Supporting information

Toward Palau' amine; $Hg(OTf)_2$-Catalyzed Synthesis of Cyclopentane Core

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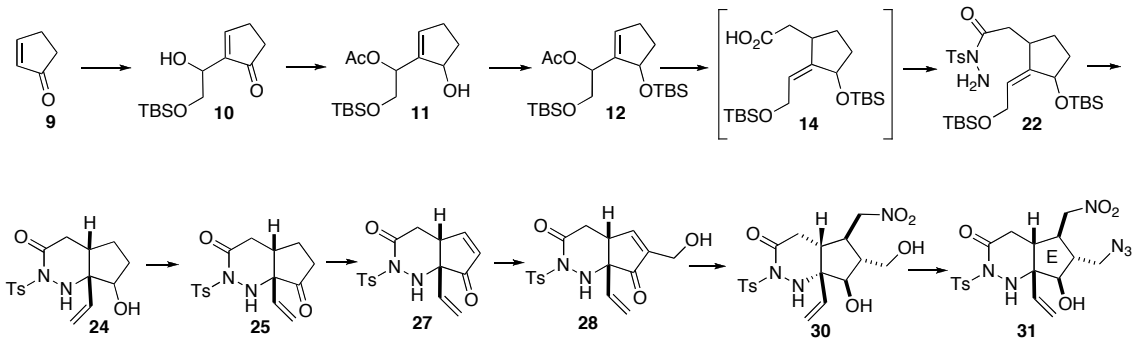
• Experimental Detail S02 - S16

• ^{1}H NMR and ^{13}C NMR spectra of each intermediate from **9** to **31** and lactone **21** S17 - S53

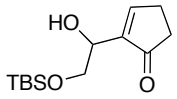


• X-ray data of **24α** and **32** S54 – S69

General Procedures and Methods

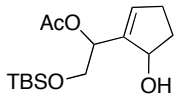
FTIR spectra were measured on a JASCO FT/IR-410 infrared spectrophotometer. NMR spectra were recorded on a Varian Mercury prus-300-4N spectrometer. Chemical shifts are reported in parts per million (ppm). For ^{1}H NMR spectra ($CDCl_3$), the residual solvent peak was used as the internal reference (7.24 ppm), whereas the central solvent peak as the reference (77.03 ppm) for ^{13}C NMR spectra ($CDCl_3$). Mass spectra were recorded on a JEOL the Mstation JMS-700. Analytical thin layer chromatography (TLC) was performed with E. Merck pre-coated TLC plates, silica gel 60F-254, layer thickness 0.25 mm. Flash chromatography was performed on Kanto Chemical 60 (63-210) mesh silica gel. Reagents and solvents are commercial grade and were used as supplied. Mercury triflate was prepared by the following procedure; to a suspension of HgO (541.4 mg, 2.5 mmol) in acetonitrile (5 mL) was dropwise added Tf_2O (705.3 mg, 2.5 mmol) at 0 °C, and the mixture was stirred at 0 °C until the yellow color disappear. The resulting colorless solution was transferred to 25 mL of messflask and diluted with anhydrous acetonitrile to give 0.1M solution.

2-(2-(*tert*-butyldimethylsilyloxy)-1-hydroxyethyl)cyclopent-2-enone (10)



To a solution of 2-cyclopentene-1-one **9** (4.71 g, 57.4 mmol) in THF (57 mL) was added (tert-Butyldimethylsilyloxy)-acetaldehyde (10.0 g, 57.4 mmol) and *n*-tributylphosphine (1.43 mL, 5.74 mmol). The mixture was stirred for 4 h at room temperature and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 4/1 to 2/1) to give **10** (10.3 g, 70%) as colorless amorphous. IR (neat) 3444, 2928, 2857, 1698, 1252, 1120, cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (td, J = 2.8, 1.6 Hz, 1H), 4.48-4.55 (m, 1H), 3.84 (dd, J = 10.0, 3.6 Hz, 1H), 3.52 (dd, J = 10.0, 6.4 Hz, 1H), 3.11 (d, J = 4.8 Hz, 1H), 2.58-2.68 (m, 2H), 2.41-2.47 (m, 2H), 0.89 (s, 9H), 0.06 (s, 3H), 0.05 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.8, 159.9, 145.1, 68.3, 65.7, 35.2, 26.8, 25.8, 18.2, -5.4, -5.5; HRMS (CI) m/z $[M+H]^+$ calcd for $[C_{13}H_{24}O_3Si+H]^+$ 257.1573, found 257.1575.

2-(*tert*-butyldimethylsilyloxy)-1-(5-hydroxycyclopent-1-enyl)ethyl acetate (11)

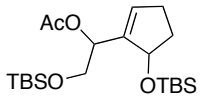


To a solution of **10** (4.0 g, 15.6 mmol) in pyridine (15 mL) was added acetic anhydride (7.37 mL, 78 mmol) at 0 °C. The mixture was stirred for 15 h at 0 °C and concentrated under reduced pressure. The residue was subjected to short-pass flash chromatography on silica gel (elution with hexane/ethyl acetate = 20/1 to 4/1) to give crude acetylated **11** which was used without further purification. To a solution of crude acetylated **11** in methanol (67 mL) was added $NaBH_4$ (1.0 g, 26.7 mmol) at -20 °C. The mixture was stirred for 1 h, quenched with saturated NH_4Cl (20 mL), and extracted with diethyl ether (40 mL x 3). The combined organic layers were washed with brine, dried over anhydrous MgSO4, filtered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 6/1) to give **11** (2.56 g, 55%) as colorless oil (1.5 : 1 diastereomeric mixture). IR (neat) 3452, 2930, 1740, 1372, 1254, cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.80 (br s, 1Ha+1Hb), 5.42 (t, *J* = 4.5 Hz, 1Ha), 5.36 (t, *J* = 5.7 Hz, 1Hb), 4.69 (br s, 1Ha), 4.67 (br s, 1 Hb), 3.79 (dd, *J* = 11.4, 3.9 Hz, 1Ha), 3.78 (d, *J* = 5.7 Hz, 2Hb), 3.71 (dd, *J* = 11.4, 4.8 Hz, 1Ha), 3.50 (br s, 1Ha), 3.11 (br s, 1Hb), 2.32-2.50 (m, 1Ha + 1Hb), 2.04-2.24 (m, 2Ha + 2Hb), 2.01 (s, 3Hb), 2.00 (s, 3Ha), 1.64-1.82 (m, 1Ha + 1Hb), 0.82 (s, 9Ha + 9Hb), 0.01 (s, 6Ha + 6Hb); ^{13}C NMR (75 MHz, $CDCl_3$) δ 142.7, 142.4, 133.2, 131.8, 76.6, 75.6, 72.6, 71.9, 64.7, 64.4, 33.3, 33.0, 29.9(x2), 25.7(x2), 21.1, 21.0, 18.2, 18.1, -5.4, -5.5; HRMS (CI) m/z $[M-H]^-$ calcd for $[C_{15}H_{28}O_4Si-H]^-$ 299.1678, found 299.1679.

The modified condition was found after the above examination. However, a large scales synthesis of modified condition was not tried, because the sufficient amount of **11** for the cyclopentane core was already obtained. The modified condition is next; to a solution of **10** (45.6 mg, 0.18 mmol) in pyridine (0.5 mL) was added acetic anhydride (84.1 μL, 78 mmol) at 0 °C. The mixture was stirred for 25 h at room temperature and concentrated under reduced pressure. The residue was subjected to short-pass flash chromatography on silica gel (elution with hexane/ethyl acetate = 9/1) to give crude acetylated **11** which was used without further purification. To a solution of crude acetylated **11** in methanol (19 mL) was added $NaBH_4$ (215 mg, 5.69 mmol) at -78 °C. The mixture was stirred for 1 h, quenched with saturated NH_4Cl (5 mL), and extracted with diethyl ether (10 mL x 3). The combined organic layers were washed with brine,

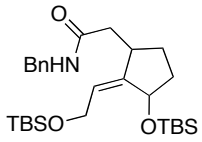
dried over anhydrous MgSO4, filtered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 6/1) to give **11** (1.0 g, 70%) as colorless oil (1.5 : 1 diastereomeric mixture).

2-(*tert*-butyldimethylsilyloxy)-1-(5-(*tert*-butyldimethylsilyloxy)cyclopent-1-enyl)ethyl acetate (12)



To a solution of **11** (3.12 g, 10.4 mmol) in dichloromethane (10.4 mL) was added trietylamine (3.62 mL, 26.0 mmol) and TBSOTf (2.87 mL, 12.5 mmol) successively at 0 °C. The mixture was stirred for 10 min at 0 °C, quenched with sat. $NaHCO_3$, and extracted with dichloromethane (x3). The combined organic layers were washed with sat. $NaHCO_3$, dried over anhydrous $MgSO_4$, filtered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/dichloromethane = 2/1 to 1/1 to 1/4) to give **12** (3.8 g, 88%) as pale yellow amorphous (2 : 1 diastereomeric mixture). **12a**; IR (neat) 2929, 2857, 1741, 1362, 1237 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.78 (br s, 1H), 5.26 (br d, *J* = 7.5 Hz, 1H), 4.85 (m, 1H), 3.84 (dd, *J* = 10.8, 3.0 Hz, 1H), 3.63 (dd, *J* = 10.8, 8.1 Hz, 1H), 2.28-2.44 (m, 1H), 2.08-2.26 (m, 2H), 2.00 (s, 3H), 1.52-1.66 (m, 1H), 0.89 (s, 9H), 0.83 (s, 9H), 0.07 (s, 3H), 0.05 (s, 3H), 0.01 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.4, 142.8, 130.2, 78.5, 72.6, 64.8, 34.1, 29.9, 25.9, 25.7, 21.2, 18.2, 18.0, -4.3, -4.9, -5.3 (x2); HRMS (CI) m/z $[M]^+$ calcd for $[C_{21}H_{42}O_4Si_2]^+$ 414.2622, found 414.2623. **12b**; IR (neat) 2929, 2857, 1751, 1362, 1234 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.78 (dd, *J* = 7.5, 3.3 Hz, 1H), 5.76 (br s, 1H), 4.73-4.83 (m, 1H), 3.78 (dd, *J* = 11.1, 7.5 Hz, 1H), 3.67 (dd, *J* = 10.8, 3.3 Hz, 1H), 2.34-2.46 (m, 1H), 2.12-2.25 (m, 2H), 2.03 (s, 3H),1.62-1.74 (m, 1H), 0.88 (s, 9H), 0.83 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H), 0.01 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.1, 142.1, 130.8, 77.2, 73.5, 64.7, 34.4, 29.9, 25.9, 25.7, 21.2, 18.2, 18.0, -4.3, -4.8, -5.3 (x2); HRMS (CI) m/z $[M-H]^-$ calcd for $[C_{21}H_{42}O_4Si_2-H]^-$ 413.2548, found 413.2547.

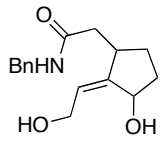
(*Z*)-*N*-benzyl-2-(3-(*tert*-butyldimethylsilyloxy)-2-(2-(*tert*-butyldimethylsilyloxy)ethylidene)cyclopentyl)acetamide (15)



To a solution of LHMDS (3.46 mL, 1M solution in THF) in THF (10 mL) was added a solution of TBSCl (661 mg, 4.38 mmol) in HMPA (2.97 mL, 17.0 mmol) at -78 °C. The mixture was stirred for 10 min. at -78 °C. To the mixture was added a solution of **12** (784 mg, 1.89 mmol) in THF (2 mL) at -78 °C. The mixture was stirred for 20 min. at 0 °C, quenched with iced water, and extracted with diethyl ether (x2). The combined organic layers were dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The solution of residue in toluene (5 mL) was heated to reflux for 1 h, cooled down to room temperature, and concentrated under reduced pressure. To the solution of residue in THF (24 mL) was added H_2O (7 mL) at room temperature. The mixture was stirred for 3 h, concentrated under reduced pressure to give carboxylic acid **14** which was used without further purification. To a solution of crude **14** in dichloromethane (7 mL) was added benzylamine (125 μL, 1.14 mmol), EDCI (272 mg, 1.42 mmol), and DMAP (23 mg, 0.19 mmol) at room temperature. The mixture was stirred for 25 min., quenched with sat. NH_4Cl, and extracted with ethyl acetate (20 mL x 3). The combined organic layers were washed with brine, dried over anhydrous MgSO4, filtered, concentrated under reduce pressure. The residue was purfied by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 10/1 to 8/1 to 6/1 to 4/1 to 2/1) to give **15** (124 mg, 70%) as colorless amorphous (2 : 1 diastereomeric mixture). **15a**: IR (neat) 3286, 2954, 2856, 1644, 1555, 1255, 1008 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.25-7.36 (m, 5H), 5.81 (br s, 1H), 5.38 (ddt, *J* = 6.8, 4.8, 2.4, 1H), 4.62 (t, *J* = 6.8, 1H), 4.48 (dd, *J* = 14.8, 6.0 Hz, 1H), 4.39 (dd, *J* = 14.8, 5.6 Hz, 1H), 4.32 (s, 2H), 2.93-3.05 (m, 1H), 2.55 (dd, *J* = 14.4, 4.8 Hz, 1H), 2.05 (dd, *J* = 14.4, 9.2 Hz, 1H), 1.94-2.08 (m, 2H), 1.48-1.60 (m, 1H), 1.10-1.23 (m, 1H), 0.89 (s, 9H), 0.88 (s, 9H), 0.09 (s, 3H), 0.07 (s, 3H), 0.06 (s, 3H), 0.05 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.8, 146.8, 138.3, 128.7, 127.9, 127.5, 125.1, 72.9, 61.2, 43.6, 41.1, 39.3, 34.9, 29.2, 26.0, 25.8, 18.4, 17.9, -3.7, -4.7, -5.0, -5.1; HRMS (CI) m/z $(M+H)^+$ calcd for $^+$ $[C_{28}H_{49}NO_3Si_2+H]^+$ 504.3329, found 504.3332. **15b**: IR (neat) 3288, 2955, 1644, 1549, 1254 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.23-7.35 (m, 5H), 5.86 (br t, *J* = 5.6 Hz, 1H), 5.48 (ddt, *J* = 8.0, 4.0, 1.6 Hz, 1H), 4.62-4.67 (m, 1H), 4.43 (d, *J* = 5.6 Hz, 2H), 4.28 (ddd, *J* = 13.2, 8.0, 0.8 Hz, 1H), 4.18 (ddd, *J* = 13.2, 4.0, 1.6 Hz, 1H), 2.87 (quint, *J* = 7.2 Hz, 1H), 2.50 (dd, *J* = 14.4, 6.8 Hz, 1H), 2.30 (dd, *J* = 14.0, 8.0 Hz, 1H),

1.55-1.92 (m, 4H), 0.89 (s, 9H), 0.82 (s, 9H), 0.06 (s, 6H), 0.05 (s, 3H), 0.05 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.9, 147.2, 138.4, 128.6, 127.9, 127.4, 125.7, 71.9, 61.1, 43.5, 42.9, 40.4, 35.0, 29.2, 25.9, 25.7, 18.4, 17.8, -4.1, -4.8, -5.1, -5.1; HRMS (CI) m/z $(M+H)^+$ calcd for $^+[C_{28}H_{49}NO_3Si_2+H]^+$ 504.3329, found 504.3322.

(*Z*)-*N*-benzyl-2-(3-hydroxy-2-(2-hydroxyethylidene)cyclopentyl)acetamide (16)



A solution of **15** (124 mg, 0.25 mmol) in acetic acid (1.5 mL), water (1.5 mL), and THF (1.5 mL) was stirred for 15 h at room temperature and concentrated under reduced pressure. The residue was purified by flash column chromatography of silica gel (elution with dichloromethane/methanol = 20/1) to give **16** (52.3 mg, 70%) as yellow amorphous (2 : 1 diastereomeric mixture). **16a**: IR (neat) 3297, 2929, 1650, 1556, 1455, 1008 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.04-7.08 (m, 5H), 6.19 (br t, *J* = 5.6 Hz, 1H), 5.63 (tt, *J* = 6.4, 1.6 Hz, 1H), 4.73 (d, *J* = 4.8 Hz, 1H), 4.41 (d, *J* = 5.6 Hz, 2H), 4.28 (ddd, *J* = 12.8, 7.2, 1.6 Hz, 1H), 4.08 (dd, *J* = 12.0, 6.4 Hz, 1H), 2.77-2.88 (m, 1H), 2.54 (dd, *J* = 14.8, 6.0 Hz, 1H), 2.39 (dd, *J* = 14.8, 7.2 Hz, 1H), 1.64-1.94 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.0, 152.1, 138.2, 128.7, 127.9, 127.6, 124.2, 71.5, 59.9, 43.6, 41.1, 39.9, 34.1, 29.2; HRMS (CI) m/z $(M+H)^+$ calcd for $^+[C_{16}H_{21}NO_3+H]^+$ 276.1599, found 276.1615. **16b**: IR (neat) 3289, 2930, 1638, 1549 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.40 (m, 5H), 5.78 (br t, *J* = 5.6 Hz, 1H), 5.64 (tt, *J* = 6.4, 2.0 Hz, 1H), 4.79 (t, *J* = 6.4 Hz, 1H), 4.44 (d, *J* = 5.6 Hz, 2H), 4.29 (dd, *J* = 13.2, 6.4 Hz, 1H), 4.19 (dd, *J* = 13.2, 6.4 Hz, 1H), 3.05-3.15 (m, 1H), 2.81 (br s, 1H), 2.55 (br s, 1H), 2.41 (dd, *J* = 14.4, 6.0 Hz, 1H), 2.11 (dd, *J* = 14.4, 8.4 Hz, 1H), 2.04-2.15 (m, 2H), 1.58-1.70 (m, 1H), 1.25-1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.7, 152.4, 138.4, 129.0, 128.2, 127.9, 124.0, 72.4, 60.1, 43.9, 41.6, 40.3, 34.1, 29.7; HRMS (CI) m/z $(M-H)^-$ calcd for $[C_{16}H_{21}NO_3-H]^-$ 274.1443., found 274.1440.

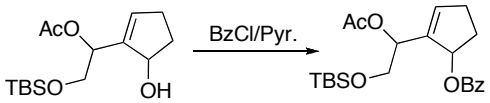
(*Z*)-*N*-benzyl-2-(2-(2-(benzyloxy)ethylidene)-3-hydroxycyclopentyl)acetamide (17) (2 : 1 diastereomeric mixture) ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.22-7.39 (m, 10Ha+10Hb), 5.85 (br s, 1Hb), 5.72 (br s, 1Ha), 5.42-5.64 (m, 1Ha+1Hb), 4.64-4.72 (m, 1Ha+1Hb), 4.53 (s, 1Ha), 4.52 (s, 1Hb), 4.43 (d, *J* = 3.9 Hz, 1Ha), 4.41 (d, *J* = 5.4 Hz,

1Hb), 4.18 (dd, *J* = 11.7, 6.0 Hz, 1Hb), 4.12-4.24 (m, 1Ha), 4.07 (dd, *J* = 11.7, 7.2 Hz, 1Hb), 4.04-4.12 (m, 1Ha), 3.32 (br s, 1Hb), 3.11 (br s, 1Ha), 2.80-2.96 (m, 1Ha+1Hb), 2.53 (dd, *J* = 14.7, 5.4 Hz, 1Hb), 2.41 (dd, *J* = 14.7, 5.4 Hz, 1Ha), 2.35 (dd, *J* = 14.4, 6.9 Hz, 1Hb), 2.34-2.44 (m, 1Ha), 1.55-2.10 (m, 4Ha+4Hb).

(*Z*)-2-(3-hydroxy-2-(2-hydroxyethylidene)cyclopentyl)acetamide (18)

(2 : 1 diastereomeric mixture) ^{1}H NMR (200 MHz, CD_3OD) δ 5.42-5.64 (m, 1Ha+1Hb), 4.56-4.64 (m, 1Ha+1Hb), 4.06-4.20 (m, 2Ha+2Hb), 2.78-2.92 (m, 1Ha), 2.61-2.74 (m, 1Hb), 2.43 (dd, *J* = 14.2, 5.8 Hz, 1Hb), 2.35 (dd, *J* = 14.2, 5.6 Hz, 1Ha), 2.14 (dd, *J* = 14.2, 9.0 Hz, 1Hb), 1.97 (dd, *J* = 14.2, 9.6 Hz, 1Ha), 1.10-205 (m, 4Ha+4Hb).

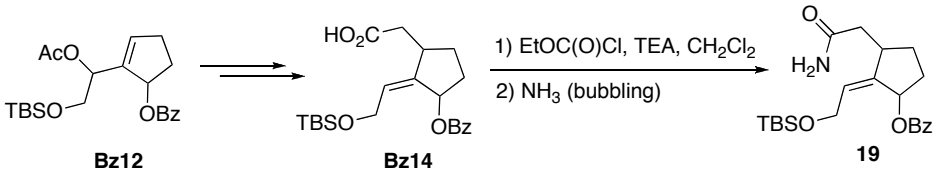
(*Z*)-3-(2-amino-2-oxoethyl)-2-(2-(*tert*-butyldimethylsilyloxy)ethylidene)cyclopentyl benzoate (19)



11 **Bz12**

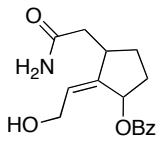
To a solution of **11** (1.62 g, 5.39 mmol) in THF (10 mL) was added pyridine (1.75 mL, 21.6 mmol), DMAP (66 mg, 0.54 mmol), and benzoyl chloride (1.25 mL, 10.8 mmol) at 0 °C. The mixture was stirred for 6 h at room temperature, quenched with sat.NH_4Cl, and extracted with ethyl acetate (x3). The combined organic layers were washed with sat. $NaHCO_3$, dried over anhydrous $MgSO_4$, filetered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 10/1) to give **Bz 12** (2.17 g, quant.) as colorless amorphous (2 : 1 diastereomeric mixture). IR (neat) 2954, 2857, 1790, 1747, 1281 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09-8.04 (m, 2Ha + 2Hb), 7.46-7.53 (m, 1Ha + 1Hb), 7.34-7.42 (m, 2Ha + 2Hb), 6.11 (br s, 1Ha), 6.02-6.05 (m, 1Hb), 5.97-6.30 (m, 1Ha), 5.89-5.94 (m, 1Hb), 5.57 (t, *J* = 4.8 Hz, 1Hb), 5.50 (t, *J* = 5.2 Hz, 1Ha), 3.70-3.85 (m, 2Ha + 2Hb), 2.28-2.58 (m, 3Ha + 3Hb), 2.01 (s, 3Hb), 1.86 (s, 3Ha), 1.82-1.85 (m, 1Ha + 1Hb), 0.81 (s, 9Ha), 0.80 (s, 9Hb), -0.01 (s, 6Ha), -0.04 (s, 6Hb); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.1(a), 170.1(b), 166.3(b), 166.1(a), 138.3(b), 138.1(a), 136.3(b), 134.9(a), 134.5(b), 132.8(a), 130.5(b), 130.3(a), 129.5(b), 129.5(a), 128.8(b), 128.2(a), 79.9(a),

79.8(b), 72.5(b), 71.7(a), 64.3(b), 63.9(a), 31.1(a), 31.1(b), 30.4 (a), 30.4 (b), 25.7 (a), 25.7(b), 21.0(a), 20.9(b), 18.1(a), 18.1(b), -5.5(a), -5.5(b); HRMS (CI) m/z $(M+H)^+$ calcd for $^+[C_{22}H_{32}N_2O_5Si+H]^+$ 405.2097, found 405.2098.



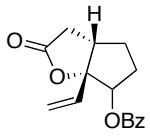
According to the Ireland-Claisen rearrangement of **12** to give **14**, the related compound **Bz14** was obtained with same manner from **Bz12** (194 mg, 0.38 mmol). To the mixture of crude **Bz14** in chloroform (0.72 mL) and triethylamine (81 *m*L, 0.58 mmol) was dropwised a solution of ethyl chlorocarbonate (55 *m*L, 0.58 mmol) in chloroform (0.72 mL) at -30 °C. The mixture was stirred for 1.5 h at 0 °C, bubbled through a ammonia gas for 20 min at 0 °C and 1.5 h at room temperature. The mixture was washed with 5% NaOH (x2), dried over anhydrous MgSO4, filtered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 4/1 to 2/1 to ethyl acetate) to give **19** (115 mg, 5 steps, 75% from **Bz12**) as colorless amorphous. (1 : 2 diastereomeric mixture). IR (neat) 3351, 3196, 2954, 2856,1716, 1680, 1391, 1276 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.90-8.02 (m, 1Ha+2Hb), 7.77 (dt, *J* = 6.9, 1.8 Hz, 1Ha), 7.42-7.54 (m, 3Ha), 7.02-7.42 (m, 3Hb), 6.46 (br s, 2Ha), 6.21 (br s, 2Hb), 5.70-5.94 (m, 1Ha+1Hb), 5.60-5.70 (m, 1Hb), 5.52-5.60 (m, 1Ha), 4.25 (ddd, *J* = 13.5, 7.2, 1.8 Hz, 1Ha), 4.14-4.26 (m, 2Hb), 4.16 (ddd, *J* = 13.5, 5.4, 2.1 Hz, 1Ha), 3.0-3.16 (m, 1Ha), 2.85-3.00 (m, 1Hb), 2.57 (dd, *J* = 14.4, 5.4 Hz, 1Hb), 2.51 (dd, *J* = 14.4, 5.1 Hz, 1Ha), 2.30 (dd, *J* = 14.4, 8.7 Hz, 1Hb), 2.18-2.34 (m, 1Ha), 2.12 (dd, *J* = 14.4, 9.3 Hz, 1Ha), 2.25 (dd, *J* = 14.4, 6.9 Hz, 1Ha), 1.80-2.14 (m, 2Ha+2Hb), 1.50-1.78 (m, 1Ha+1Hb), 1.31 (dq, *J* = 12.6, 8.4 Hz, 1Hb), 0.79 (s, 9Ha+9Hb), -0.05 (s, 6Ha), -0.05 (s, 6Hb); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.5, 169.8, 165.9, 165.7, 143.3, 143.2, 132.9, 131.9, 130.2, 130.0, 129.5, 128.7, 128.3, 128.3, 127.4, 127.3, 74.5, 74.3, 60.9, 60.6, 41.6, 40.0 (x2), 39.3, 32.5, 31.6, 29.8, 29.5, 25.9, 25.8, 18.2 (x2), -5.2 (x2); HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{22}H_{33}NO_4Si+H]^+$ 404.2257, found 404.2267.

(*Z*)-3-(2-amino-2-oxoethyl)-2-(2-hydroxyethylidene)cyclopentyl benzoate (20)



The mixture of **19** (115 mg, 0.29 mmol) in acetic acid (1.5 mL), H_2O (0.5 mL), and THF (0.5 mL) was stirred for 4.6 h at room temperature and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with ethyl acetate to ethyl acetate/methanol = 8/1) to give **20** (104 mg, quant.) as colorless amorphous (2 : 1 diastereomeric mixture). IR (neat) 3347, 3198, 2961, 1714, 1452, 1279 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.88-8.01 (m, 2Ha+2Hb), 7.55 (tt, *J* = 7.6, 1.2 Hz, 1Ha+1Hb), 7.42 (td, *J* = 7.6, 1.2 Hz, 2Ha+2Hb), 6.17 (br s, 1Hb), 6.04 (br s, 1Ha), 5.88-5.98 (m, 2Ha+2Hb), 5.77 (tt, *J* = 6.4, 2.0 Hz, 1Ha), 5.69 (tt, *J* = 6.8, 2.0 Hz, 1Hb), 4.14-4.28 (m, 2Ha+2Hb), 3.02-3.18 (m, 1Hb), 2.90-3.0 (m, 1Ha), 2.54 (dd, *J* = 14.4, 6.0 Hz, 1Ha), 2.49 (dd, *J* = 14.4, 6.0 Hz, 1Hb), 2.14-2.40 (m, 1Ha+1Hb), 2.35 (dd, *J* = 14.4, 8.0 Hz, 1Ha), 2.20 (dd, *J* = 14.4, 8.0 Hz, 1Hb), 1.84-2.32 (m, 2Ha+3Hb), 1.72-1.84 (m, 1Hb), 1.60-1.74 (m, 1Ha), 1.39 (dq, *J* = 12.4, 7.6 Hz, 1Ha); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.8, 174.7, 166.2, 166.0, 145.0, 144.9, 133.2, 133.2, 130.2, 130.0, 129.6, 129.5, 128.5, 128.4, 128.0, 126.5, 74.6, 74.4, 60.0, 59.6, 41.8, 40.0, 39.8, 39.1, 32.4, 31.4, 29.8, 29.4; HRMS (CI) m/z $(M+H)^+$ calcd for $^+$ $[C_{16}H_{19}NO_4+H]^+$ 289.1392, found 290.1396.

