Efficient Synthesis of the C_1-C_{11} Fragment of the Tedanolides. The Non-aldol Aldol Process in Synthesis

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(*S*)-2-Methyl-3-[bis(4-methoxyphenyl)phenylmethoxy]-1-propanol, 8. Methyl (*R*)(-)-3-hydroxy-2-methylpropionate **7** (0.75 g, 6.35 mmol) was dissolved in dichloromethane (35 mL). Collidine (2.54 mL, 19 mmol) was then added to the solution which was stirred for 2 min at 25 °C. The reaction mixture was then cooled to 0 °C, treated with 4,4'-dimethoxytrityl chloride (2.79 g, 8.25 mmol), and the reaction allowed to warm to 25 °C and stir overnight. The reaction was quenched with 50% NH_4Cl (30 mL), the phases were separated, and the aqueous phase extracted with dichloromethane (2 x 30 mL). The organic phases were combined, washed with brine (40 mL), and dried over Na_2SO_4. Removal of the solvent under vacuum yielded a crude orange oil which was used without any further purification. A solution of the crude dimethoxytrityl methyl ester in THF (80 mL) was cooled to 0 °C and treated with LAH (490 mg, 12.7 mmol). The suspension was then allowed to warm to 25 °C and stir for 1 h. After being cooled to 0 °C, the reaction was quenched by the successive addition of water (0.65 ml), 15% sodium hydroxide (0.65 mL), and water (1.95 mL). The insoluble materials were filtered off through Celite and the solute washed with diethyl ether (3 x 40 mL). The filtrate and washings were concentrated under vacuum and the residue purified by flash column chromatography (silica gel, 1% triethylamine, 20% ethyl acetate, 79% hexanes) to yield 5.1 g (100%) of the DMTr monoprotected diol **8** as a very viscous yellow oil. $[\alpha]$= -23.3 ° (c, 0.9 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 7.30 (10H, m), 6.85 (3H, m), 3.80 (6H, s), 3.61 (2H, m), 3.22 (1H, dd, J = 9.1, 4.5 Hz), 2.98 (1H, dd, J = 9.0, 7.9 Hz), 2.40 (1H, dd, J = 6.7, 4.7 Hz), 2.04 (1H, m), 0.85 (3H, d, J = 6.9 Hz). ^{13}C NMR ($CDCl_3$) δ: 158.33, 144.73, 135.99, 135.85, 129.88, 127.95, 127.74, 126.65, 113.01, 86.26, 67.77, 67.64, 55.08, 35.81, 13.65 (3 lowfield carbons unresolved). IR (neat) 3427, 2959, 2932, 2837,

1608, 1510, 1464, 1446, 1302, 1251, 1176, 1035, 829, 702 cm^{-1}.

(4*S*)-2,4-Dimethyl-5-[bis(4-methoxyphenyl)phenylmethoxy]-2-penten-1-ol, 9. A solution of oxalyl chloride (1.60 mL, 19.04 mmol) in dry dichloromethane (220 mL) was treated with a DMSO (2.70 mL, 38.08 mmol) solution in dichloromethane (40 mL) at -78 °C and allowed to stir for 2 min. The dimethoxytrityl alcohol **8** (4.99 g, 12.69 mmol) in dichloromethane (100 mL) was then added and the mixture stirred for 15 min at -78 °C. Finally, triethylamine (8.84 mL, 63.46 mmol) was added and the temperature kept constant for a further 5 min before allowing the reaction to warm up to 25 °C. Once the reaction reached 25 °C, it was diluted with water (250 mL) and the layers separated. Extraction of the aqueous layer with dichloromethane (2 x 60 mL), followed by successive washings of the combined organic phases with 1% HCl (100 mL), water (100 mL), 5% $NaHCO_3$ (100 mL), water (100 mL) and brine (100 mL), drying of the solution over Na_2SO_4 and concentration under vacuum yielded the crude aldehyde intermediate. This crude aldehyde was then dissolved in dichloromethane (300 mL), treated with (carboethoxyethylidene)triphenylphosphorane (5.75 g, 16.50 mmol), and refluxed for 2 d. Addition of water (200 mL), followed by separation, extraction with dichloromethane (2 x 50 mL), drying over Na_2SO_4, and filtration (silica gel, 5% ethyl acetate in hexanes) yielded the semi-crude ester. This crude ester was then dissolved in diethyl ether (200 mL), and treated at 25 °C with a 1 M solution of DIBAL-H in hexanes (25 mL, 25 mmol). The solution was stirred for 30 min and was then quenched with 0.5M Rochelle's Salt solution (20 mL) and diluted with water (30 mL). The emulsion was stirred until both layers were clearly visible and the organic layer was clear. The phases were separated and the aqueous layer was acidified with 1% HCl and extracted with diethyl ether (2 x 50 mL). The combined organic layers were dried over Na_2SO_4, the solvent removed under vacuum, and the oily residue sujected to flash column chromatography (1% triethylamine, 20% ethyl acetate in hexanes) to yield 4.72 g (86%) of the desired alkenol **9** as a colorless oil. [a]= + 14.8 ° (c, 1.4 in $CHCl_3$).

^{1}H NMR ($CDCl_3$, 500 MHz) δ: 7.45 (2H, m), 7.35 (4H, m), 7.29 (2H, m), 7.21 (1H, m), 6.68 (4H, m), 5.19 (1H, dq, J = 9.4, 1.2 Hz), 4.13 (2H, s), 3.80 (6H, s), 2.99 (1H, dd, J = 8.7, 6.3 Hz), 2.91 (1H, dd, J = 8.6, 7.1 Hz), 2.72 (1H, m), 1.69 (3H, d, J = 1.2 Hz), 1.50 (1H, bs), 1.02 (3H, d, J = 6.7 Hz). ^{13}C NMR ($CDCl_3$) δ: 158.12, 145.26, 136.54, 136.50, 134.76, 129.99, 129.98, 129.19, 128.16, 127.55, 126.47, 112.84, 85.50, 68.71, 67.85, 55.08, 33.06, 17.79, 13.85 (2 low field carbons unresolved). IR (neat) 3600-3150 (b), 2957, 2930, 2910, 2835, 2864, 1608, 1577, 1508, 1444, 1300, 1250, 1176, 1064, 1033, 829, 702 cm^{-1}.

(2*S*)(*E*)-2,4-Dimethyl-5-[((1,1-dimethyl)ethyl)dimethylsilyloxy]pent-3-en-1-ol, 10. The dimethoxytrityl alcohol **9** (4.72 g, 10.9 mmol) was dissolved in anhydrous DMF (60 mL) and treated with imidazole (2.60 g, 38 mmol). The reaction mixture was then stirred at 25 °C until clear before being treated with TBSCl (2.86 g, 19 mmol). The reaction was stirred at 25 °C until TLC indicated completion of the reaction (ca. 2 h). The reaction was then diluted with diethyl ether (100 mL) and quenched with water (100 mL). The organic phase was separated and throughly washed with water (4 x 100 mL). The diethyl ether phase was then dried over $MgSO_4$, concentrated under vacuum and then purified by column chromatography (silica gel, 5% ethyl acetate in hexanes) to yield 5.95 g (100%) of the desired TBS ether. This TBS ether (373.4 mg, 0.68 mmol) was dissolved in absolute ethanol (50 mL). Dry Amberlist-15 resin was then added and the suspension stirred at 25 °C until TLC indicated completion of the reaction (ca. 8 h). The resin was then filtered off through a cotton plug and washed with diethyl ether (2 x 5 mL). The ether washings were combined with the filtrate and allowed to sit overnight. An extra portion of ether (40 mL) was added and the mixture washed with 5% $NaHCO_3$ (30 mL), water (30 mL), and brine (20 mL). The organic layer was dried over $MgSO_4$, concentrated under vacuum, and purified by column chromatography (7.5 % ethyl acetate in hexanes) to yield 13 mg (3.5%) of recovered starting material and 144 mg (93%) of a the free alcohol **10** as

a clear yellow oil. $[\alpha]_D^{25}$ = -20.9 ° (c, 1.1 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 5.17 (1H, dq, *J* = 9.5, 1.4 Hz), 4.03 (2H, s), 3.48 (1H, m), 3.63 (1H, dd, *J* = 10.3, 8.0 Hz), 2.65 (1H, m), 1.65 (3H, s), 1.39 (1H, bs), 0.95 (3H, d, *J* = 6.7 Hz), 0.91 (9H, s), 0.06 (6H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 136.86, 126.29, 68.16, 67.74, 34.91, 25.80, 18.29, 16.74, 13.72, -5.37 (2C's). IR (neat): 3391, 2930, 2860, 1473, 1464, 1361, 1255, 1074, 1035, 939, 837, 775 cm^{-1}.

(2*R*,3*S*,4*R*)-3-Bromo-2,4-dimethyl-2-[([(1,1-dimethyl)ethyl]dimethylsilyloxy)methyl]tetrahydrofuran, 11. (2*S*)(*E*)-2,4-Dimethyl-5-[((1,1-dimethyl)ethyl)dimethylsilyloxy]pent-3-en-1-ol **10** (124.4 mg, 0.546 mmol) was dissolved in anhydrous dichloromethane (18 mL). *N*-Bromosuccinimide (214 mg, 1.20 mmol) was added and the reaction refluxed in the dark for 1.5 h. Water (30 mL) was added, the layers separated, and the aqueous layer extracted with dichloromethane (2 x 15 mL). Combination of the organic layers, followed by drying over $MgSO_4$, concentration under vacuum, and flash column chromatography (silica gel, 4% ethyl acetate in hexanes) yielded 146.7 mg (88%) of the bromotetrahydrofuran **11** as a clear oil. $[\alpha]_D^{25}$ = -12.88 ° (c, 0.73 in $CHCl_3$). ^1H NMR (C_6D_6, 500 MHz) δ: 4.07 (1H, d, *J* = 10.7 Hz), 3.69 (1H, app t, *J* = 8.1 Hz), 3.54 (1H, d, *J* = 10.8 Hz), 3.52 (1H, d, *J* = 10.8 Hz), 3.18 (1H, dd, *J* = 10.0, 8.3 Hz), 2.26 (1H, m), 1.26 (3H, s), 0.96 (9H, s), 0.84 (3H, d, *J* = 6.5 Hz), 0.07 (3H, s), 0.06 (3H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 84.19, 72.09, 66.60, 56.32, 42.13, 25.76, 21.64, 18.15, 14.08, -5.46, -5.64. IR (neat) 2957, 2930, 2856, 1460, 1381, 1251, 1103, 1037, 925, 837, 777 cm^{-1}. HRMS (EI) 325.102149, calc for $C_{13}H_{28}O_2Si^{81}Br$, 325.101870; 323.103716, calc for $C_{13}H_{28}O_2SiBr$, 323.104195.

Ethyl (*E*)-3-((2*R*,3*S*,4*R*)-3-bromo-2,4-dimethyltetrahydrofuran-2-yl)-2-methylprop-2-enoate, 12. A solution of the bromotetrahydrofuran silyl ether **11** (146.7 mg, 0.479 mmol) in THF (10 mL) was treated with a 1.0 M solution of TBAF in

THF (0.96 mL, 0.96 mmol). The reaction was allowed to stir at 0 °C for 5 min and then allowed to stir at 25 °C until completion of the reaction as indicated by TLC (ca. 1 h). The reaction was then quenched by the addition of water (20 mL), the layers separated, and the aqueous layer extracted with diethyl ether (2 x 20 mL). The combined organic phases were dried over $MgSO_4$, concentrated under vacuum, and purified by flash column chromatography (25% ethyl acetate in hexanes) to yield 79 mg (86%) of (2*R*,3*S*,4*R*)-3-bromo-2,4-dimethyltetrahydrofuran-2-methanol. $[\alpha]_D^{25}$ = -47.2 ° (c, 1.1 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 4.05 (1H, app t, *J* = 8.3 Hz), 3.94 (1H, d, *J* = 10.8 Hz)), 3.52 (2H, m), 3.37 (1H, dd, *J* = 9.7, 8.4 Hz), 2.55 (1H, m), 2.20 (1H, bs), 1.22 (3H, s), 1.12 (3H, d, *J* = 6.5 Hz). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 84.51, 72.17, 65.19, 55.01, 41.39, 20.77, 14.34. IR (neat) 3427 (bs), 2970, 2934, 2874, 1456, 1381, 1332, 1300, 1240, 1062, 1024, 920, 808 cm^{-1}. A solution of oxalyl chloride (0.48 mL, 5.54 mmol) in dry dichloromethane (120 mL) cooled to -78 °C was treated with DMSO (0.78 mL, 11.08 mmol) in dichloromethane (10 mL) and allowed to stir for 2 min. The bromotetrafuran alcohol (768 mg, 3.69 mmol) in dichloromethane (20 mL) was then added and the mixture stirred for 15 min at -78 °C. Triethylamine (2.57 mL, 18.5 mmol) was added and the temperature kept constant for a further 5 min before allowing the reaction to warm up to 25 °C. The reaction was then treated with water and the layers separated. Extraction of the aqueous layer with dichloromethane (2 x 30 mL), followed by successive washings of the combined organic phases with 1% HCl (50 mL), water (50 mL), 5% $NaHCO_3$ (50 mL), water (50 mL) and brine (50 mL), yielded, after drying over $MgSO_4$ and concentration under vacuum, the crude aldehyde. This crude aldehyde was then dissolved in benzene (100 mL), treated with (carboethoxyethylidene)triphenylphosphorane (3.86 g, 11.07 mmol), and the solution refluxed overnight. Addition of water (100 mL), followed by separation of the layers, extraction of the aqueous layer with diethyl ether (2 x 30 mL), drying over $MgSO_4$, concentration under vacuum and flash column chromatography (silica gel, 5% ethyl acetate in hexanes) yielded 984 mg (92%) of the ester **12** as a clear oil. [α]=

+29.5 ° (c, 1.38 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 6.80 (1H, q, J = 1.4 Hz), 4.19 (2H, q, J = 7.1 Hz)), 4.06 (1H, app t, J = 8.4 Hz), 3.75 (1H, d, J = 9.4 Hz), 3.38 (1H, app t, J = 9.0 Hz), 2.54 (1H, m), 2.02 (3H, d, J = 1.4 Hz), 1.47 (3H, s), 1.30 (3H, t, J = 7.1 Hz), 1.12 (3H, d, J = 6.6 Hz). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 168.25, 142.24, 129.26, 83.94, 71.36, 61.81, 60.76, 42.13, 24.17, 14.78, 14.12, 13.23. IR (neat) 2980, 2936, 1716, 1456, 1373, 1253, 1176, 1126, 1093, 1030, 804, 748 cm^{-1}. HRMS (EI) 291.0592, calc for $C_{12}H_{20}O_3Br$ 291.0596, 293.0572, calc for $C_{12}H_{20}O_3{}^{81}Br$ 293.0575.

(2*R*,3*S*,4*R*)-3-Bromo-2,4-dimethyl-2-((*E*)-2-methyl-3-hydroxy-1-propenyl)tetrahydrofuran, 13. A solution of the bromotetrahydrofuran ester **12** (90 mg, 0.329 mmol) in diethyl ether (15 mL) was treated with a 1 M solution of DIBAL-H in hexanes (0.82 ml, 0.821 mmol) at 25 °C. The reaction was quenched after 5 min by addition of a 0.5 M Rochelle's salt solution (ca. 7 mL), followed by dilution with diethyl ether (20 mL), and addition of water (5 mL). The reaction was stirred at 25 °C until both phases were clearly separated and the organic layer was clear. Separation of the phases, acidification of the aqueous layer with 1N HCl to pH 1, extraction with diethyl ether (2 x 30 mL), combination of the organic extracts, followed by drying over $MgSO_4$, concentration under vacuum, and flash column chromatography (silica gel, 25% ethyl acetate in hexanes) afforded 70 mg (91%) of the desired alkenol **13** as a pale yellow oil. [α]= +18.82 ° (c, 1.2 in $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz) δ: 5.58 (1H, q, J = 1.4 Hz), 4.03 (1H, app t, J = 8.5 Hz), 3.96 (2H, s), 3.71 (1H, d, J = 9.6 Hz), 3.60 (1H, app t, J = 8.8 Hz), 2.51 (1H, m), 1.82 (3H, d, J = 1.4 Hz), 1.79 (1H, bs), 1.43 (3H, s), 1.11 (3H, d, J = 6.6 Hz). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 137.63, 127.47, 83.94, 71.25, 68.68, 63.09, 42.08, 24.60, 15.17, 14.59. IR (neat) 3375, 2970, 2932, 2874, 1676, 1456, 1379, 1238, 1196, 1014, 924, 843, 787 cm^{-1}.

(2*R*,3*S*,4*R*) 3-Bromo-2-{(2*S*,3*R*)-3-[(1,1-dimethyl)ethyl)dimethylsilyloxy]-methyl-3-methyloxiran-2-yl}-2,4-dimethyltetrahydrofuran, 14 and (2*R*,3*S*,4*R*) 3-Bromo-2-{(2*R*,3*S*)-3-[(1,1-dimethyl)ethyl)dimethylsilyloxy]-methyl-3-methyloxiran-2-yl}-2,4-dimethyltetrahydrofuran, 15.

