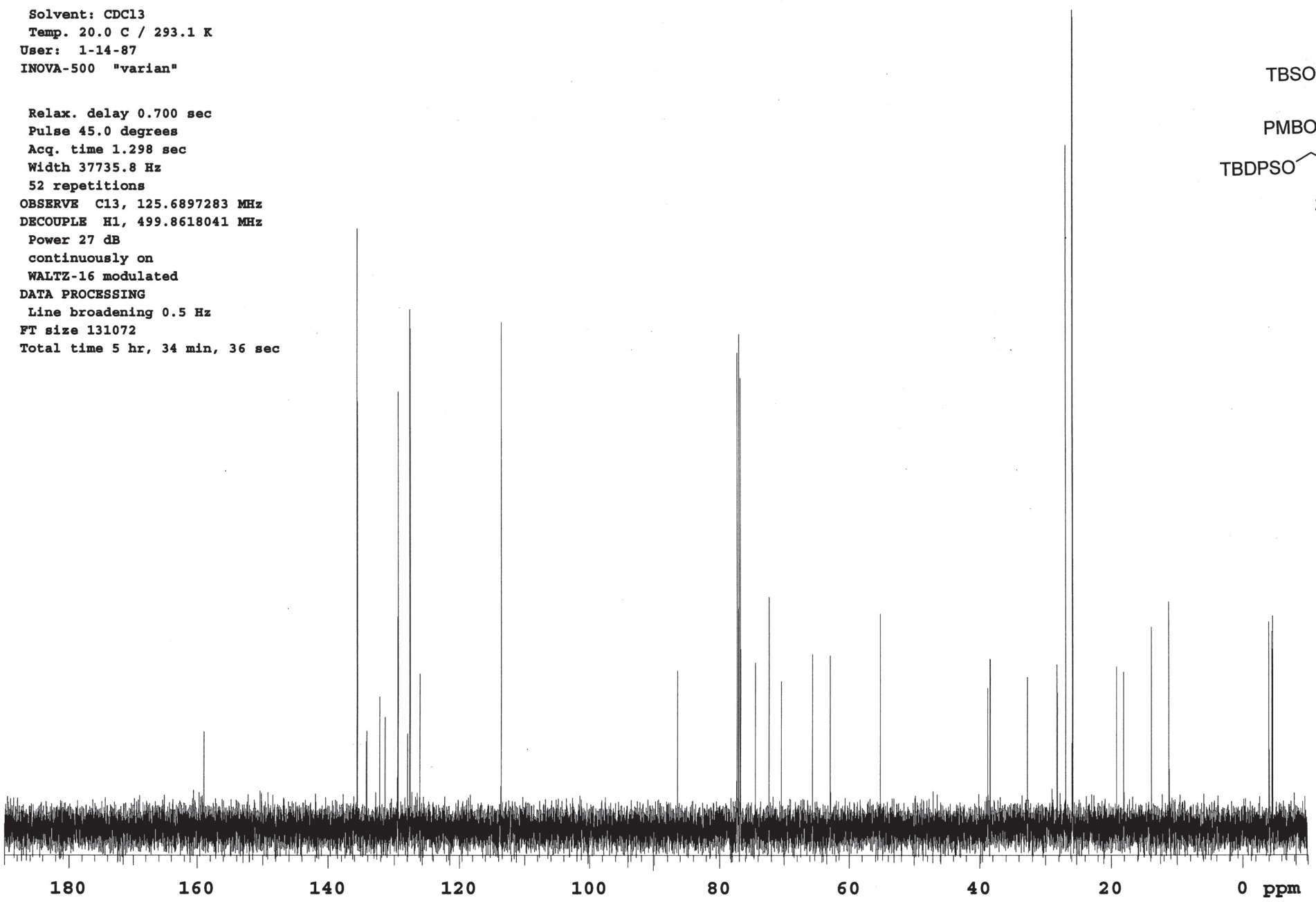
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
52 repetitions
OBSERVE C13, 125.6897283 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