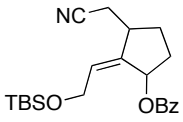
2-oxo-6a-vinylhexahydro-2*H*-cyclopenta[*b*]furan-6-yl benzoate (21)



To a solution of **19** (14.5 mg, 0.05 mmol) in nitromethane (0.25 mL) was added $Hg(OTf)_2$ (100 μL, 0.1 M solution in acetonitrile). The mixture was heated to 60 °C for 7 h, quenched with triethylamine (0.2 mL), and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with chloroform) to give **21** (10.9 mg, 80%) as colorless amorphous (1 : 1.5 diastereomeric mixture). IR (neat) 2961, 1787, 1724, 1275, 1117 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ **21a**; 7.96-8.04 (m, 2H), 7.59 (tt, *J* = 7.5, 1.2 Hz, 1H), 7.47 (tt, 8.4, *J* = 1.2 Hz, 2H), 6.07 (dd, *J* = 17.1, 11.1 Hz, 1H), 5.45-5.51 (m, 1H), 5.44 (dd, *J* = 17.1, 0.9 Hz, 1H), 5.25 (dd, *J* = 11.1, 0.9 Hz, 1H), 2.92 (td, *J* = 9.3, 4.5 Hz, 1H), 2.84 (dd, *J* = 17.7, 9.3 Hz, 1H), 2.40 (d, *J* = 17.1 Hz, 1H), 2.20-2.45 (m, 2H), 1.94-2.06 (m, 1H), 1.58-1.72 (m, 1H), **21b**; 8.02-8.10 (m, 2H), 7.57 (tt, *J* = 7.5, 1.8 Hz, 1H), 7.44 (tt, *J* = 7.4, 1.5 Hz, 2H), 5.94 (dd, *J* = 17.4, 10.8 Hz, 1H),

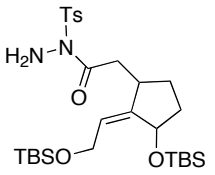
5.43 (dd, *J* = 17.4, 0.6 Hz, 1H), 5.32 (dd, *J* = 9.3, 5.7 Hz, 1H), 5.24 (dd, *J* = 10.8, 0.3 Hz, 1H), 2.90 (dd, *J* = 18.0, 9.3 Hz, 1H), 2.70-2.80 (m, 1H), 2.38 (dd, *J* = 18.0, 2.1 Hz, 1H), 1.95-2.28 (m, 3H), 1.61-1.72 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ **21a**; 176.1, 165.0, 133.9, 133.3, 129.8, 129.6, 128.5, 116.2, 95.7, 80.5, 42.2, 35.4, 30.9, 30.8, **21b**; 176.7, 166.0, 135.7, 133.3, 129.9, 129.5, 128.4, 116.5, 93.2, 77.7, 40.7, 36.3, 28.4, 28.3; HRMS (CI) m/z $(M+H)^+$ calcd for $^+[C_{16}H_{16}O_4+H]^+$ 273.1127, found 273.1126.

(*Z*)-2-(2-(*tert*-butyldimethylsilyloxy)ethylidene)-3-(cyanomethyl)cyclopentyl benzoate (1 : 1.5 diastereomeric mixture)



IR (neat) 2955, 2856, 2247, 1715, 1264, 1109 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.94-8.02 (m, 2Ha+2Hb), 7.49-7.57 (m, 1Ha+1Hb), 7.41 (t, *J* = 7.8 Hz, 1Ha+1Hb), 5.82-5.95 (m, 1Ha+1Hb), 5.74 (ddt, *J* = 6.9, 4.5, 1.5 Hz, 1Hb), 5.66 (tt, *J* = 6.0, 2.4 Hz, 1Ha), 4.40 (ddd, *J* = 13.5, 7.5, 1.5 Hz, 1Ha), 4.24 (dd, *J* = 6.3, 1.8 Hz, 2Hb), 4.19 (ddd, *J* = 13.5, 4.5, 2.1 Hz, 1Ha), 2.92-3.06 (m, 1Ha), 2.76-2.90 (m, 1Hb), 2.64 (dd, *J* = 16.5, 5.4 Hz, 1Hb), 2.58 (dd, *J* = 16.5, 5.1 Hz, 1Ha), 2.54 (dd, *J* = 16.5, 7.8 Hz, 1Hb), 2.39 (dd, *J* = 16.5, 8.1 Hz, 1Ha), 1.70-2.40 (m, 4Ha+4Hb), 0.82 (s, 9Hb), 0.81 (s, 9Ha), -0.01 (s, 3Ha+3Hb), -0.03 (s, 3Hb), -0.03 (s, 3Ha); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.8, 165.7, 133.1, 133.1, 130.6, 130.0, 129.6, 129.6, 129.5, 129.4, 128.4, 128.4, 118.3, 118.3, 74.0, 73.9, 60.8, 60.5, 39.5, 38.9, 32.4, 31.4, 29.5, 29.3, 25.8, 23.0, 21.6, 18.2, -5.3, -5.3; HRMS (FAB) m/z $(M+Na)^+$ calcd for $^+[C_{22}H_{31}NO_3Si+Na]^+$ 408.1971, found 408.1988.

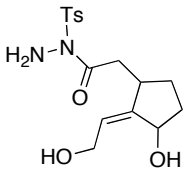
(*Z*)-*N*-(2-(3-(*tert*-butyldimethylsilyloxy)-2-(2-(*tert*-butyldimethylsilyloxy)ethylidene)cyclopentyl)acetyl)-4-methylbenzenesulfonohydrazide (23)



To a solution of LHMDS (10.5 mL, 1.6 M solution in THF) in THF (25 mL) was added a solution of TBSCl (3.2 g, 21.3 mmol) in HMPA (14.4 mL, 82.6 mmol) at -78 °C. The mixture was stirred for 15 min. at -78 °C. To the mixture was added a solution of **12** (3.8 mg, 9.16 mmol) in THF (5 mL) at -78 °C. The mixture was stirred for 1 h at 0 °C, quenched with iced water, and extracted with hexane (x2). The combined organic layers were dried over $MgSO_4$, filtered, and concentrated under

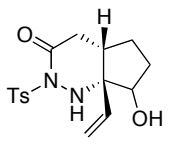
reduced pressure. The solution of residue in toluene (15 mL) was heated to reflux for 50 min, cooled down to room temperature, and concentrated under reduced pressure. To the solution of residue in THF (65 mL) was added H_2O (10 mL) at room temperature. The mixture was stirred for 3 h, concentrated under reduced pressure to give carboxylic acid **14** which was used without further purification. To a solution of crude **14** in dichloromethane (70 mL) was added *N*-tosylhydrazide (3.3 g, 17.8 mmol), EDCI (4.3 g, 22.2 mmol), and DMAP (362 mg, 3.0 mmol) at room temperature. The mixture was stirred for 1 h, quenched with sat. NH_4Cl, and extracted with dichloromethane (50 mL x 3). The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, filtered, concentrated under reduce pressure. The residue was purfied by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 8/1) to give **23** (3.6 g, 68%) as colorless amorphous (2 : 1 diastereomeric mixture). **23a**: IR (neat) 3363, 2955, 2857, 1703, 1360, 1255, 1167 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.89 (dt, *J* = 8.4, 2.0 Hz, 2H), 7.33 (d, *J* = 8.4 Hz, 2H), 5.29-5.35 (m, 1H), 4.62 (br t, *J* = 6.0 Hz, 1H), 4.42 (s, 2H), 4.33 (ddd, *J* = 13.6, 7.6, 1.6 Hz, 1H), 4.29 (dddd, *J* = 13.6, 4.4, 3.2, 1.2 Hz, 1H), 3.00 (dd, *J* = 15.2, 4.8, 1H), 2.87-2.97 (m, 1H), 2.60 (dd, *J* = 15.6, 9.2 Hz, 1H), 2.44 (s, 3H), 1.91-2.02 (m, 2H), 1.44-1.56 (m, 1H), 1.08-1.16 (m, 1H), 0.90 (s, 9H), 0.86 (s, 9H), 0.09 (s, 3H), 0.07 (s, 3H), 0.06 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.8, 146.7, 145.2, 134.9, 129.6, 128.7, 125.0, 72.8, 61.2, 40.0, 38.5, 34.9, 29.3, 26.0, 25.8, 21.7, 18.4, 17.9, -3.8, -4.7, -5.04, -5.07; HRMS (CI) m/z $(M+H)^+$ calcd for $^+$ $[C_{28}H_{50}N_2O_5SSi_2+H]^+$ 583.3057., found 583.3055. **23b**: IR (neat) 3369, 2955, 2857, 1703, 1359, 1169 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.89 (dt, *J* = 8.4, 1.6 Hz, 2H), 7.33 (d, J = 8.4 Hz, 2H), 5.37 (ddt, *J* = 8.0, 4.0, 1.6 Hz, 1H), 4.61 (t, *J* = 3.2 Hz, 1H), 4.40 (s, 2H), 4.29 (ddd, *J* = 13.2, 8.0, 0.8 Hz, 1H), 4.19 (ddd, *J* = 13.2, 4.0, 1.6 Hz, 1H), 3.03 (d, *J* = 11.2 Hz, 1H), 2.73-2.84 (m, 2H), 2.44 (s, 3H), 1.82 (dtd, *J* = 12.0, 6.8, 4.8 Hz, 1H), 1.64-1.72 (m, 2H), 1.42-1.52 (m, 1H), 0.89 (s, 9H), 0.86 (s, 9H), 0.08 (s, 3H), 0.07 (s, 3H), 0.06 (s, 3H), 0.05 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.1, 147.8, 145.4, 135.2, 129.8, 128.9, 125.6, 72.2, 61.5, 42.6, 39.2, 35.3, 29.5, 26.2, 26.1, 21.9, 18.6, 18.1, -3.8, -4.5, -4.8, -4.9; HRMS (CI) m/z $(M-H)^-$ calcd for $^+$ $[C_{28}H_{50}N_2O_5SSi_2-H]^-$ 581.2901, found 581.2900.

_N_-(2-(3-hydroxy-2-(2-hydroxyethylidene)cyclopentyl)acetyl)-4-methylbenzenesulfonohydrazide (24)



A mixture of **23** (3.6 g, 6.25 mmol) in acetic acid (20 mL), H_2O (20 mL), and THF (20 mL) was stirred for 15 h at room temperature and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with dichloromethane/methanol = 20/1) to give **24** (1.73 g, 78%) as colorless amorphous. **24a**: IR (neat) 3370, 2955, 2871, 1696, 1595, 1354, 1171 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.89 (dt, *J* = 8.4, 1.8 Hz, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 5.53 (tt, *J* = 6.6, 1.8 Hz, 1H), 4.71-4.78 (m, 1H), 4.48 (s, 2H), 4.25 (ddd, *J* = 12.6, 6.9, 1.2 Hz, 1H), 4.08 (dd, *J* = 12.0, 6.6 Hz, 1H), 3.08 (dd, *J* = 16.2, 5.4 Hz, 1H), 2.87 (dd, *J* = 15.9, 7.2 Hz, 1H), 2.74-2.86 (m, 1H), 2.45 (s, 3H), 1.55-1.90 (m, 4H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.8, 152.2, 145.4, 134.7, 129.6, 128.8, 124.2, 71.7, 59.8, 40.2, 39.5, 34.1, 29.3, 21.7; HRMS (CI) m/z $(M-H)^+$ calcd for $[C_{16}H_{22}N_2O_5S-H]^+$ 353.1178., found 353.1180. **24b**: IR (neat) 3362, 2957, 2871, 1695, 1359, 1170 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.89 (dt, *J* = 8.4, 1.8 Hz, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 5.54 (tt, *J* = 6.3, 2.1 Hz, 1H), 4.74-4.83 (m, 1H), 4.43 (s, 2H), 4.26 (ddd, *J* = 13.2, 6.3, 1.5 Hz, 1H), 4.16 (dd, *J* = 13.2, 6.3 Hz, 1H), 2.98-3.10 (m, 1H), 2.93 (dd, *J* = 15.9, 5.7 Hz, 1H), 2.76 (br s, 1H), 2.62 (dd, *J* = 15.9, 8.1 Hz, 1H), 2.45 (s, 3H), 1.95-2.15 (m, 2H), 1.69 (br, s, 1H), 1.53-1.70 (m, 1H), 1.16-1.32 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 173.5, 152.0, 145.4, 134.7, 129.6, 128.7, 123.9, 72.0, 59.8, 40.2, 39.3, 33.8, 29.4, 21.7; HRMS (CI) m/z $(M-H)^-$ calcd for $[C_{16}H_{22}N_2O_5S-H]^-$ 353.1178., found 353.1189.

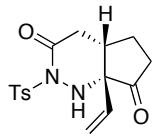
7-hydroxy-2-tosyl-7a-vinylhexahydro-1*H*-cyclopenta[*c*]pyridazin-3(2*H*)-one (25)



To a solution of **24** (507 mg, 1.43 mmol) in nitromethane (14.3 mL) was added $Hg(OTf)_2$ (0.29 mL, 0.1 M solution in acetonitrile) at room temperature. The mixture was stirred for 20 min, quenched with triethylamine (10 mL), and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 1/1) to give **25α** (136 mg, 28%) as colorless crystals and **25β** (270 mg, 56%) as colorless amorphous. **25α**; mp 166 °C (from dichloromethane-diethyl ether); IR (neat) 3492, 3294, 2958, 1715,

1360, 1173 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 2H), 5.98 (dd, *J* = 17.6, 10.8 Hz, 1H), 5.28 (d, *J* = 17.6 Hz, 1H); 5.25 (d, *J* = 10.8 Hz, 1H), 4.85 (s, 1H), 4.08 (q, *J* = 6.8 Hz, 1H), 2.81 (d, *J* = 6.8 Hz, 1H), 2.52-2.61 (m, 2H), 2.49 (dd, *J* = 15.6, 9.2 Hz, 1H), 2.44 (s, 3H), 1.97-2.08 (m, 1H), 1.93 (dtd, *J* = 13.6, 7.6, 5.6 Hz, 1H), 1.82 (ddt, *J* = 13.6, 8.0, 5.6 Hz, 1H), 1.63 (dtd, *J* = 12.4, 7.6, 5.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.0, 145.2, 140.0, 135.2, 129.5, 128.9, 117.0, 78.4, 70.2, 39.3, 32.9, 30.9, 28.3, 21.7; HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{16}H_{20}N_2O_4S+H]^+$ 337.1222, found 337.1220. **25β**; IR (neat) 3483, 3282, 2961, 1714, 1359, 1179 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.1 Hz, 2H), 7.33 (d, *J* = 8.1 Hz, 2H), 5.97 (dd, *J* = 17.7, 11.1 Hz, 1H), 5.37 (d, *J* = 11.1 Hz, 1H); 5.32 (d, *J* = 17.7 Hz, 1H), 4.48 (s, 1H), 4.05-4.32 (m, 1H), 2.66 (tdd, *J* = 8.7, 8.7, 6.3, 4.5 Hz, 1H), 2.55 (dd, *J* = 15.3, 6.3 Hz, 1H), 2.44 (s, 3H), 2.37 (dd, *J* = 15.3, 4.5 Hz, 1H), 2.32-2.43 (m, 1H), 1.88-2.03 (m, 2H), 1.51 (dddd, *J* = 12.0, 12.0, 10.2, 6.6 Hz, 1H), 1.19-1.32 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.9, 145.2, 137.3, 134.9, 129.4, 128.8, 117.6, 76.9, 70.4, 40.2, 38.0, 30.9, 27.2, 21.7; HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{16}H_{20}N_2O_4S+H]^+$ 337.1222, found 337.1213.

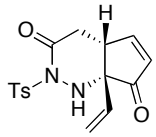
2-tosyl-7a-vinyltetrahydro-1*H*-cyclopenta[*c*]pyridazine-3,7(2*H*,7a*H*) -dione (26)



To a solution of the mixture of **25α** and **25β** (499 mg, 1.48 mmol) in dichrolometane (10 mL) was added DMSO (5 mL, 70.6 mmol), triethylamine (1.24 mL, 8.91 mmol), and a solution of SO_3•Pyr (591 mg, 3.71 mmol) successively at 0 °C. The mixture was stirred for 1 h at room temperature, quenched with sat. NH_4Cl, extracted with dichloromethane (20 mL x 3). The combined organic layers were washed with brine, dried over anhydrous MgSO4, filtered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 2/1 to 1/1) to give **26** (494 mg, quant.) as colorless amorphous; IR (neat) 3289, 2958, 2254, 1747, 1368, 1175 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.4 Hz, 2H), 7.28 (d, *J* = 8.4 Hz, 2H), 5.81 (dd, *J* = 17.4, 10.5 Hz, 1H), 5.45 (d, *J* = 17.4 Hz, 1H); 5.32 (d, *J* = 10.5 Hz, 1H), 5.28 (s, 1H), 2.83 (tt, *J* = 7.8, 5.4 Hz, 1H), 2.65 (dd, *J* = 15.0, 5.4 Hz, 1H), 2.48 (dd, *J* = 15.0, 8.1 Hz, 1H), 2.42 (s, 3H), 2.32-2.45 (m 1H), 2.12-2.34 (m, 2H), 1.45-1.59 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$)

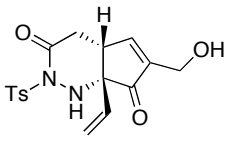
δ 213.6, 171.1, 145.1, 134.7, 134.6, 129.2, 128.9, 118.6, 70.5, 39.0, 37.3, 35.5, 24.0, 21.6; HRMS (CI) m/z $(M)^+$ calcd for $[C_{16}H_{18}N_2O_4S]^+$ 334.0987, found 333.0989.

2-tosyl-7a-vinyl-4,4a-dihydro-1*H*-cyclopenta[*c*]pyridazine-3,7(2*H*, 7a*H*)-dione (28)



A solution of **26** (385 mg, 1.15 mmol) and HMDS (0.48 mL, 2.3 mmol) in dichloromethane (12 mL) was stirred for 30 min at room temperature. To the mixture was added Trimethylsilyliodide (0.25 mL, 1.70 mmol) at 0 °C. The mixture was stirred for 1 h at 0 °C, stirrerd for 15 min. at room temperature, quenched with sat. $NaHCO_3$, extracted with dichloromethane (20 mL x 2). The combined organic layers were dried over anhydrous $MgSO_4$, filtered, concentrated under reduced pressure. To a solution of reside in DMSO (12 mL) was added $Pd(OAc)_2$ (258 mg, 1.15 mmol) was added at room temperature. The mixture was stirred for 4 h, quenched with H_2O, extracted with ethyl acetate. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, filtered, concentrated under reduced pressure. The residue was purified by flash columnchromatography on silica gel (elution with hexane/ethyl acetate = 2/3) to give **28** (298 mg, 78% from **26**) as white solid. mp 182 °C (from dichloromethane-diethyl ether); IR (neat) 3243, 2924, 1715, 1354, 1167 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.4 Hz, 2H), 7.50 (dd, *J* = 6.0, 2.8 Hz, 1H), 7.30 (d, *J* = 8.4 Hz, 2H), 6.09 (dd, *J* = 6.0, 2.0 Hz, 1H), 5.89 (dd, *J* = 17.6, 10.8 Hz, 1H), 5.47 (d, *J* = 17.6 Hz, 1H); 5.46 (s, 1H), 5.40 (d, *J* = 10.8 Hz, 1H), 3.48 (dddd, *J* = 6.8, 4.8, 2.8, 2.0 Hz, 1H), 2.94 (dd, *J* = 14.4, 6.8 Hz, 1H), 2.55 (dd, *J* = 14.4, 4.8 Hz, 1H), 2.43 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 204.6, 168.3, 163.4, 145.5, 134.6, 134.4, 133.2, 129.4, 129.3, 119.6, 68.1, 46.4, 36.2, 21.8; HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{16}H_{16}N_2O_4S+H]^+$ 333.0909, found 333.0904.

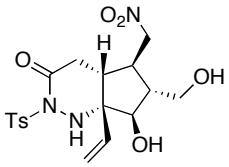
6-(hydroxymethyl)-2-tosyl-7a-vinyl-4,4a-dihydro-1*H*-cyclopent a[*c*]pyridazine-3,7(2*H*,7a*H*)-dione (29)



To a solution of **28** (289 mg, 0.87 mmol) in THF (9 mL) was added formaldehyde (0.35 mL, 4.34 mmol, 37% water solution) and *n*-tributhylphosphine (87 μL, 0.35 mmol) at room temperature. The mixture was stirred

for 2 h, quenched with H_2O, extracted with ethyl acetate (x 3). The combined organic layers were dried over anhydrous $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with hexane/ethyl acetate = 1/4) to give **29** (289 mg, 92%) as colorless amorphous; IR (neat) 3460, 3208, 2979, 2595, 1709, 1357 cm^{-1}; ^1H NMR (300 MHz, CD_3OD) δ 7.71 (d, *J* = 8.4 Hz, 2H), 7.36 (dt, *J* = 2.7, 1.8 Hz, 1H), 7.27 (d, *J* = 8.4 Hz, 2H), 5.78 (dd, *J* = 17.4, 10.8 Hz, 1H), 5.37 (d, *J* = 17.4 Hz, 1H), 5.22 (d, *J* = 10.8 Hz, 1H), 4.00 (dt, *J* = 15.3, 1.8 Hz, 1H), 3.83 (br d, *J* = 15.3 Hz, 1H), 3.40-3.47 (m, 1H), 2.89 (dd, *J* = 15.3, 7.2 Hz, 1H), 2.45 (dd, *J* = 15.3, 3.6 Hz, 1H), 2.33 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 204.9, 172.7, 159.6, 148.1, 147.0, 137.1, 135.5, 130.7, 130.4, 119.4, 71.2, 57.5, 46.1, 37.1, 21.9; HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{17}H_{18}N_2O_5S+H]^+$ 363.1014, found 363.1008

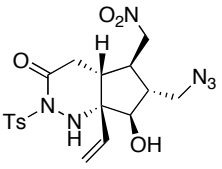
7-hydroxy-6-(hydroxymethyl)-5-(nitromethyl)-2-tosyl-7a-vinyl hexahydro-1*H*-cyclopenta[*c*]pyridazin-3(2*H*)-one (31)



To a solution of **29** (229 mg, 0.63 mmol) in nitromethane (12.6 mL) was added tetramethylguanidine (33 μL, 0.27 mmol) at 0 °C. The mixture was stirred for 3.5 h, quenched with sat. 1 M HCl, and extracted with ethyl acetate (30 mL x 3). The combined organic layers were washed with sat. $NaHCO_3$ and brine, dried over anhydrous $MgSO_4$, filtered, and concentrated under reduced pressure to give crude **30**. The solution of crude **30** in methanol (5 mL) was added a solution of $NaBH_4$ (19.0 mg, 0.5 mmol) in methanol (1.3 mL) at -78 °C. The mixture was stirred for 30 min, quenched with sat. NH_4Cl, and extracted with ethyl acetate (20 mL x 3). The combined organic layers were dried over anhydrous $MgSO_4$, filtered, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (elution with dichloromethane/methanol = 20/1) to give **31** (132 mg, 49% from **29**) as colorless amorphous. IR (neat) 3487, 3289, 2922, 2253, 1715, 1550, 1361, 1169 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 5.97 (dd, *J* = 17.6, 10.8 Hz, 1H), 5.33 (d, *J* = 10.8 Hz, 1H), 5.25 (d, *J* = 17.6 Hz, 1H), 5.03 (s, 1H), 4.62 (dd, *J* = 12.4, 4.0 Hz, 1H), 4.43 (dd, *J* = 12.4, 7.2 Hz, 1H), 4.08 (d, *J* = 10.8 Hz, 1H), 3.96 (br s, 1H), 3.82 (br d, *J* = 9.2 Hz, 1H), 3.76 (br d, *J* = 9.2 Hz, 1H), 3.30 (br s, 1H), 2.52-2.65 (m, 2H), 2.49 (dd, *J* = 16.8, 8.0 Hz, 1H), 2.42 (s, 3H), 2.18-2.32 (m,

1H), 1.65-1.76 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 145.8, 136.6, 134.4, 129.6, 129.0, 118.7, 76.6, 75.4, 69.4, 59.5, 46.6, 42.2, 39.3, 36.8, 21.7; HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{18}H_{23}N_3O_7S+H]^+$ 426.1335, found 426.1338.

6-(azidomethyl)-7-hydroxy-5-(nitromethyl)-2-tosyl-7a-vinylhexa hydro-1*H*-cyclopenta[*c*]pyridazin-3(2*H*)-one (32)

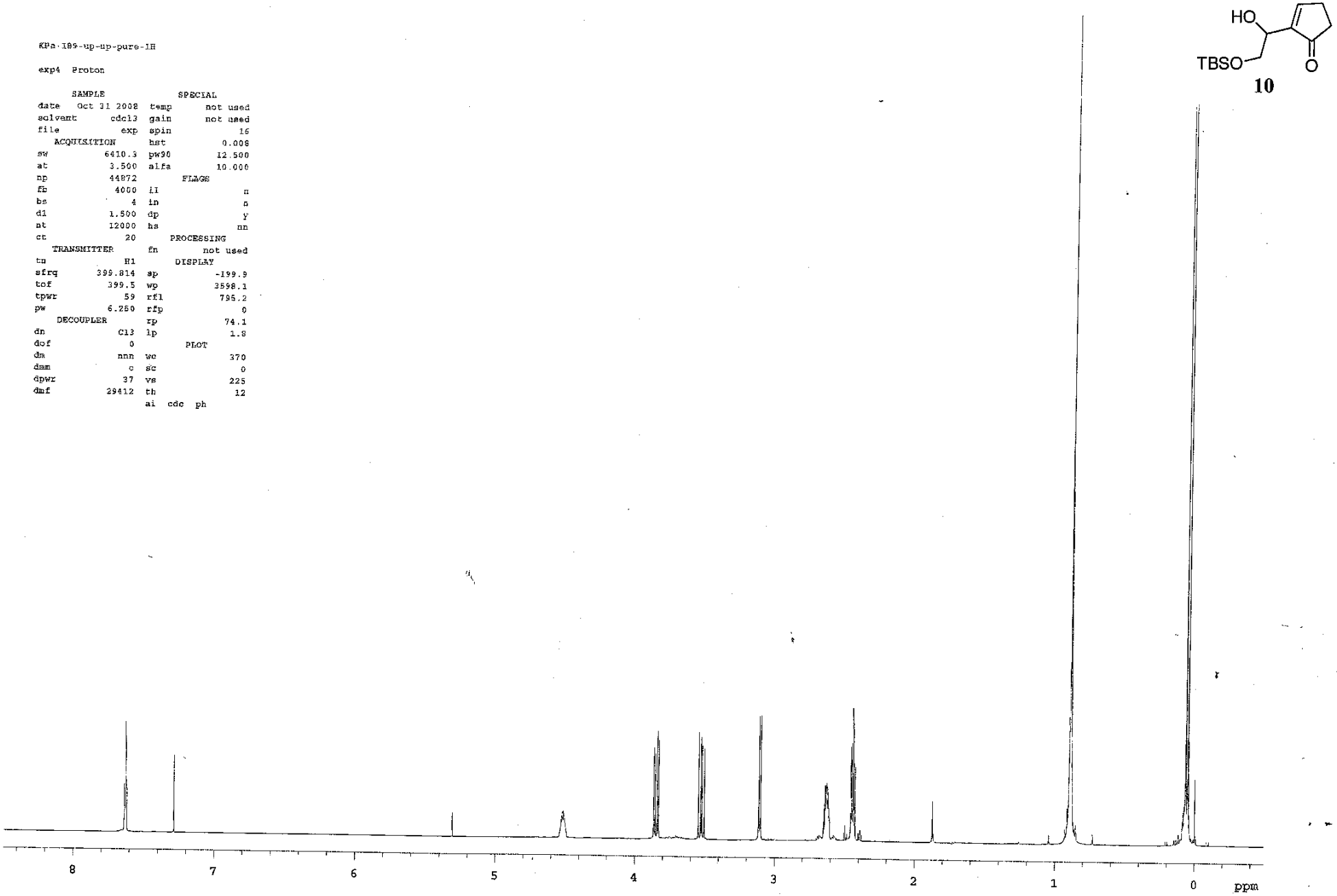


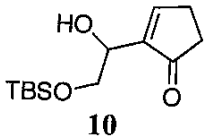
To a solution of **31** (22.4 mg, 0.053 mmol) in pyridine (0.27 mL) was added methanesufonylchloride (9.0 mg, 0.079 mmol) at 0 °C. The mixture was stirred for 45 min at room temperature, quenched with sat. $NaHCO_3$, and extracted with ethyl acetate (20 mL x 2). The combined organic layers were dried over anhydrous $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was filtered through silica gel pad (elution with dichloromethane/methanol = 9/1) and concentrated under reduced pressure. The solution of residue in DMF (0.57 mL) was added sodium azide (7.2 mg, 0.11 mmol) at room temperature. The mixture was heated to 60 °C for 3 h, diluted with ethyl acetate (5 mL), filtered, and washed with sat. $NaHCO_3$. The aqueous layer was extracted with ethyl acetate (20 mL x 3). The combined organic layers were dried over anhydrous $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography of silica gel (elution with hexane/ethyl acetate = 1/1) to give **32** (16 mg, 67% from **31**) as colorless crystal. mp 151 °C (from dichloromethane-diethyl ether); IR (neat) 3489, 3289, 2924, 2104, 1715, 1555, 1366, 1276, 1174cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.94 (d, J = 8.1 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 5.96 (dd, *J* = 17.4, 11.1 Hz, 1H), 5.43 (d, *J* = 11.1 Hz, 1H), 5.33 (d, *J* = 17.4 Hz, 1H), 4.66 (s, 1H), 4.58 (dd, *J* = 12.3, 4.2 Hz, 1H), 4.41 (dd, *J* = 12.3, 6.6 Hz, 1H), 3.85 (d, *J* = 10.8 Hz, 1H), 3.63 (dd, *J* = 12.9, 3.3 Hz, 1H), 3.54 (dd, *J* = 12.9, 5.1 Hz, 1H), 2.57-2.69 (m, 2H), 2.45 (s, 3H), 2.42-2.48 (m, 1H), 1.95-2.10 (m, 1H), 1.74 (tdd, *J* = 11.4, 5.1, 3.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.5, 145.8, 135.8, 134.4, 129.6, 129.0, 118.8, 75.9, 75.1, 68.7, 49.5, 43.7, 42.1, 40.2, 36.3, 21.8; HRMS (CI) m/z $(M+H)^+$ calcd for $[C_{18}H_{22}N_6O_6S+H]^+$ 451.1400, found 451.1403.