Procedure A. L(+)-Diisopropyl tartrate (98.9 mg, 0.212 mmol) and 4Å powdered molecular sieves (84 mg) were suspended in dichloromethane (2 mL). The suspension was cooled to -20 °C and treated with titanium (IV) isopropoxide (123 μL, 0.417 mmol) followed by vigorous stirring for 20 min at -20 °C. A 5.8 M solution of *t*-butyl hydroperoxide in decane (0.410 mL, 2.360 mmol) was then added and the reaction stirred for a further 20 min at -20 °C. A solution of the alcohol **13** (279.3 mg, 1.126 mmol) in dichloromethane (3 mL) was then introduced and the reaction temperature kept at -23 °C for 24 h. The reaction was then diluted with diethyl ether (10 mL) and filtered through a mixture of Celite and silica gel. The solvent was then removed under vacuum to yield a mixture of epoxy alcohols which were taken on to the next step without further purification. A solution of the crude epoxy alcohols in anhydrous DMF (25 mL) at 25 °C was treated sequentially with imidazole (230 mg, 3.380 mmol) and TBSCl (255 mg, 1.690 mmol). The reaction was stirred vigorously until completion of the reaction as indicated by TLC (ca. 2 h) and was then diluted with diethyl ether (50 mL) and poured into water (80 mL). The newly formed mixture was shaken and the aqueous layer removed after separation. The diethyl ether layer was repeatedly washed with water (3 x 80 mL), dried over $MgSO_4$, and then concentrated under vacuum. Flash column chromatography of the residue (silica gel, 2% ethyl acetate in hexanes) yielded 330 mg (81%) of the desired major diastereomer **15** $[\alpha]$= +0.72 (c, 1.38 in $CHCl_3$) and 33 mg (8%) of the undesired minor diastereomer **14** $[\alpha]$= +1.39 (c, 0.86 in $CHCl_3$).

Procedure B. A crude sample of the allylic alcohol **13** (8 mg, 0.034 mmol) in benzene (10 mL) was treated with a catalytic amount of $VO(acac)_2$ (1 mg, 0.0007 mmol) at 25 °C. The suspension was then treated with a 5.8 M solution of *t*-butyl hydroperoxide in decane

(8.2 μL, 0.047 mmol) and the reaction allowed to stir until completion of the reaction as indicated by TLC (ca. 2 h). The solvent was removed under vacuum and the crude residue suspended in diethyl ether (5 mL). The suspension was then filtered through Fluorisil and the solvent removed under vacuum to yield a clear oil that was taken on crude to the next step without further purification. The crude epoxy alcohol mixture was then suspended in anhydrous DMF (5 mL) and the clear solution treated with imidazole (10 mg, 0.109 mmol). The homogeneous mixture was then treated with TBSCl (10 mg, 0.054 mmol) and stirred until completion of the reaction as indicated by TLC (ca. 1 h). The mixture was then diluted with diethyl ether (10 mL), washed with water (3 x 10 mL), and dried over $MgSO_4$. Solvent removal under vacuum, followed by flash column chromatography (silica gel, 2.5% ethyl acetate in hexanes), gave a mixture of three compounds: the protected TBS allylic alcohol (1 mg, 9%), and a mixture of the diastereomeric epoxides (9.3 mg, 81%). The epoxides, although they could not be separated at this scale, were shown to be a 2.3 : 1 mixture of diastereomers favoring the undesired epoxide **14** by NMR analysis.

Procedure C. A solution of *m*-chloroperbenzoic acid (*m*CPBA, 17 mg, 0.067 mmol) in dichloromethane (5 mL) cooled to 0 °C was treated with a solution of the allylic alcohol **13** (13 mg, 0.056 mmol) in dichloromethane (3 mL). The reaction mixture was then allowed to warm to 25 °C where it was stirred until completion of the reaction as indicated by TLC (ca. 3 h). The reaction was quenched by the addition of saturated $NaHCO_3$ (5 mL) and a 1 M solution of $NaHSO_3$ (5 mL). The mixture was then extracted with diethyl ether (2 x 15 mL) and the combined organic layers dried over $MgSO_4$. Solvent removal under vacuum yielded the crude epoxides, which were taken on the next step without further purification. The crude epoxy alcohols were then suspended in anhydrous DMF (7 mL) and the clear solution treated with imidazole (11 mg, 0.168 mmol). The homogeneous mixture was then treated with TBSCl (12.6 mg, 0.084 mmol) and stirred until completion of the reaction as indicated by TLC (ca 1 h). The mixture was then diluted with diethyl ether (10 mL), washed with water (3 x 20 mL), and dried over $MgSO_4$. Solvent removal under vacuum

yielded 16.7 mg (90%) of a crude mixture of diastereomeric epoxides which NMR analysis indicated to be a 6.7 : 1 ratio favoring the undesired epoxide **14**.

Procedure D. A solution of *m*CPBA (excess) in dichloromethane (3 mL) cooled to 0 °C was treated with a solution of the allylic TBS ether (ca. 1 mg) in dichloromethane (1.5 mL). The reaction mixture was then allowed to warm to 25 °C where it was stirred until completion of the reaction as indicated by TLC (ca. 1 h). The reaction was quenched by the addition of saturated $NaHCO_3$ (2 mL) and a 1 M solution of $NaHSO_3$ (2 mL). The mixture was then extracted with diethyl ether (2 x 5 mL), and the combined organic layers dried over $MgSO_4$. Solvent removal under vacuum yielded a crude mixture of diastereomeric epoxides (1 mg, 70%) which NMR analysis indicated to be a 6.2 : 1 ratio favoring the undesired epoxide **14**.

15: ^{1}H NMR ($CDCl_3$, 500 MHz) δ: 3.95 (1H, app t, J = 8.5 Hz), 3.82 (1H, d, J = 9.1 Hz), 3.55 (1H, d, J = 11.2 Hz), 3.51 (1H, d, J = 11.1 Hz), 3.27 (1H, dd, J = 10.0, 8.8 Hz), 3.05 (1H, s), 2.56 (1H, m), 1.44 (3H, s), 1.39 (3H, s), 1.12 (3H, d, J = 6.6 Hz), 0.89 (9H, s), 0.06 (3H, s), 0.05 (3H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 82.40, 71.08, 67.83, 65.79, 60.21, 58.32, 44.19, 25.70, 23.69, 18.15, 14.17, 13.88, -5.50, -5.51. IR (neat): 2959, 2934, 2858, 1473, 1464, 1379, 1257, 1093, 1045, 839, 779 cm^{-1}.

14: ^{1}H NMR ($CDCl_3$, 500 MHz) δ: 3.98 (1H, app t, J = 8.2 Hz), 3.92 (1H, d, J = 10.7 Hz), 3.57 (2H, s), 3.39 (1H, dd, J = 9.9, 8.5 Hz), 3.02 (1H, s), 2.42 (1H, m), 1.49 (3H, s), 1.33 (3H, s), 1.11 (3H, d, J = 6.5 Hz), 0.88 (9H, s), 0.06 (3H, s), 0.05 (3H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 81.03, 72.06, 67.54, 62.72, 62.21, 59.79, 40.59, 25.70, 21.69, 18.16, 13.80, 13.54, -5.48, -5.52. IR (neat): 2957, 2930, 2858, 1471, 1462, 1375, 1253, 1186, 1101, 1033, 914, 839, 777 cm^{-1}.

(2*R*,3*S*,4*R*)-3-Bromo-2,4-dimethyl-2-[(*E*)-3-[((1,1-dimethyl)ethyl)-

dimethylsilyloxy]-2-methyl-1-propenyl]tetrahydrofuran. A solution of the alkenol **13** in anhydrous DMF (10 mL) was treated with imidazole (34 mg, 0.499 mmol) and stirred at 25 °C until clear. TBSCl (38 mg, 0.250 mmol) was then added while the solution was vigorously stirred. Upon completion of the reaction as indicated by TLC (1 h), the reaction was diluted with diethyl ether (25 mL) and quenched with water (40 mL). The two layers were separated, the organic layer was thoroughly washed with water (3 x 30 mL), dried over $MgSO_4$, concentrated under vacuum, and purified by flash column chromatography (silica gel, 2.5% ethyl acetate in hexanes) to yield 50 mg (86%) of the desired silyl ether as a yellow oil. [α]= +20.0 (c, 1.35 in CH_2Cl_2). ^1H NMR ($CDCl_3$, 500 MHz) δ: 5.61 (1H, q, J = 1.3 Hz), 4.04 (1H, app t, J = 8.5 Hz), 3.97 (2H, s), 3.72 (1H, d, J = 9.4 Hz), 3.39 (1H, app t, J = 8.8 Hz), 2.53 (1H, m), 1.76 (3H, d, J = 0.7 Hz), 1.43 (3H, s), 1.11 (3H, d, J = 6.7 Hz), 0.91 (9H, s), 0.06 (6H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 136.84, 126.12, 83.97, 71.10, 68.09, 63.28, 42.09, 25.80, 24.56, 18.26, 15.11, 14.12, -5.38, -5.40. IR (neat) 2959, 2932, 2858, 1684, 1471, 1464, 1361, 1257, 1159, 1115, 1080, 939, 839, 777, 667 cm^{-1}.

(α*R*,β*R*,2*R*,3*S*,4*R*) 3-Bromo-α,2,4-trimethyl-β-trimethylsilyloxytetra-hydrofuran-2-propanal, 16. A solution of the epoxy TBS ether **15** (285.5 mg, 0.755 mmol) in dichloromethane (35 mL) was treated with anhydrous diisopropylethyl-amine (0.395 mL, 2.266 mmol) and the resulting mixture cooled to -78 °C. Trimethylsilyl triflate (TMSOTf, 0.410 mL, 2.266 mmol) was then added and the reaction allowed to stir at -78 °C until completion of the reaction as indicated by TLC (ca. 5 h). The reaction was then poured into a water:diethyl ether (1:1, 200 mL total volume) mixture and the newly formed mixture shaken vigorously. The aqueous layer was removed and the organic phase washed with water (100 mL), 1 M KH_2PO_4 solution (100 mL), and water (100 mL), and dried over Na_2SO_4. Removal of the solvent under vacuum yielded 225 mg (89%) of the crude aldehyde **16** as a clear oil. ^1H NMR ($CDCl_3$, 500 MHz) δ: 9.63 (1H, d, J = 1.4 Hz),

4.13 (1H, d, J = 4.3 Hz), 3.91 (1H, app t, J = 8.2 Hz), 3.80 (1H, d, J = 10.2 Hz), 3.25 (1H, dd, J = 10.3, 8.5 Hz), 2.69 (1H, m), 2.50 (1H, m), 1.30 (3H, s), 1.17 (3H, d, J = 7.3 Hz), 1.10 (3H, d, J = 6.5 Hz), 0.12 (9H, s).

(4*R*,5*S*)-4-((2*R*,3*S*,4*R*)-3-Bromo-2,4-dimethyltetrahydrofuran-2-yl)-2,2,5-trimethyl-1,3-dioxane, 17. A solution of the aldehyde **16** (50 mg, 0.149 mmol) in diethyl ether (10 mL) was treated a 1.0 M DIBAL-H solution in hexanes (0.327, 0.372 mmol) and the mixture stirred until completion of the reaction as indicated by TLC (20 min). The reaction was quenched by addition of a 0.5 M Rochelle's salt solution (ca. 4 mL), followed by dilution with diethyl ether (15 mL), and extra addition of water (6 mL). The reaction was stirred at 25 °C until both phases were clearly separated and the organic layer was clear. The phases were separated and the aqueous layer acidified with 1N HCl to pH 1. The aqueous layer was then extracted with diethyl ether (2 x 30 mL). The combined organic extracts were dried over $MgSO_4$ and concentrated under vacuum to yield the crude alcohol which was used without further purification. The alcohol was dissolved in THF (5 mL) and was then treated at 0 °C with a 1.0 M tetra-*n*-butylammonium fluoride (TBAF) solution in THF (0.158 mL, 0.158 mmol). The reaction was allowed to warm and stir at 25 °C until completion of the reaction was indicated by TLC (1 h). The reaction was then diluted with diethyl ether (10 mL) and poured into water (25 mL). The organic phase was separated, dried over $MgSO_4$, and concentrated under vacuum to yield the desired crude diol (9.5 mg, 0.036 mmol) which was used without purification. This diol was then dissolved in THF (4 mL) and treated with 2,2-dimethoxypropane (9 μL, 0.072 mmol) at 25 °C. *p*-Toluenesulfonic acid (cat. amount) was then added to the mixture and the reaction stirred until completion of the reaction as indicated by TLC (30 min). The reaction was then diluted with diethyl ether (10 mL) and quenched by the addition of water (10 mL). The layers were separated, the organic layer dried over $MgSO_4$, the solvent removed under vacuum, and the residue purified by flash column chromatography (silica gel, 10% ethyl

acetate in hexanes) to yield 39 mg (86%) of the desired ketal **17** as a clear oil. ^{1}H NMR ($CDCl_3$, 500 MHz) δ: 4.11 (1H, dd, J = 11.4, 2.6 Hz), 4.05 (1H, d, J = 8.6 Hz), 4.04 (1H, d, J = 2.6 Hz), 3.89 (1H, t, J = 8.1 Hz), 3.56 (1H, dd, J = 11.4, 1.7 Hz), 3.39 (1H, dd, J = 10.0, 8.2 Hz), 2.58 (1H, m), 1.56 (1H, m), 1.44 (3H, s), 1.41 (3H, s), 1.31 (3H, s), 1.18 (3H, d, J = 6.9 Hz), 1.11 (3H, d, J = 6.6 Hz).

(4*S*,5*R*) Ethyl (*E*)-5-((2*R*,3*S*,4*R*)-3-bromo-2,4-dimethyltetrahydro-furan-2-yl)-2,4-dimethyl-5-trimethylsilyloxypent-2-enoate, 18. A solution of the epoxy TBS ether **15** (330 mg, 0.912 mmol) in dichloromethane (55 mL) was treated with anhydrous diisopropylethylamine (0.476 mL, 2.73 mmol) and the resulting mixture cooled to -78 °C. TMSOTf (0.495 mL, 2.73 mmol) was then added and the reaction allowed to stir at -78 °C until completion of the reaction as indicated by TLC (ca. 5 h). The reaction was then poured into a water:diethyl ether (1:1, 200 mL total volume) mixture and the newly formed mixture shaken vigorously. The aqueous layer was removed and the organic phase washed with water (100 mL), 1 M KH_2PO_4 solution (100 mL), water (100 mL) and dried over Na_2SO_4. Solvent removal under vacuum yielded the crude aldehyde **16** as a clear oil, which was used without further purification. The crude aldehyde was then dissolved in benzene (60 mL) and treated with (carboethoxyethylidene)triphenylphosphorane (953 mg, 2.73 mmol). The reaction was refluxed until completion of the reaction as indicated by NMR monitoring (6 h). The reaction was then cooled to 25 °C and quenched by the addition of water (50 mL). The layers were separated and the organic layer dried over Na_2SO_4 followed by concentration under vacuum. Flash column chromatography (5% ethyl acetate in hexanes) yielded 334.2 mg (83%) of the desired conjugated ester **18** as a colorless oil. ^{1}H NMR ($CDCl_3$, 500 MHz) δ: 6.69 (1H, dq, J = 9.9, 1.4 Hz), 4.22 (1H, dq, J = 14.9, 7.1 Hz), 4.15 (1H, dq, J = 14.9, 7.1 Hz), 3.96 (1H, d, J = 10.3 Hz), 3.91 (1H, app t, J = 8.1 Hz), 3.59 (1H, d, J = 5.5 Hz), 3.29 (1H, dd, J = 10.2, 8.4 Hz), 2.87 (1H, m), 2.49 (1H, m), 1.85 (3H, d, J = 1.4 Hz), 1.29 (3H, t, J = 7.1 Hz), 1.27

(3H, s), 1.10 (3H, d, J = 6.5 Hz), 1.01 (3H, d, J = 6.8 Hz). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 146.42, 125.46, 86.51, 80.44, 71.56, 60.35, 56.44, 43.20, 35.16, 22.69, 16.18, 14.14, 14.04, 12.28, 0.56 (one low field carbon unresolved).