20

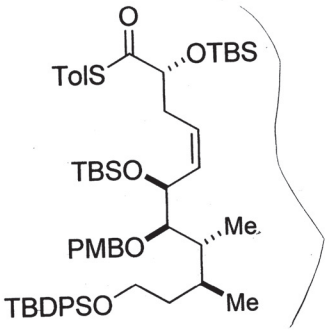


STANDARD PROTON PARAMETERS

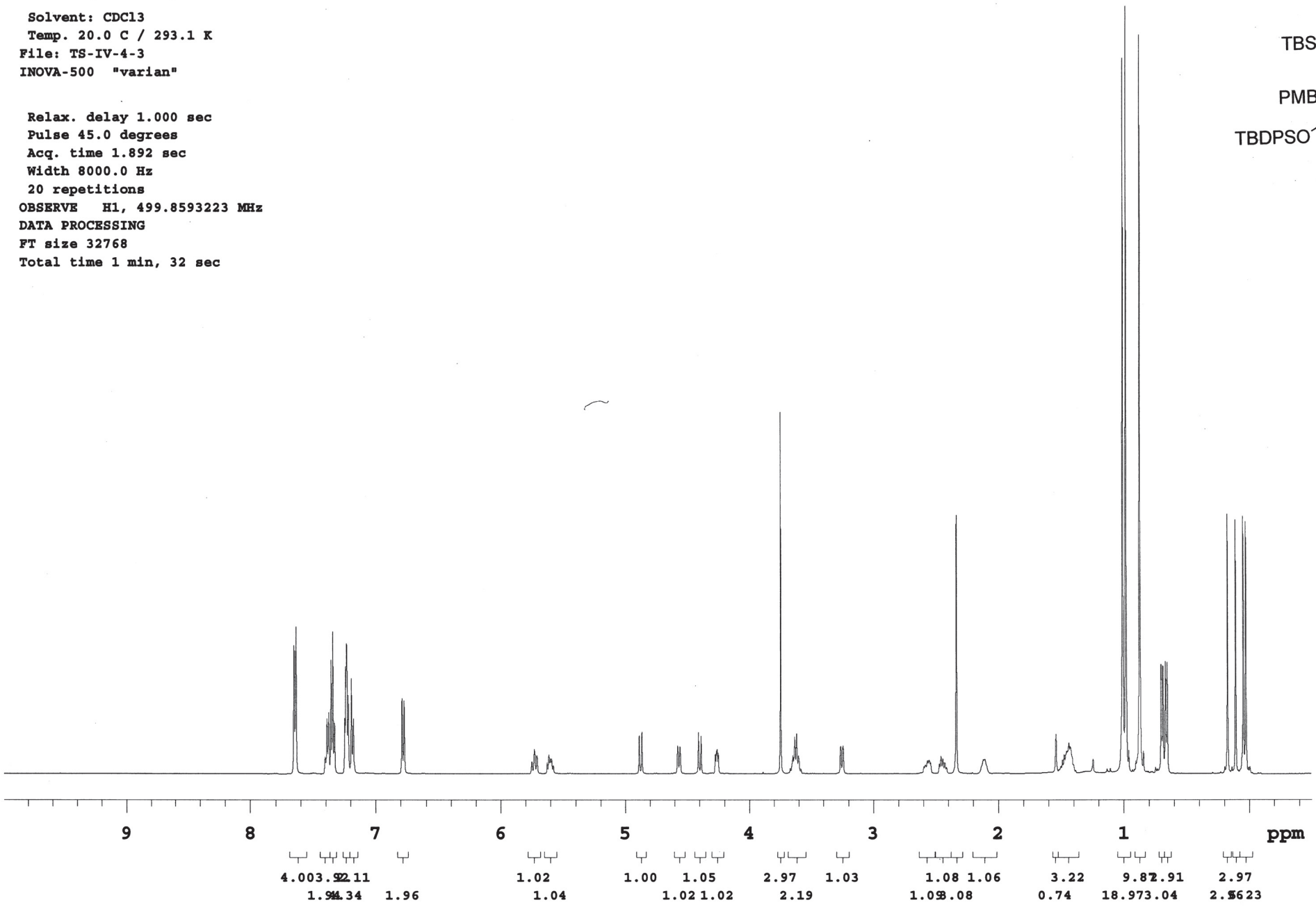
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
File: TS-IV-4-3
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
20 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