KPa-189-up-up-pure-1H

exp4 Proton

SAMPLE		SPECIAL	
date	Oct 31 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.560	alfa	10.000
np	44872	FLAGS	
fb	4000	il	n
bs	4	in	n
d1	1.500	dp	y
nt	12000	hs	nn
ct	20	PROCESSING	
TRANSMITTER		fn	not used
tn	H1	DISPLAY	
sfrq	399.814	sp	-199.9
tof	399.5	wp	3598.1
tpwr	59	rfl	795.2
pw	6.250	rfp	0
DECOUPLER		rp	74.1
dn	C13	lp	1.8
dof	0	PLOT	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	225
dmf	29412	th	12
		ai cdc ph	



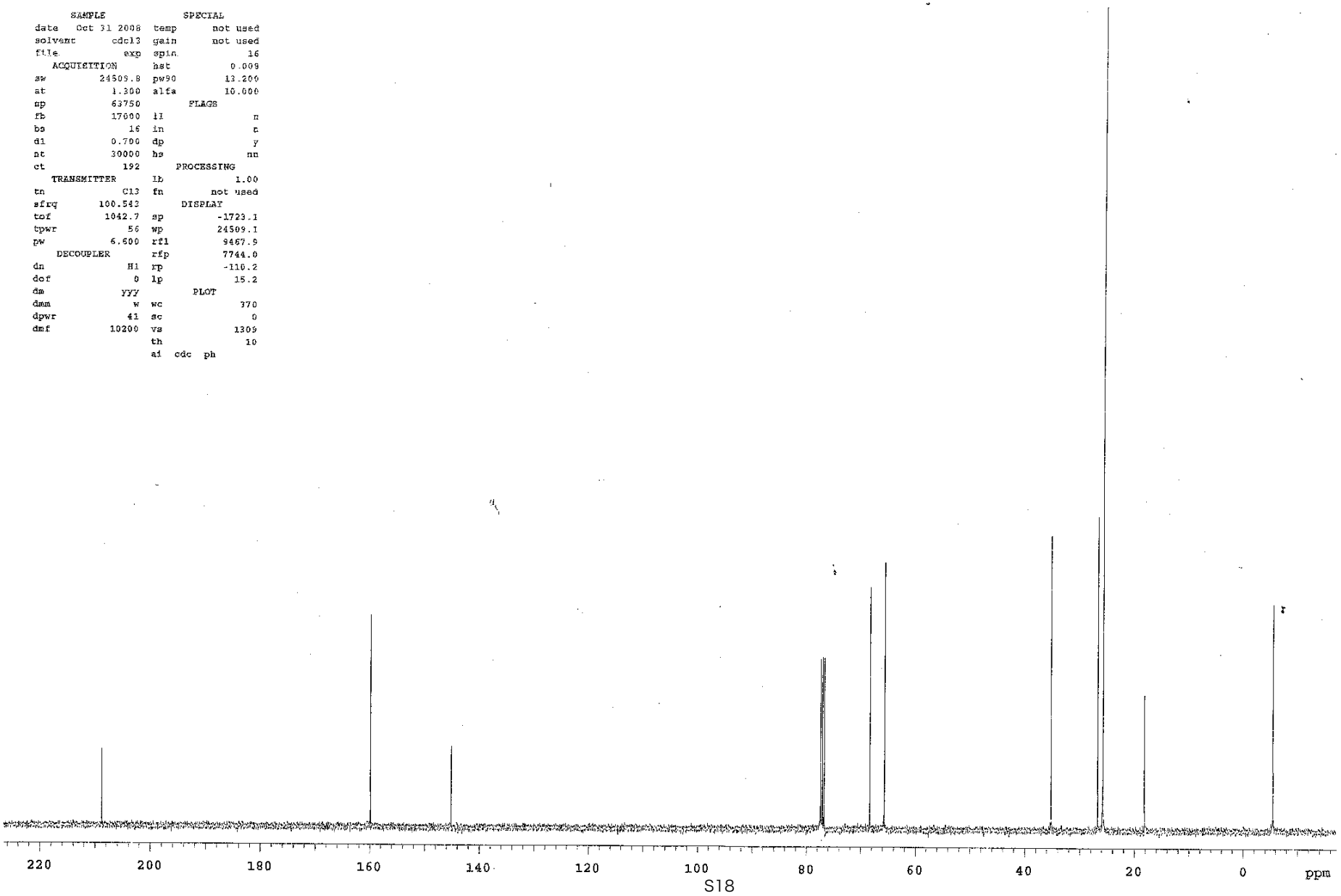


10

KPa-189-up-up-pure-13C

exp5 Carbon

SAMPLE		SPECIAL	
date	Oct 31 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.009
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17000	il	n
bs	16	in	n
d1	0.700	dp	y
nt	30000	hs	nn
ct	192	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-1723.1
tpwr	56	wp	24509.1
pw	6.600	rf1	9467.9
DECOUPLER		rfp	7744.0
dn	H1	rp	-110.2
dof	0	lp	15.2
dm	yyy	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	1309
		th	10
		ai	cdc ph

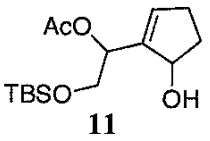


KPa-373-down-1H

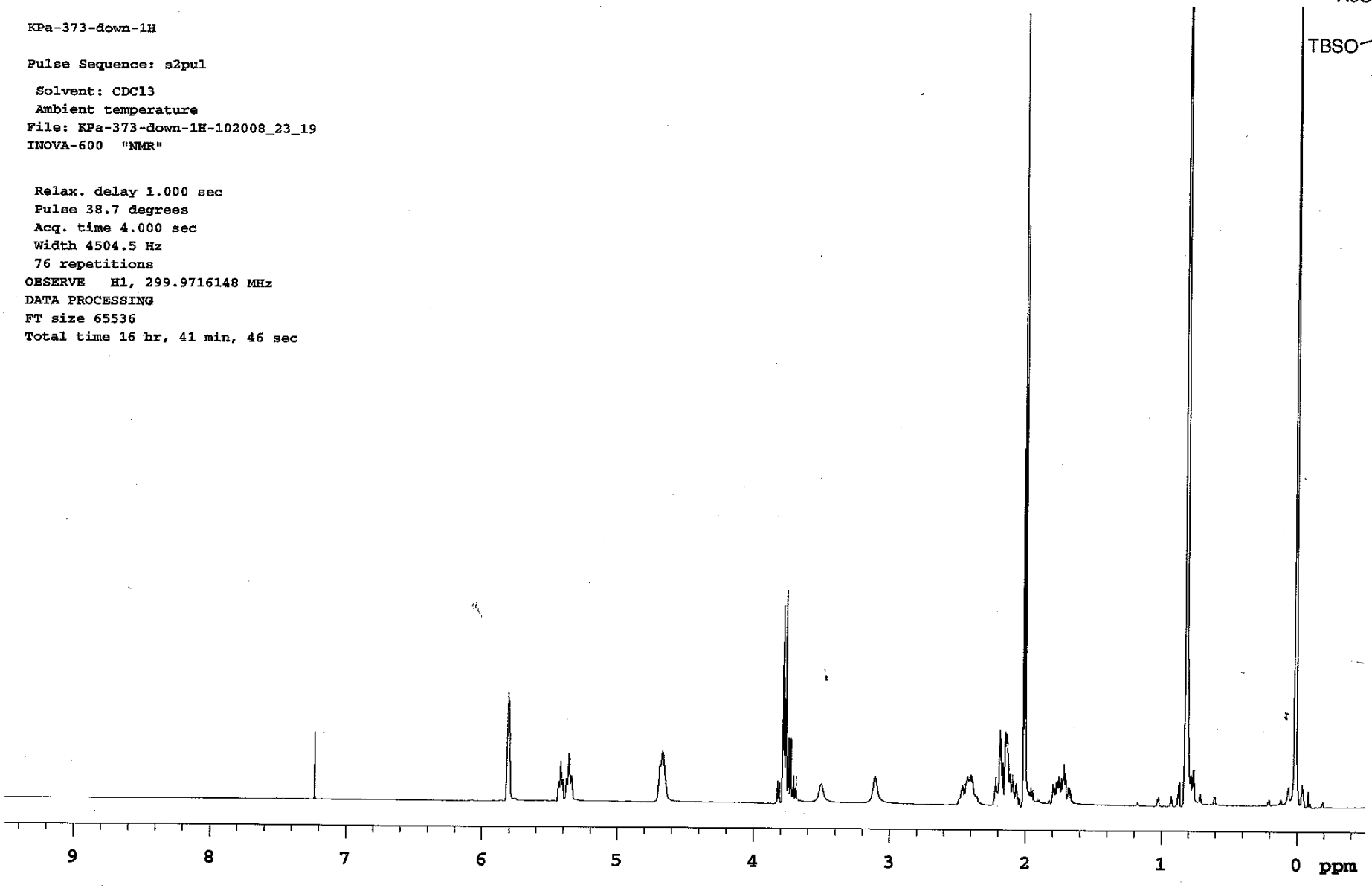
Pulse Sequence: s2pul

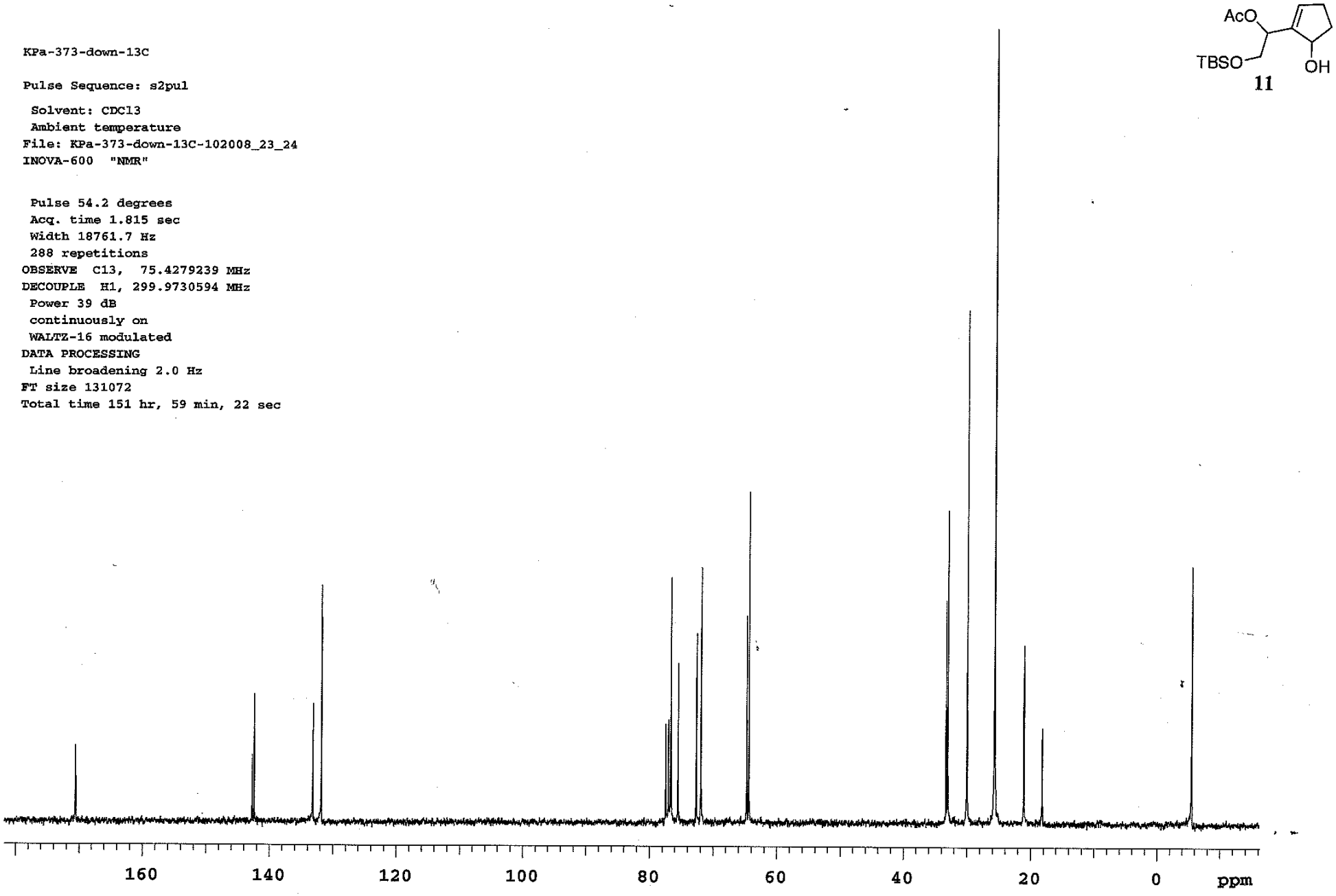
Solvent: CDCl3
Ambient temperature
File: KPa-373-down-1H-102008_23_19
INOVA-600 "NMR"

Relax. delay 1.000 sec
Pulse 38.7 degrees
Acq. time 4.000 sec
Width 4504.5 Hz
76 repetitions
OBSERVE H1, 299.9716148 MHz
DATA PROCESSING
FT size 65536
Total time 16 hr, 41 min, 46 sec



11

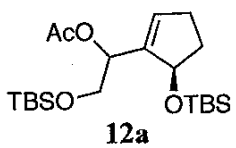



KPa-373-down-13C
Pulse Sequence: s2pul
Solvent: CDCl3
Ambient temperature
File: KPa-373-down-13C-102008_23_24
INOVA-600 "NMR"
Pulse 54.2 degrees
Acq. time 1.815 sec
Width 18761.7 Hz
288 repetitions
OBSERVE C13, 75.4279239 MHz
DECOUPLE H1, 299.9730594 MHz
Power 39 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 2.0 Hz
FT size 131072
Total time 151 hr, 59 min, 22 sec
AcO
TBSO
OH
11
160
140
120
100
80
60
40
20
0
ppm

Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.500 sec
Pulse 31.3 degrees
Acq. time 3.555 sec
Width 4500.5 Hz
32 repetitions
OBSERVE H1, 300.1944050 MHz
DATA PROCESSING
FT size 32768
Total time 2 minutes



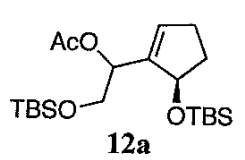
12a

13C OBSERVE

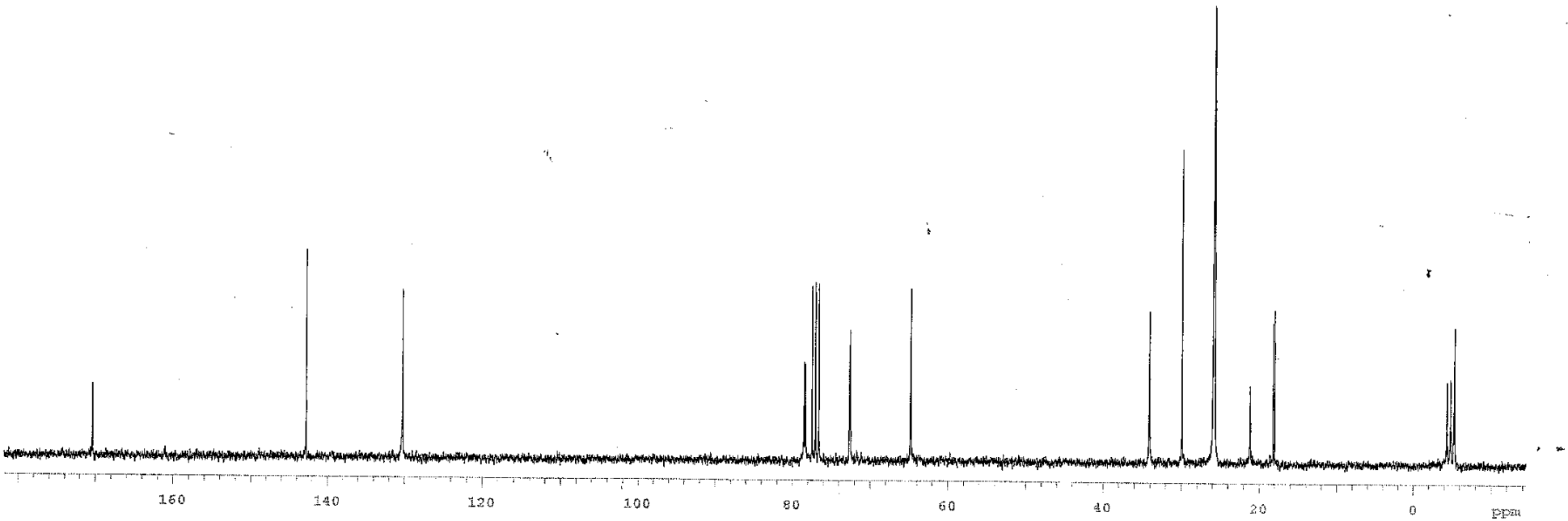
Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.294 sec
Pulse 40.0 degrees
Acq. time 1.705 sec
Width 18863.2 Hz
464 repetitions
OBSERVE C13, 75.4839403 MHz
DECOUPLE H1, 300.1958432 MHz
Power 38 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 65536
Total time 15 minutes



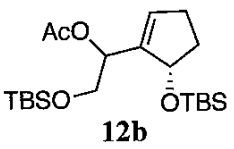
12a



Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.500 sec
Pulse 31.3 degrees
Acq. time 3.555 sec
Width 4500.5 Hz
36 repetitions
OBSERVE H1, 300.1944053 MHz
DATA PROCESSING
FT size 32768
Total time 2 minutes



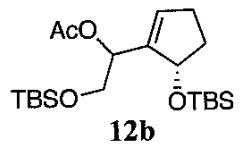
12b

13C OBSERVE

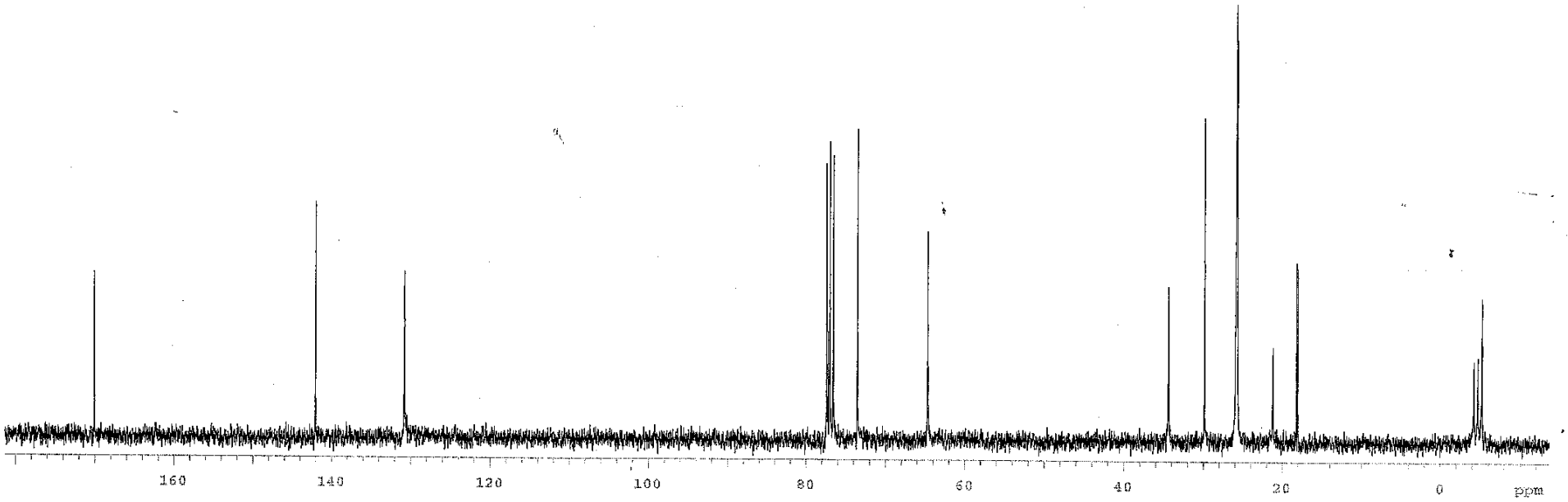
Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.294 sec
Pulse 40.0 degrees
Acq. time 1.705 sec
Width 18863.2 Hz
280 repetitions
OBSERVE C13, 75.4839403 MHz
DECOUPLE H1, 300.1958432 MHz
Power 38 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 65536
Total time 9 minutes



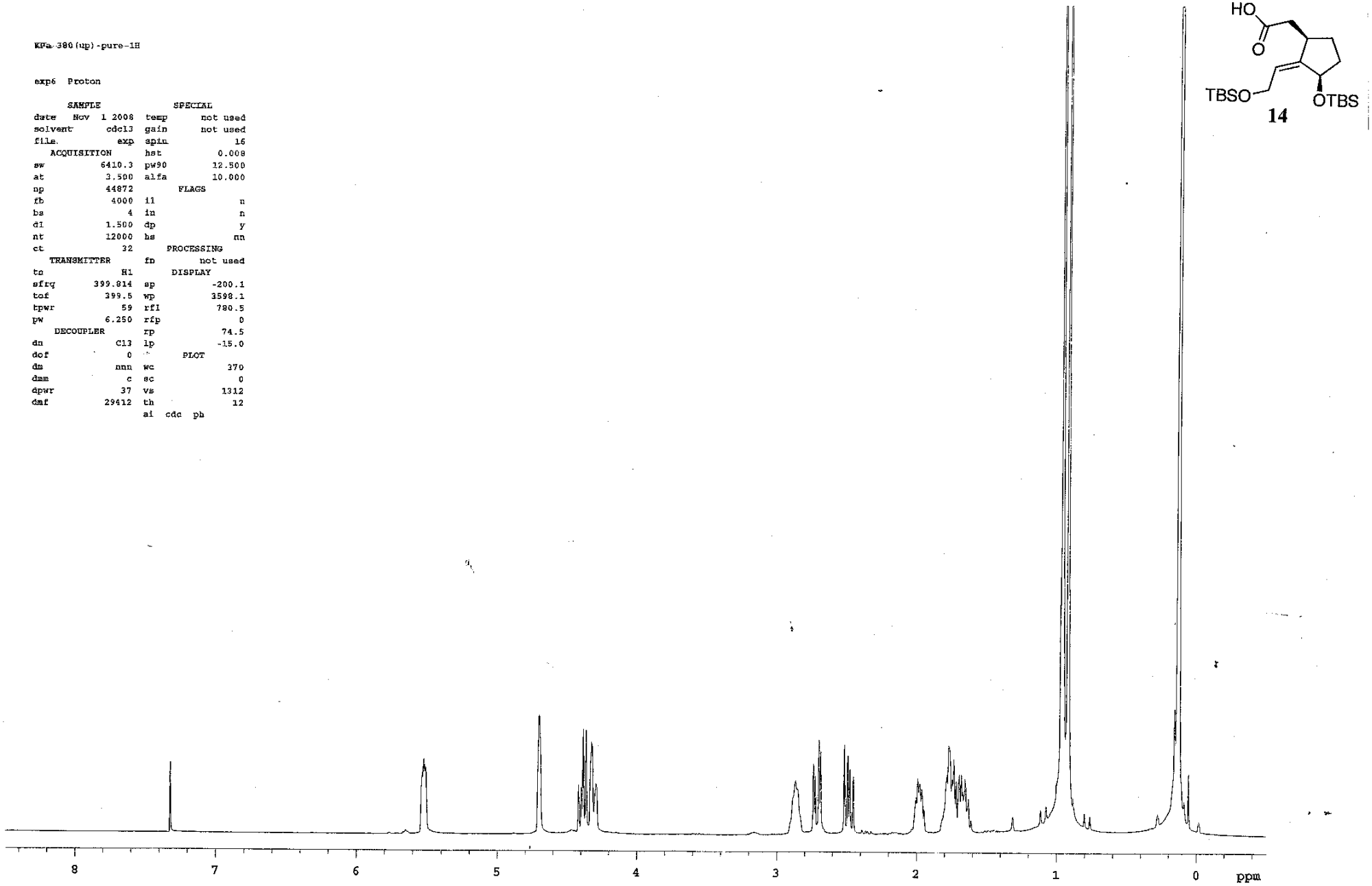
12b

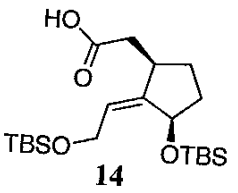


KFa-380(up)-pure-1H

exp6 Proton

SAMPLE		SPECIAL	
date	Nov 1 2006	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.500	alfa	10.000
np	44872	**FLAGS**	
fb	4000	il	n
bs	4	in	n
d1	1.500	dp	y
nt	12000	hs	nn
ct	32	**PROCESSING**	
TRANSMITTER		fn	not used
tn	H1	**DISPLAY**	
sfrq	399.814	sp	-200.1
tof	399.5	wp	3598.1
tpwr	59	rfl	780.5
pw	6.250	rfp	0
DECOUPLER		rp	74.5
dn	C13	lp	-15.0
dof	0	**PLOT**	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	1312
dmf	29412	th	12
		al cdc ph	