(α*R*,2*R*,3*S*,4*R*) 3-Bromo-2,4-dimethyl-α-[(2*S*-(*E*)-5-[((1,1-dimethyl)-ethyl)dimethylsilyloxy]-4-methyl-3-penten-2-yl]tetrahydrofuran-2-methanol, 19. A solution of the conjugated ester **18** in diethyl ether (25 mL) was treated with a 1.0 M DIBAL-H solution in hexanes (0.75 mL, 0.75 mmol) and stirred at 25 °C until completion of the reaction as indicated by TLC (30 min). The reaction was then quenched with a 0.5 M Rochelle's salt solution (10 mL) and diluted with water (20 mL). Care had to be taken to separate the phases as soon as the two layers become visible due to the possibility of product decomposition in the presence of water. The aqueous layer was acidified to pH 1 with a 1N HCl solution and then extracted with diethyl ether (2 x 30 mL). The combined organic extracts were combined, dried over $MgSO_4$, and the solvent removed in vacuo to yield the desired crude alcohol. The crude alcohol was then suspended in THF (10 mL) and treated with a 1.0 M TBAF solution in THF (0.6 mL, 0.60 mmol) at 25 °C. The solution was stirred at 25 °C until TLC indicated completion of the reaction (ca. 1 h). The reaction was then treated with water (10 mL) and extracted with diethyl ether (2 x 15 mL). The organic extracts were combined and dried over $MgSO_4$. Solvent removal under vacuum followed by flash column chromatography (silica gel, 35% ethyl acetate in hexanes) yielded 67 mg (83%) of the desired diol. A solution of the diol (236 mg, 0.776 mmol) in dichloromethane (40 mL) was cooled to 0 °C and then treated with diisopropylethylamine (0.340 mL, 1.94 mmol). The reaction was stirred for 5 min at 0 °C before TBSOTf (0.360 mL, 1.00 mmol) was introduced and the resulting solution stirred until completion of the reaction as indicated by TLC (15 min). The reaction was then poured onto a diethyl ether:water mixture (1:1 60 mL total volume) and the resulting solution vigorously stirred and the phases separated. The organic phase was then washed with a 1 M KH_2PO_4 (30 mL),

water (30 mL), and subsequently dried over $MgSO_4$. Solvent removal under vacuum followed by flash column chromatography (silica gel, 20% ethyl acetate in hexanes) yielded 306.3 mg (94%) of the desired TBS ether **19** as a clear oil. $[\alpha]_D^{20}$ = -36.35 ° (c, 1.3 in $CHCl_3$). ^1H NMR ($CDCl_3$, 200 MHz) δ: 5.38 (1H, dq, *J* = 9.4, 1.3 Hz), 3.99 (4H, m), 3.48 (1H, dd, *J* = 7.1, 3.3 Hz), 3.34 (1H, dd, *J* = 9.9, 8.5 Hz), 2.74 (1H, m), 2.52 (1H, m), 2.34 (1H, d, *J* = 3.3 Hz), 1.61 (3H, d, *J* = 1.2 Hz), 1.33 (3H, s), 1.11 (3H, d, *J* = 6.5 Hz), 1.04 (3H, d, *J* = 6.7 Hz), 0.90 (9H, s), 0.05 (6H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 132.40, 128.53, 87.08, 79.85, 71.96, 68.14, 54.98, 43.05, 33.26, 25.80, 22.73, 18.23, 17.28, 14.00, 13.53, -5.35, -5.40. IR (neat) 3458, 2959, 2932, 2858, 1471, 1462, 1381, 1251, 1111, 1068, 837, 775, 669 cm^{-1}.

(α*R*,2*R*,3*S*,4*R*) 3-Bromo-2,4-dimethyl-α-[(2*S*-(*E*)-5-hydroxymethyl-4-methyl-3-penten-2-yl]tetrahydrofuran-2-methanol methanesulfonate, 20. A solution of the TBS ether **19** (157 mg, 0.376 mmol) in pyridine (7 mL) was cooled to 0 °C and treated with freshly recrystallized (from diethyl ether) methanesulfonic anhydride (196 mg, 1.127 mmol). The suspension was then allowed to warm and stir at 25 °C until TLC indicated completion of the reaction (1 h). The solvent was then removed under vacuum and the crude residue purified by flash column chromatography (silica gel, 10% ethyl acetate in hexanes) to yield 182.7 mg (98%) of (α*R*,2*R*,3*S*,4*R*) 3-bromo-2,4-dimethyl-α-[(2*S*-(*E*)-5-[((1,1-dimethyl)ethyl)dimethylsilyl-oxy]-4-methyl-3-penten-2-yl]tetrahydrofuran-2-methanol methanesulfonate as a colorless oil. [α]= -10.8 ° (c, 0.76 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 5.41(1H, dq, *J* = 9.5, 1.4 Hz), 4.54 (1H, d, *J* = 6.2 Hz), 3.99 (2H, s), 3.98 (1H, app t, *J* = 8.2 Hz), 3.92 (1H, d, *J* = 10.5 Hz), 3.34 (1H, dd, *J* = 10.4, 8.5 Hz), 3.08 (3H, s), 3.08 (1H, m), 2.51 (1H, m), 1.62 (3H, d, *J* = 1.2 Hz), 1.37 (3H, s), 1.20 (3H, d, *J* = 6.5 Hz), 1.10 (3H, d, *J* = 6.9 Hz), 0.89 (9H, s), 0.05 (6H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 134.06, 127.01, 89.79, 85.10, 71.63, 67.87, 55.92, 42.75, 38.43, 32.62, 25.79, 22.89, 18.24, 17.79, 13.69, 13.46, -5.39, -5.42. IR (neat)

2959, 2930, 2858, 1471, 1458, 1350, 1251, 1176, 1115, 1078, 1033, 949, 931, 837, 777 cm^{-1}. A solution of the TBS ether (94 mg, 0.189 mmol) in THF (10 mL) was cooled to 0 °C and was treated with a 1 M TBAF solution in THF (0.285 mL, 0.285 mmol). The reaction was kept at 0 °C for 5 min and then allowed to warm to 25 °C where it was stirred until completion of the reaction as indicated by TLC (15 min). The reaction was then quenched with water (6 mL) and extracted with diethyl ether (2 x 20 mL). The combined extracts were dried over $MgSO_4$ and the solvent removed under vacuum. Flash column chromato-graphy (silica gel, 45% ethyl acetate in hexanes) yielded 69 mg (95%) of the desired free alcohol **20** as a colorless oil. [α]= -5.45 ° (c, 0.14 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 5.44 (1H, dq, *J* = 9.4, 1.3 Hz), 4.52 (1H, d, *J* = 5.4 Hz), 3.98 (2H, s), 3.97 (1H, app t, *J* = 8.1 Hz), 3.90 (1H, d, *J* = 10.5 Hz), 3.33 (1H, dd, *J* = 10.4, 8.5 Hz), 3.08 (3H, s), 3.07 (1H, m), 2.50 (1H, m), 1.69 (1H, s), 1.68 (3H, d, *J* = 1.3 Hz), 1.36 (3H, s), 1.12 (3H, d, *J* = 5.8 Hz), 1.11 (3H, d, *J* = 6.2 Hz). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 134.36, 128.78, 89.40, 85.01, 71.64, 68.23, 56.32, 42.80, 38.40, 32.60, 22.74, 17.37, 13.71, 13.65.

(α*R*,2*R*,3*S*,4*R*) 3-Bromo-2,4-dimethyl-α-1-[[(1*S*,2'*S*,3'*S*)-3-[[((1,1-dimethyl)ethyl)dimethylsilyloxy]methyl-3-methyloxiran-2-yl]ethyl]-tetra-hydrofuran-2-methanol, methanesulfonate, 21. A solution of the allylic alcohol **20** (41.7 mg, 0.109 mmol) in benzene (10 mL) was treated with a catalytic amount of $VO(acac)_2$ (3 mg, 0.0109 mmol) at 25 °C. The suspension was then treated with a 5.8 M solution of *t*-butyl hydroperoxide in decane (56.5 μL, 0.327 mmol) and the reaction allo-wed to stir until completion of the reaction as indicated by TLC (ca. 2 h). The solution was diluted with diethyl ether (10 mL). The suspension was then filtered through silica gel and the solvent removed under vacuum to yield a yellow oil that was taken on crude to the next step without further purification. This crude epoxy alcohol mixture was then suspended in anhydrous DMF (5 mL) and the clear solution treated with imidazole (23 mg, 0.327

mmol). The homogeneous mixture was then treated with TBSCl (25 mg, 0.163 mmol) and stirred until completion of the reaction as indicated by TLC (ca. 1 h). The mixture was then diluted with diethyl ether (10 mL), washed with water (3 x 10 mL), and dried over $MgSO_4$. Solvent removal under vacuum, followed by flash column chromatography (silica gel, 5% ethyl acetate in hexanes), yielded the two diastereomeric epoxides in a 2.4:1 ratio favoring the desired epoxide **21** (35.6 mg, 65%) $[\alpha]$= +11.85 ° (c, 0.54 in $CHCl_3$) versus the undesired one (14.8 mg, 27%). It should be pointed out that the structure of the minor isomer has not been conclusively assigned. ^1H NMR ($CDCl_3$, 500 MHz) δ: 4.56 (1H, d, J = 1.7 Hz), 3.97 (1H, app t, J = 8.1 Hz), 3.85 (1H, d, J = 10.5 Hz), 3.68 (1H, d, J = 11.3 Hz), 3.49 (1H, d, J = 11.3 Hz), 3.30 (1H, dd, J = 10.6, 8.7 Hz), 3.13 (3H, s), 2.97 (1H, d, J = 9.5 Hz), 2.51 (1H, m), 2.01 (1H, m), 1.38 (3H, s), 1.33 (3H, s), 1.26 (3H, d, J = 6.8 Hz), 1.13 (3H, d, J = 6.5 Hz), 0.89 (9H, s), 0.06 (3H, s), 0.05 (3H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 84.95, 84.64, 71.54, 67.69, 63.99, 62.30, 57.98, 43.20, 38.48, 33.39, 25.73, 22.18, 18.15, 14.18, 13.49, 13.07, -5.50, -5.63. IR (neat) 2955, 2932, 2856, 1458, 1350, 1255, 1176, 1101, 931, 898, 777 cm^{-1}.

(4*S*,5*R*,6*S*,7*R*)(*Z*) Ethyl 7-((2*R*,3*S*,4*R*)-3-bromo-2,4-dimethyltetrahydro-furan-2-yl)-4,6-dimethyl-7-(methanesulfonyloxy)-5-trimethylsilyloxyhept-2-enoate, 22. A solution of the epoxide **21** (15.6 mg, 0.031 mmol) in dichloromethane (5 mL) was cooled to -78 °C and stirred for 15 min before being treated with anhydrous diisopropylethylamine (21.6 μL, 0.124 mmol). After the reaction stirred for an extra 5 min, TMSOTf (22.5 μL, 0.124 mmol) was then added and the reaction allowed to stir at -78 °C until completion of the reaction as indicated by TLC (ca. 3 h). The reaction was then poured into a water:diethyl ether mixture (1:1, 50 mL total volume) and the newly formed mixture shaken vigorously. The aqueous layer was removed and the organic phase washed with water (60 mL), 1 M KH_2PO_4 solution (60 mL), and water (60 mL), and dried over Na_2SO_4. Solvent removal under vacuum yielded the crude aldehyde as a clear oil

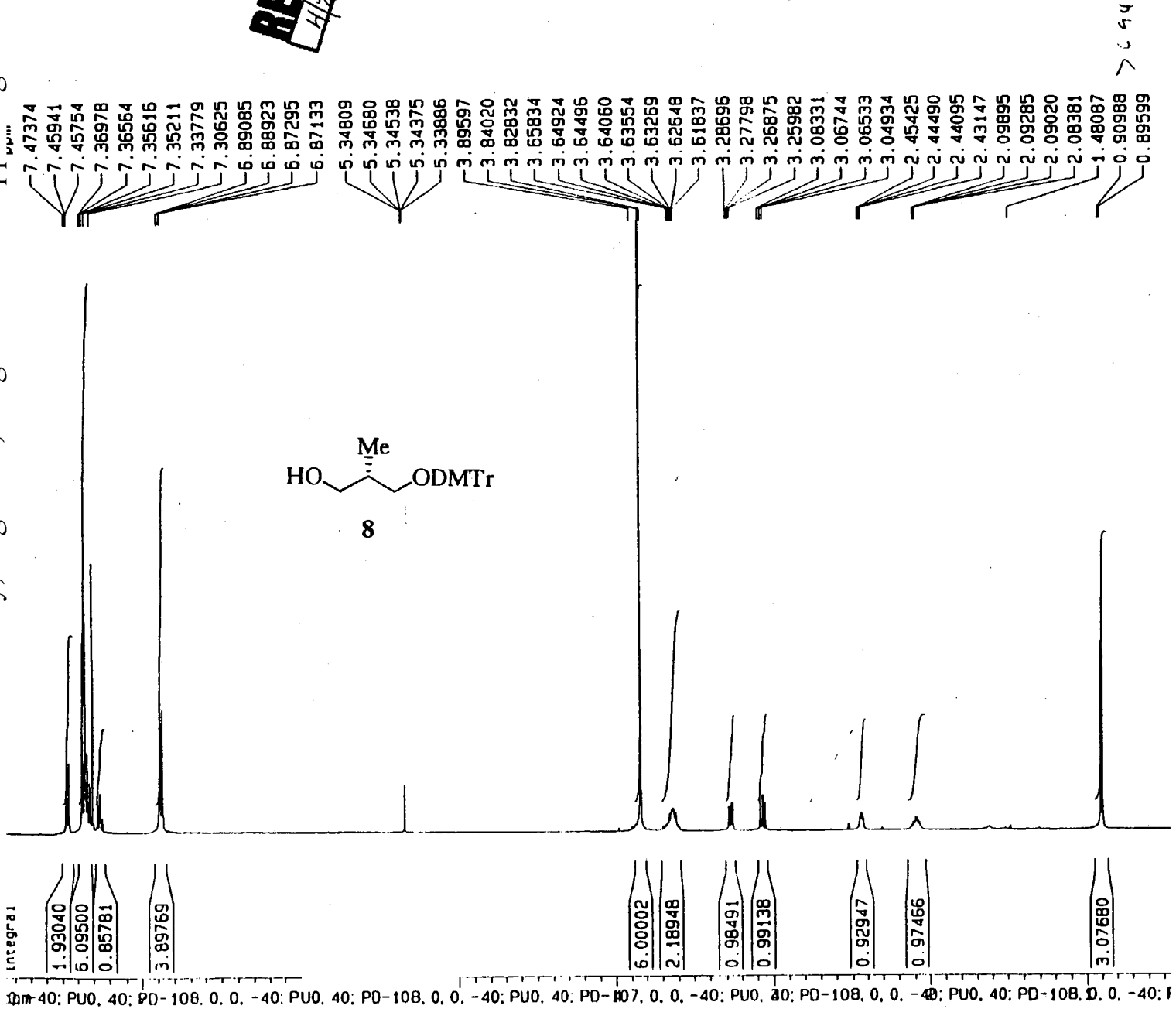
which was used without further purification. A solution of bis(2,2,2-trifluoroethyl) ethyl phosphonoacetate (20.6 mg, 0.062 mmol) in THF (10 mL) cooled to -78 °C was treated with a 0.5 M KHMDS solution in toluene (0.109 mL, 0.054 mmol). After the reaction stirred for 10 min, the mixture was treated with the crude aldehyde as a solution in THF (2.5 mL total volume) and the reaction stirred at -78 °C for 30 min before being allowed to warm to 25 °C where it was stirred for a further 45 min before being quenched with water (10 min). The reaction mixture was then extracted with diethyl ether (2 x 30 mL), the combined organic extracts were dried over Na_2SO_4, and the solvent removed under vacuum. Flash column chromatography (silica gel, 4% ethyl acetate in hexanes) yielded 13.2 mg (80%) of a 1:1 mixture of the desired *Z* conjugated ester **22** and a side product **23** which was further derivatized for ease of characterization. [α]= +56.25 ° (c, 0.16 in $CHCl_3$). ^1H NMR ($CDCl_3$, 500 MHz) δ: 6.17 (1H, dd, *J* = 11.4, 10.4 Hz), 5.75 (1H, dd, *J* = 11.4, 0.7 Hz), 4.81 (1H, d, *J* = 2.0 Hz), 4.15 (2H, q, *J* = 7.1 Hz), 3.97 (1H, d, *J* = 10.8 Hz), 3.96 (1H, app t, *J* = 8.0 Hz), 3.76 (1H, dd, *J* = 9.4, 1.7 Hz), 3.44 (1H, dd, *J* = 10.8, 8.5 Hz), 3.08 (3H, s), 3.07 (1H, m), 2.49 (1H, m), 2.27 (1H, m), 1.40 (3H, s), 1.27 (3H, t, *J* = 7.1 Hz), 1.13 (3H, d, *J* = 6.5 Hz), 1.00 (3H, d, *J* = 7.1 Hz), 0.96 (3H, d, *J* = 6.5 Hz), 0.12 (9H, s). ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 165.96, 154.35, 118.23, 84.72, 84.66, 77.40, 71.50, 59.70, 58.18, 43.18, 37.71, 36.20, 34.46, 21.68, 14.10, 13.21, 12.66, 12.32, 0.60. IR (neat) 2961, 2930, 2876, 2855, 1714, 1637, 1456, 1417, 1342, 1251, 1192, 1176, 1091, 1032, 927, 873, 839 cm^{-1}. HRMS (CI) 543.143164, calc for $C_{21}H_{40}O_7SiSBr$ 543.144740; 545.142694, calc for $C_{21}H_{40}O_7SiS^{81}Br$ 545.141532.