5

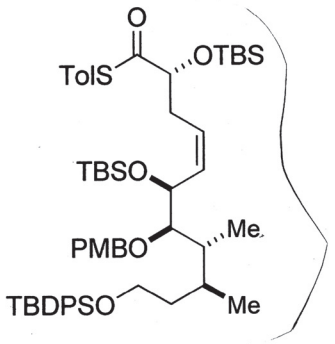


STANDARD CARBON PARAMETERS

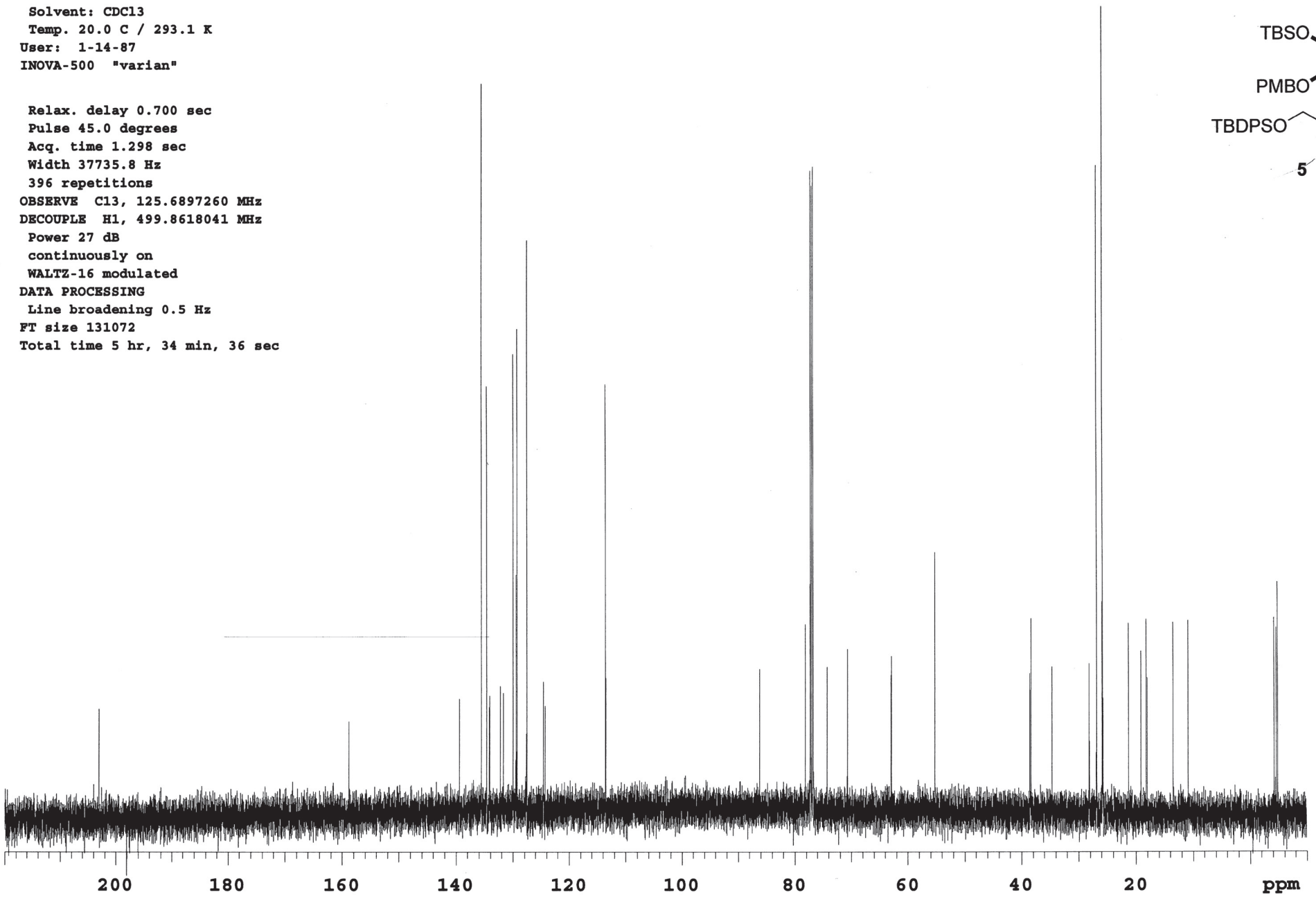
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
396 repetitions
OBSERVE C13, 125.6897260 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 5 hr, 34 min, 36 sec