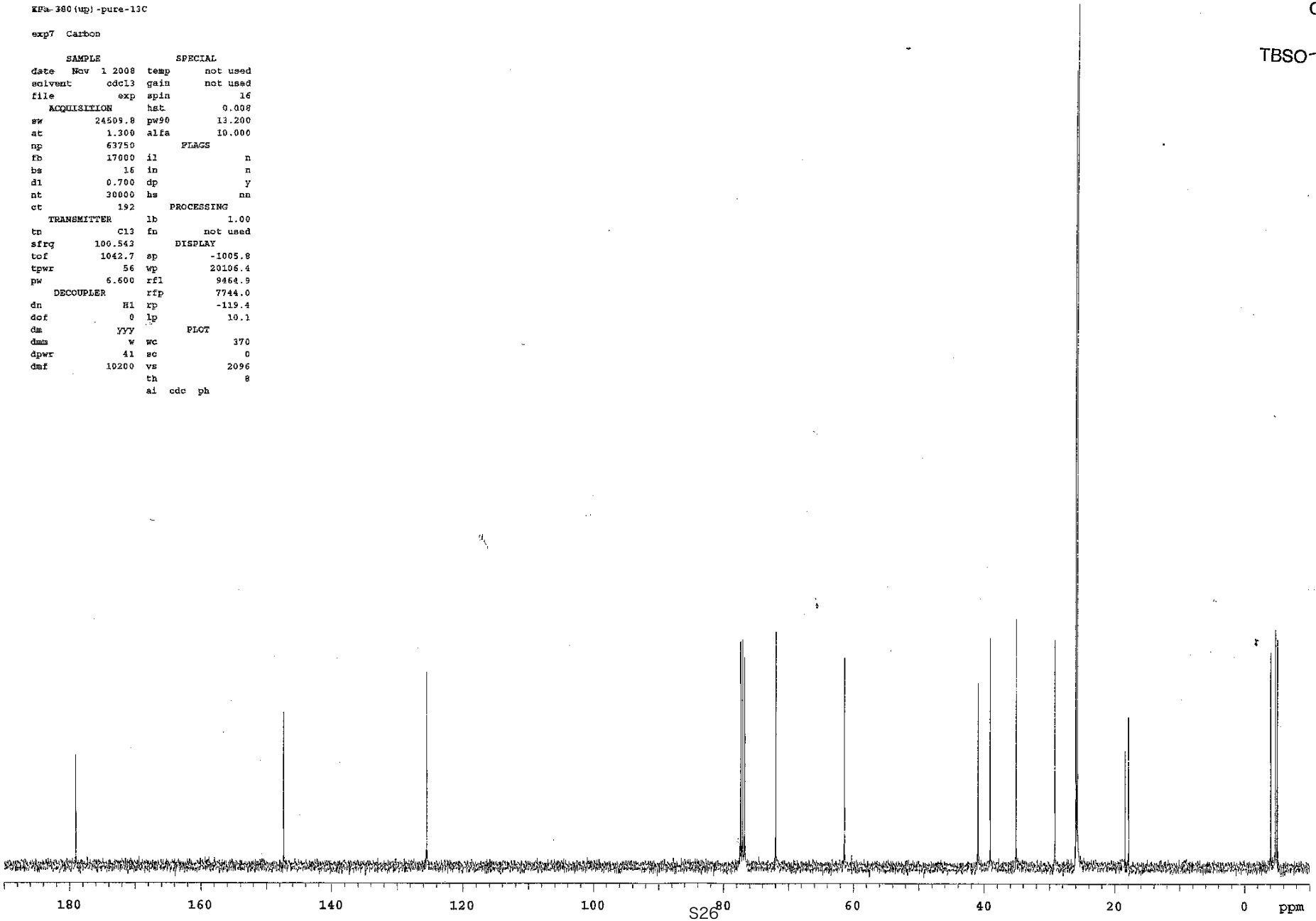


14

KPa-380(up)-pure-13C

exp7 Carbon

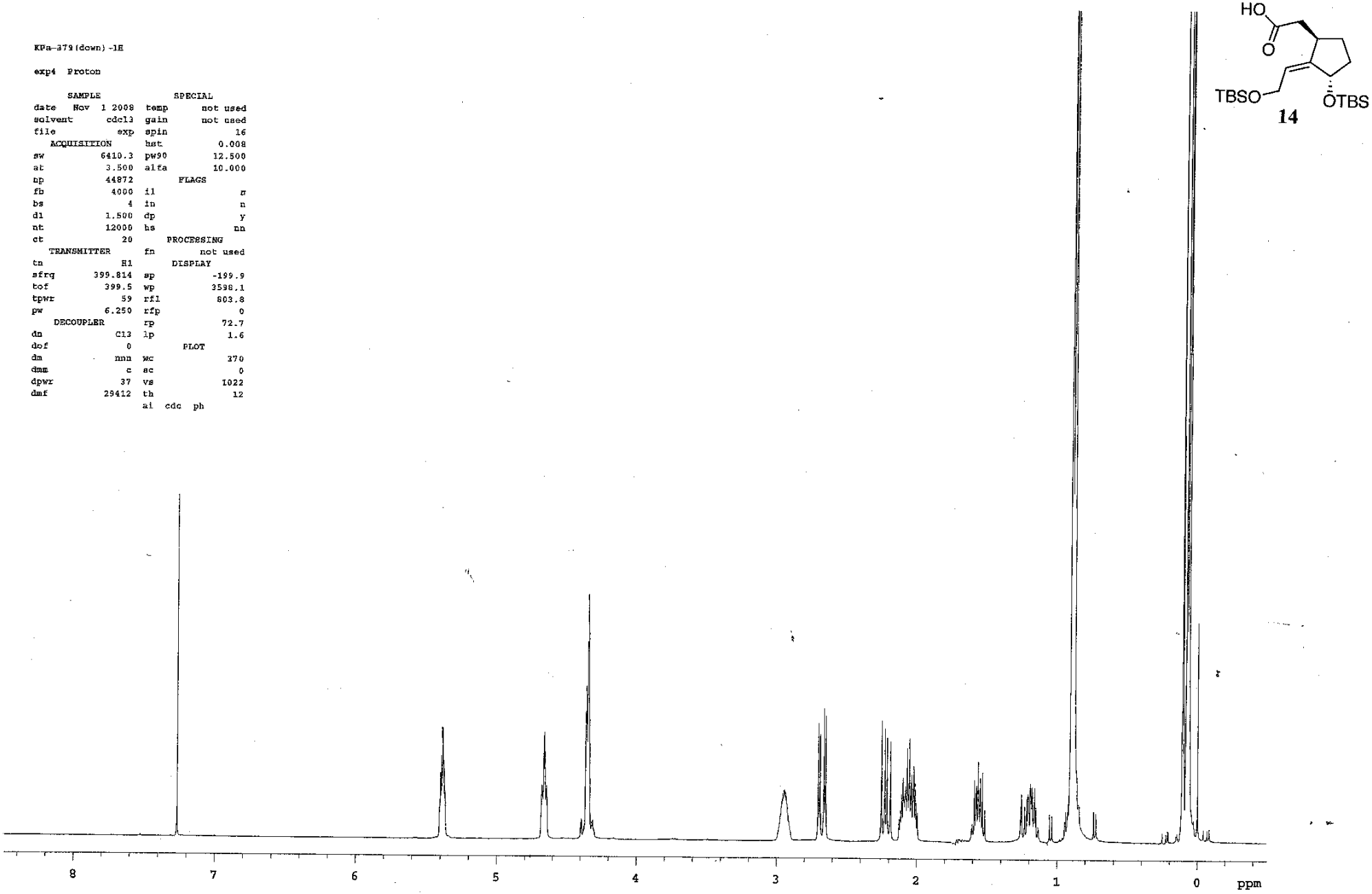
SAMPLE		SPECIAL	
date	Nov 1 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17000	il	n
bs	16	in	n
d1	0.700	dp	y
nt	30000	hs	nn
ct	192	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-1005.8
tpwr	56	wp	20106.4
pw	6.600	rfl	9464.9
DECOUPLER		rfp	7744.0
dn	H1	rp	-119.4
dof	0	lp	10.1
dm	yyy	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	2096
		th	8
		ai cdc ph	



KPa-379(down) -1E

exp4 Proton

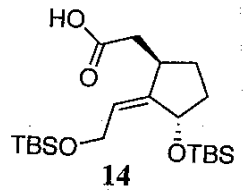
SAMPLE		SPECIAL	
date	Nov 1 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.500	alfa	10.000
np	44872	FLAGS	
fb	4000	il	n
bs	4	in	n
d1	1.500	dp	y
nt	12000	hs	nn
ct	20	PROCESSING	
TRANSMITTER		fn	not used
tn	H1	DISPLAY	
sfrq	399.814	sp	-199.9
tof	399.5	wp	3598.1
tpwr	59	rfl	803.8
pw	6.250	rfp	0
DECOUPLER		rp	72.7
dn	C13	lp	1.6
dof	0	PLOT	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	1022
dmf	29412	th	12
		ai cdc ph	



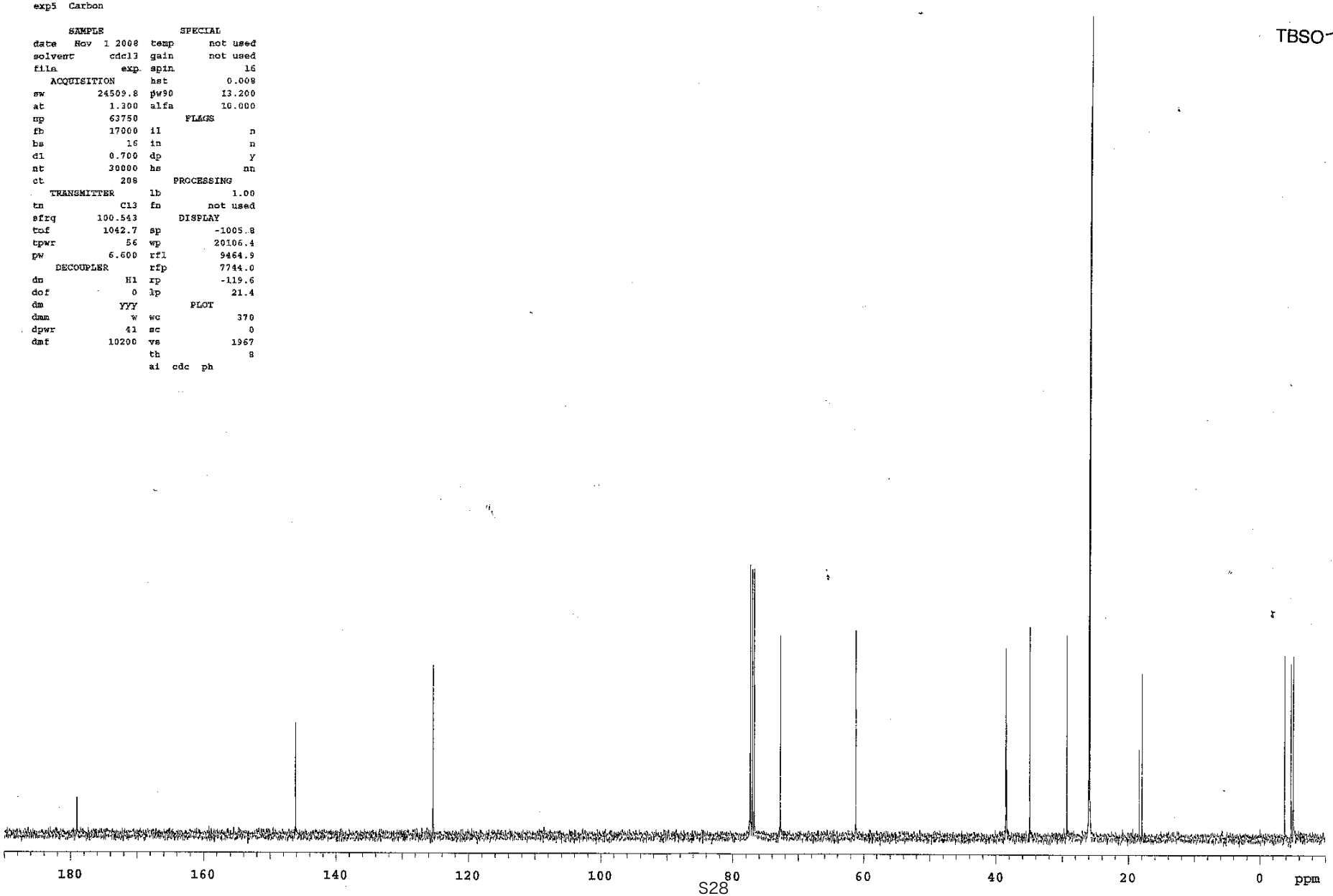
KFa-379(down)-13C

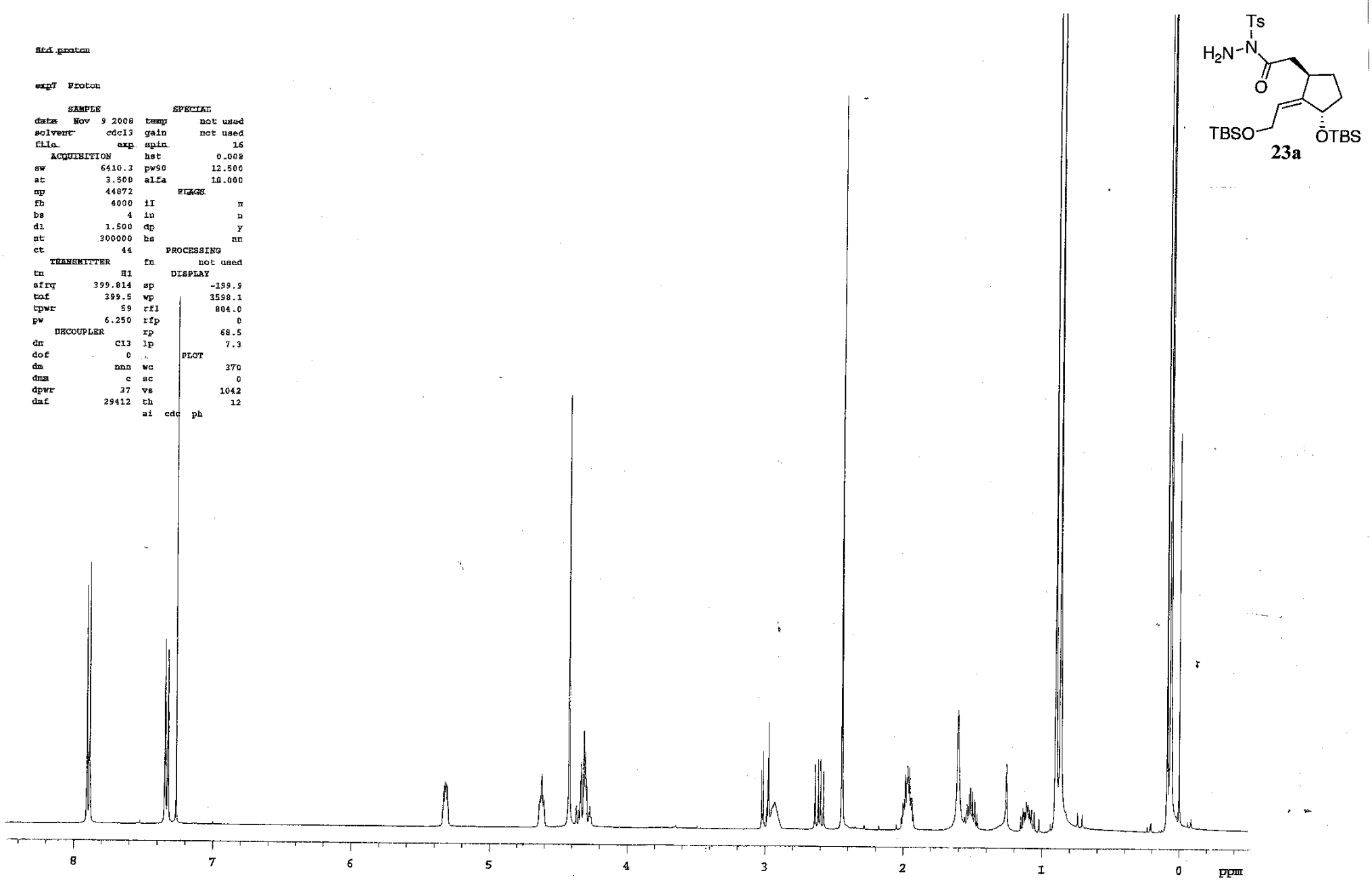
exp5 Carbon

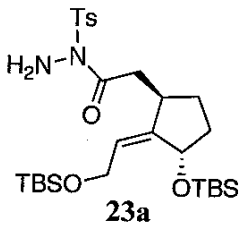
SAMPLE		SPECIAL	
date	Nov 1 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17000	il	n
bs	16	in	n
d1	0.700	dp	y
nt	30000	hs	nn
ct	208	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-1005.8
tpwr	56	wp	20106.4
pw	6.600	rfl	9464.9
DECOUPLER		rfp	7744.0
dn	H1	rp	-119.6
dof	0	lp	21.4
dm	YYY	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	1967
		th	8
		ai	cdc ph



14




std proton
exp7 Proton
SAMPLE
date Nov 9 2008
solvent cdcl3
file exp
ACQUISITION
sw 6410.3
at 3.500
np 44872
fb 4000
bs 4
d1 1.500
nt 300000
ct 44
TRANSMITTER
tn H1
sfrq 399.814
tof 399.5
tpwr 59
pw 6.250
DECOUPLER
dn C13
dof 0
dm nnn
dmm c
dpwr 37
dmf 29412
SPECIAL
temp not used
gain not used
spin 16
hst 0.008
pw90 12.500
alfa 10.000
FLAGS
il n
in n
dp y
hs nn
PROCESSING
fn not used
DISPLAY
sp -199.9
wp 3598.1
rfl 804.0
rfp 0
rp 68.5
lp 7.3
PLOT
wc 370
sc 0
vs 1042
th 12
ai cdc ph
Ts
H2N-N
O
TBSO
OTBS
23a
8
7
6
5
4
3
2
1
0
ppm

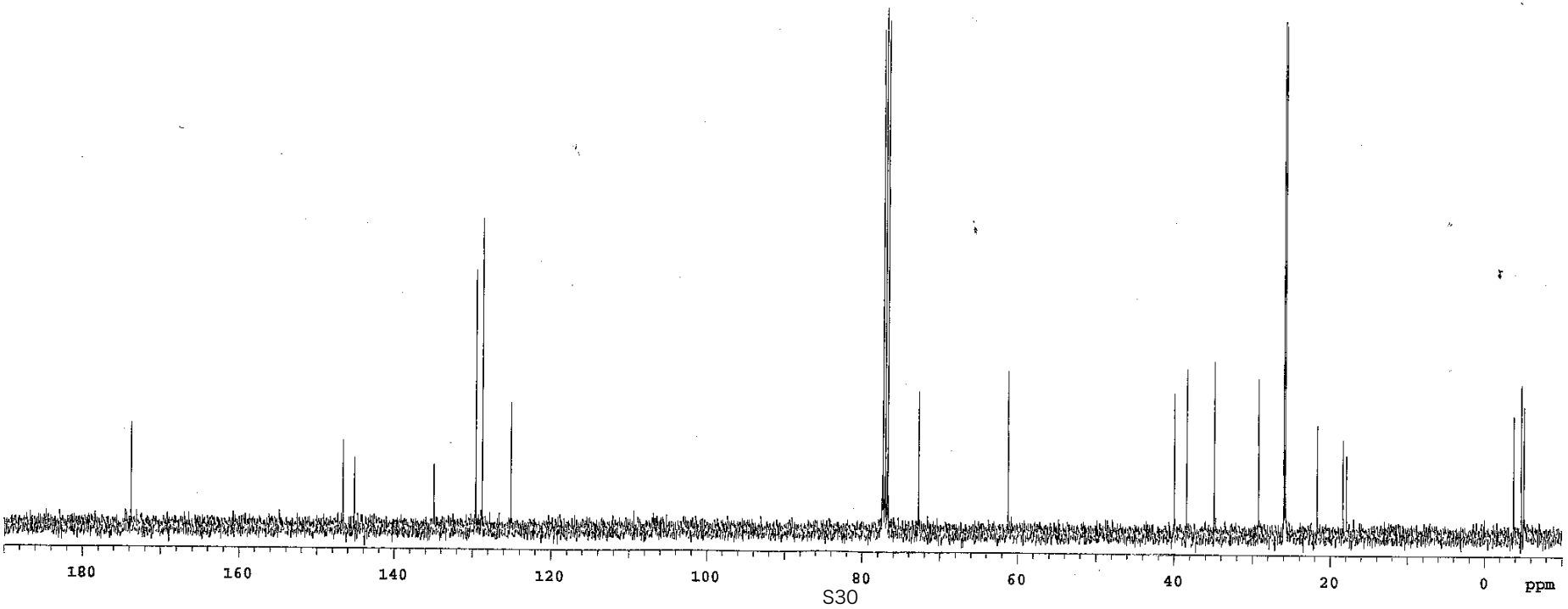


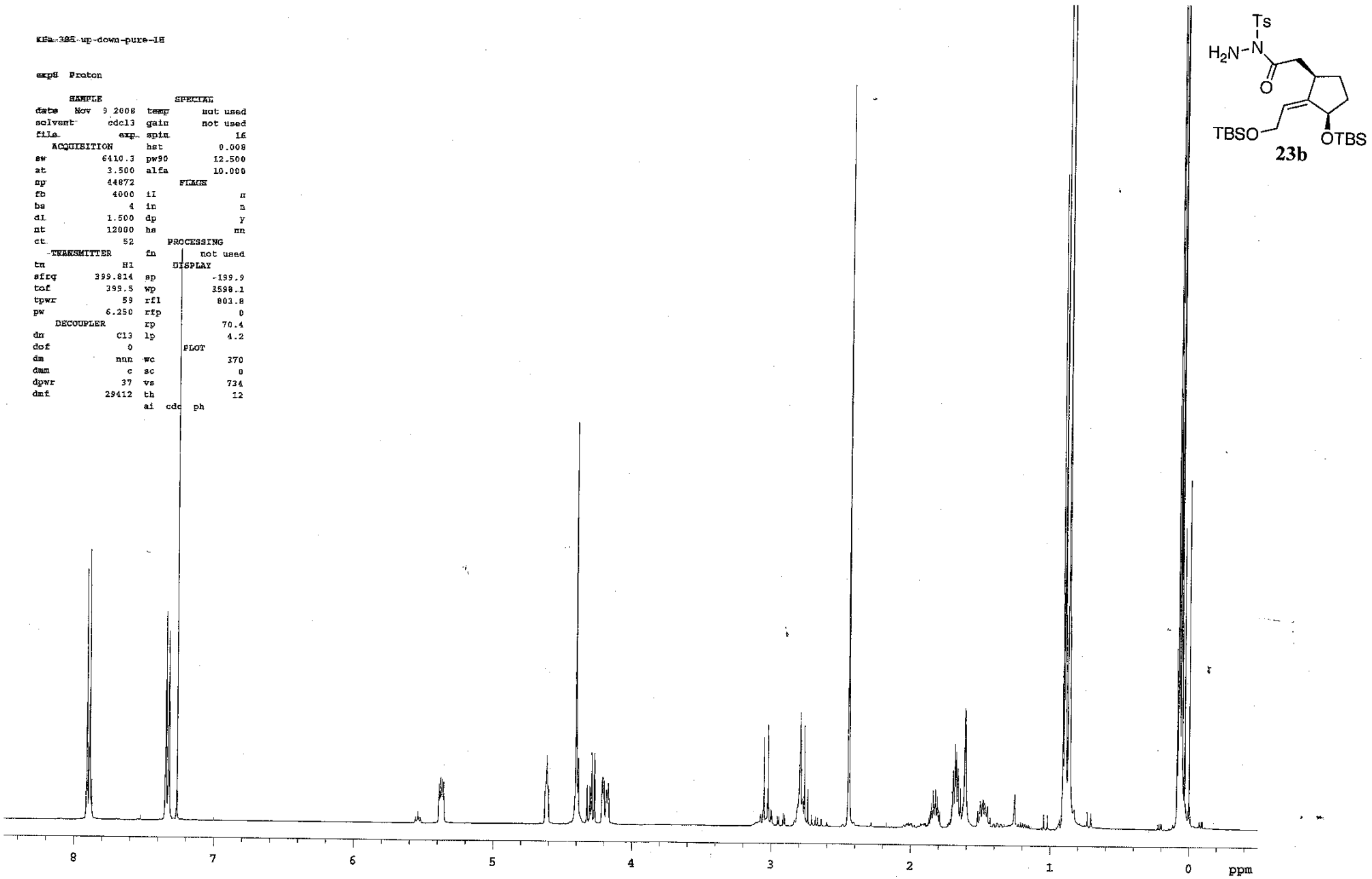
23a

~~RFa-386-down-down~~

~~exp1~~ Carbon

SAMPLE		SPECIAL	
~~date~~	Nov 7 2008	~~temp~~	not used
~~solvent~~	cdcl3	~~gain~~	not used
~~file~~	~~exp~~	~~spin~~	16
ACQUISITION		~~hst~~	0.008
~~sw~~	24509.8	~~pw90~~	13.200
~~at~~	1.300	~~alfa~~	10.000
~~np~~	63750	FLAGS	
~~fb~~	17600	~~ii~~	n
~~bs~~	16	~~in~~	n
~~dl~~	0.700	~~dp~~	y
~~nt~~	30000	~~hs~~	nn
~~ct~~	272	PROCESSING	
TRANSMITTER		~~lb~~	1.00
~~tn~~	C13	~~fn~~	not used
~~sfrq~~	100.543	DISPLAY	
~~tof~~	1042.7	~~sp~~	-1005.8
~~tpwr~~	56	~~wp~~	20106.4
~~pw~~	6.600	~~rfl~~	9465.7
DECOUPLER		~~rfp~~	7744.0
~~dn~~	H1	~~rp~~	-135.2
~~dof~~	0	~~lp~~	62.5
~~dm~~	yyy	PLOT	
~~dmm~~	w	~~wc~~	370
~~dpwr~~	41	~~sc~~	0
~~dmf~~	10200	~~vs~~	3682
		~~th~~	11
		~~ai~~ cdc ph	

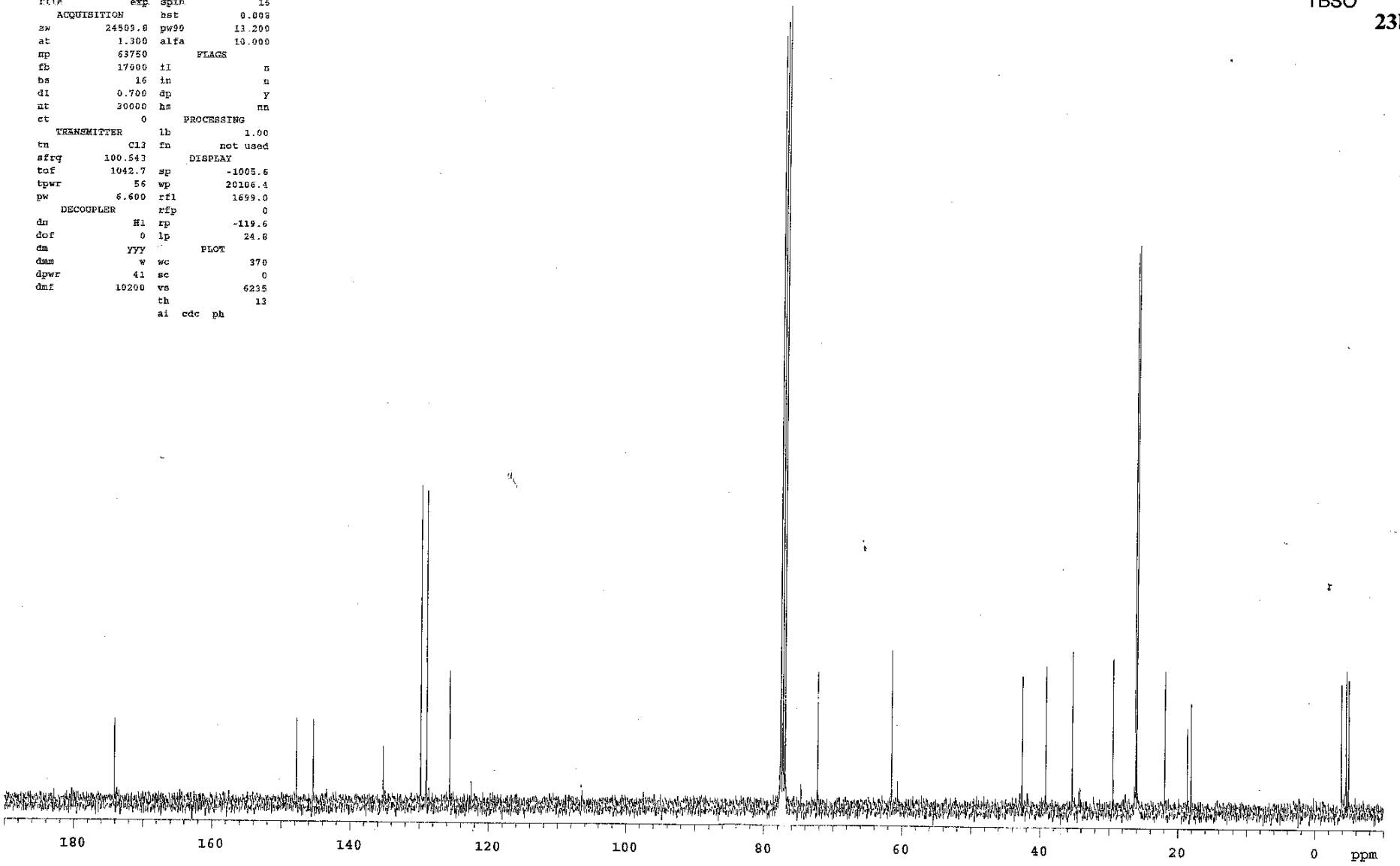


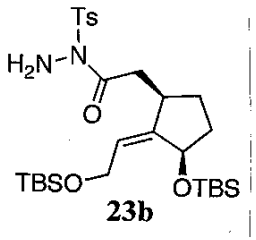

KBa-385-up-down-pure-1H
exp8 Proton
SAMPLE
date Nov 9 2008
solvent cdcl3
file exp
ACQUISITION
sw 6410.3
at 3.500
np 44872
fb 4000
bs 4
d1 1.500
nt 12000
ct 52
TRANSMITTER
tn H1
sfrq 399.814
tof 393.5
tpwr 59
pw 6.250
DECOUPLER
dn C13
dof 0
dm nnn
dmm c
dpwr 37
dmf 29412
SPECIAL
temp not used
gain not used
spin 16
hst 0.008
pw90 12.500
alfa 10.000
FLAGS
il n
in n
dp y
hs nn
PROCESSING
fn not used
DISPLAY
sp -199.9
wp 3598.1
rfl 803.8
rfp 0
rp 70.4
lp 4.2
PLOT
wc 370
sc 0
vs 734
th 12
ai cdc ph
8
7
6
5
4
3
2
1
0
ppm
Ts
H2N-N
O
TBSO
OTBS
23b

KPa 185 up-down

exp7 Carbon

SAMPLE		SPECIAL	
date	Nov 7 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17500	il	n
bs	16	in	n
dl	0.700	dp	y
nt	30000	hs	nn
ct	0	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-1005.6
tpwr	56	wp	20106.4
pw	6.600	rfl	1699.0
DECOUPLER		rfp	0
dn	H1	rp	-119.6
dof	0	lp	24.8
dm	yyy	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	6235
		th	13
		ai cdc ph	