(2*R*,3*R*,4*S*,5*S*,6*R*) 2-[(1*S*,2*R*) 3-Acetyloxy-1-bromo-2-methylpropyl]-6-[(1,1-dimethyl)ethyldimethylsilyloxymethyl]-3-methanesulfonyl-2,4,6-trimethyl-5-trimethylsilyloxytetrahydropyran, acetate of 24. A solution of the pyran derivative **24** (ca. 7 mg) in pyridine (2 mL) was treated with acetic anhydride (0.25

mL, excess) and the solution stirred at 25 °C until completion of the reaction as indicated by TLC (1 h). The solvent was then removed under vacuum and the crude residue purified by flash column chromatography (silica gel, 5% ethyl acetate in hexanes) to yield 7 mg (85%) of the acetate derivative as a clear oil. ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 4.89 (1H, d, J = 4.9 Hz), 4.22 (1H, d, J = 2.2 Hz), 3.99 (1H, dd, J = 11.0, 5.4 Hz), 3.88 (1H, dd, J = 11.1, 9.2 Hz), 3.53 (1H, d, J = 8.4 Hz), 3.47 (1H, d, J = 10.1 Hz), 3.37 (1H, d, J = 10.1 Hz), 3.07 (3H, s), 2.60 (1H, m), 2.40 (1H, m), 2.05 (3H, s), 1.40 (3H, s), 1.28 (3H, d, J = 7.1 Hz), 1.22 (3H, s), 1.07 (3H, d, J = 6.6 Hz), 0.88 (9H, s), 0.11 (9H, s), 0.04 (6H, s).

REVISED 4/24/00

RMM-vi-95



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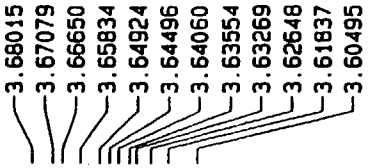
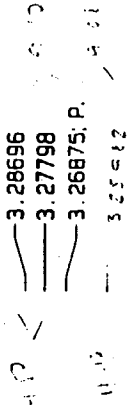
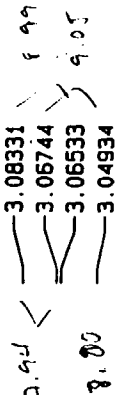
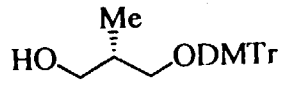
RMN-vi-95









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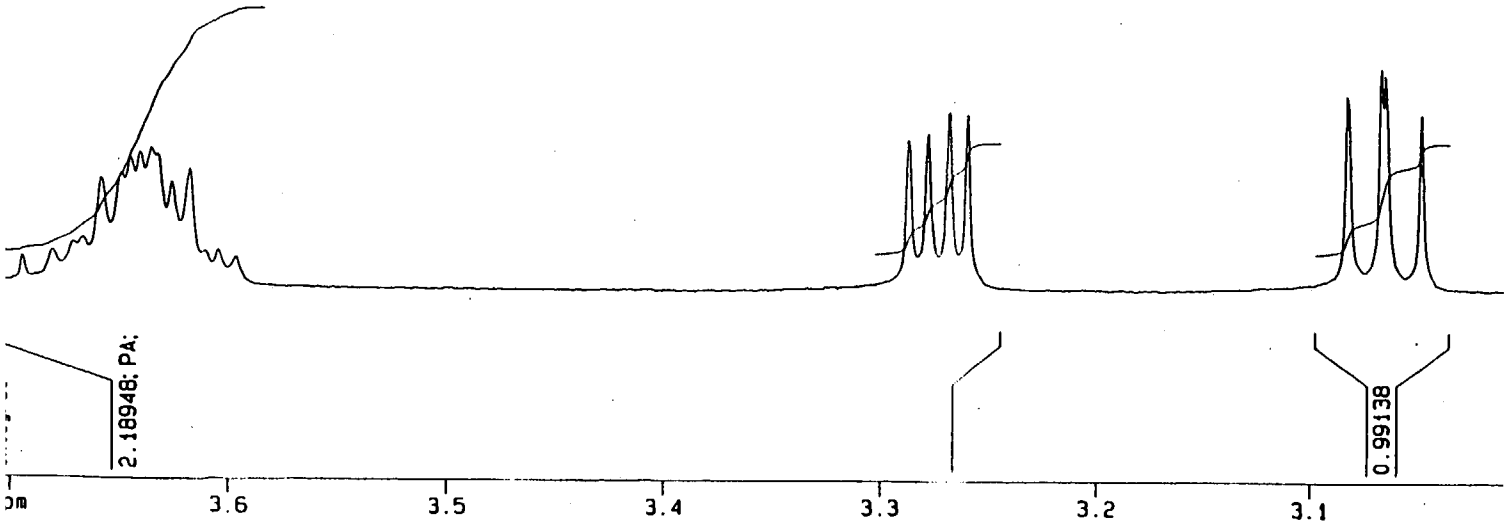

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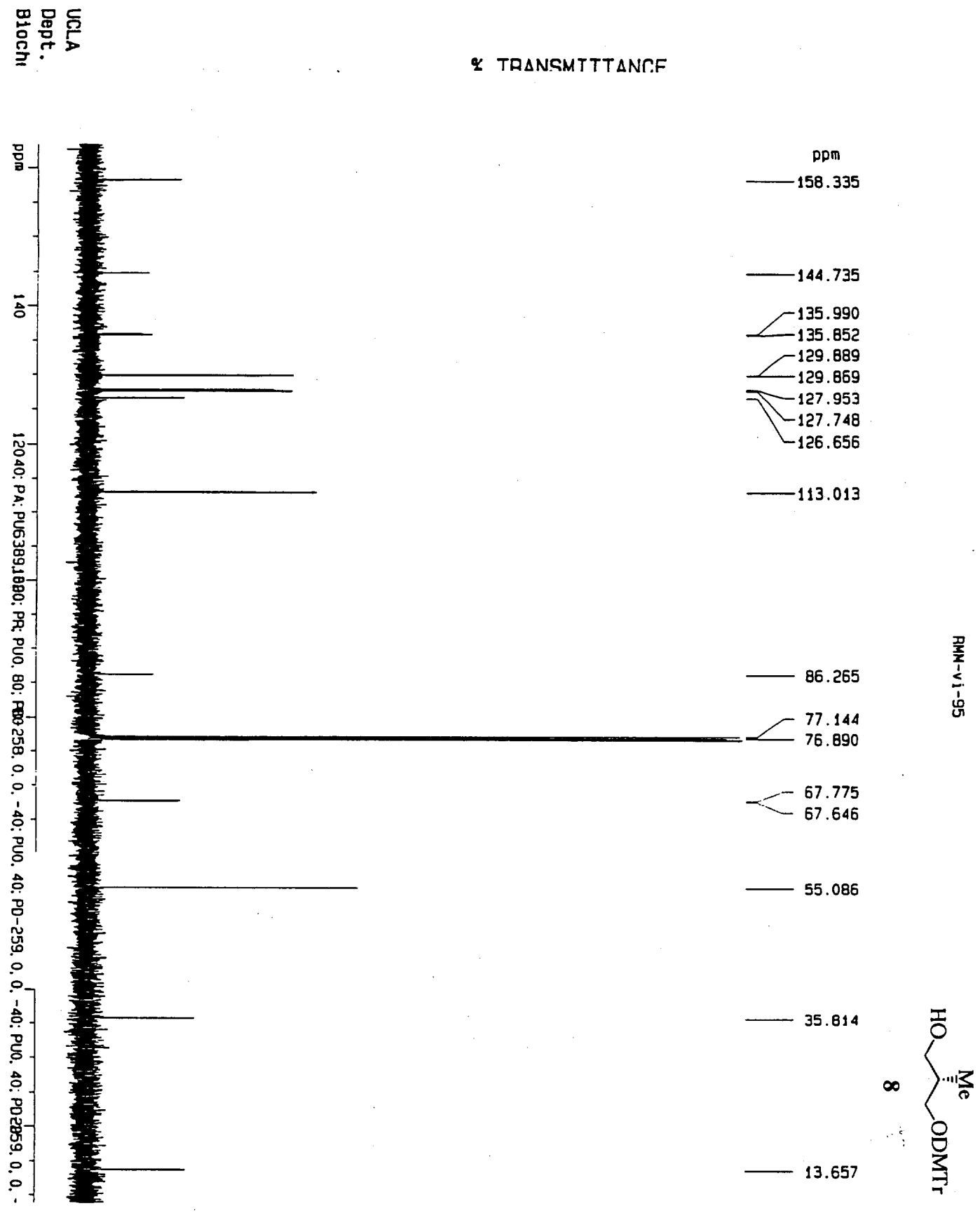
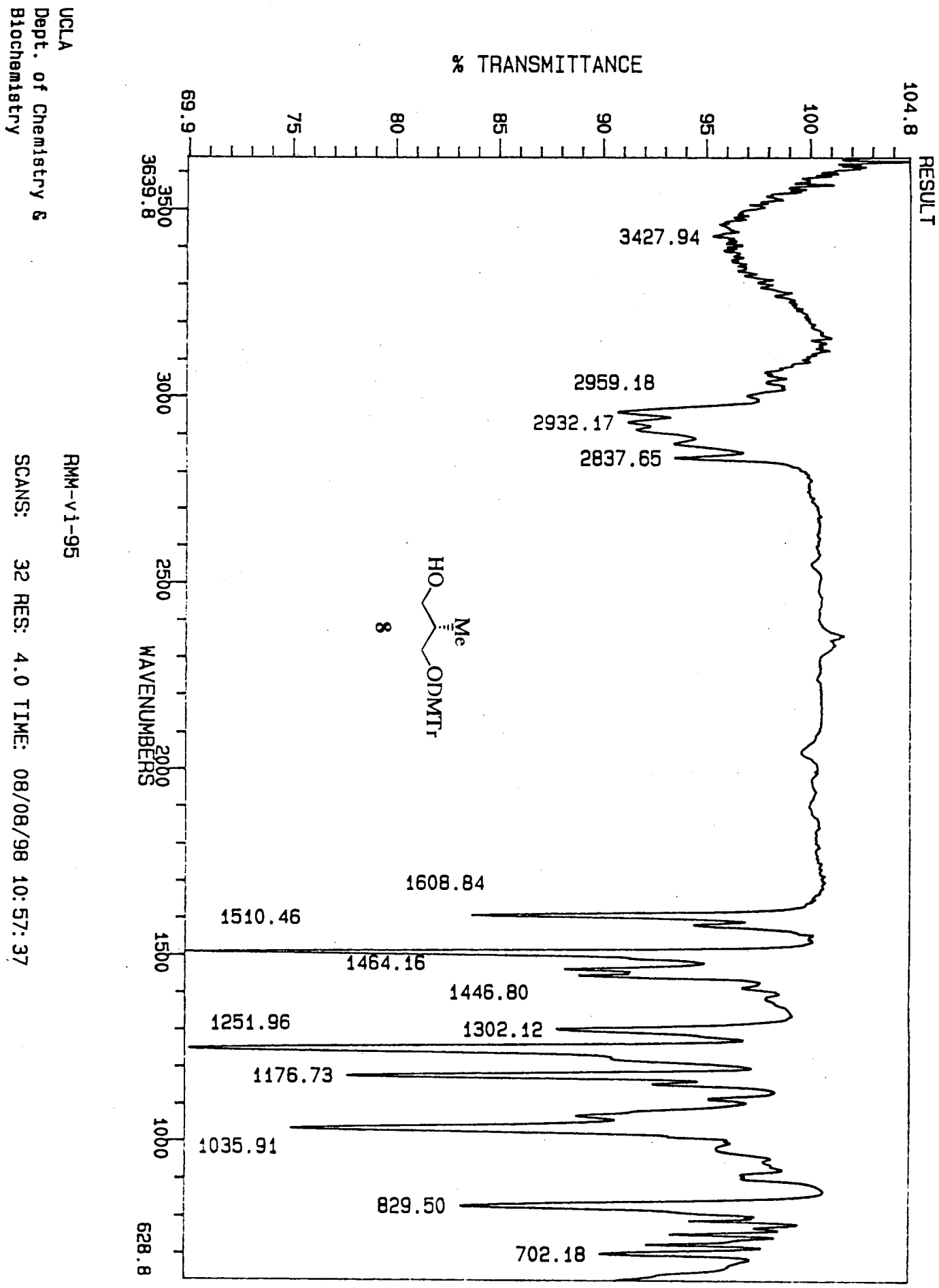
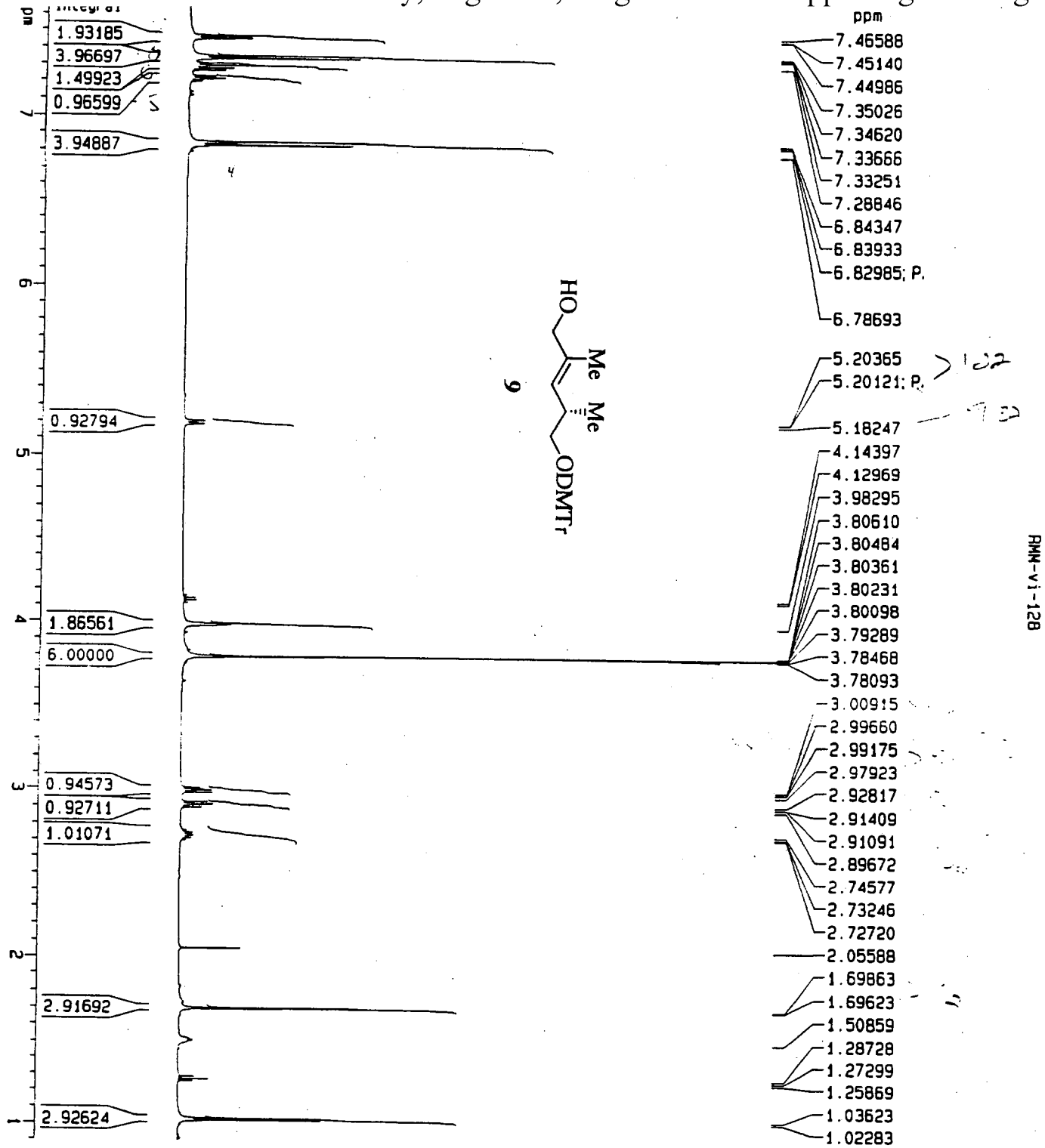
HZCM	17.48626 Hz/