5

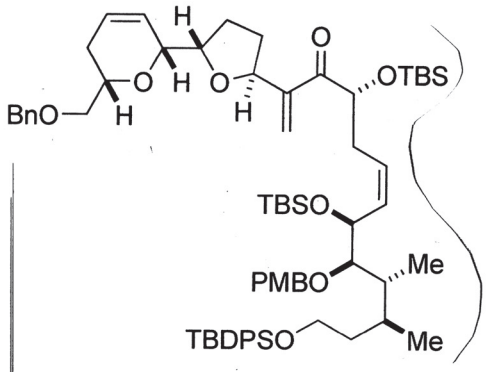


STANDARD PROTON PARAMETERS

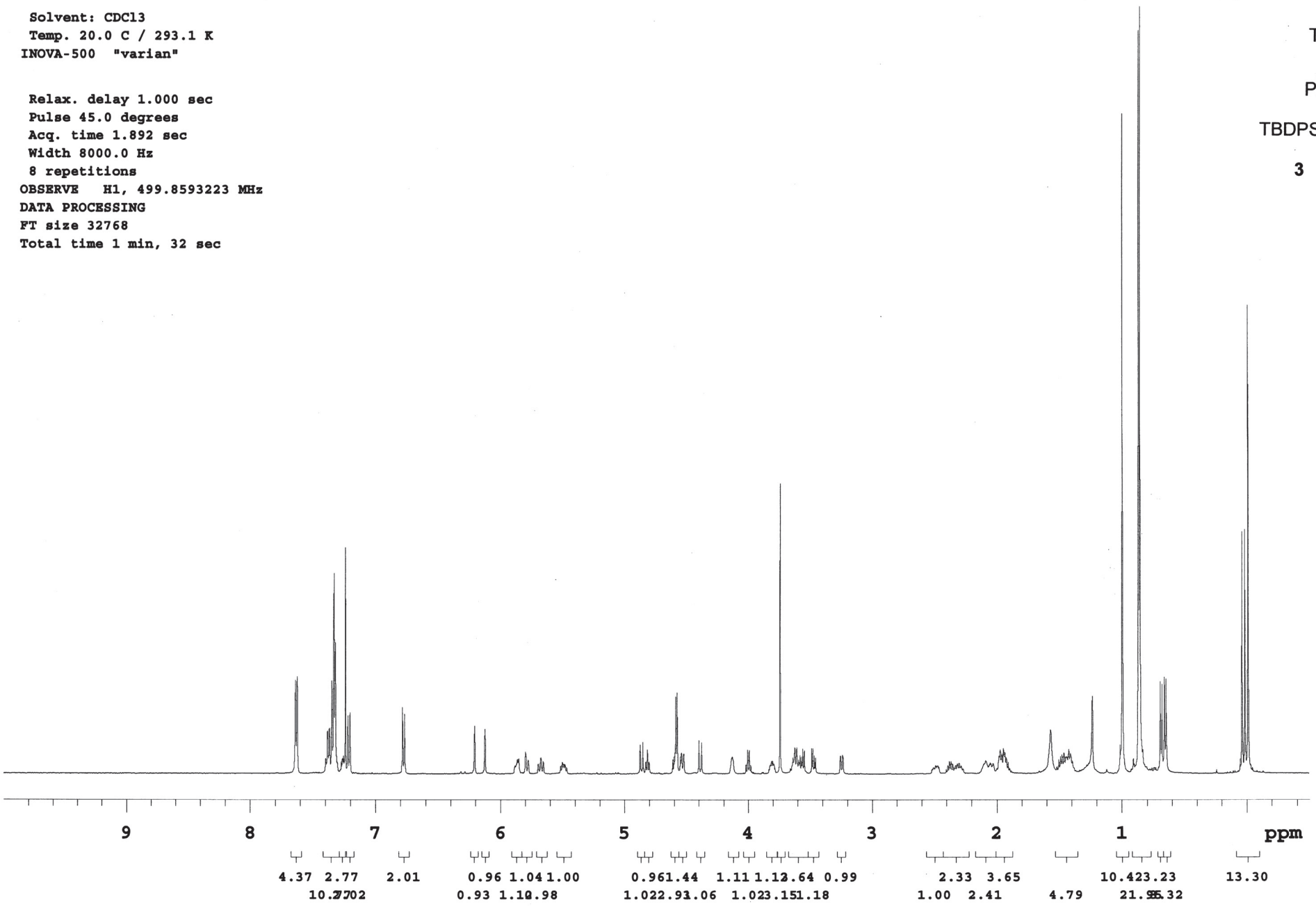
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
8 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 1 min, 32 sec