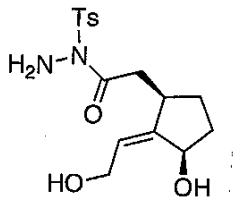


23b

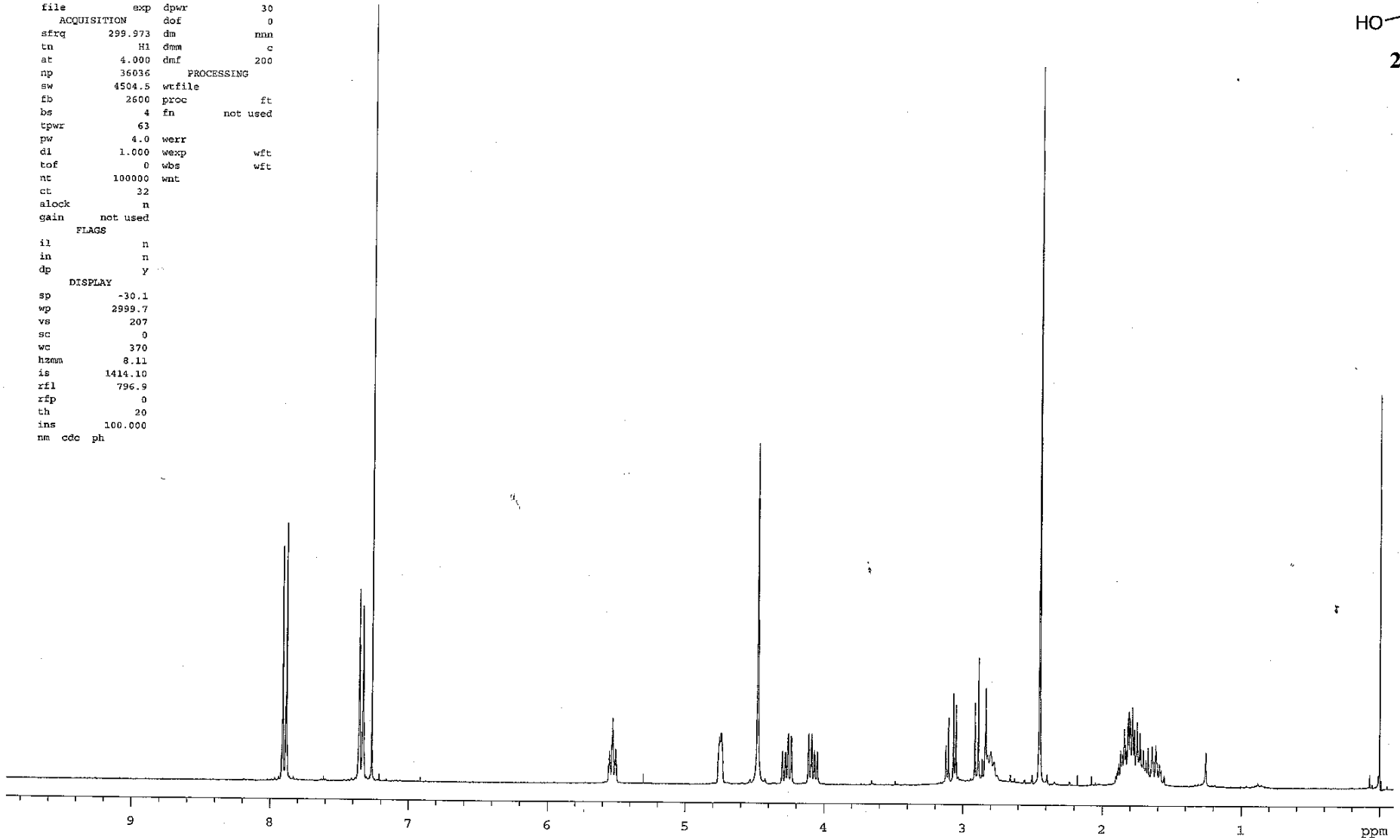
KPa-388-up-major-H

exp7 std1h

SAMPLE		DEC. & VT	
date	Nov 11 2008	dfrq	299.973
solvent	CDCl3	dn	H1
file	exp	dpwr	30
ACQUISITION		dof	0
sfrq	299.973	dm	nnn
tn	H1	dmm	c
at	4.000	dmf	200
np	36036	PROCESSING	
sw	4504.5	wrfile	
fb	2600	proc	ft
bs	4	fn	not used
tpwr	63		
pw	4.0	werr	
d1	1.000	wexp	wft
tof	0	wbs	wft
nt	100000	wnt	
ct	32		
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
DISPLAY			
sp	-30.1		
wp	2999.7		
vs	207		
sc	0		
wc	370		
hzmm	8.11		
is	1414.10		
rfl	796.9		
rfp	0		
th	20		
ins	100.000		
nm cdc ph			



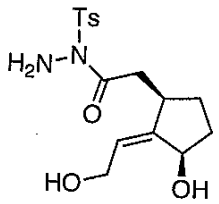
24a



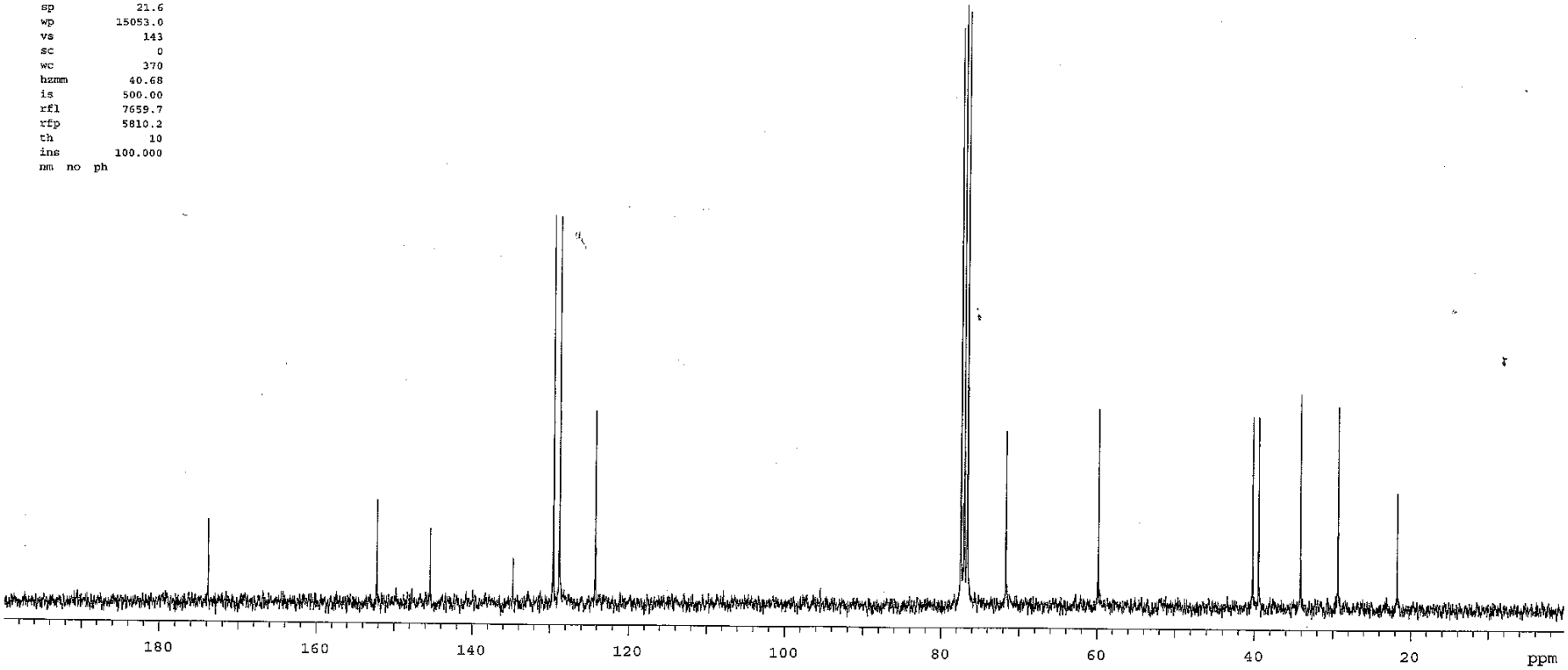
KPa-up-major-C

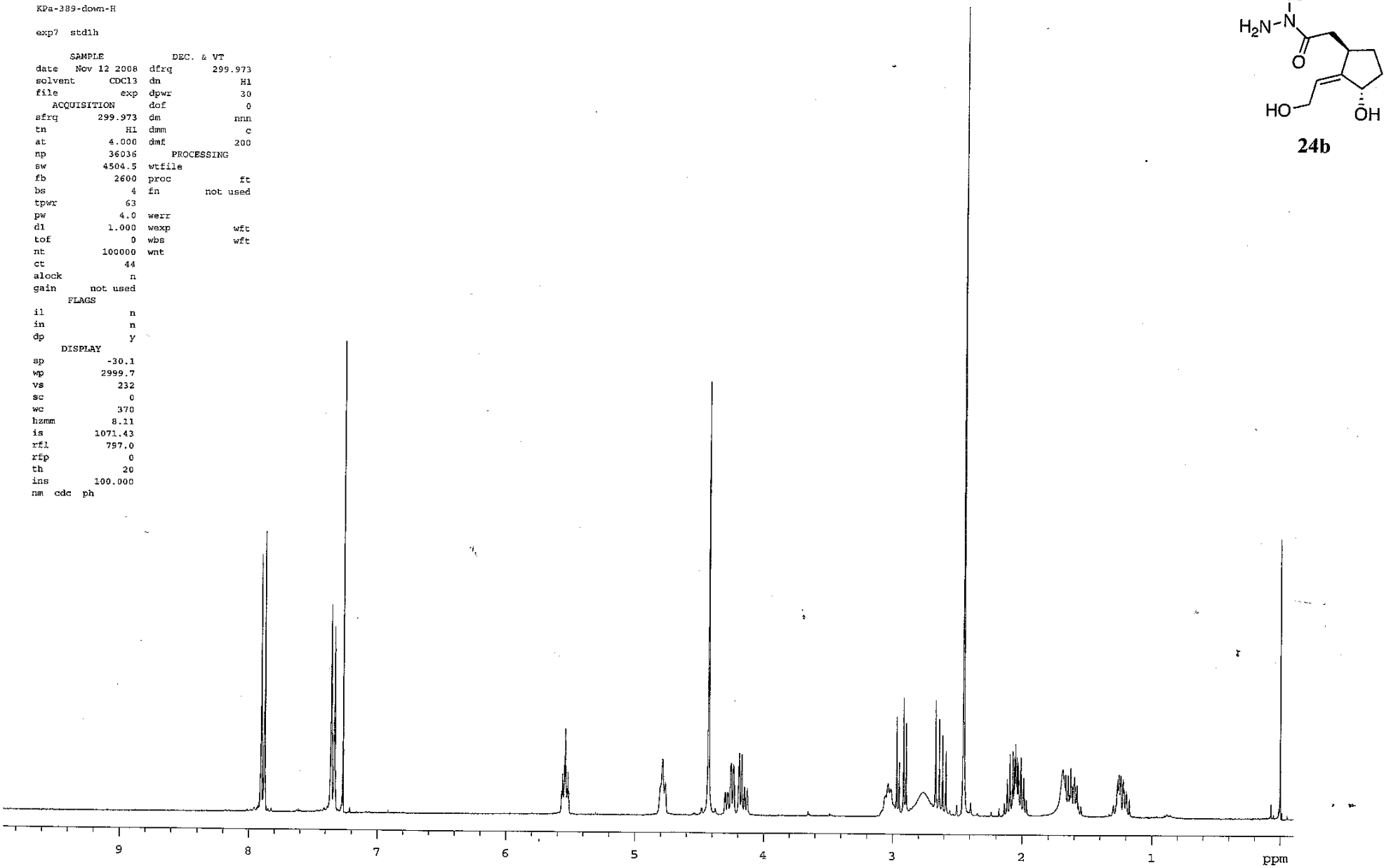
exp7 std13c

SAMPLE		DEC. & VT	
date	Nov 11 2008	dfrq	299.973
solvent	CDCl3	dn	H1
file	exp	dpwr	39
ACQUISITION		dof	0
sfrq	75.435	dm	yyy
tn	C13	dmm	w
at	1.815	dmf	11000
np	68106	PROCESSING	
sw	18761.7	lb	2.00
fb	10400	wtfile	
bs	16	proc	ft
tpwr	57	fn	not used
pw	8.7		
d1	0	werr	
tof	0	wexp	wft
nt	100000	wbs	wft
ct	2208	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
DISPLAY			
sp	21.6		
wp	15053.0		
vs	143		
sc	0		
wc	370		
hzmm	40.68		
is	500.00		
rfl	7659.7		
rfp	5810.2		
th	10		
ins	100.000		
nm no ph			



24a

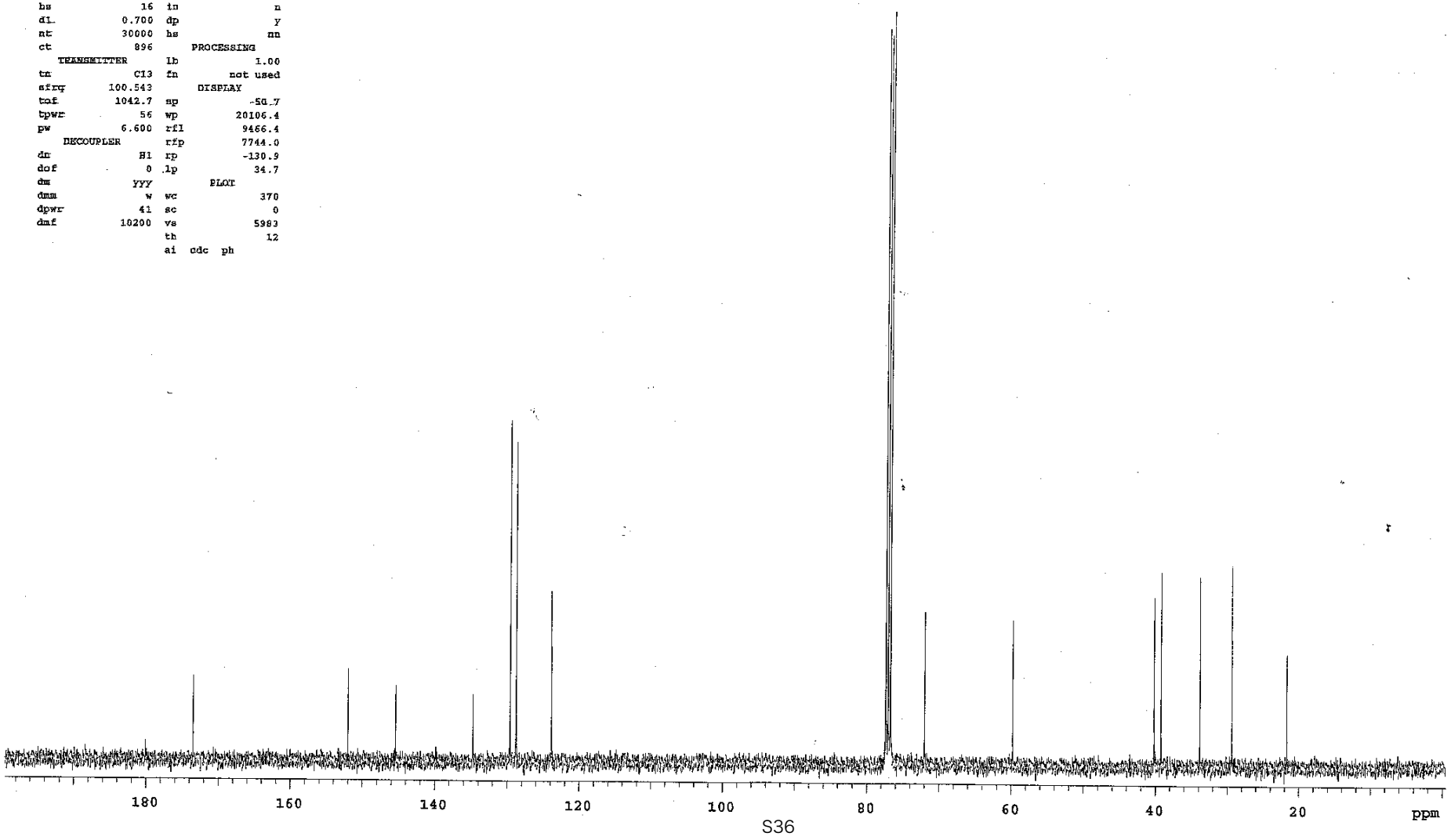


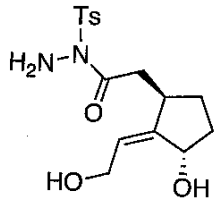

KPa-389-down-H
exp7 std1h
SAMPLE
date Nov 12 2008
solvent CDCl3
file exp
ACQUISITION
sfrq 299.973
tn H1
at 4.000
np 36036
sw 4504.5
fb 2600
bs 4
tpwr 63
pw 4.0
d1 1.000
tof 0
nt 100000
ct 44
alock n
gain not used
FLAGS
il n
in n
dp y
DISPLAY
sp -30.1
wp 2999.7
vs 232
sc 0
wc 370
hzmm 8.11
is 1071.43
rfl 797.0
rfp 0
th 20
ins 100.000
nm cdc ph
DEC. & VT
dfrq 299.973
dn H1
dpwr 30
dof 0
dm nnn
dmm c
dmf 200
PROCESSING
wtfile
proc ft
fn not used
werr
wexp wft
wbs wft
wnt
Ts
H2N-N
O
HO
OH
24b
9
8
7
6
5
4
3
2
1
ppm

KPA-185-13C

expl Carbon

SAMPLE		SPECIAL	
date	Nov 15 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17000	il	n
bs	16	in	n
dl	0.700	dp	y
nt	30000	hs	nn
ct	896	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-50.7
tpwr	56	wp	20106.4
pw	6.600	rfl	9466.4
DECOUPLER		rfp	7744.0
dn	H1	rp	-130.9
dof	0	lp	34.7
dm	YYY	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	5983
		th	12
		ai	cdc ph



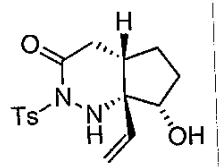


24b

KPa-360-up-1H-pure

exp1 Proton

SAMPLE		SPECIAL	
date	Oct 4 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.500	alfa	10.000
np	44872	FLAGS	
fb	4000	il	n
bs	4	in	n
d1	1.500	dp	y
nt	12000	hs	nn
ct	40	PROCESSING	
TRANSMITTER		fn	not used
tn	H1	DISPLAY	
sfrq	399.814	sp	-40.1
tof	399.5	wp	3998.0
tpwr	59	rfl	804.8
pw	6.250	rfp	0
DECOUPLER		rp	75.8
dn	C13	lp	5.0
dof	0	PLOT	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	459
dmf	29412	th	12
		ai cdc ph	

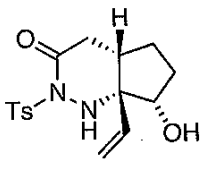


25α

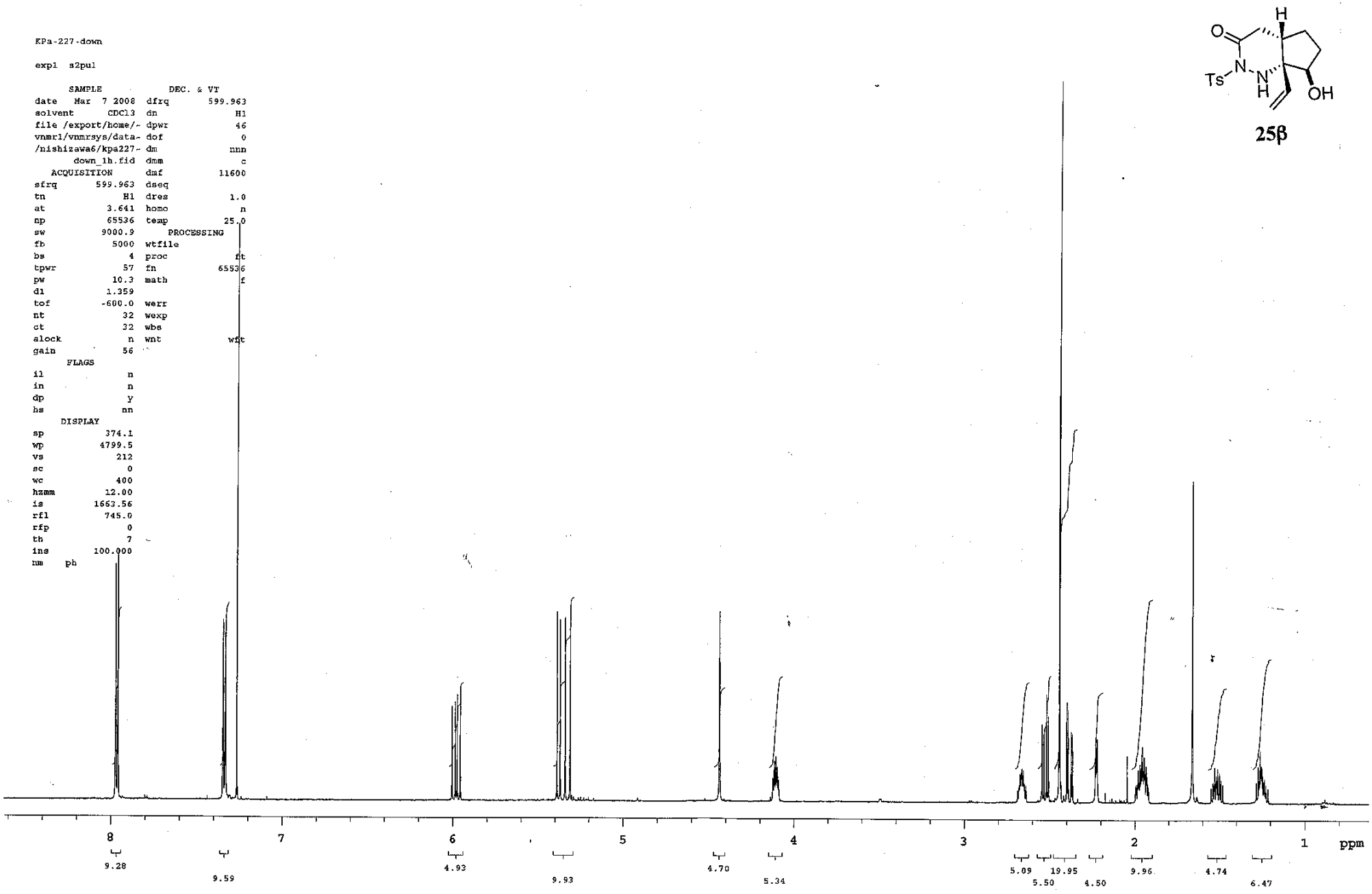
KPa-360-up-13C-pure

exp4 Carbon

SAMPLE		SPECIAL	
date	Oct 4 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	**FLAGS**	
fb	17000	il	n
bs	16	in	n
d1	0.700	dp	y
nt	30000	hs	nn
ct	14352	**PROCESSING**	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	**DISPLAY**	
tof	1042.7	sp	-417.9
tpwr	56	wp	18517.7
pw	6.600	rfl	9464.9
DECOUPLER		rfp	7744.0
dn	H1	rp	-108.9
dof	0	lp	-29.6
dm	yyy	**PLOT**	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	33366
		th	10
		ai	cdc ph



25α

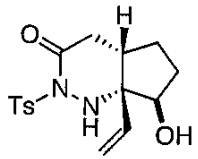

KPa-227-down
exp1 s2pul
SAMPLE
date Mar 7 2008
solvent CDCl3
file /export/home/-
vnmr1/vnmrsys/data-
/nishizawa6/kpa227-
down_1h.fid
ACQUISITION
sfrq 599.963
tn H1
at 3.641
np 65536
sw 9000.9
fb 5000
bs 4
tpwr 57
pw 10.3
dl 1.359
tof -600.0
nt 32
ct 32
alock n
gain 56
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp 374.1
wp 4799.5
vs 212
sc 0
wc 400
hzmm 12.00
is 1663.56
rfl 745.0
rfp 0
th 7
ins 100.000
nm ph
DEC. & VT
dfrq 599.963
dn H1
dpwr 46
dof 0
dm nnn
dmm c
dmf 11600
dseq
dres 1.0
homo n
temp 25.0
PROCESSING
wtfile
proc ft
fn 65536
math f
werr
wexp
wbs
wnt wft
8
7
6
5
4
3
2
1
ppm
9.28
9.59
4.93
9.93
4.70
5.34
5.09
19.95
5.50
4.50
9.96
4.74
6.47
O
N
Ts
N
H
H
OH
25β

13C OBSERVE

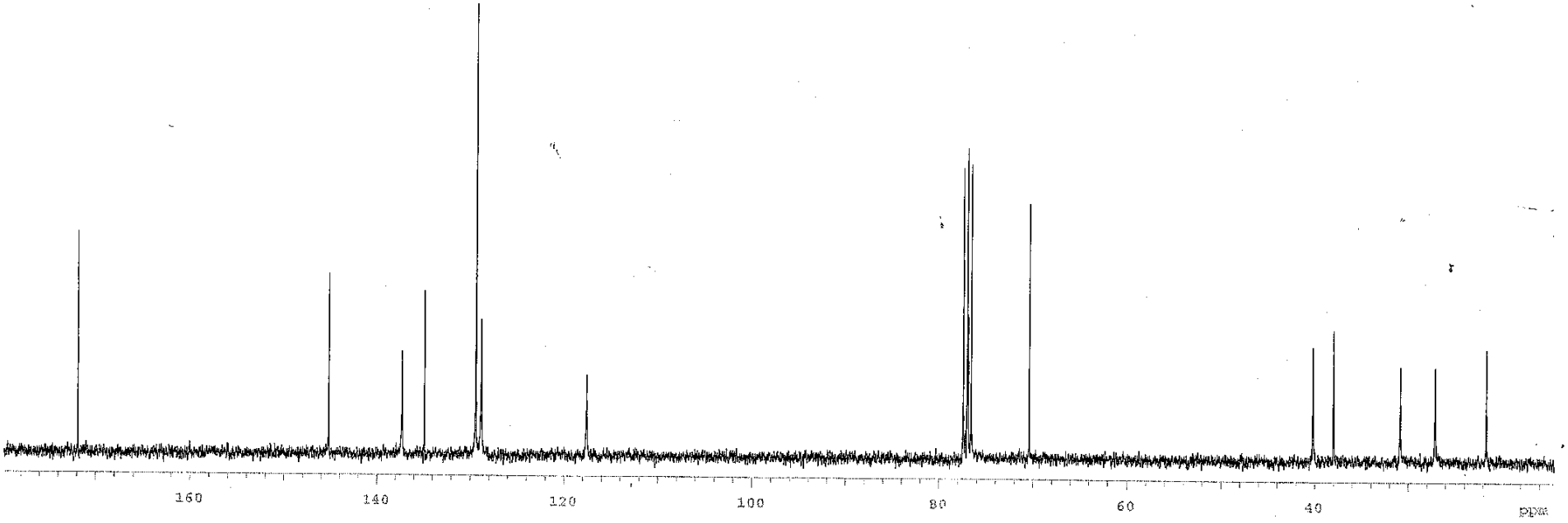
Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.294 sec
Pulse 40.0 degrees
Acq. time 1.705 sec
Width 18863.2 Hz
608 repetitions
OBSERVE C13, 75.4839462 MHz
DECOUPLE H1, 300.1958432 MHz
Power 38 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 65536
Total time 20 minutes



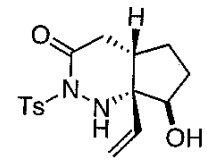
25β



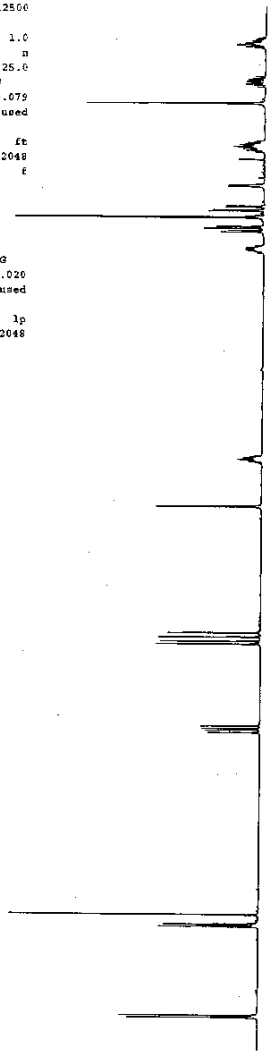
KPa-227-down

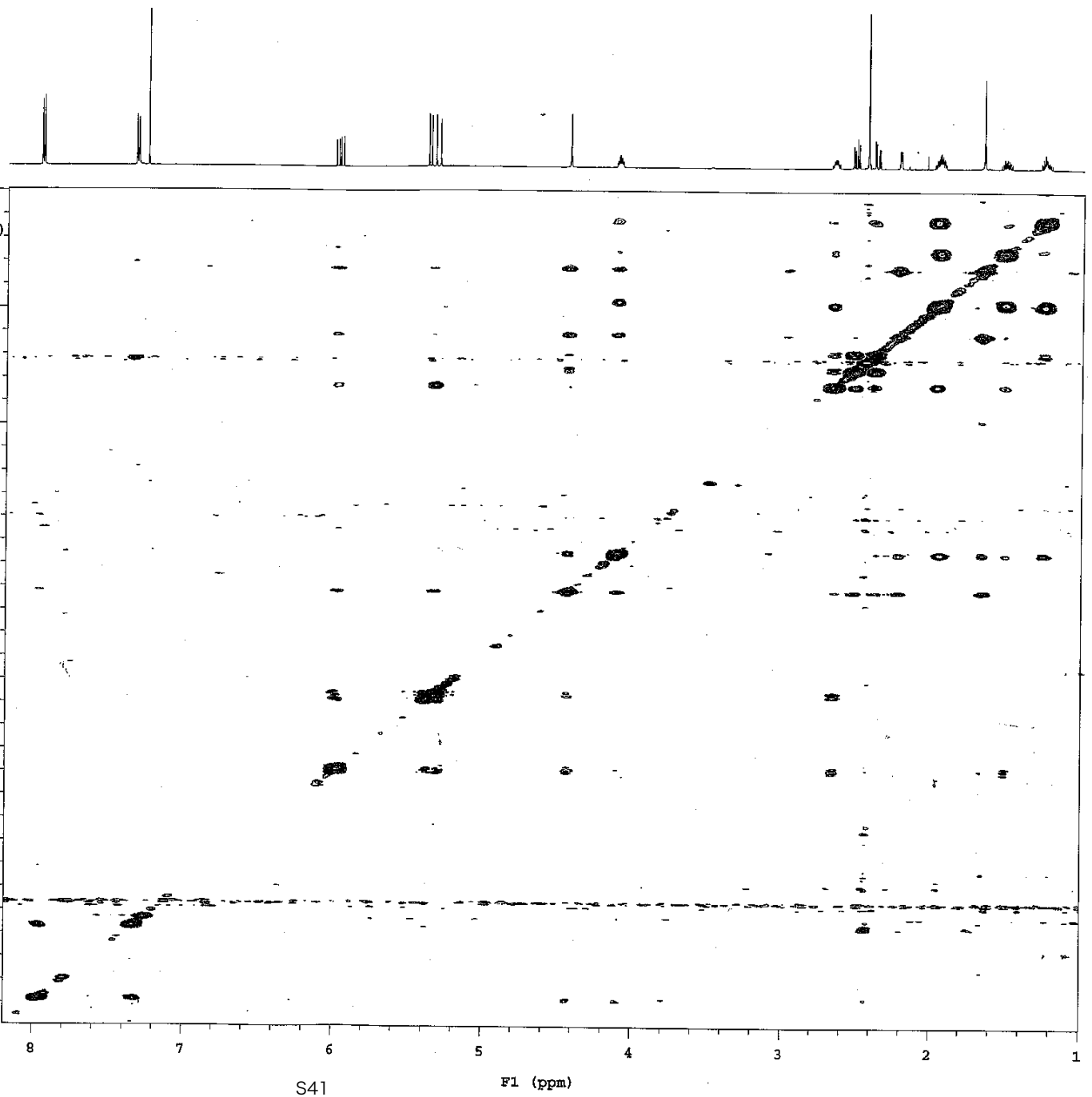
exp4 noesy

SAMPLE		DEC. & VT		ACQUISITION ARRAYS	
date	Mar 7 2008	dfrq	599.963	array	phase
solvent	CDCl3	dn	H1	arraydim	256
file	/export/home/-	dpwr	45		
vnmrl/vnmrsys/data-		dof	0	i	phase
/nishizawa6/kpa227-		dm	n	1	1
down_noesy.fid		dmm	c	2	2
ACQUISITION		dmf	12500		
sfrq	599.961	dseq			
tn	H1	dres	1.0		
at	0.170	homo	n		
np	2048	temp	25.0		
sw	6024.1	PROCESSING			
fb	3400	gf	0.079		
bs	4	gfs	not used		
ss	8	wtfile			
tpwr	57	proc	ft		
pw	14.0	fn	2048		
dl	1.500	math	f		
presat	0				
mix	1.200	werr			
tof	-2077.0	wexp			
nt	16	wbs			
ct	8	wnt			
alock	n	2D PROCESSING			
gain	10	gf1	0.020		
FLAGS		gfs1	not used		
il	y	wtfile1			
in	n	proc1	lp		
dp	y	fn1	2048		
hs	yn				
sspul	y				
2D ACQUISITION					
sw1	6024.1				
ni	128				
phase	arrayed				
DISPLAY					
sp	597.0				
wp	4316.4				
vs	14500				
sc	9				
wc	270				
hzmm	16.00				
is	33.57				
rf1	733.8				
rfp	0				
th	1				
ins	100.000				
ai ph					
2D DISPLAY					
sp1	597.0				
wp1	4316.4				
sc2	0				
wc2	210				
rf11	733.8				
rfp1	0				