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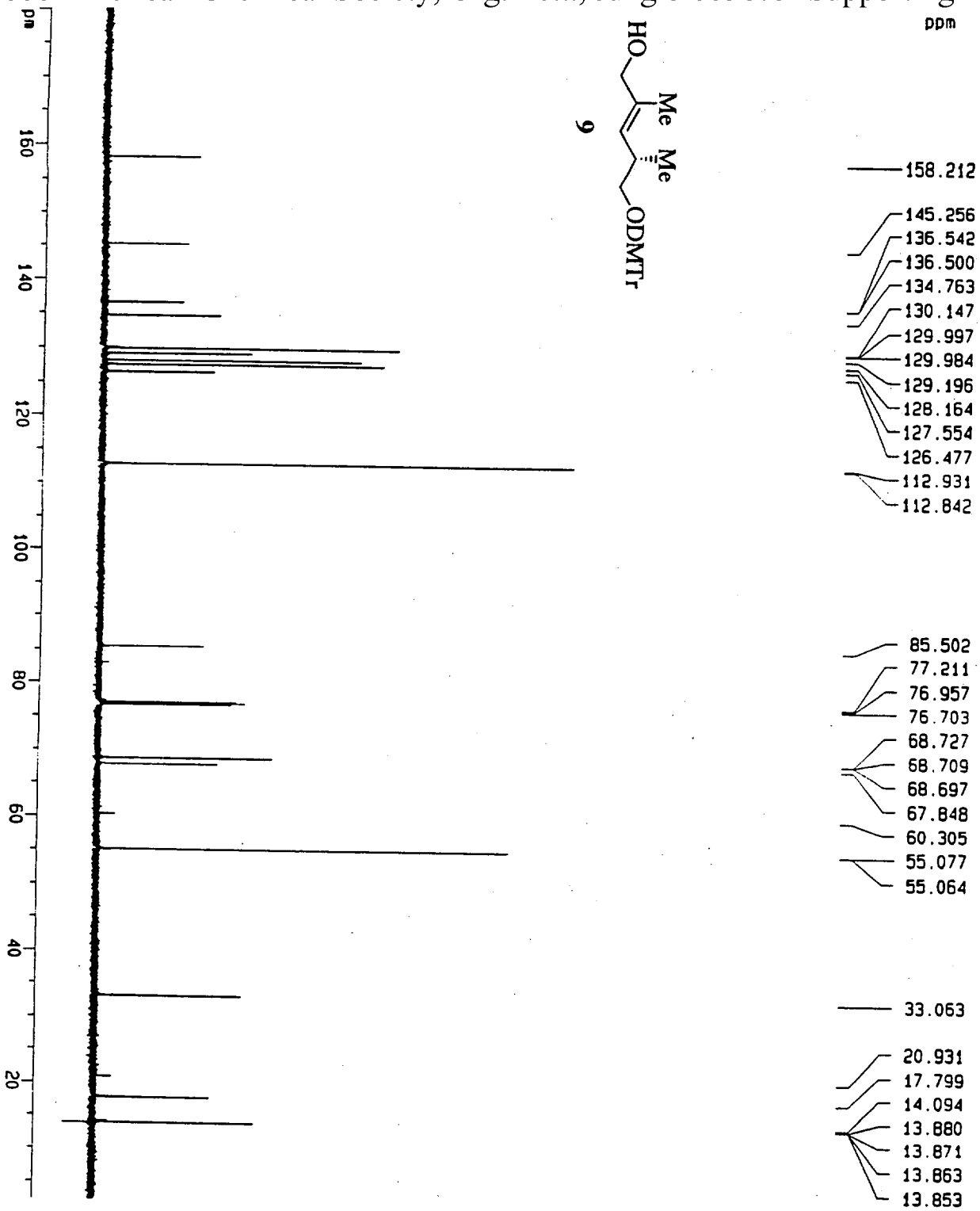
Current Data Parameters
NAME                  RMN-vi-12B-H
EXPNO                           1
PROCNO                          1

F2 - Acquisition Parameters
Date_                    980826
Time                       7.05
INSTRUM                  arx500
PROBHD      5 mm broadba

TD                          32768
SOLVENT                     CDCl3
NS                             16
DS                              0
SWH                     10204.082 Hz
FIDRES                   0.311404 Hz
AQ                       1.6056820 sec
RG                            180
DW                         49.000 usec
DE                         70.00 usec
TE                          300.0 K
D1                       2.00000000 sec
P1                         14.00 usec
SFO1                    500.1330008 MHz
NUCLEUS                       1H

F2 - Processing parameters
SI                          32768
SF                    500.1300225 MHz
WDW                            no
SSB                             0
LB                           0.00 Hz
GB                              0
PC                           1.00