3

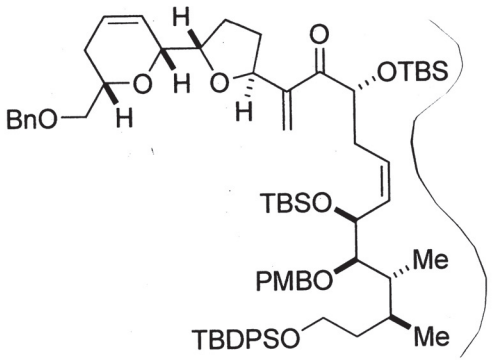


STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
File: TS-IV-10-13C
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
18064 repetitions
OBSERVE C13, 125.6897254 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



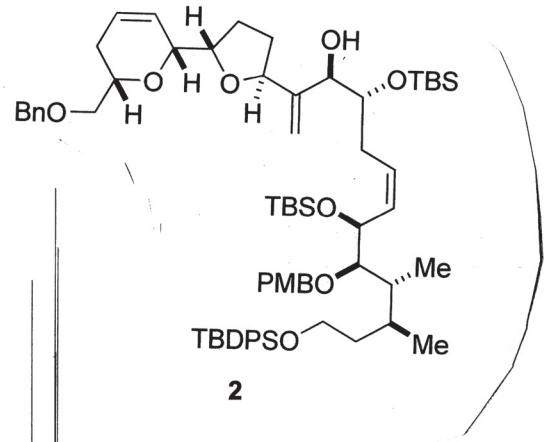
3

STANDARD PROTON PARAMETERS

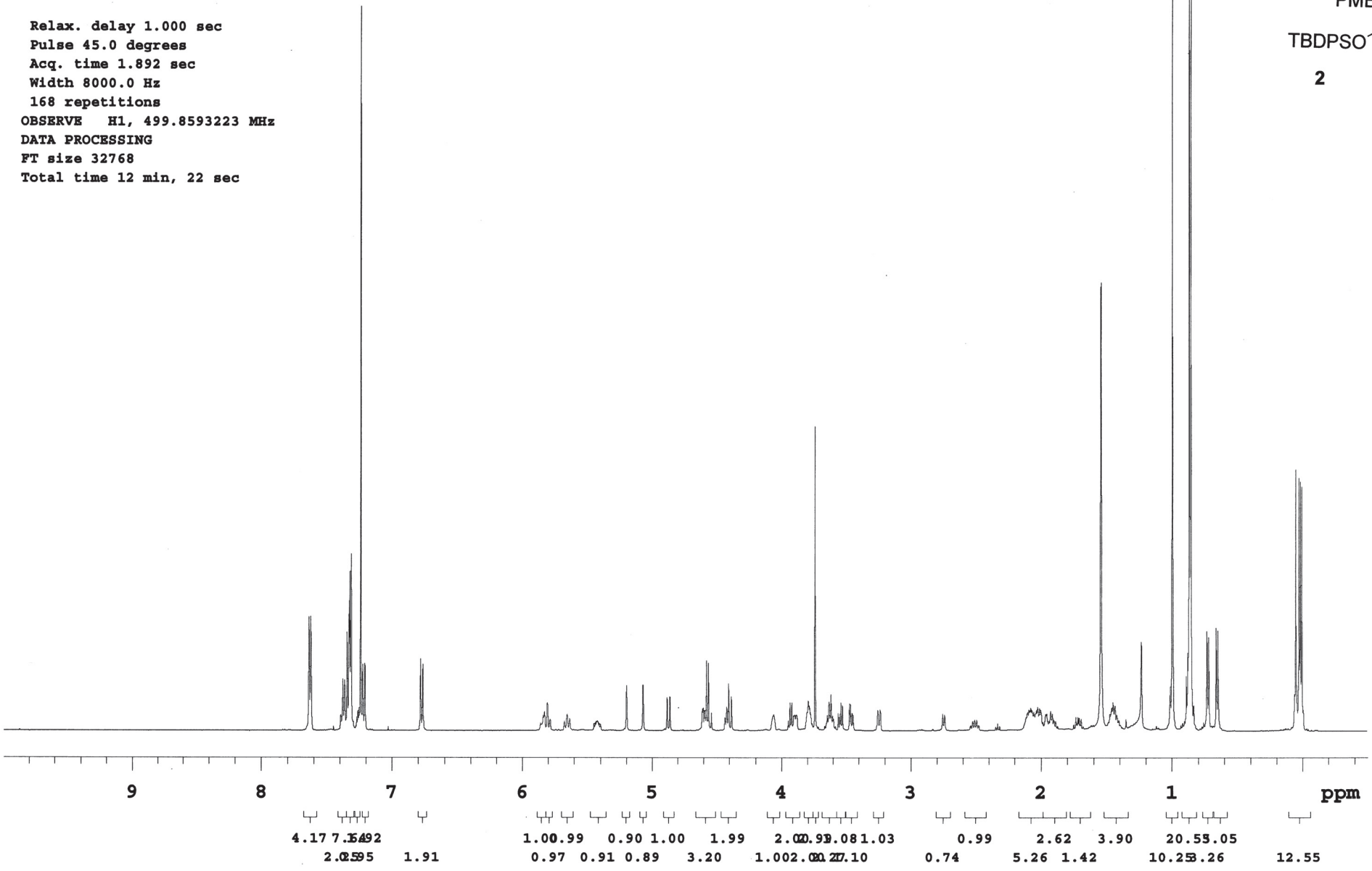
Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
168 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 12 min, 22 sec



2

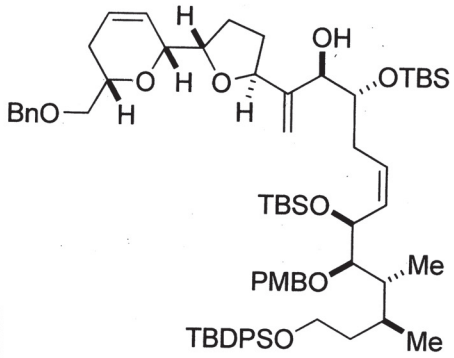


STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
19524 repetitions
OBSERVE C13, 125.6897243 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec



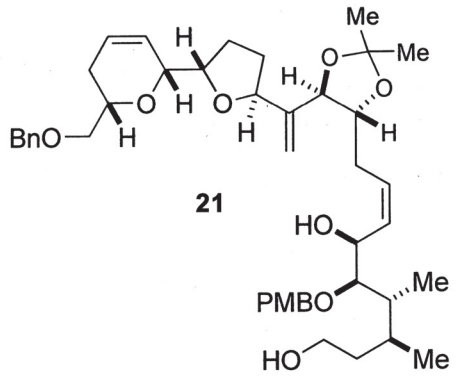
2

STANDARD PROTON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
124 repetitions
OBSERVE H1, 499.8593223 MHz
DATA PROCESSING
FT size 32768
Total time 12 min, 22 sec



STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
File: TS-IV-8-13C
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
22716 repetitions
OBSERVE C13, 125.6897243 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 55 hr, 46 min, 8 sec