25β

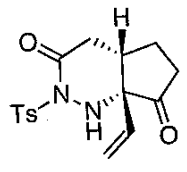




Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.500 sec
Pulse 31.3 degrees
Acq. time 3.555 sec
Width 4500.5 Hz
64 repetitions
OBSERVE H1, 300.1943863 MHz
DATA PROCESSING
FT size 32768
Total time 4 minutes



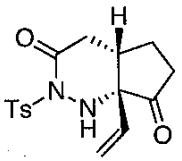
26

13C OBSERVE

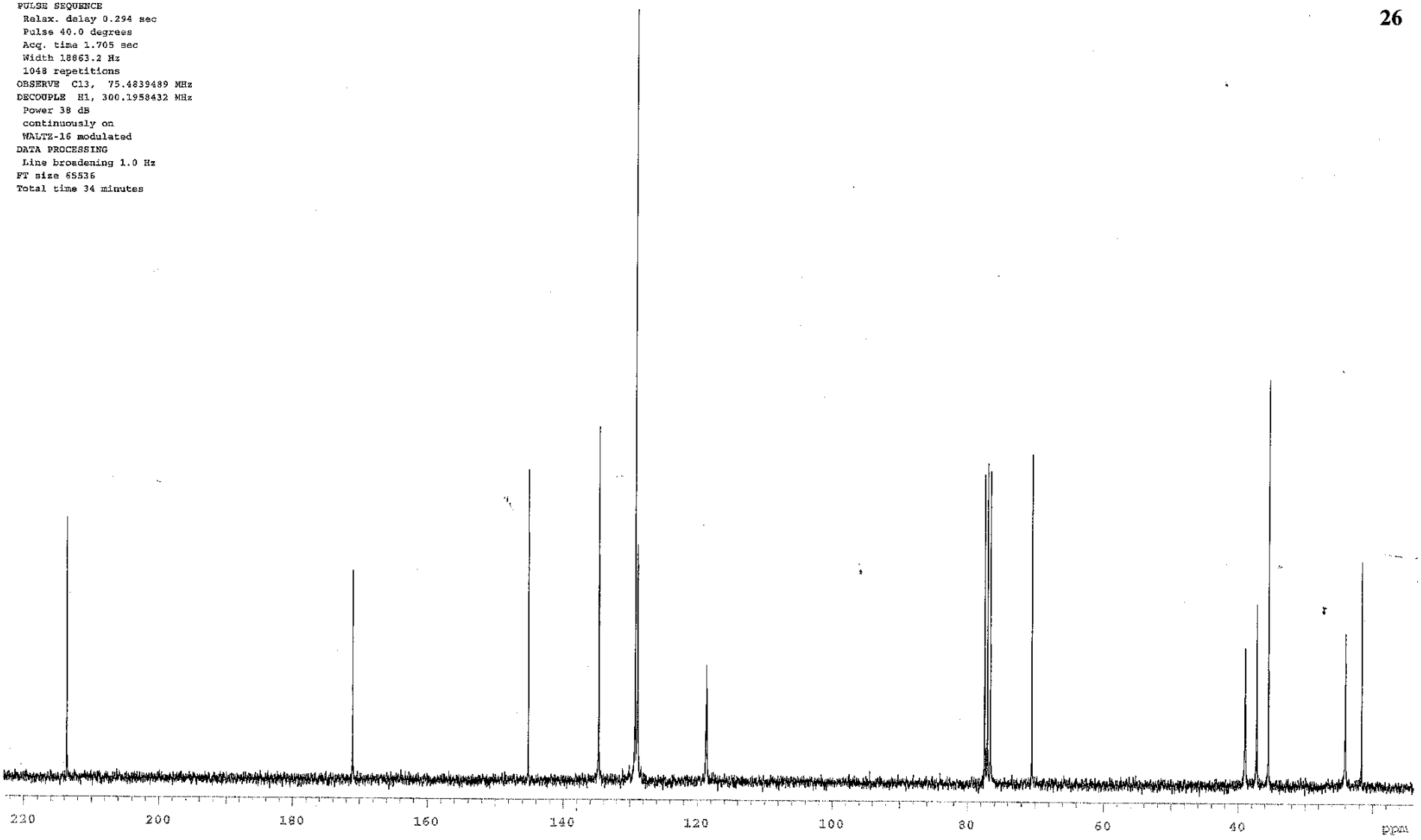
Pulse Sequence: s2pul

Solvent: CDCl3
Ambient temperature
Mercury-300 "m300"

PULSE SEQUENCE
Relax. delay 0.294 sec
Pulse 40.0 degrees
Acq. time 1.705 sec
Width 18863.2 Hz
1048 repetitions
OBSERVE C13, 75.4839489 MHz
DECOUPLE H1, 300.1958432 MHz
Power 38 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 65536
Total time 34 minutes



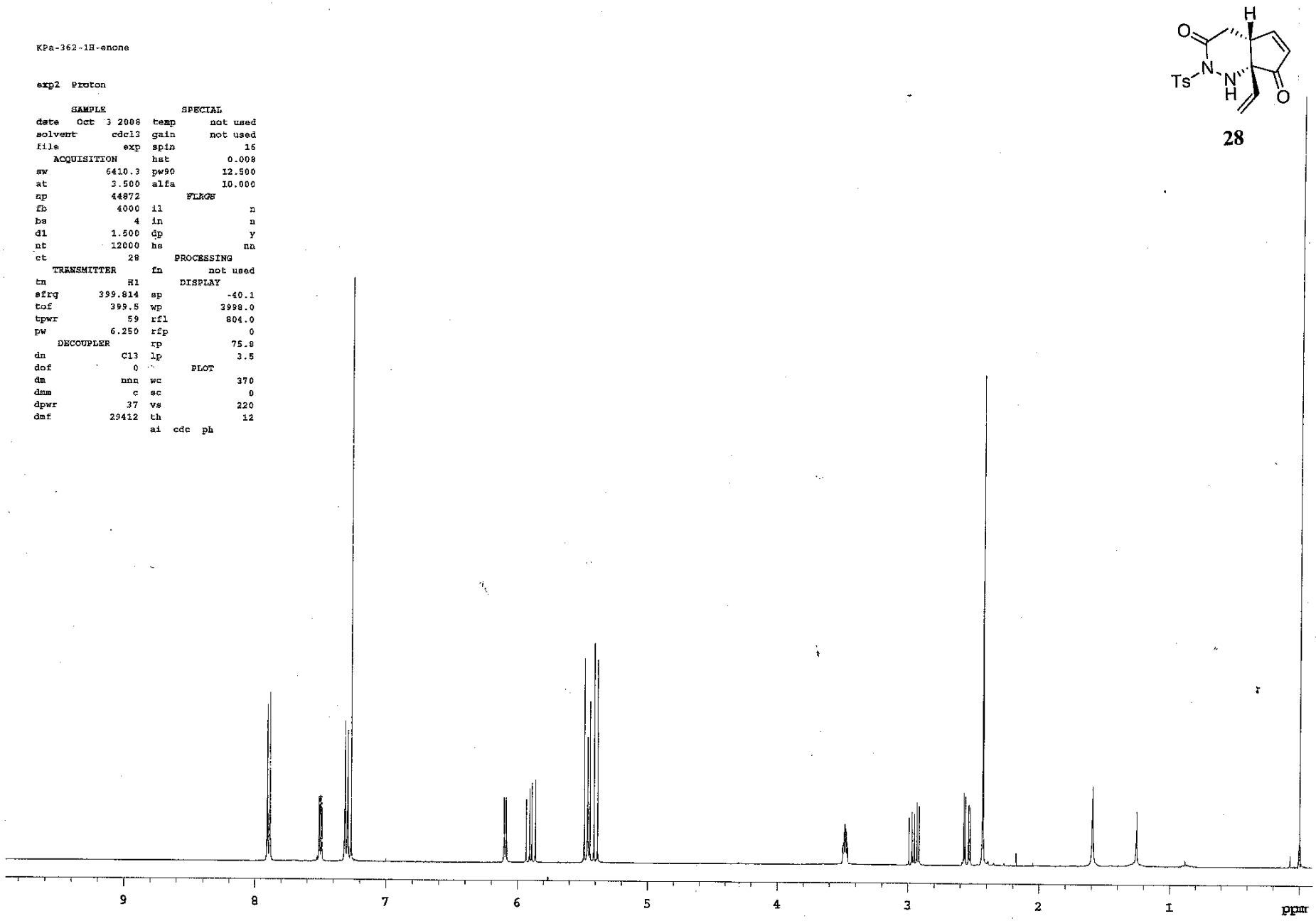
26



KPa-362-1H-enone

exp2 Proton

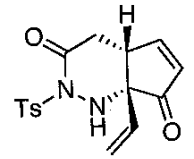
SAMPLE		SPECIAL	
date	Oct 3 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.500	alfa	10.000
np	44872	FLAGS	
fb	4000	il	n
bs	4	in	n
dl	1.500	dp	y
nt	12000	hs	nn
ct	28	PROCESSING	
TRANSMITTER		fn	not used
tn	H1	DISPLAY	
sfrq	399.814	sp	-40.1
tof	399.5	wp	3998.0
tpwr	59	rfl	804.0
pw	6.250	rfp	0
DECOUPLER		rp	75.8
dn	C13	lp	3.5
dof	0	PLOT	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	220
dmf	29412	th	12
		ai cdc ph	



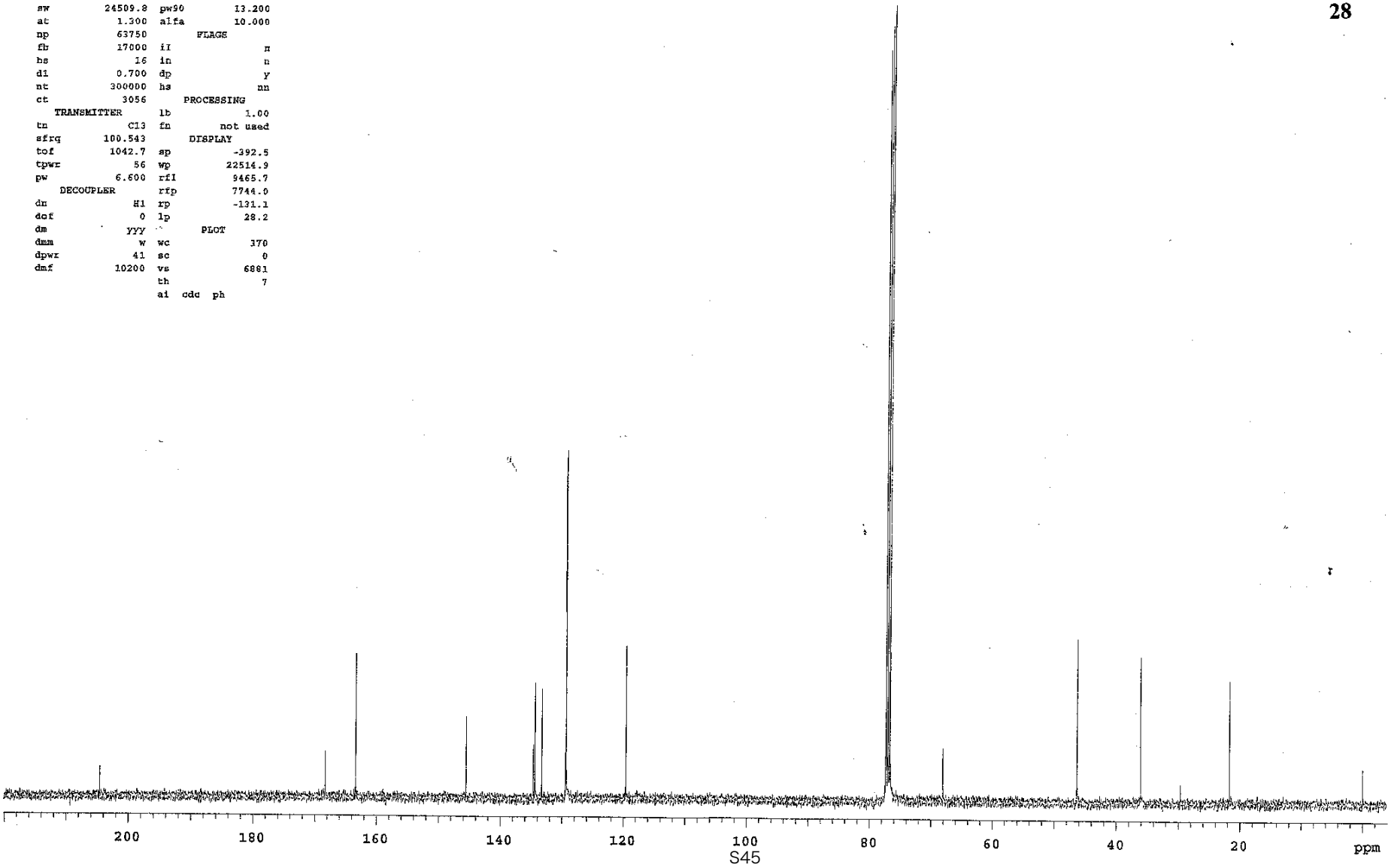
KPa-363-13C-enone

exp1 Carbon

SAMPLE		SPECIAL	
date	Oct 3 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hat	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17000	il	n
bs	16	in	n
d1	0.700	dp	y
nt	300000	hs	nn
ct	3056	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-392.5
tpwr	56	wp	22514.9
pw	6.600	rfl	9465.7
DECOUPLER		rfp	7744.0
dn	H1	rp	-131.1
dof	0	lp	28.2
dm	yyy	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	6881
		th	7
		ai cdc ph	



28

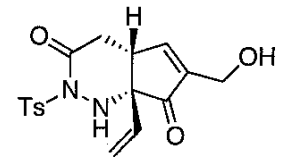


STANDARD 1H OBSERVE

exp1 stdlh

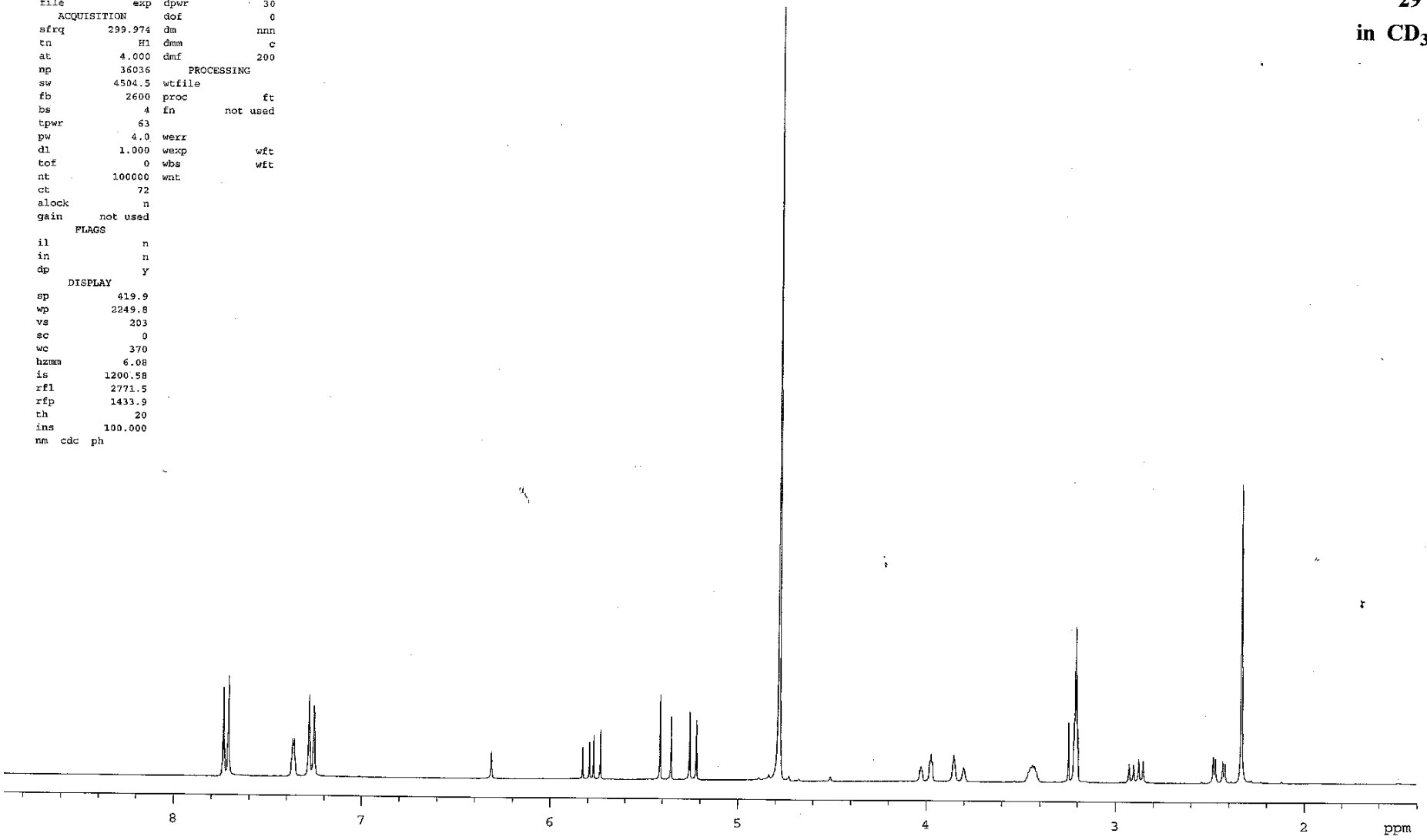
SAMPLE		DEC. & VT	
date	Sep 21 2008	dfrq	299.974
solvent	methanol	dn	H1
file	exp	dpwr	30
ACQUISITION		dof	0
sfrq	299.974	dm	nnn
tn	H1	dmm	c
at	4.000	dmf	200
np	36036	PROCESSING	
sw	4504.5	wtfile	
fb	2600	proc	ft
bs	4	fn	not used
tpwr	63		
pw	4.0	werr	
dl	1.000	wexp	wft
tof	0	wbs	wft
nt	100000	wnt	
ct	72		
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
DISPLAY			
sp	419.9		
wp	2249.8		
vs	203		
sc	0		
wc	370		
hzmm	6.08		
is	1200.58		
rfl	2771.5		
rfp	1433.9		
th	20		
ins	100.000		

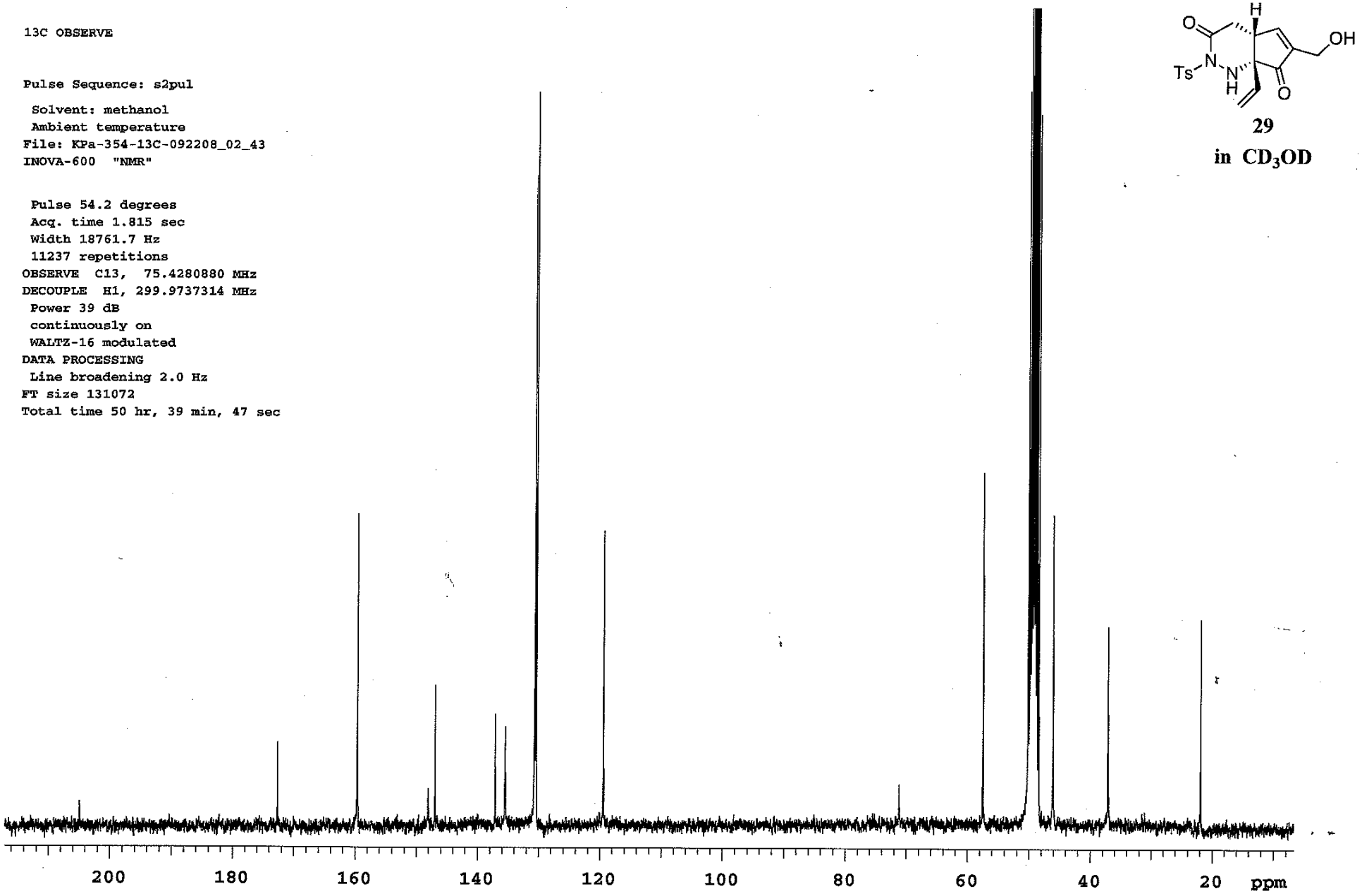
nm cdc ph



29

in CD_3OD

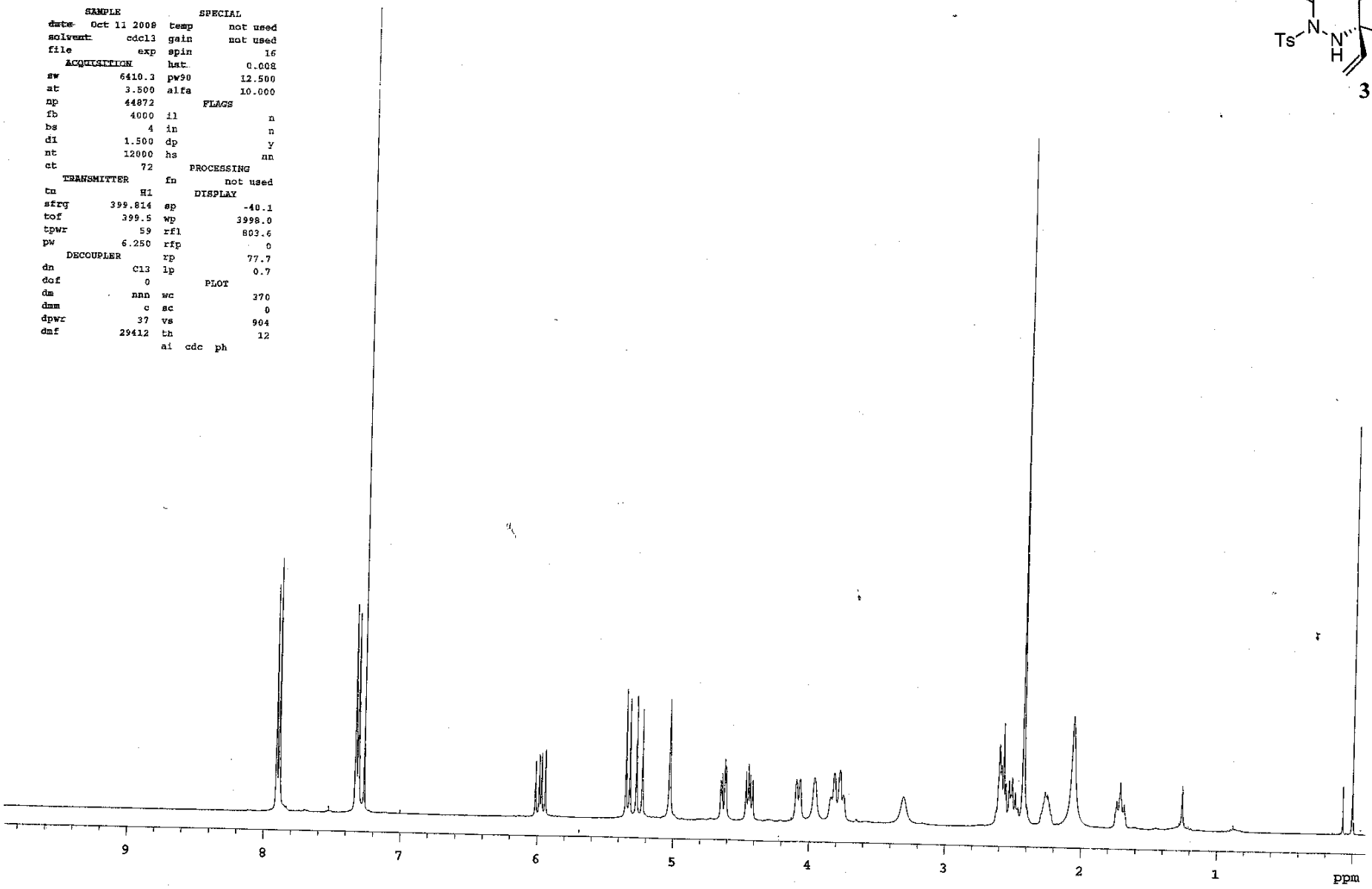


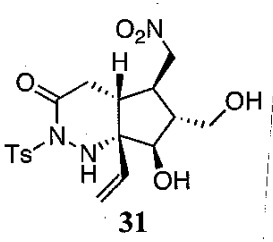

13C OBSERVE
Pulse Sequence: s2pul
Solvent: methanol
Ambient temperature
File: KPa-354-13C-092208_02_43
INOVA-600 "NMR"
Pulse 54.2 degrees
Acq. time 1.815 sec
Width 18761.7 Hz
11237 repetitions
OBSERVE C13, 75.4280880 MHz
DECOUPLE H1, 299.9737314 MHz
Power 39 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 2.0 Hz
FT size 131072
Total time 50 hr, 39 min, 47 sec
O
H
OH
Ts
N
N
H
O
29
in CD3OD
200
180
160
140
120
100
80
60
40
20
ppm