1D NMR plot parameters
CX                          20.00 cm
F1P                          7.686 ppm
F1                        3843.76 Hz
F2P                          0.898 ppm
F2                         449.07 Hz
PPMCM                     0.33938 ppm/cm
HZCM                    169.73427 Hz/cm
```



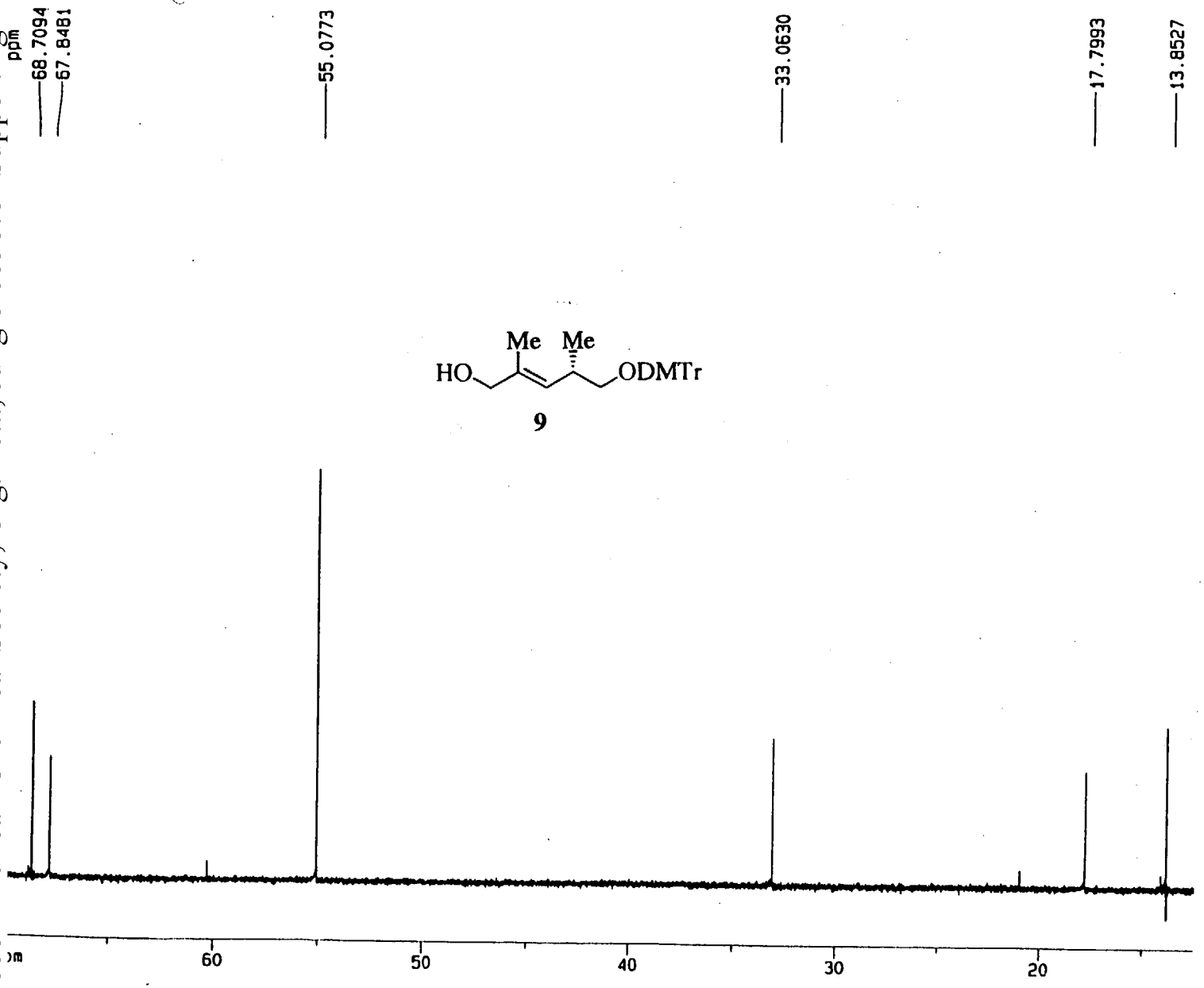
Current Data Parameters
NAME RMM-vi-128-C
EXPNO 1
PROCNO 1

F2 - Acquisition Parameters
Date_ 980826
Time 7.13
INSTRUM arx500
PROBHD 5 mm broadba
PULPROG zgdc30
TD 65536
SOLVENT CDCl3
NS 145
DS 0
SWH 35714.285 Hz
FIDRES 0.544957 Hz
AQ 0.9175540 sec
RG 32768
DW 14.000 usec
DE 20.00 usec
TE 300.0 K
D12 0.0000200 sec
DL5 16.00 dB
CPDPRG waltz16
P31 100.00 usec
D1 2.00000000 sec
P1 7.25 usec
SFO1 125.7728999 MHz
NUCLEUS 13C
D11 0.0300000 sec

F2 - Processing parameters
SI 65536
SF 125.7578090 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.40

1D NMR plot parameters
CX 20.00 cm
F1P 181.438 ppm
F1 22817.21 Hz
F2P 2.453 ppm
F2 308.54 Hz
PPMCM 8.94921 ppm/cm
HZCM 1125.43372 Hz/cm

RMM-vi-128



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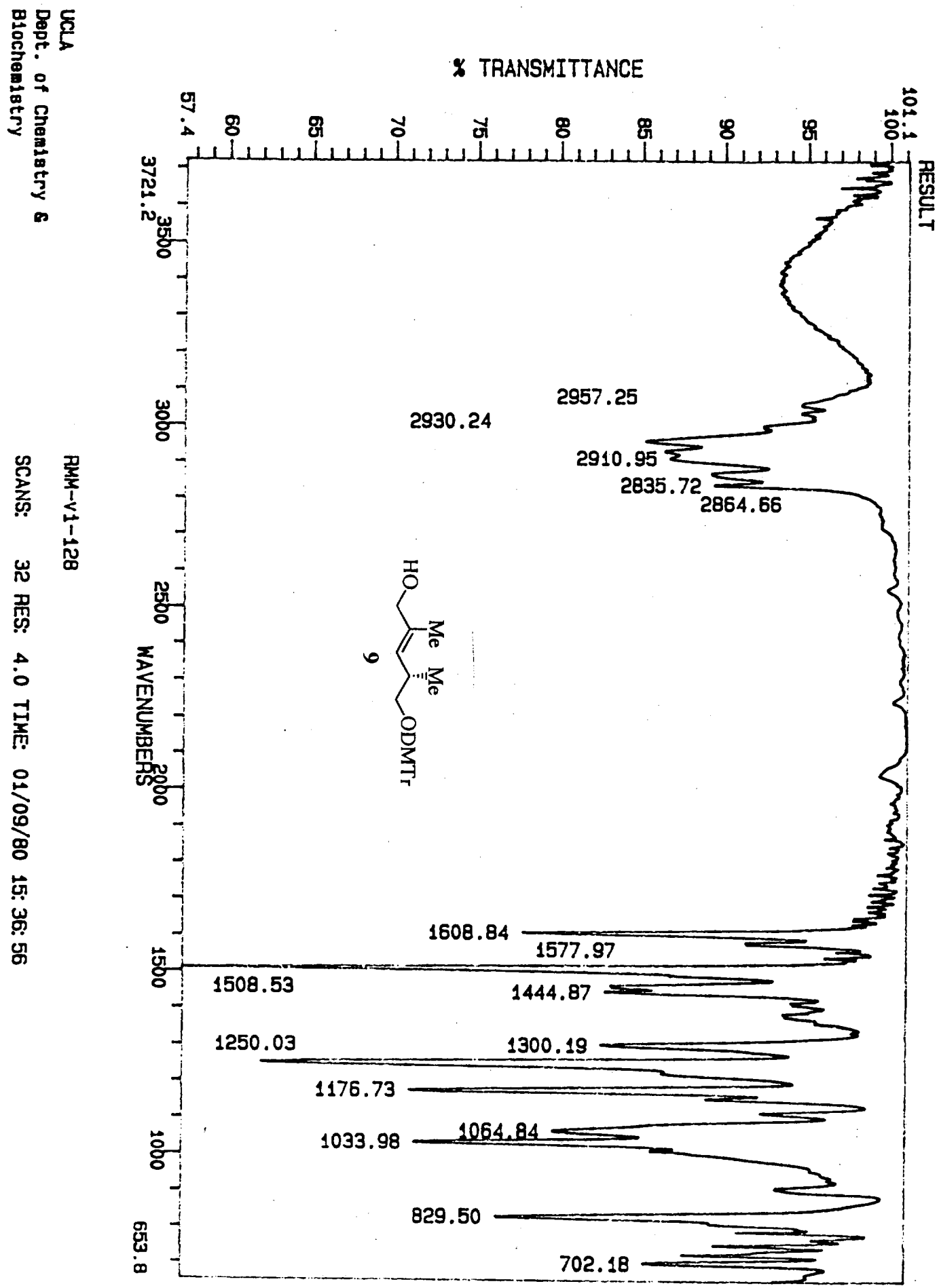
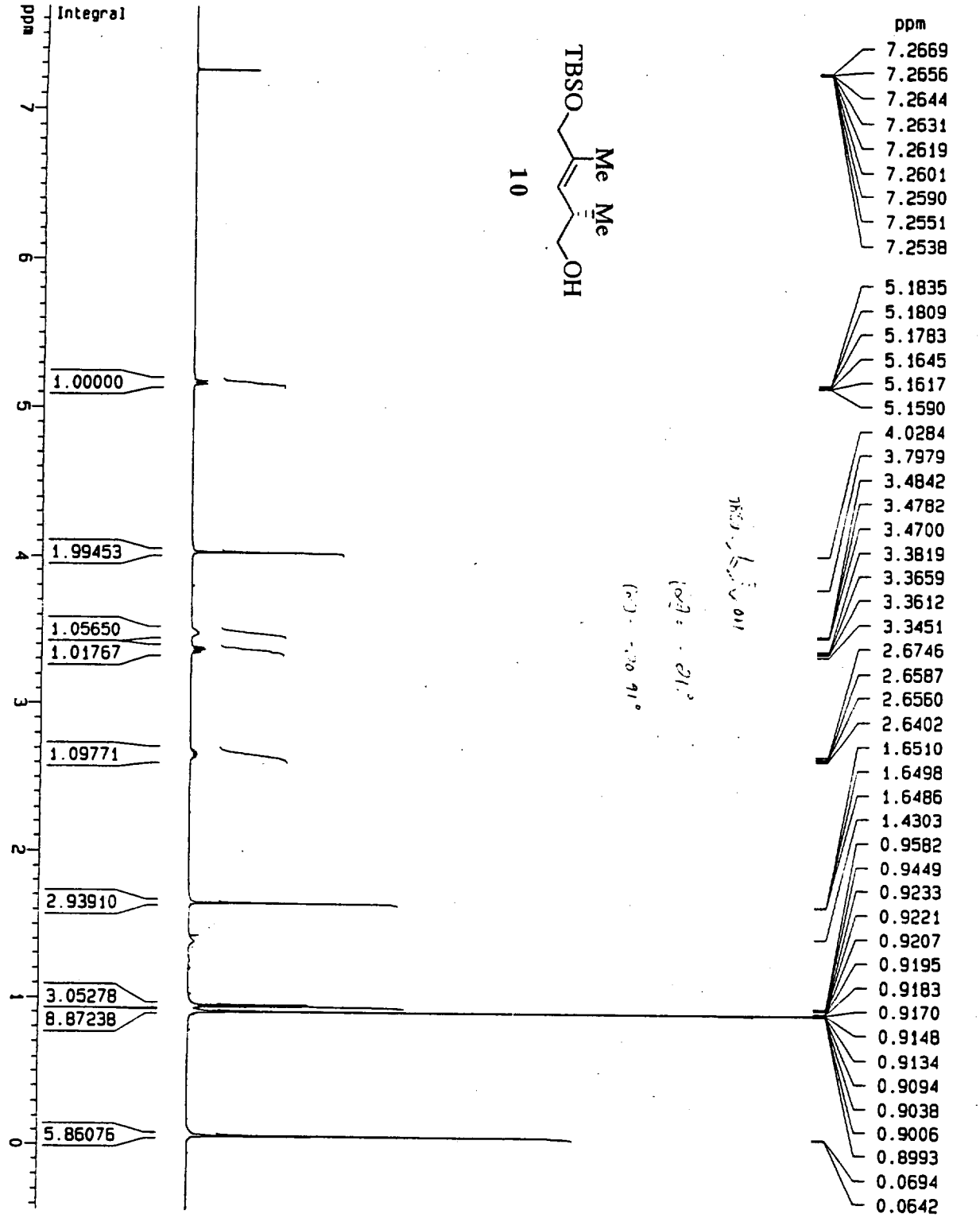
Current Data Parameters	
NAME	RMM-vi-128-C
EXPNO	1
PROCNO	1

F2 - Acquisition Parameters	
Date_	980826
Time	7.13
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zgdc30
TD	65536
SOLVENT	CDCl3
NS	145
DS	0
SWH	35714.285 Hz
FIDRES	0.544957 Hz
AQ	0.9175540 sec
RG	32768
DW	14.000 usec
DE	20.00 usec
TE	300.0 K
D12	0.0000200 sec
DL5	16.00 dB
CPDPRG	waltz16
P31	100.00 usec
D1	2.00000000 sec
P1	7.25 usec
SFO1	125.7728999 MHz
NUCLEUS	13C
D11	0.0300000 sec

F2 - Processing parameters	
SI	65536
SF	125.7578090 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.40

1D NMR plot parameters	
CX	20.00 cm
F1P	70.539 ppm
F1	8870.89 Hz
F2P	12.465 ppm
F2	1567.53 Hz
PPMCM	2.90374 ppm/cm
HZCM	365.16782 Hz/cm





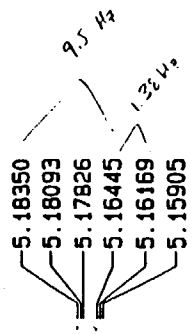
Current Data Parameters
NAME RMN-vi-67-H
EXPNO 1
PROCNO 1

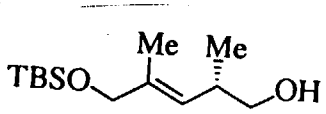
F2 - Acquisition Parameters
Date_ 980727
Time 22.42
INSTRUM arx500
PROBHD 5 mm broadba
PULPROG 2g30
TD 32768
SOLVENT CDCl3
NS 16
DS 0
SWH 10204.082 Hz
FIDRES 0.311404 Hz
AQ 1.6056820 sec
RG 715
DW 49.000 use
DE 70.00 use
TE 300.0 K
D1 2.00000000 sec
P1 14.00 use
SFO1 500.1330008 MHz
NUCLEUS 1H

F2 - Processing parameters
SI 32768
SF 500.1300232 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00

1D NMR plot parameters
CX 20.00 cm
F1P 7.688 ppm
F1 3844.85 Hz
F2P -0.442 ppm
F2 -221.01 Hz
PPMCM 0.40648 ppm/
HZCM 203.29326 Hz/

RMM-vi-67





10

Current Data Parameters

NAME	RMM-vi-67-H
EXPNO	1
PROCNO	1

F2 - Acquisition Parameters

Date_	980727
Time	22.42
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	16
DS	0
SWH	10204.082 Hz
FIDRES	0.311404 Hz
AQ	1.6056820 sec
RG	715
DW	49.000 use
DE	70.00 use
TE	300.0 K
D1	2.00000000 sec
P1	14.00 use
SFO1	500.1330008 MHz
NUCLEUS	1H

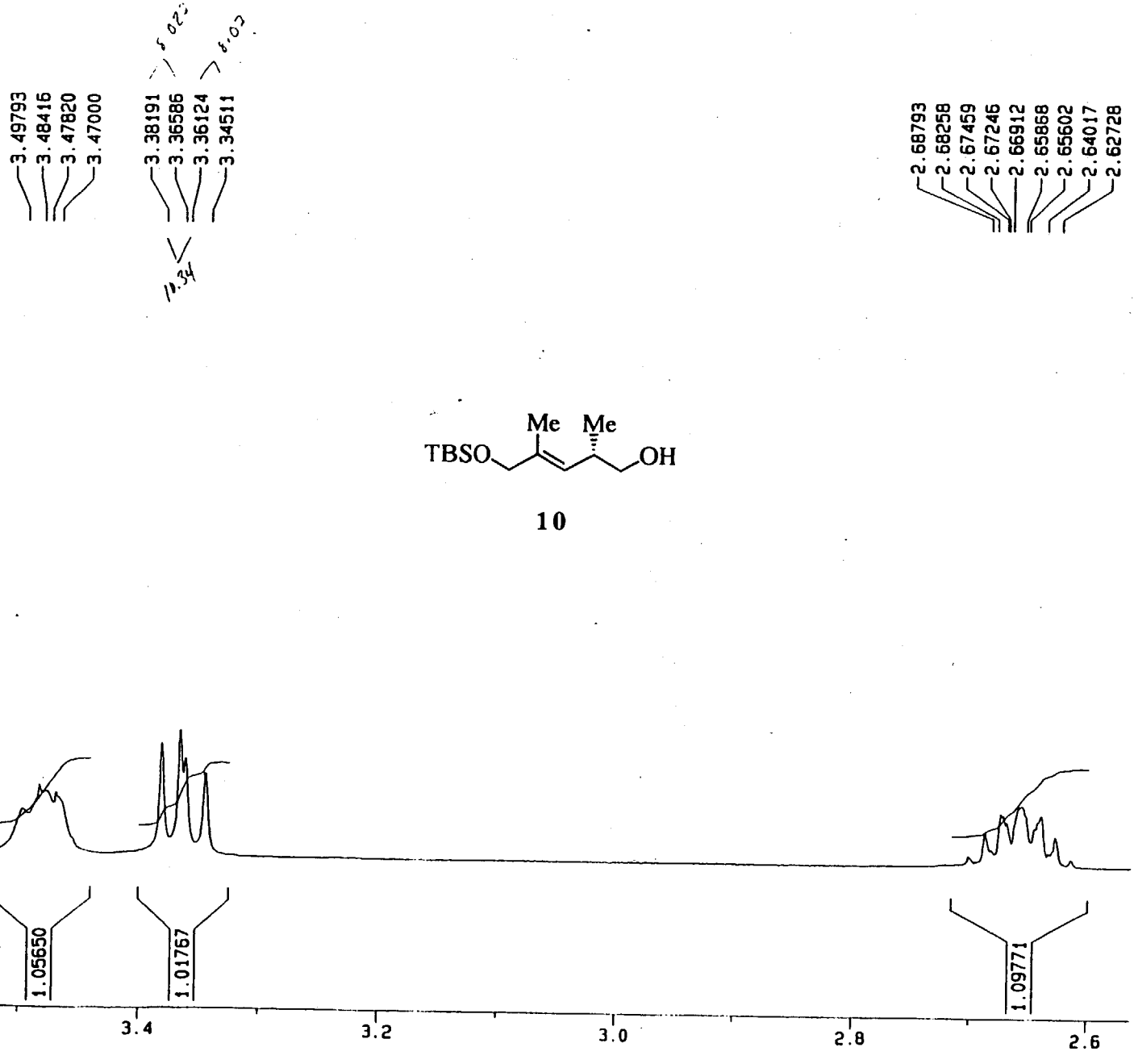
F2 - Processing parameters

SI	32768
SF	500.1300232 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0

1D NMR plot parameters

CX	20.00 cm
F1P	5.285 ppm
F1	2643.38 Hz
F2P	3.895 ppm
F2	1948.05 Hz
PPMCM	0.06952 ppm
HZCM	34.76689 Hz/

RMM-vi-67



10

Current Data Parameters

NAME	RMM-vi-67-H
EXPNO	1
PROCNO	1

F2 - Acquisition Parameters

Date_	980727
Time	22.42
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	16
DS	0
SWH	10204.082 Hz
FIDRES	0.311404 Hz
AQ	1.6056820 sec
RG	715
DW	49.000 use
DE	70.00 use
TE	300.0 K
D1	2.00000000 sec
P1	14.00 use
SFO1	500.1330008 MHz
NUCLEUS	1H