KPa-366-1H-pure

exp1 Proton

SAMPLE		SPECIAL	
~~date~~	Oct 11 2008	temp	not used
~~solvent~~	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.500	alfa	10.000
np	44872	**FLAGS**	
fb	4000	il	n
bs	4	in	n
d1	1.500	dp	y
nt	12000	hs	nn
ct	72	**PROCESSING**	
TRANSMITTER		fn	not used
tn	H1	**DISPLAY**	
sfrq	399.814	sp	-40.1
tof	399.5	wp	3998.0
tpwr	59	rf1	803.6
pw	6.250	rfp	0
DECOUPLER		rp	77.7
dn	C13	lp	0.7
dof	0	**PLOT**	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	904
dmf	29412	th	12
		ai cdc ph	



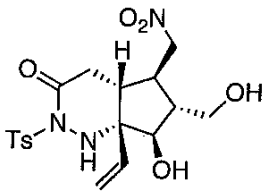


31

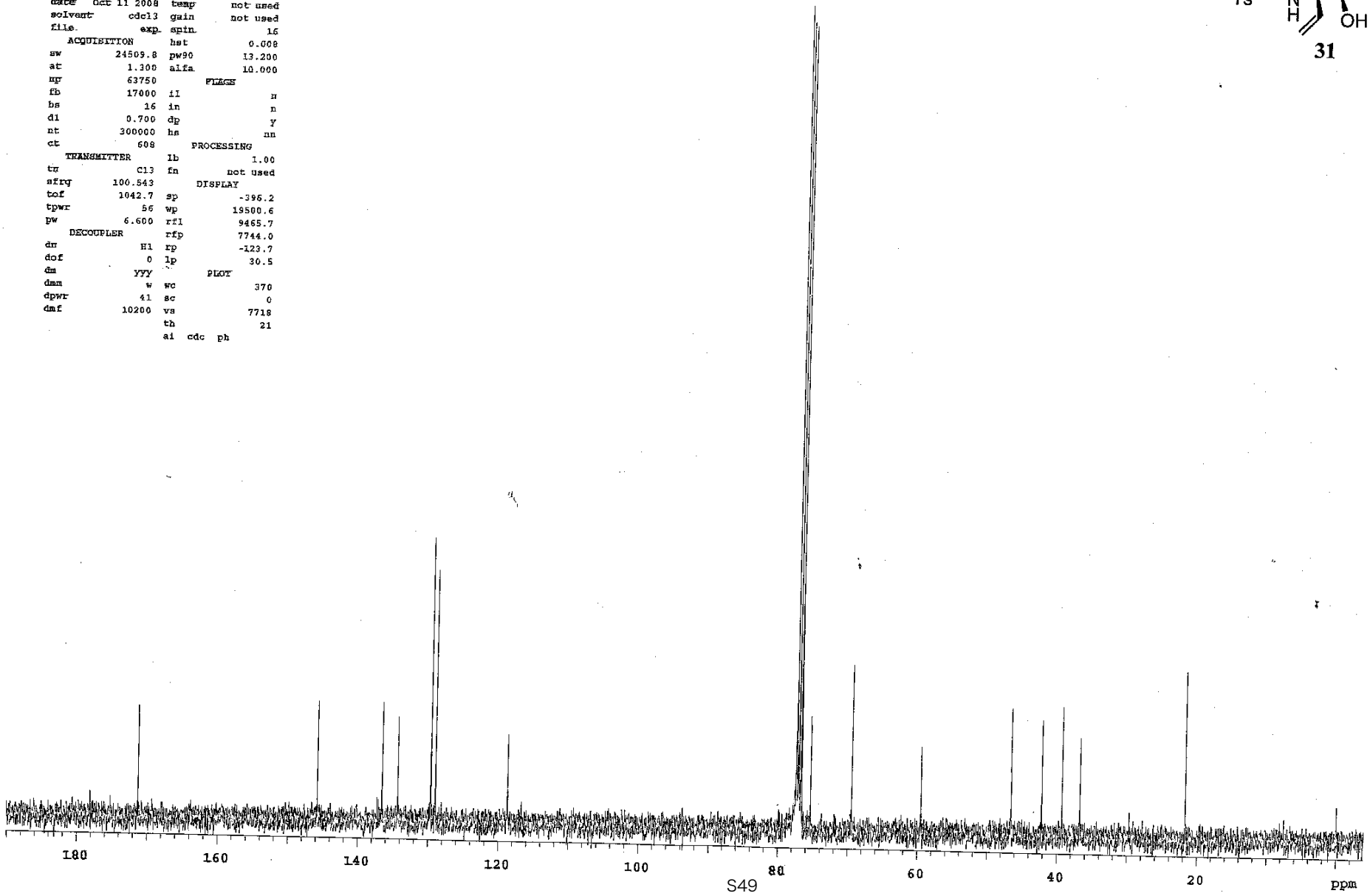
KRa-366-13C-pure

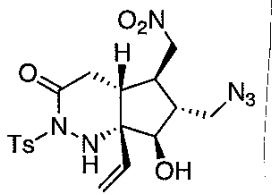
exp4 Carbon

SAMPLE		SPECIAL	
date	Oct 11 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	**FLAGS**	
fb	17000	fl	n
bs	16	in	n
d1	0.700	dp	y
nt	300000	hs	nn
ct	608	**PROCESSING**	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	**DISPLAY**	
tof	1042.7	sp	-396.2
tpwr	56	wp	19500.6
pw	6.600	rf1	9465.7
DECOUPLER		rfp	7744.0
dn	H1	rp	-123.7
dof	0	lp	30.5
dm	yyy	**PLOT**	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	7718
		th	21
		al cdc ph	



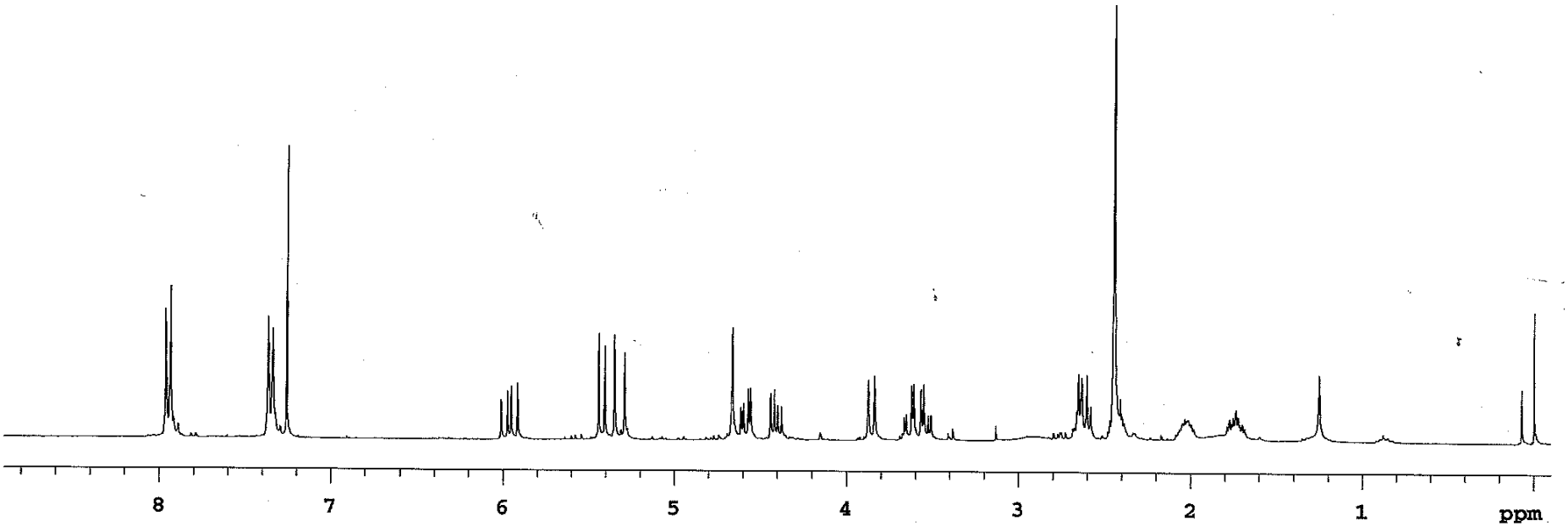
31





32

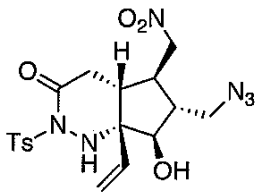
```
Pulse Sequence: s2pul
 Solvent: CDCl3
 Ambient temperature
File: KPa-403-pure-1H-112608_23_51
INOVA-600  "NMR"

 Relax. delay 0.500 sec
 Pulse 31.3 degrees
 Acq. time 3.555 sec
 Width 4500.5 Hz
 268 repetitions
OBSERVE   H1, 300.1943971 MHz
DATA PROCESSING
FT size 32768
Total time 11 hr, 17 min, 20 sec
```



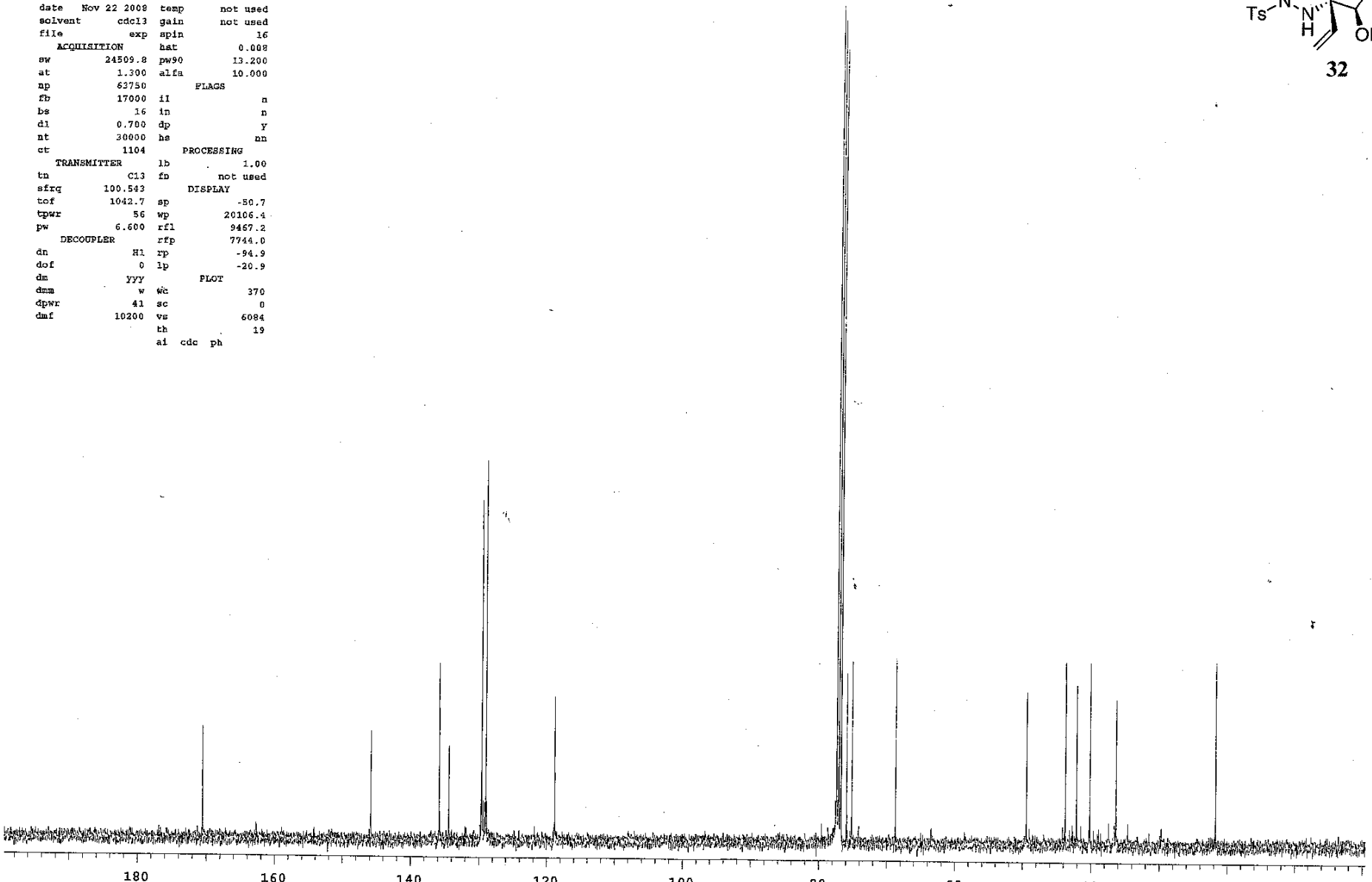
KPa-403-13C

exp4 Carbon

SAMPLE		SPECIAL	
date	Nov 22 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hat	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	**FLAGS**	
fb	17000	il	n
bs	16	in	n
dl	0.700	dp	y
nt	30000	hs	nn
ct	1104	**PROCESSING**	
TRANSMITTER		lb	1.00
tn	C13	fb	not used
sfrq	100.543	**DISPLAY**	
tof	1042.7	sp	-50.7
tpwr	56	wp	20106.4
pw	6.600	rfl	9467.2
DECOUPLER		rfp	7744.0
dn	H1	rp	-94.9
dof	0	lp	-20.9
dm	yyy	**PLOT**	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	6084
		th	19
		ai	cdc ph



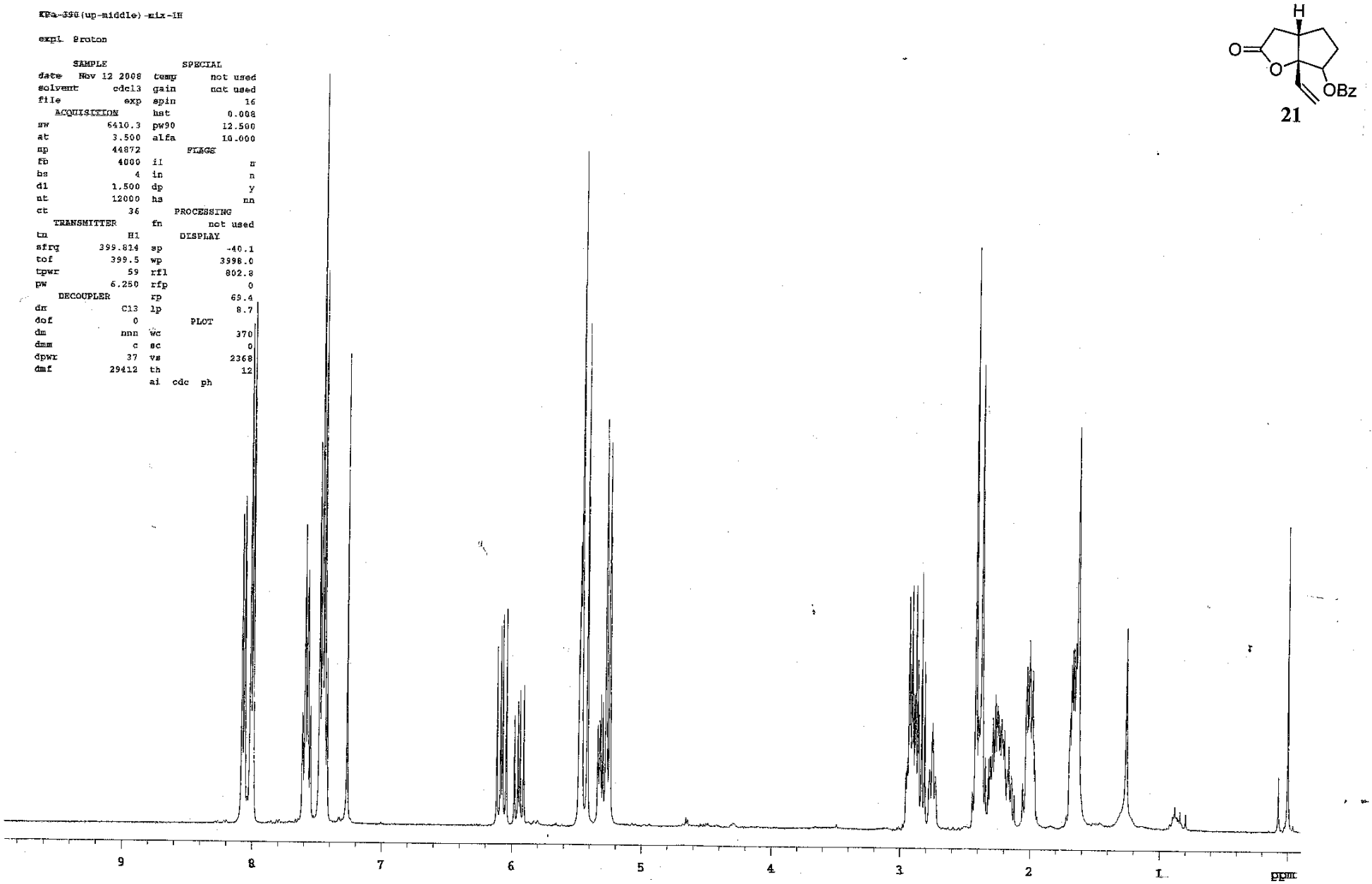
32



KPa-390(up-middle)-mix-1H

expl 1proton

SAMPLE		SPECIAL	
date	Nov 12 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	6410.3	pw90	12.500
at	3.500	alfa	10.000
np	44872	FLAGS	
fb	4000	il	n
bs	4	in	n
d1	1.500	dp	y
nt	12000	hs	nn
ct	36	PROCESSING	
TRANSMITTER		fn	not used
tn	H1	DISPLAY	
sfrq	399.814	sp	-40.1
tof	399.5	wp	3998.0
tpwr	59	rfl	802.8
pw	6.250	rfp	0
DECOUPLER		rp	69.4
dn	C13	lp	8.7
dof	0	PLOT	
dm	nnn	wc	370
dmm	c	sc	0
dpwr	37	vs	2368
dmf	29412	th	12
		ai cdc ph	

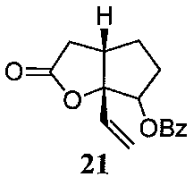


21

KHa-196(up-middle)-mix-13C

exp3 Carbon

SAMPLE		SPECIAL	
date	Nov 12 2008	temp	not used
solvent	cdcl3	gain	not used
file	exp	spin	16
ACQUISITION		hst	0.008
sw	24509.8	pw90	13.200
at	1.300	alfa	10.000
np	63750	FLAGS	
fb	17600	il	n
bs	16	in	n
dl	0.700	dp	y
nt	30000	hs	nn
ct	1056	PROCESSING	
TRANSMITTER		lb	1.00
tn	C13	fn	not used
sfrq	100.543	DISPLAY	
tof	1042.7	sp	-50.7
tpwr	56	wp	20106.4
pw	6.600	rfl	9467.2
DECOUPLER		rfp	7744.0
dn	H1	rp	-123.7
dof	0	lp	33.5
dm	yyy	PLOT	
dmm	w	wc	370
dpwr	41	sc	0
dmf	10200	vs	6834
		th	9
		ai	cdc ph



21

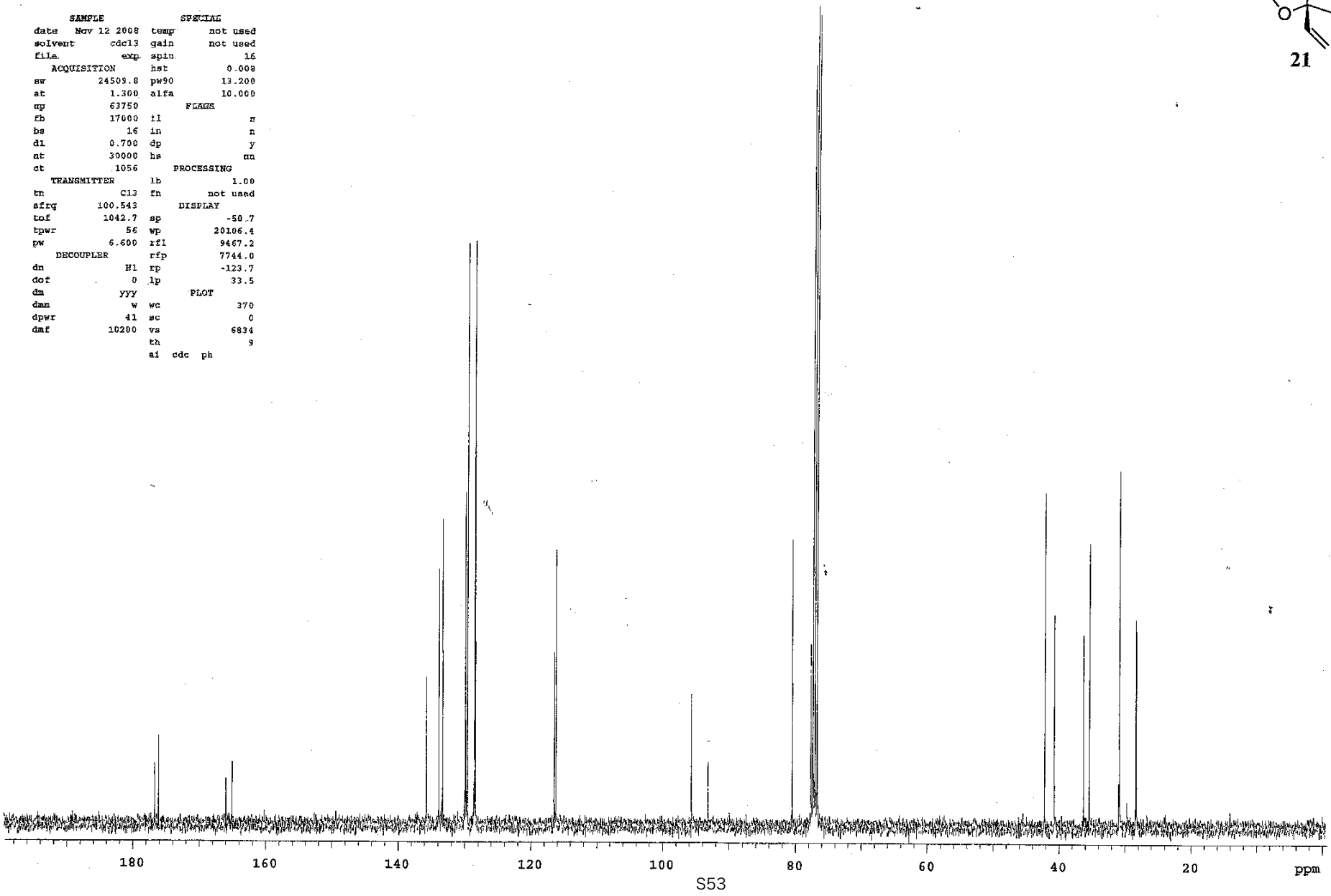


Table 1. Crystal data and structure refinement for p2.

Identification code	p2	
Empirical formula	C16 H20 N2 O4 S	
Formula weight	336.40	
Temperature	296 K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2(1)/c	
Unit cell dimensions	a = 15.677(5) Å	α= 90°.
	b = 8.062(3) Å	β= 99.968(4)°.
	c = 12.985(4) Å	γ = 90°.
Volume	1616.3(9) $Å^3$	
Z	4	
Density (calculated)	1.382 Mg/m^3	
Absorption coefficient	0.222 mm^{-1}	
F(000)	712	
Crystal size	0.43 x 0.25 x 0.23 mm^3	
Theta range for data collection	1.32 to 27.55°.	
Index ranges	-20<=h<=9, -10<=k<=10, -16<=l<=16	
Reflections collected	7922	
Independent reflections	3654 [R(int) = 0.0632]	
Completeness to theta = 27.55°	97.6 %	
Absorption correction	None	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3654 / 0 / 211	
Goodness-of-fit on F^2	1.053	
Final R indices [I>2sigma(I)]	R1 = 0.0875, wR2 = 0.2392	
R indices (all data)	R1 = 0.0897, wR2 = 0.2436	
Extinction coefficient	0.002(4)	
Largest diff. peak and hole	0.932 and -0.872 e.$Å^{-3}$	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for p2. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	2442(1)	10919(1)	3056(1)	17(1)
C(2)	3985(2)	5770(3)	789(2)	24(1)
C(3)	3350(1)	6960(3)	1215(2)	18(1)
C(4)	3041(2)	6321(3)	2199(2)	23(1)
C(5)	2502(2)	7638(3)	2602(2)	20(1)
C(6)	3849(1)	8638(2)	1451(2)	15(1)
C(7)	4808(1)	8168(3)	1459(2)	20(1)
C(8)	4734(2)	6876(3)	587(2)	25(1)
C(9)	3583(2)	9993(3)	656(2)	23(1)
C(10)	1512(1)	11258(3)	2108(2)	17(1)
C(11)	709(2)	10696(3)	2294(2)	21(1)
C(12)	-26(2)	11071(3)	1565(2)	24(1)
C(13)	34(2)	11997(3)	669(2)	23(1)
C(14)	846(2)	12517(3)	498(2)	24(1)
C(15)	1593(2)	12165(3)	1219(2)	21(1)
C(16)	-776(2)	12413(3)	-102(2)	31(1)
O(1)	5128(1)	7430(2)	2451(1)	23(1)
O(2)	1776(1)	7476(2)	2795(2)	27(1)
N(1)	2927(1)	9172(2)	2705(2)	16(1)
N(2)	3781(1)	9313(2)	2495(1)	14(1)
O(3)	2184(1)	10601(3)	4043(1)	27(1)

O(4)	3061(1)	12211(2)	2972(1)	24(1)
C(17)	2982(2)	9926(4)	-184(2)	37(1)

Table 3. Bond lengths [Å] and angles [°] for p2.

S(1)-O(3)	1.4316(18)
S(1)-O(4)	1.4403(17)
S(1)-N(1)	1.6995(19)
S(1)-C(10)	1.759(2)
C(2)-C(8)	1.532(4)
C(2)-C(3)	1.552(3)
C(3)-C(4)	1.532(3)
C(3)-C(6)	1.567(3)
C(4)-C(5)	1.505(3)
C(5)-O(2)	1.215(3)
C(5)-N(1)	1.400(3)
C(6)-N(2)	1.481(3)
C(6)-C(9)	1.511(3)
C(6)-C(7)	1.549(3)
C(7)-O(1)	1.429(3)
C(7)-C(8)	1.528(3)
C(9)-C(17)	1.314(4)
C(10)-C(15)	1.391(3)
C(10)-C(11)	1.397(3)
C(11)-C(12)	1.391(3)
C(12)-C(13)	1.400(3)
C(13)-C(14)	1.393(4)
C(13)-C(16)	1.513(3)
C(14)-C(15)	1.397(3)
N(1)-N(2)	1.417(3)
O(3)-S(1)-O(4)	119.72(11)
O(3)-S(1)-N(1)	107.47(10)
O(4)-S(1)-N(1)	103.91(10)
O(3)-S(1)-C(10)	109.03(11)
O(4)-S(1)-C(10)	108.79(11)
N(1)-S(1)-C(10)	107.18(10)
C(8)-C(2)-C(3)	105.02(18)
C(4)-C(3)-C(2)	113.85(18)
C(4)-C(3)-C(6)	110.27(17)
C(2)-C(3)-C(6)	105.90(18)
C(5)-C(4)-C(3)	109.28(17)
O(2)-C(5)-N(1)	121.5(2)
O(2)-C(5)-C(4)	126.7(2)
N(1)-C(5)-C(4)	111.76(19)
N(2)-C(6)-C(9)	107.74(17)
N(2)-C(6)-C(7)	107.93(16)
C(9)-C(6)-C(7)	109.50(17)
N(2)-C(6)-C(3)	112.57(16)
C(9)-C(6)-C(3)	114.87(18)
C(7)-C(6)-C(3)	103.98(16)
O(1)-C(7)-C(8)	110.75(19)
O(1)-C(7)-C(6)	107.22(17)
C(8)-C(7)-C(6)	102.25(17)
C(7)-C(8)-C(2)	103.45(18)
C(17)-C(9)-C(6)	127.7(2)
C(15)-C(10)-C(11)	121.9(2)

C(15)-C(10)-S(1)	118.63(17)
C(11)-C(10)-S(1)	119.41(17)
C(12)-C(11)-C(10)	118.5(2)
C(11)-C(12)-C(13)	121.0(2)
C(14)-C(13)-C(12)	119.2(2)
C(14)-C(13)-C(16)	120.9(2)
C(12)-C(13)-C(16)	119.9(2)
C(13)-C(14)-C(15)	121.0(2)
C(10)-C(15)-C(14)	118.5(2)
C(5)-N(1)-N(2)	120.11(17)
C(5)-N(1)-S(1)	122.06(16)
N(2)-N(1)-S(1)	117.82(14)
N(1)-N(2)-C(6)	111.50(16)

Symmetry transformations used to generate equivalent atoms:

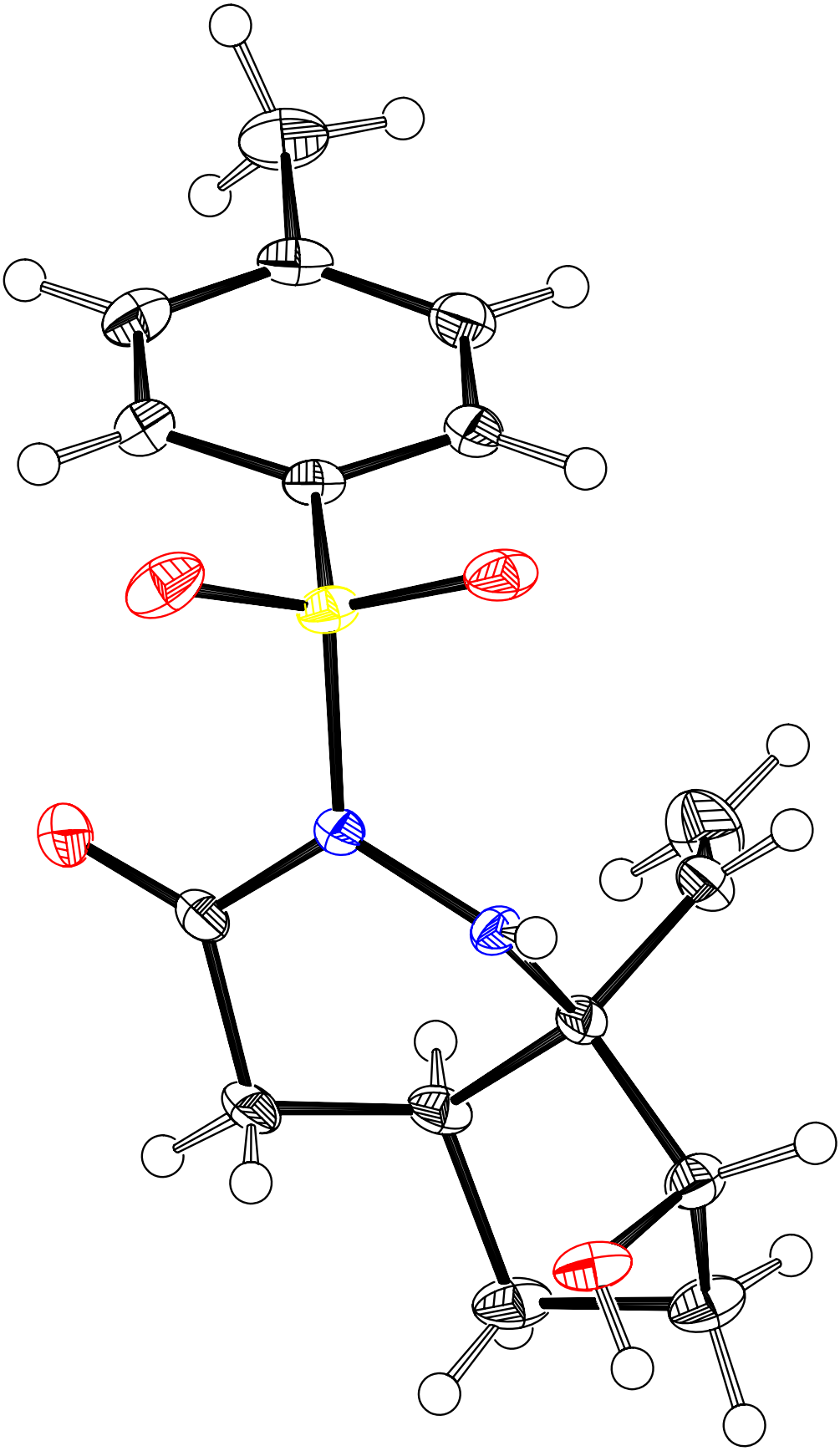
Table 4. Anisotropic displacement parameters ($Å^2$x 10^3)for p2. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	16(1)	16(1)	20(1)	-5(1)	3(1)	2(1)
C(2)	22(1)	18(1)	30(1)	-11(1)	1(1)	3(1)
C(3)	19(1)	12(1)	21(1)	-3(1)	-1(1)	0(1)
C(4)	24(1)	9(1)	36(1)	2(1)	7(1)	-1(1)
C(5)	20(1)	13(1)	26(1)	5(1)	5(1)	1(1)
C(6)	17(1)	12(1)	16(1)	-1(1)	4(1)	0(1)
C(7)	17(1)	19(1)	23(1)	-5(1)	5(1)	0(1)
C(8)	24(1)	26(1)	26(1)	-9(1)	6(1)	5(1)
C(9)	30(1)	16(1)	26(1)	6(1)	10(1)	4(1)
C(10)	15(1)	14(1)	20(1)	-3(1)	1(1)	3(1)
C(11)	19(1)	21(1)	22(1)	-1(1)	6(1)	2(1)
C(12)	17(1)	27(1)	27(1)	-2(1)	4(1)	4(1)
C(13)	23(1)	17(1)	27(1)	-4(1)	1(1)	7(1)
C(14)	28(1)	19(1)	25(1)	3(1)	6(1)	5(1)
C(15)	22(1)	14(1)	28(1)	-1(1)	7(1)	1(1)
C(16)	26(1)	33(1)	30(1)	-3(1)	-4(1)	10(1)
O(1)	18(1)	24(1)	26(1)	-4(1)	0(1)	9(1)
O(2)	22(1)	19(1)	42(1)	5(1)	11(1)	-3(1)
N(1)	16(1)	12(1)	22(1)	1(1)	6(1)	0(1)
N(2)	12(1)	15(1)	17(1)	-2(1)	3(1)	0(1)
O(3)	23(1)	39(1)	19(1)	-5(1)	4(1)	8(1)
O(4)	18(1)	16(1)	38(1)	-10(1)	3(1)	0(1)
C(17)	48(2)	39(2)	24(1)	14(1)	4(1)	6(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for p2.

	x	y	z	U(eq)
H(2)	4191	4917	1298	29
H(2B)	3705	5243	147	29
H(3)	2844	7146	667	21
H(4A)	2698	5323	2035	27
H(4B)	3536	6050	2730	27

H(7)	5156	9127	1319	24
H(8A)	5265	6243	631	30
H(8B)	4602	7396	-96	30
H(9)	3880	10992	776	28
H(11)	667	10085	2890	25
H(12)	-564	10702	1676	28
H(14)	890	13107	-106	29
H(15)	2133	12529	1108	25
H(16A)	-1073	11408	-344	46
H(16B)	-621	13002	-685	46
H(16C)	-1149	13094	234	46
H(1)	5572	6911	2417	35
H(2A)	4207	9737	2920	17
H(17A)	2663	8958	-344	45
H(17B)	2874	10846	-619	45



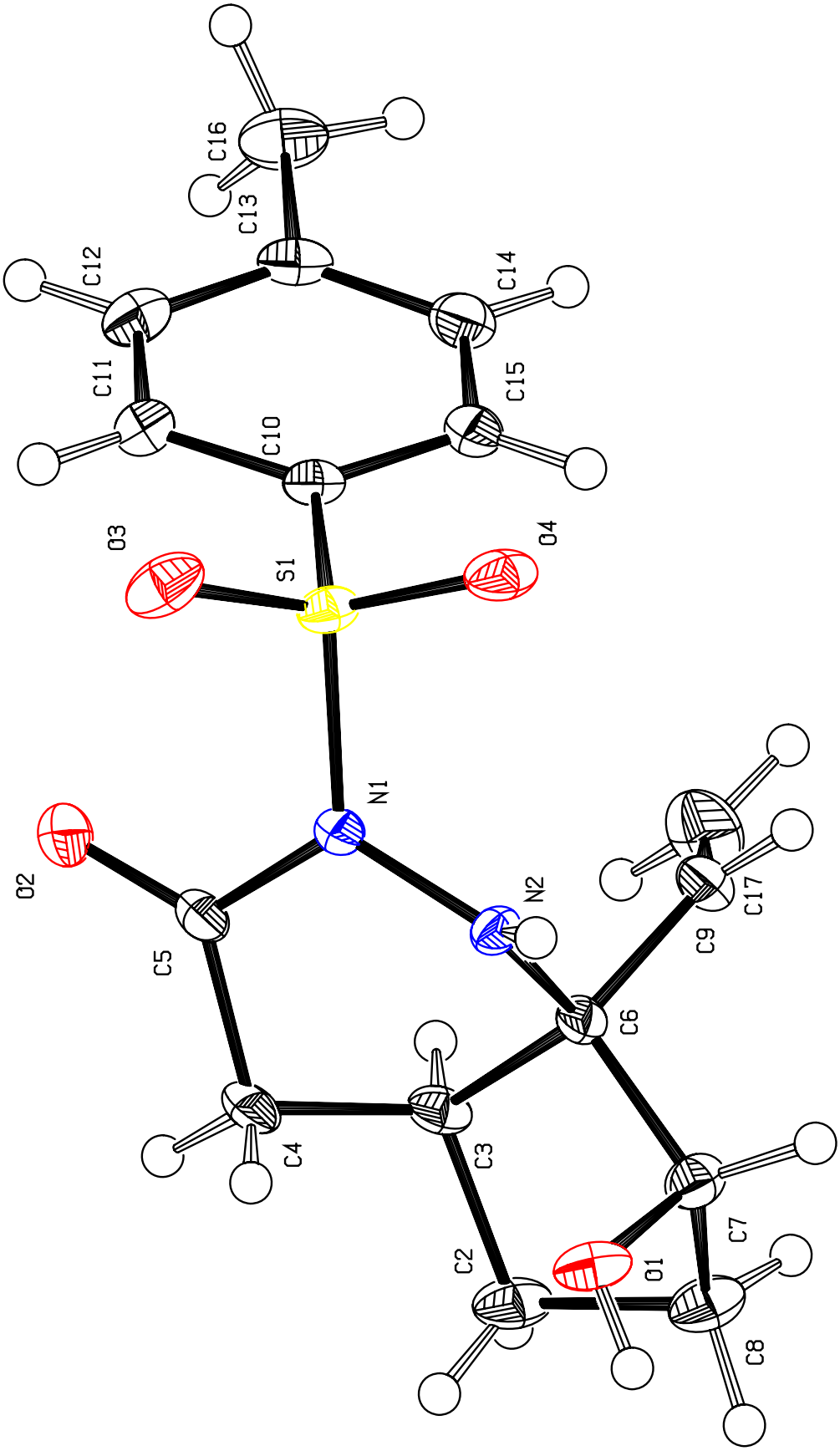

C16
C13
C12
C14
C11
C15
C10
O3
S1
O4
N1
O2
N2
C5
C9
C17
C6
C4
C3
C7
C2
O1
C8

Table 1. Crystal data and structure refinement for **Kpa403**.

Identification code	**Kpa403**	
Empirical formula	C18 H22 N6 O6 S	
Formula weight	450.48	
Temperature	296 K	
Wavelength	0.71073	
Crystal system	Monoclinic	
Space group	P2(1)/c	
Unit cell dimensions	a = 13.493(7)	α= 90
	b = 16.902(9)	β= 96.042(7)
	c = 9.145(5)	γ = 90
Volume	2074.0(18)	
Z	4	
Density (calculated)	1.443 Mg/m^3	
Absorption coefficient	0.205 mm^{-1}	
F(000)	944	
Crystal size	? x ? x ? mm^3	
Theta range for data collection	1.52 to 27.78	
Index ranges	-17<=h<=12, -21<=k<=21, -11<=l<=11	
Reflections collected	11416	
Independent reflections	4748 [R(int) = 0.0735]	
Completeness to theta = 27.78°	96.9 %	
Absorption correction	Empirical	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	4748 / 0 / 287	
Goodness-of-fit on F^2	1.014	
Final R indices [I>2sigma(I)]	R1 = 0.0660, wR2 = 0.1686	
R indices (all data)	R1 = 0.0894, wR2 = 0.1858	
Extinction coefficient	0.0000(13)	
Largest diff. peak and hole	0.581 and -0.397 e	

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for p21. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	-1077(1)	1757(1)	3146(1)	27(1)
C(5)	1499(2)	532(1)	236(2)	26(1)
C(6)	2617(2)	685(2)	277(2)	30(1)
C(1)	502(2)	2587(1)	2303(2)	26(1)
C(7)	2723(2)	1575(2)	635(2)	29(1)
C(2)	1396(2)	2527(1)	1457(2)	28(1)
C(3)	1938(2)	1735(1)	1717(2)	28(1)
C(4)	1189(2)	1027(1)	1556(2)	26(1)
C(8)	3787(2)	1793(2)	1233(3)	38(1)
C(9)	1168(2)	511(2)	2909(2)	31(1)
C(10)	1761(2)	546(2)	4151(3)	42(1)
C(11)	3033(2)	428(2)	-1133(3)	34(1)
C(12)	-2014(2)	2331(2)	2174(2)	27(1)
C(13)	-2072(2)	3139(2)	2449(2)	31(1)
C(14)	-2766(2)	3586(2)	1594(3)	35(1)
C(15)	-3405(2)	3242(2)	465(3)	36(1)
C(16)	-3347(2)	2430(2)	237(3)	37(1)
C(17)	-2656(2)	1965(2)	1079(2)	31(1)
C(18)	-4104(3)	3748(2)	-532(3)	50(1)
O(1)	-1317(1)	940(1)	2977(2)	34(1)
O(2)	-813(1)	2094(1)	4567(2)	35(1)
O(3)	1301(2)	-285(1)	354(2)	32(1)
O(4)	4279(3)	2863(2)	2739(3)	81(1)
O(5)	3560(2)	3133(1)	614(3)	59(1)
N(1)	-65(2)	1899(1)	2215(2)	24(1)
N(2)	149(2)	1314(1)	1171(2)	24(1)
N(3)	3888(2)	2661(2)	1559(3)	42(1)
N(4)	4129(2)	373(2)	-789(3)	57(1)
N(5)	4632(2)	289(1)	-1805(2)	40(1)
N(6)	5205(2)	216(2)	-2619(3)	56(1)
O(6)	314(2)	3162(1)	3039(2)	32(1)

Table 3. Bond lengths [Å] and angles [°] for p21.

S(1)-O(1)	1.423(2)
S(1)-O(2)	1.4292(17)
S(1)-N(1)	1.700(2)
S(1)-C(12)	1.759(3)
C(5)-O(3)	1.412(3)
C(5)-C(6)	1.528(4)
C(5)-C(4)	1.561(3)
C(6)-C(11)	1.522(3)
C(6)-C(7)	1.543(3)
C(1)-O(6)	1.223(3)
C(1)-N(1)	1.389(3)
C(1)-C(2)	1.504(3)
C(7)-C(8)	1.528(4)
C(7)-C(3)	1.547(3)
C(2)-C(3)	1.533(3)
C(3)-C(4)	1.564(4)
C(4)-N(2)	1.491(3)
C(4)-C(9)	1.516(3)
C(8)-N(3)	1.500(4)
C(9)-C(10)	1.320(4)
C(11)-N(4)	1.482(4)
C(12)-C(13)	1.393(4)
C(12)-C(17)	1.398(3)
C(13)-C(14)	1.380(4)
C(14)-C(15)	1.400(4)
C(15)-C(16)	1.392(4)
C(15)-C(18)	1.507(4)
C(16)-C(17)	1.388(4)
O(4)-N(3)	1.200(3)
O(5)-N(3)	1.225(3)
N(1)-N(2)	1.426(3)
N(4)-N(5)	1.214(3)
N(5)-N(6)	1.135(3)
O(1)-S(1)-O(2)	121.13(10)
O(1)-S(1)-N(1)	105.57(10)

O(2)-S(1)-N(1)	105.22(11)
O(1)-S(1)-C(12)	109.68(12)
O(2)-S(1)-C(12)	109.72(11)
N(1)-S(1)-C(12)	103.99(11)
O(3)-C(5)-C(6)	111.0(2)
O(3)-C(5)-C(4)	113.37(18)
C(6)-C(5)-C(4)	103.57(19)
C(5)-C(6)-C(11)	112.5(2)
C(5)-C(6)-C(7)	103.8(2)
C(11)-C(6)-C(7)	115.0(2)
O(6)-C(1)-N(1)	123.5(2)
O(6)-C(1)-C(2)	124.0(2)
N(1)-C(1)-C(2)	112.4(2)
C(8)-C(7)-C(6)	111.9(2)
C(8)-C(7)-C(3)	114.2(2)
C(6)-C(7)-C(3)	104.63(19)
C(1)-C(2)-C(3)	111.98(19)
C(2)-C(3)-C(7)	113.65(19)
C(2)-C(3)-C(4)	111.2(2)
C(7)-C(3)-C(4)	106.50(19)
N(2)-C(4)-C(9)	106.31(19)
N(2)-C(4)-C(5)	108.25(18)
C(9)-C(4)-C(5)	110.66(19)
N(2)-C(4)-C(3)	110.87(19)
C(9)-C(4)-C(3)	115.50(19)
C(5)-C(4)-C(3)	105.11(19)
N(3)-C(8)-C(7)	111.7(2)
C(10)-C(9)-C(4)	128.0(3)
N(4)-C(11)-C(6)	106.7(2)
C(13)-C(12)-C(17)	121.4(2)
C(13)-C(12)-S(1)	120.07(19)
C(17)-C(12)-S(1)	118.47(19)
C(14)-C(13)-C(12)	118.8(2)
C(13)-C(14)-C(15)	121.3(3)
C(16)-C(15)-C(14)	118.7(3)
C(16)-C(15)-C(18)	120.7(3)
C(14)-C(15)-C(18)	120.5(3)
C(17)-C(16)-C(15)	121.3(3)

C(16)-C(17)-C(12)	118.5(2)
C(1)-N(1)-N(2)	118.08(19)
C(1)-N(1)-S(1)	123.73(16)
N(2)-N(1)-S(1)	117.85(16)
N(1)-N(2)-C(4)	108.61(18)
O(4)-N(3)-O(5)	122.8(3)
O(4)-N(3)-C(8)	118.6(3)
O(5)-N(3)-C(8)	118.6(2)
N(5)-N(4)-C(11)	118.1(3)
N(6)-N(5)-N(4)	171.1(3)

Symmetry transformations used to generate equivalent atoms:

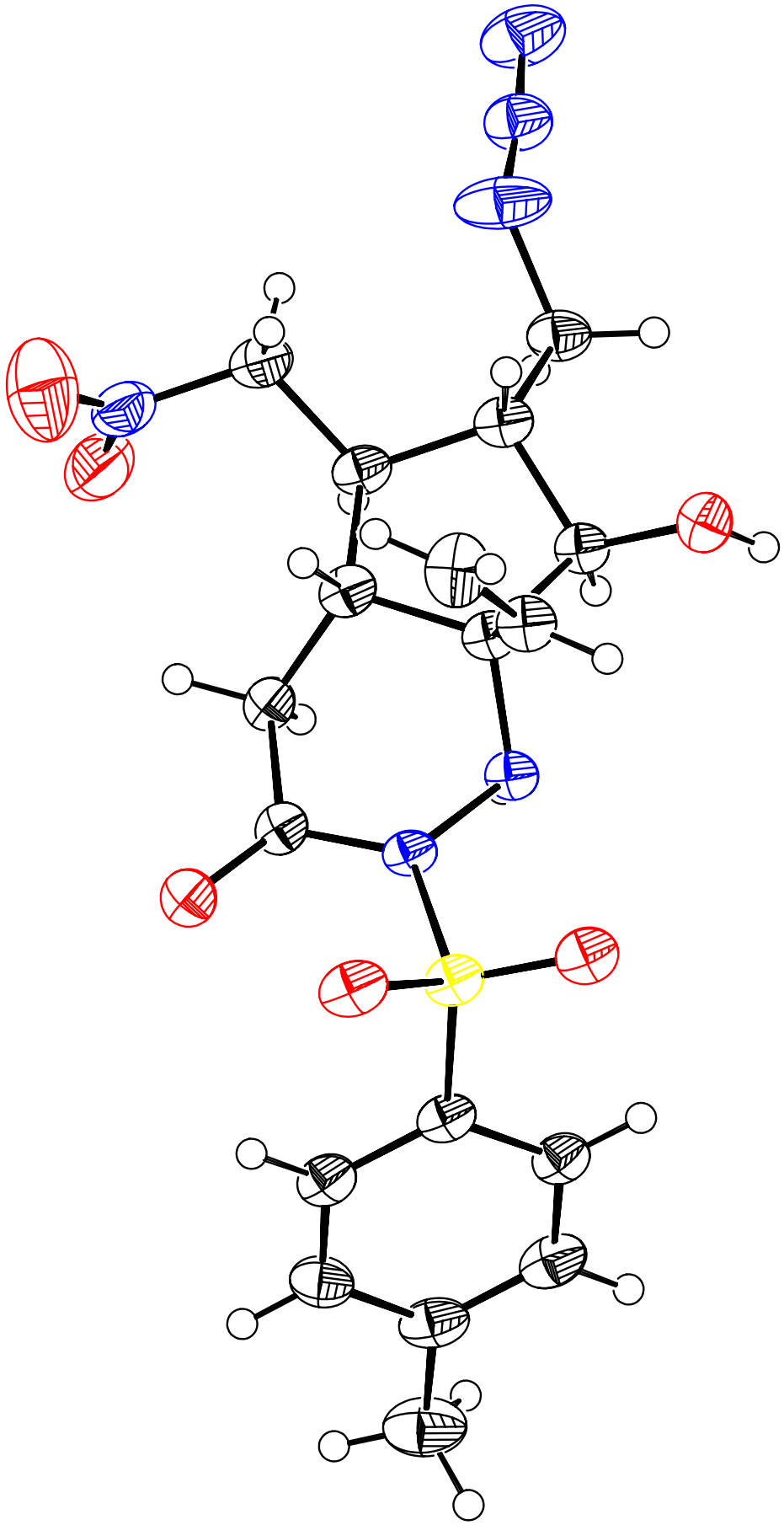
Table 4. **Anisotropic displacement parameters** ($Å^2$x 10^3)for p21. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

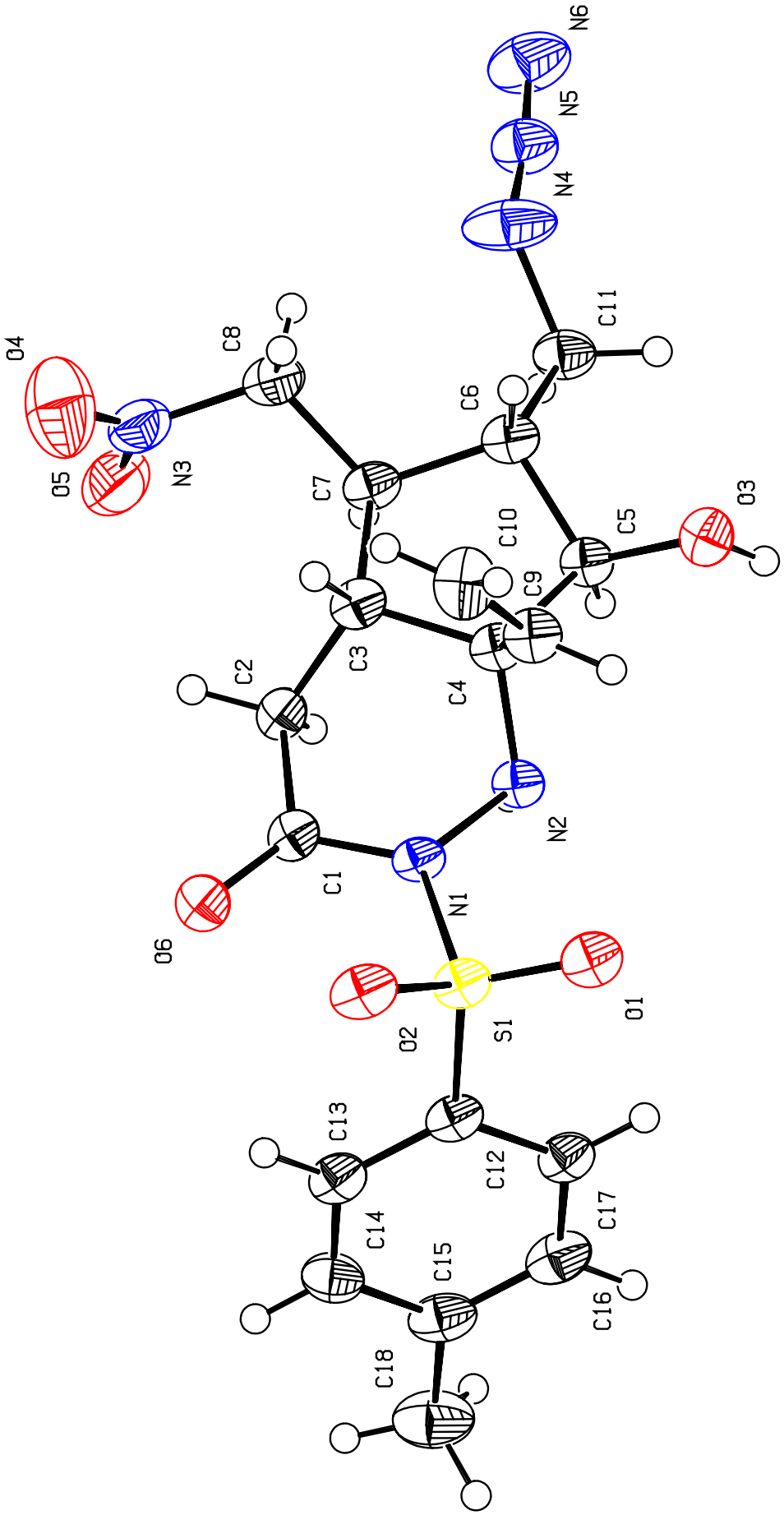
	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	28(1)	41(1)	14(1)	1(1)	6(1)	0(1)
C(5)	28(1)	34(1)	18(1)	0(1)	4(1)	2(1)
C(6)	28(2)	38(1)	24(1)	2(1)	4(1)	3(1)
C(1)	28(1)	36(1)	14(1)	-1(1)	1(1)	-1(1)
C(7)	26(1)	40(1)	22(1)	2(1)	6(1)	1(1)
C(2)	28(1)	35(1)	20(1)	-3(1)	5(1)	-4(1)
C(3)	28(2)	41(1)	15(1)	-1(1)	1(1)	0(1)
C(4)	26(1)	36(1)	16(1)	2(1)	4(1)	2(1)
C(8)	28(2)	46(2)	41(2)	-1(1)	4(1)	2(1)
C(9)	35(2)	38(1)	20(1)	4(1)	5(1)	2(1)
C(10)	56(2)	48(2)	21(1)	6(1)	-2(1)	-5(1)
C(11)	30(2)	44(2)	29(1)	1(1)	8(1)	4(1)
C(12)	24(1)	42(1)	15(1)	2(1)	6(1)	0(1)
C(13)	28(2)	46(2)	20(1)	-4(1)	7(1)	-2(1)
C(14)	34(2)	42(2)	31(1)	-1(1)	12(1)	5(1)
C(15)	28(2)	56(2)	24(1)	3(1)	8(1)	5(1)
C(16)	28(2)	60(2)	23(1)	-2(1)	2(1)	0(1)
C(17)	27(2)	43(1)	23(1)	-2(1)	7(1)	-2(1)
C(18)	43(2)	73(2)	34(2)	6(1)	1(1)	16(2)
O(1)	35(1)	43(1)	24(1)	4(1)	9(1)	-1(1)
O(2)	32(1)	60(1)	13(1)	-1(1)	7(1)	1(1)
O(3)	37(1)	38(1)	22(1)	0(1)	1(1)	-2(1)
O(4)	112(3)	72(2)	54(2)	-16(1)	-9(2)	-11(2)
O(5)	42(2)	51(1)	80(2)	9(1)	-6(1)	-4(1)
N(1)	23(1)	36(1)	15(1)	-2(1)	7(1)	1(1)
N(2)	27(1)	33(1)	13(1)	-1(1)	4(1)	2(1)
N(3)	29(1)	52(2)	46(1)	-5(1)	9(1)	-4(1)
N(4)	36(2)	103(2)	33(1)	5(1)	11(1)	21(2)
N(5)	37(2)	53(2)	32(1)	-1(1)	6(1)	4(1)
N(6)	39(2)	89(2)	41(1)	-1(1)	14(1)	1(2)
O(6)	36(1)	41(1)	19(1)	-6(1)	7(1)	-2(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for p21.

	x	y	z	U(eq)
H(5)	1157	737	-685	32
H(6)	2959	385	1098	36
H(7)	2540	1877	-268	35
H(2A)	1853	2955	1750	33
H(2B)	1185	2587	416	33
H(3)	2276	1732	2720	34
H(8A)	3977	1495	2125	46
H(8B)	4238	1649	517	46
H(9)	676	124	2858	37
H(10A)	2266	922	4268	50
H(10B)	1673	194	4909	50
H(11A)	2760	-81	-1456	41
H(11B)	2865	812	-1907	41
H(13)	-1651	3374	3196	37
H(14)	-2811	4126	1771	42
H(16)	-3780	2194	-493	44
H(17)	-2621	1423	918	37
H(18A)	-4021	3630	-1539	75
H(18B)	-3956	4297	-340	75
H(18C)	-4779	3641	-352	75
H(3A)	942	-431	-376	48
H(3)	80(30)	1576(17)	300(40)	46(9)

Table 6. Torsion angles [°] for p21.




N6
N5
N4
C11
C8
O4
C6
O5
N3
C7
C10
C5
O3
C9
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C2
C4
N2
C1
O6
N1
O2
S1
O1
C13
C12
C14
C17
C15
C16
C18