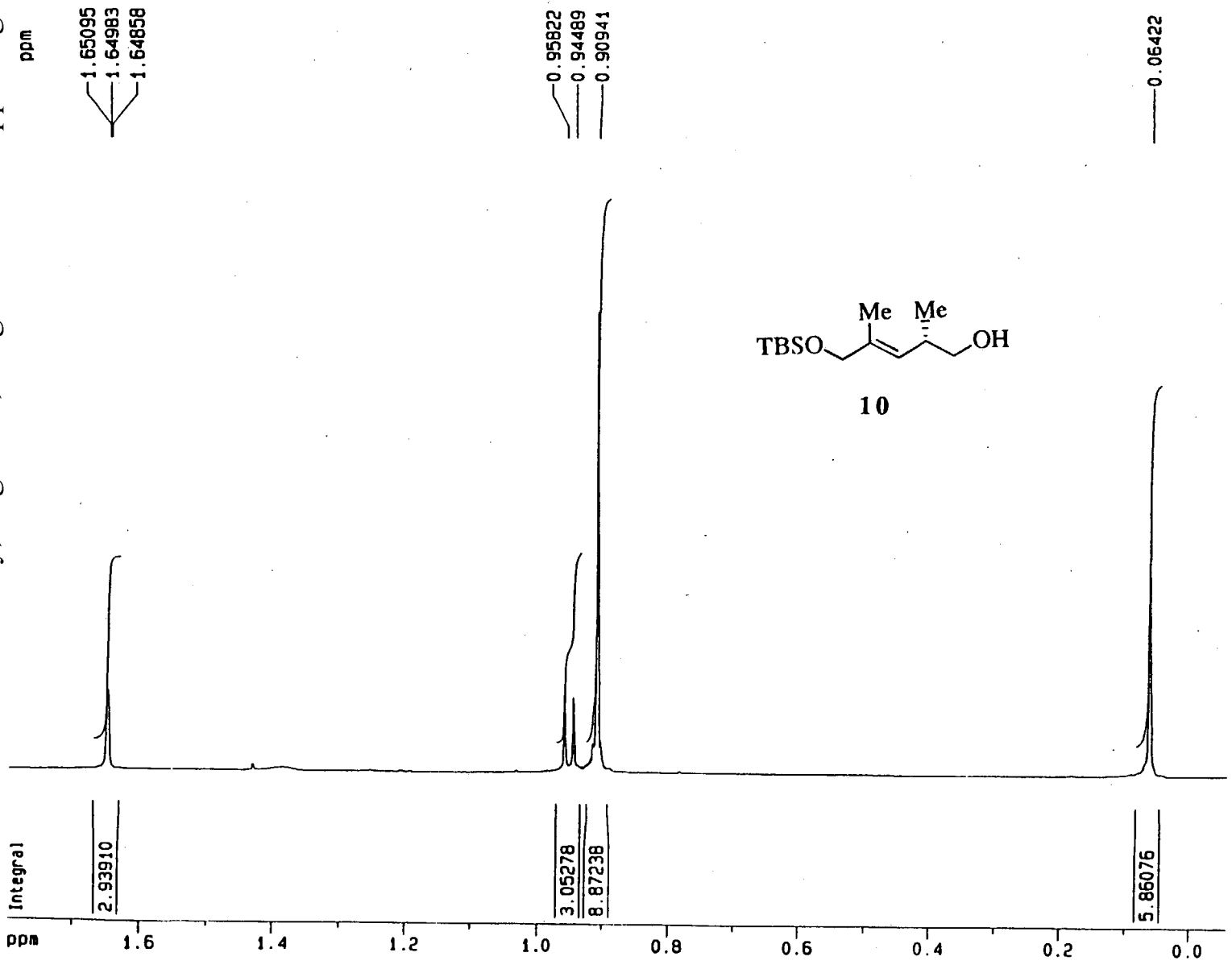
F2 - Processing parameters

SI	32768
SF	500.1300232 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.00

1D NMR plot parameters

CX	20.00 cm
F1P	3.590 ppm
F1	1795.66 Hz
F2P	2.563 ppm
F2	1281.84 Hz
PPMCM	0.05137 ppm
HZCM	25.69079 Hz/

RMN-vi-67



10

Current Data Parameters

NAME	RMN-vi-67-H
EXPNO	1
PROCNO	1

F2 - Acquisition Parameters

Date_	980727
Time	22.42
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	16
DS	0
SWH	10204.082 Hz
FIDRES	0.311404 Hz
AQ	1.6056820 sec
RG	715
DW	49.000 use
DE	70.00 use
TE	300.0 K
D1	2.00000000 sec
P1	14.00 use
SFO1	500.1330008 MHz
NUCLEUS	1H

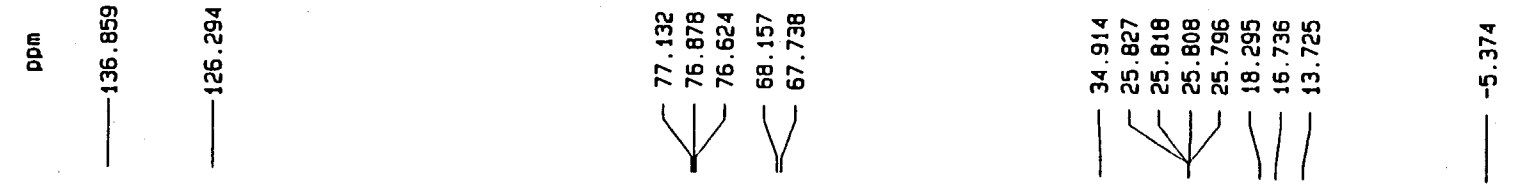
F2 - Processing parameters

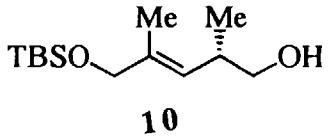
SI	32768
SF	500.1300232 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.00

1D NMR plot parameters

CX	20.00 cm
F1P	1.798 ppm
F1	899.01 Hz
F2P	-0.057 ppm
F2	-28.67 Hz
PPMCM	0.09274 ppm
HZCM	46.38412 Hz/

AMM-vi-67





10

Current Data Parameters

NAME	AMM-vi-67-C
EXPNO	1
PROCNO	1

F2 - Acquisition Parameters

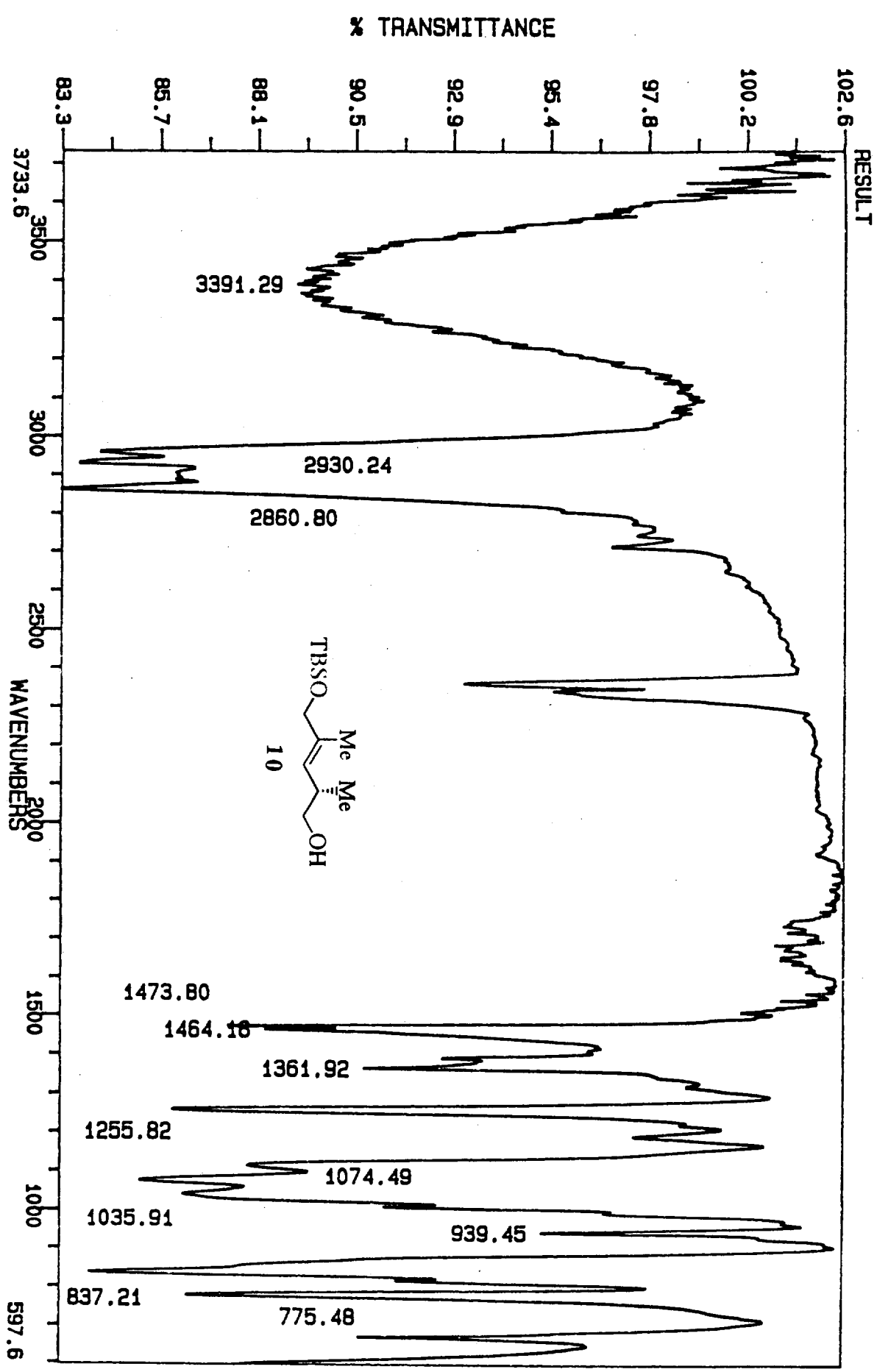
Date_	980727
Time	22.45
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zgdc30
TD	65536
SOLVENT	CDCl3
NS	172
DS	0
SWH	35714.285 Hz
FIDRES	0.544957 Hz
AQ	0.9175540 sec
RG	11400
DW	14.000 usec
DE	20.00 usec
TE	300.0 K
D12	0.0000200 sec
DL5	16.00 dB
CPDPRG	waltz16
P31	100.00 usec
D1	2.00000000 sec
P1	7.25 usec
SFO1	125.7728999 MHz
NUCLEUS	13C
D11	0.0300000 sec

F2 - Processing parameters

SI	65536
SF	125.7578090 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.40

1D NMR plot parameters

CX	20.00 cm
F1P	146.101 ppm
F2P	-9.995 ppm
F2	-1256.90 Hz
PPMCM	7.80478 ppm/cm
HZCM	981.51251 Hz/cm



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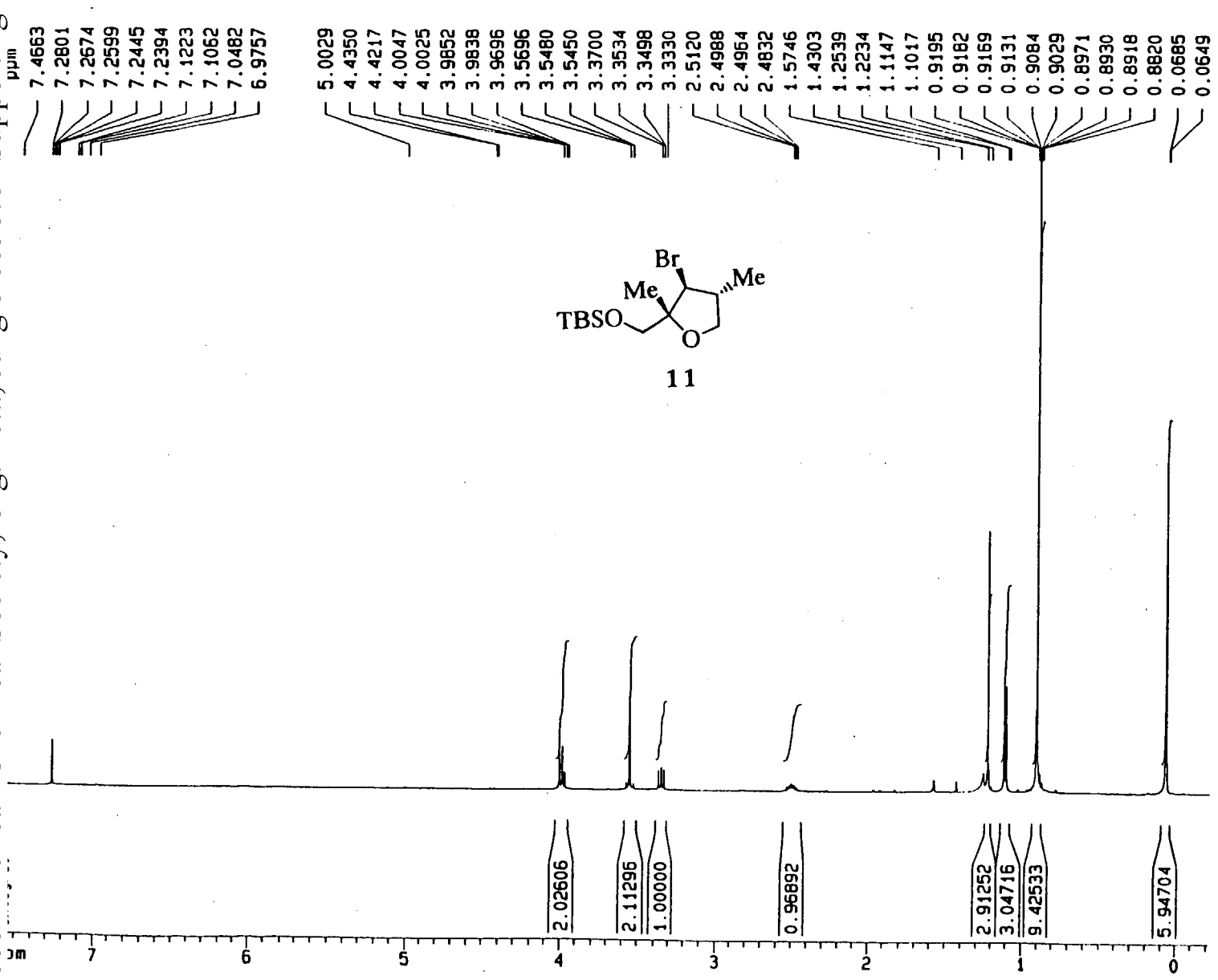
RMM-v1-67

SCANS: 32 RES: 4.0 TIME: 07/28/98 10:38:04

RMN-v-295



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Current Data Parameters

NAME	RMN-v-295-H
EXPNO	2
PROCNO	1

F2 - Acquisition Parameters

Date_	980704
Time	7.53
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	8
DS	0
SWH	10204.082 Hz
FIDRES	0.311404 Hz
AQ	1.6056820 sec
RG	512
DW	49.000 use
DE	70.00 use
TE	300.0 K
D1	2.00000000 sec
P1	14.00 use
SFO1	500.1330008 MHz
NUCLEUS	1H

F2 - Processing parameters

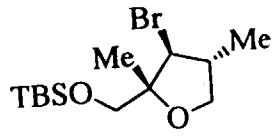
SI	32768
SF	500.1300228 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.00

1D NMR plot parameters

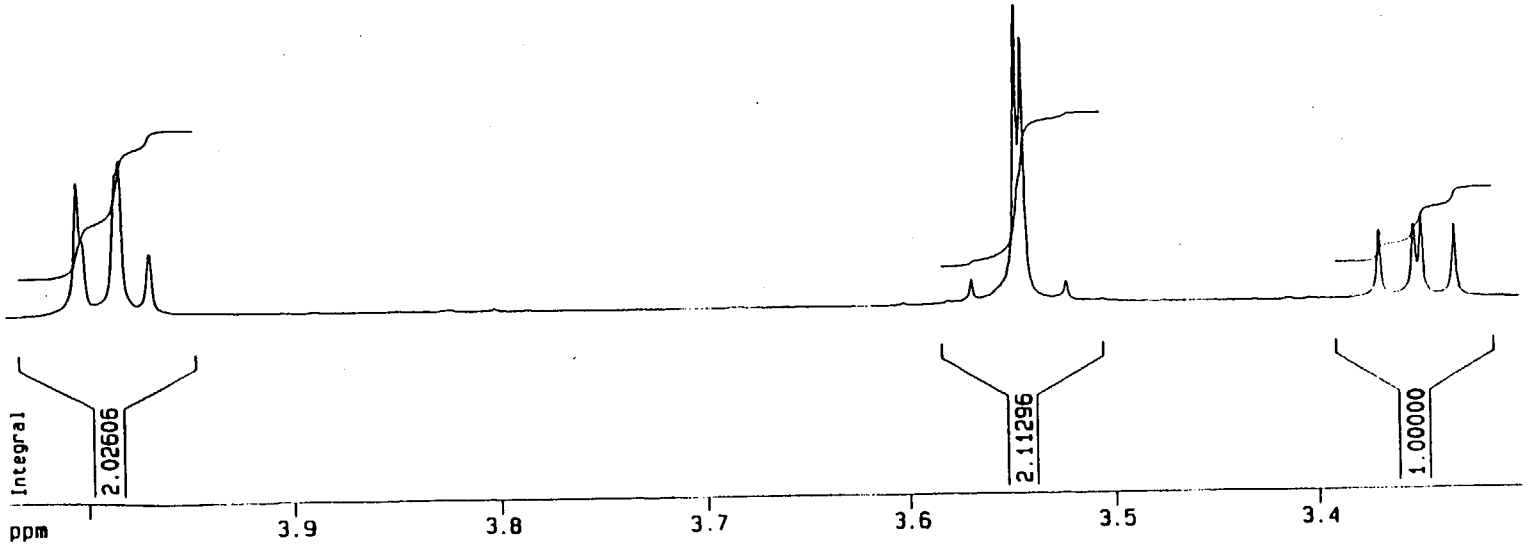
CX	20.00 cm
F1P	7.621 ppm
F1	3811.38 Hz
F2P	-0.216 ppm
F2	-108.07 Hz
PPMCM	0.39184 ppm
HZCM	195.97243 Hz/

RMN-v-295

ppm
4.00471
4.00245
3.98523
3.98383
3.96961
3.56960
3.54799
3.54502
3.52341
3.36996
3.35337
3.34977
3.33304



11



Current Data Parameters

NAME	RMN-v-295-H
EXPNO	2
PROCNO	1

F2 - Acquisition Parameters

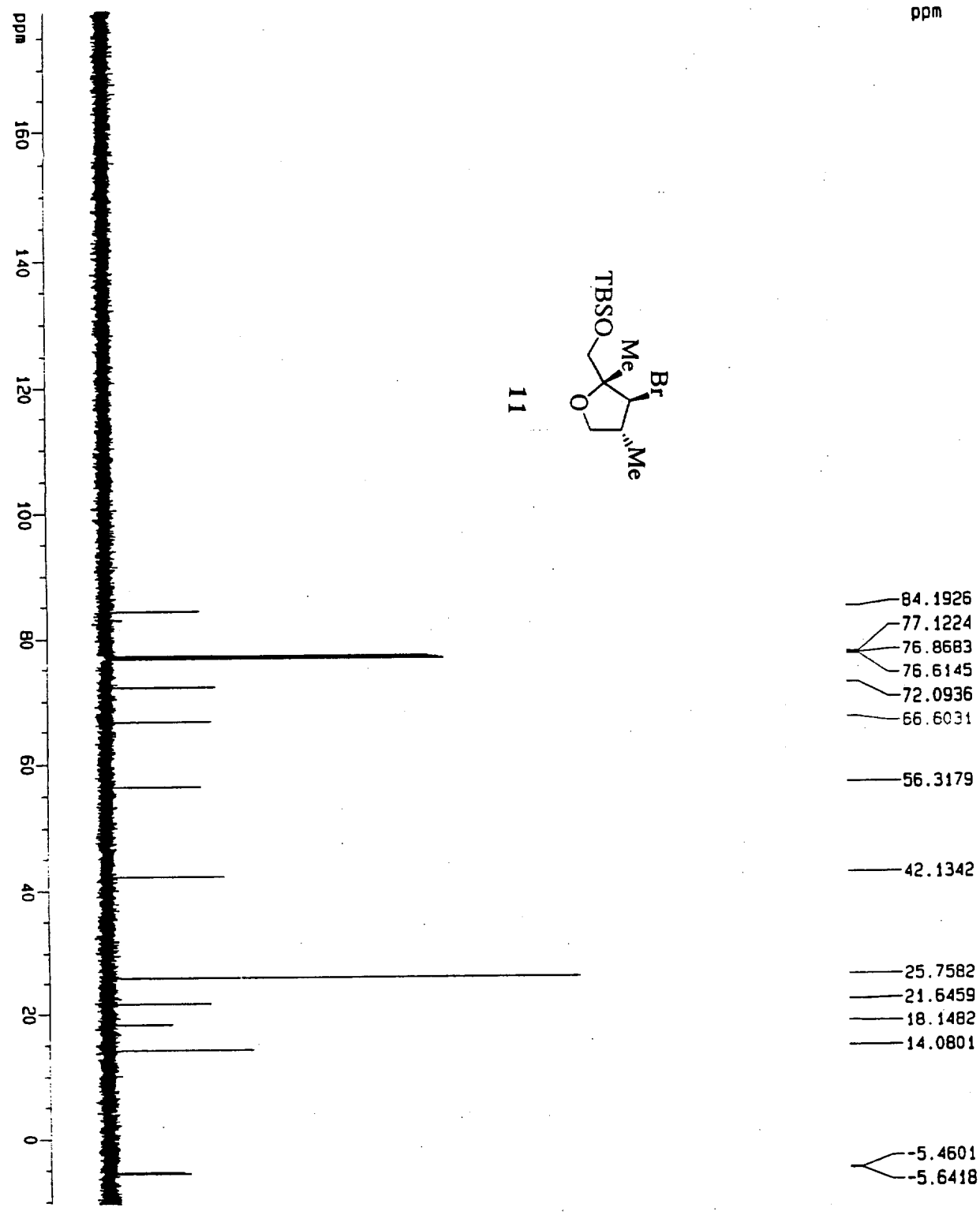
Date_	980704
Time	7.53
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	8
SWH	10204.082 Hz
FIDRES	0.311404 Hz
AQ	1.6056820 sec
RG	512
DW	49.000 use
DE	70.00 use
D1	2.00000000 sec
P1	14.00 use
SFO1	500.1330008 MHz
NUCLEUS	1H

F2 - Processing parameters

SI	32768
SF	500.1300228 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.00

1D NMR plot parameters

CX	20.00 cm
F1P	4.039 ppm
F1	2019.98 Hz
F2P	3.301 ppm
F2	1651.05 Hz
PPMCM	0.03688 ppm
HZCM	18.44641 Hz/

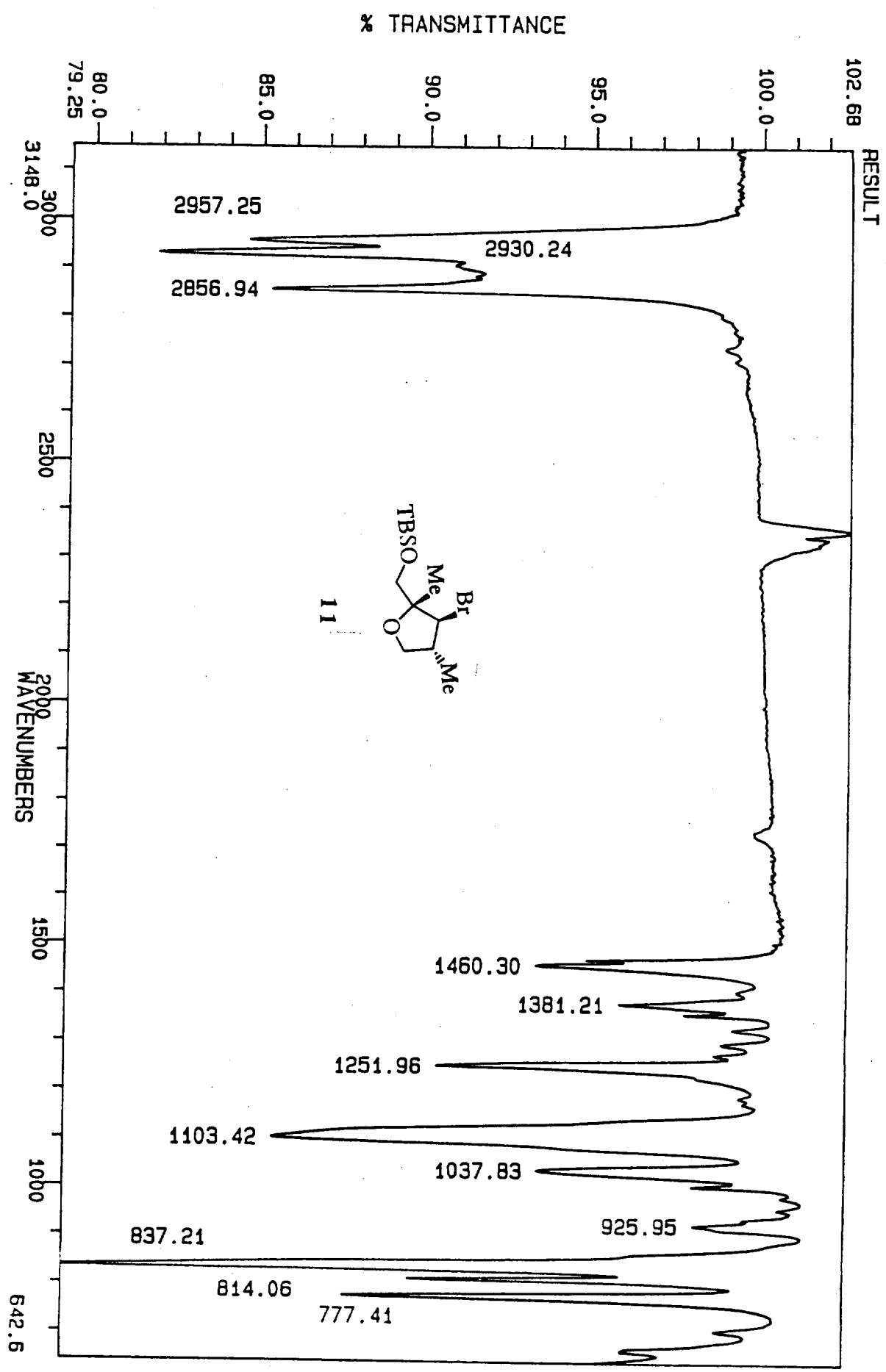


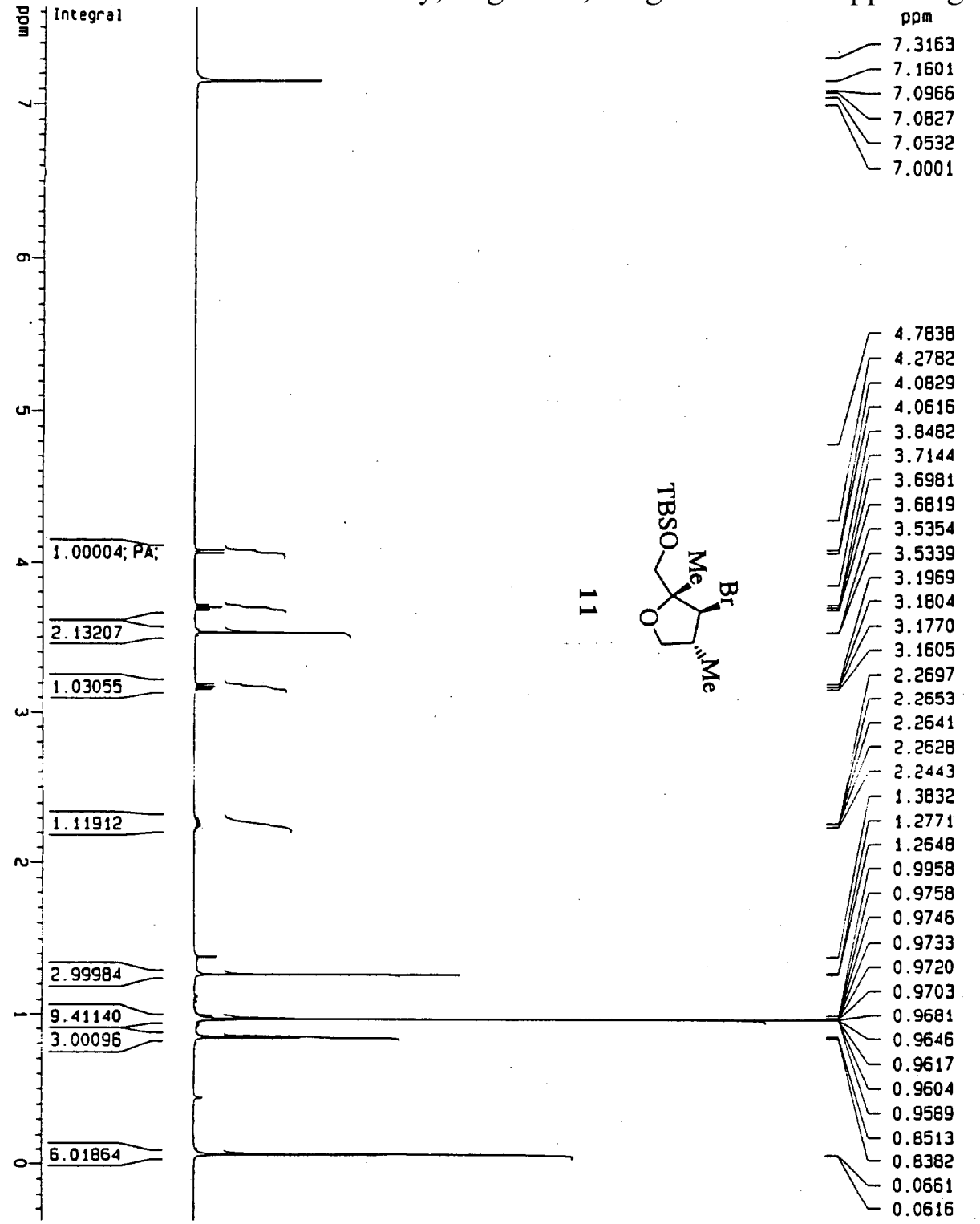
Current Data Parameters
NAME RMN-V-295-C
EXPNO 2
PROCNO 1

F2 - Acquisition Parameters
Date_ 980704
Time 8.09
INSTRUM arx500
PROBHD 5 mm broadba
PULPROG zgdc30
TD 65536
SOLVENT CDCl3
NS 140
DS 0
SWH 35714.285 Hz
FIDRES 0.544957 Hz
AQ 0.9175540 sec
RG 32768
DW 14.000 usec
DE 20.00 usec
TE 300.0 K
D12 0.0000200 sec
DL5 16.00 dB
CPDPRG waltz16
P31 100.00 usec
D1 2.00000000 sec
P1 7.25 usec
SFO1 125.7728999 MHz
NUCLEUS 13C
D11 0.0300000 sec

F2 - Processing parameters
SI 65536
SF 125.7578090 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.40

1D NMR plot parameters
CX 20.00 cm
F1P 179.243 ppm
F1 22541.27 Hz
F2P -10.398 ppm
F2 -1307.67 Hz
PPMCM 9.48209 ppm/cm
HZCM 1192.44714 Hz/cm





RMN-v-295-C6D6

Current Data Parameters
NAME RMN-v-295-2H
EXPNO 2
PROCNO 1

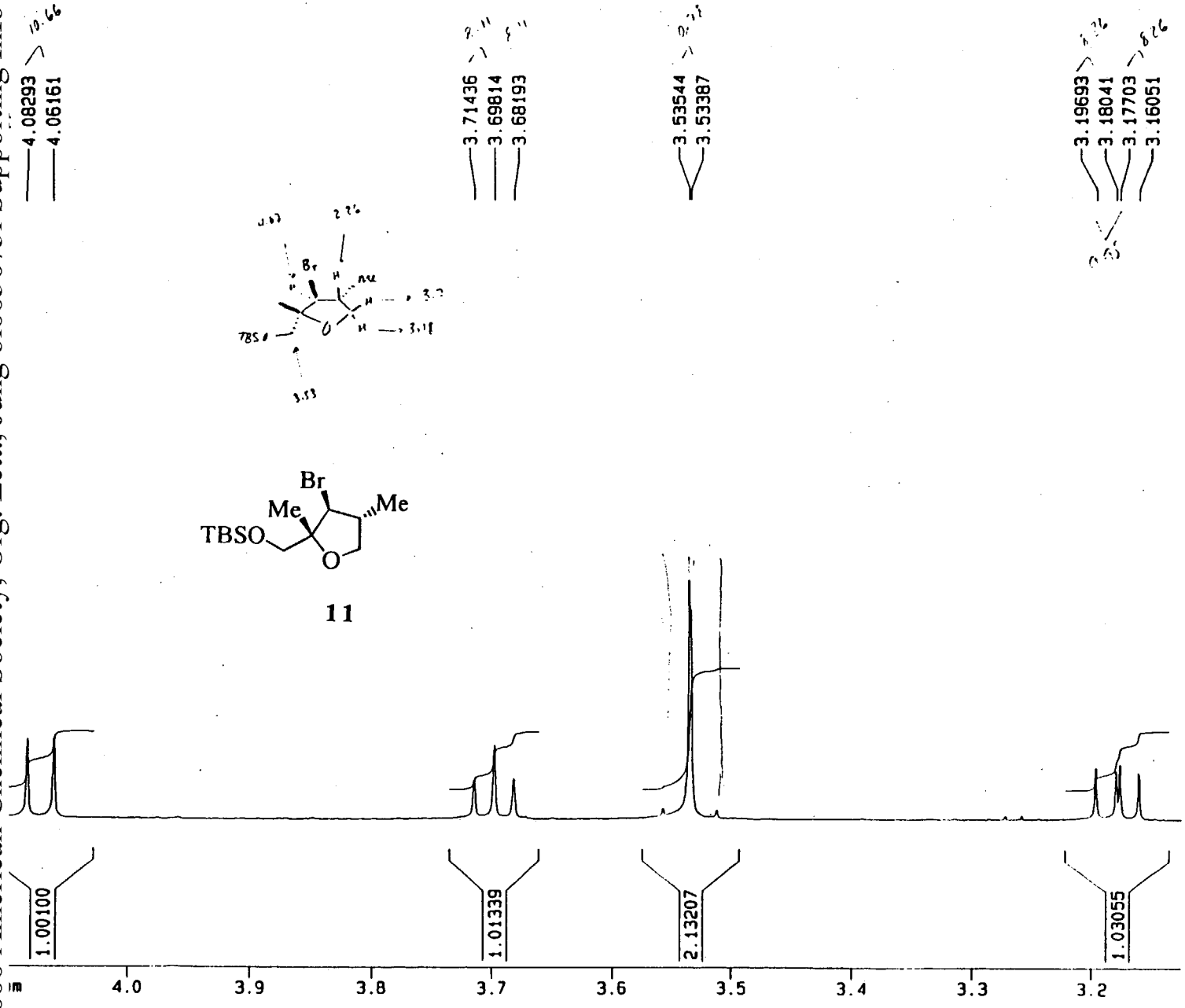
F2 - Acquisition Parameters
Date_ 980704
Time 8.49
INSTRUM ar×500
PROBHD 5 mm broadba
PULPROG zg30
TD 32768
SOLVENT C6D6
NS 8
DS 0
SWH 10204.082 Hz
FIDRES 0.311404 Hz
AQ 1.6056820 sec
RG 715
DW 49.000 use
DE 70.00 use
TE 300.0 K

P1 14.00 use
SFO1 500.1330008 MHz
NUCLEUS 1H

F2 - Processing parameters
SI 32768
SF 500.1300570 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00

1D NMR plot parameters
CX 20.00 cm
F1P 7.643 ppm
F1 3822.30 Hz
F2P -0.374 ppm
F2 -187.25 Hz
PPMCM 0.40085 ppm
HZCM 200.47755 Hz/

RMM-v-295-C606



11

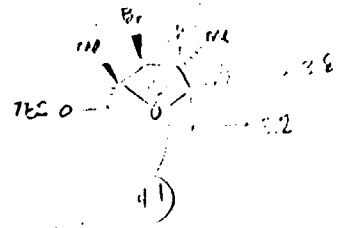
Current Data Parameters	
NAME	RMM-v-295-2H
EXPNO	2
PROCNO	1

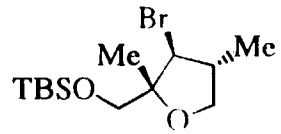
F2 - Acquisition Parameters	
Date_	980704
Time	8.49
INSTRUM	arx500
PROBHD	5 mm broadba
PULPROG	zg30
TD	32768
SOLVENT	C606
NS	8
DS	0
SWH	10204.082 Hz
FIORES	0.311404 Hz
AQ	1.6056820 sec
RG	715
DW	49.000 use
DE	70.00 use
TE	300.0 K
D1	2.00000000 sec
P1	14.00 use
SFO1	500.1330008 MHz
NUCLEUS	1H

F2 - Processing parameters	
SI	32768
SF	500.1300570 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.00

1D NMR plot parameters	
CX	20.00 cm
F1P	4.111 ppm
F1	2056.06 Hz
F2P	3.124 ppm
F2	1562.63 Hz
PPMCM	0.04933 ppm
HZCM	24.67172 Hz/

RMM-v-295





11

Current Data Parameti

NAME	RMM-v-syn
EXPNO	1
PROCNO	1

F2 - Acquisition Param

Date_	980706
Time	17.14
INSTRUM	jarx500
	, PA: PU9771.65i0; PR; PU0, -
TD	1024
SOLVENT	C606
NS	8
DS	8
SWH	2747.253 Hz
FIDRES	2.682864 Hz
AQ	0.1864180 sec
RG	715
DW	182.000 usec
DE	227.50 usec
TE	300.0 K
D1	2.00000000 sec
D11	0.0300000 sec
P1	14.00 usec
D0	0.0000030 sec
D8	1.50000000 sec
SF01	500.1311915 MHz
NUCLEUS	1H
L3	128
IN0	0.00036400 sec

F1 - Acquisition param

ND0	1
TD	256
SF01	500.1312 MHz
FIDRES	10.731457 Hz
SW	5.493 ppm

F2 - Processing parame

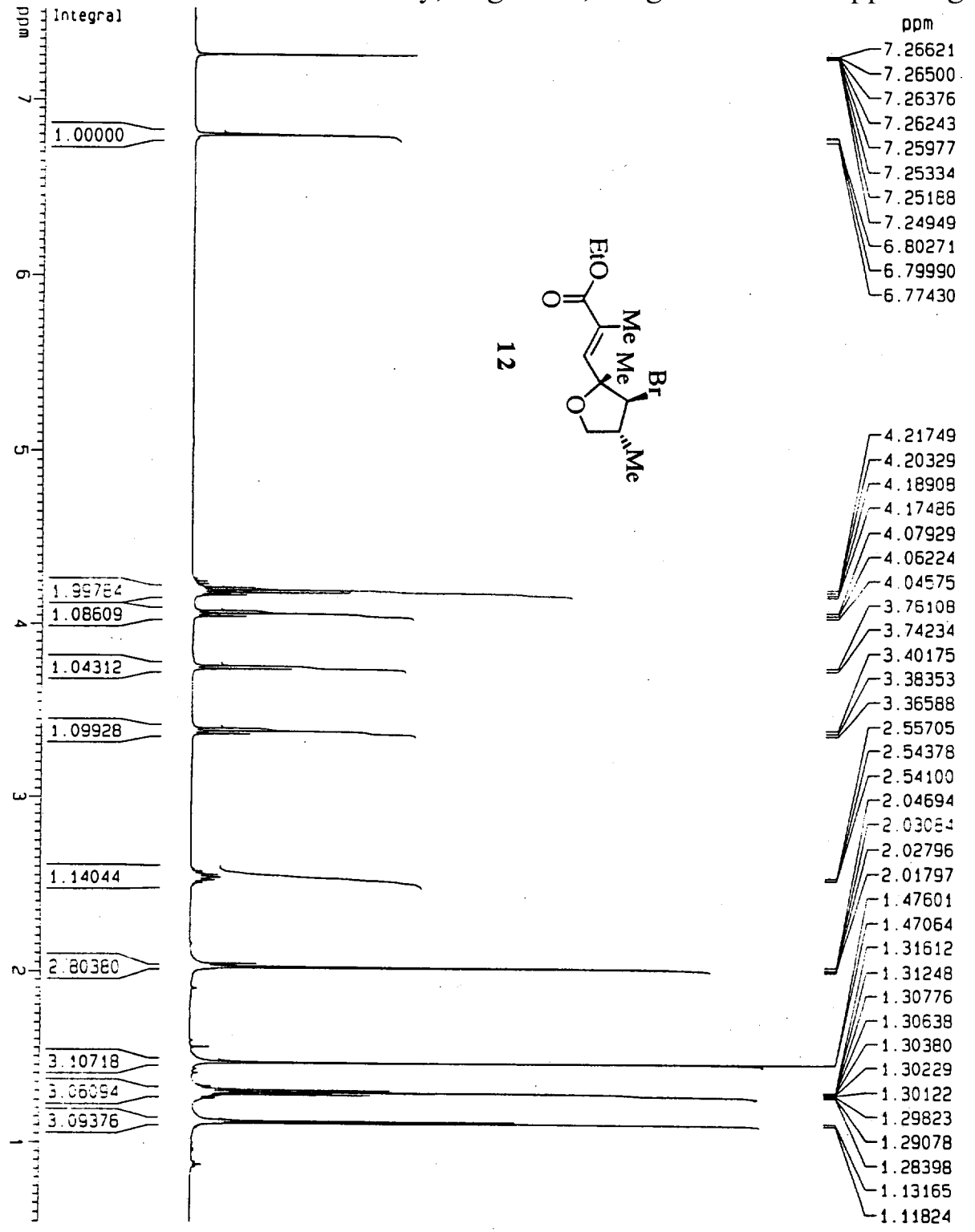
SI	1024
SF	500.1300564 MHz
WDW	QSINE
SSB	2
LB	0.00 Hz
GB	0
PC	1.00

F1 - Processing parame

SI	512
MC2	States-TPPI
SF	500.1300564 MHz
WDW	QSINE
SSB	2
LB	0.00 Hz
GB	0

2D NMR plot parame

CX2	15.00 cm
CX1	15.00 cm
F2PPO	5.016 ppm
F2PO	2508.82 Hz
F2PPI	-0.477 ppm
F2HI	-238.44 Hz
F1PPO	5.016 ppm
F1PO	2508.82 Hz
F1PPI	-0.477 ppm
F1HI	-238.44 Hz
F2PPMCM	0.36621 ppm/
F2HZCM	183.15019 Hz/c
F1PPMCM	0.36621 ppm/
F1HZCM	183.15019 Hz/c



RMM-vi-60

40

Current Data Parameters
NAME RMM-vi-60
EXPNO 1
PROCNO 1

F2 - Acquisition Parameters
Date_ 980724
Time 22.20
INSTRUM ar×500
PROBHD 5 mm broadba
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 8
DS 0
SWH 10204.082 Hz
FIDRES 0.311404 Hz
AQ 1.6056820 sec
RG 715
DW 49.000 use
DE 70.00 use
TE 300.0 K
D1 2.00000000 sec
P1 14.00 use
SFO1 500.1330008 MHz
NUCLEUS 1H

F2 - Processing parameters
SI 32768
SF 500.1300215 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00

1D NMR plot parameters
CX 20.00 cm
F1P 7.4[illegible] ppm
F1 3765.70 Hz
F2P 0.[illegible]48 ppm
F2 2[illegible].94 Hz
PPMCM 0.[illegible]96 ppm
HZCM 174.[illegible]15 Hz/