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Supporting Information

69451 Weinheim, Germany

Asymmetric Total Synthesis and X-Ray Crystal Structure of the Cytotoxic Marine Diterpene (+)-Vigulariol

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Supporting material: Procedures for the syntheses of all new compounds, of (+)-vigulariol (**1**), and for the preparation of carbamate **6** from commercial eucalyptus oil. Analyses data for all new compounds and for (+)-vigulariol (**1**). NMR spectra of compounds **12**, **13**, **14**, **16**/**17**, **18**, **19**, **21**, **22**, **23**, α-**23**, **25**, **1**, and HPLC data for **6**.

General remarks: All solvents were dried and purified prior to use: Et_2O was distilled from sodium benzophenone ketyl, toluene was distilled from sodium, THF was distilled from potassium benzophenone ketyl, and CH_2Cl_2 was distilled from CaH_2. Solutions of *sec*-butyllithium[1] (~1.3 M in cyclohexane/hexane, 92:8) were filtered through a pad of Celite under argon (Ar) in order to remove any precipitate and were stored in a freezer (–30 °C); only a slight yellow hue is acceptable. The content of *s*BuLi was determined by titration.[2] Triethylsilyl chloride (TESCl), benzyl 2,2,2-trichloroacetimidate[3], oxalyl chloride, *rac*-*trans*-1,2-bis(dimethylamino)-cyclohexane[4] (TMCDA), tetraisopropoxytitanium (TiPT), and acetone were distilled and stored under Ar at 4 °C. *N*,*N*-Dimethylformamide (DMF) and dimethyl sulfoxide (DMSO) were distilled and stored under Ar over 4 Å molecular sieves. Diisopropylethyl amine (DIPEA) was distilled and stored under Ar over KOH. Ruthenium carbene catalysts were stored and handled in a dry box under Ar. Solutions of dimethyldioxirane (DMDO) in acetone were stored under Ar over 3 Å molecular sieves in a freezer (–30 °C).[5] The content was determined by the oxidation of methylphenyl sulfide to its sulfoxide.[5] Molecular hydrogen was prepared with a *Domnick Hunter* UHP-40 hydrogen generator. All other commercially available reagents were used as received. Reactions at –78 °C were performed in a dry ice/acetone bath. For other temperatures below 0 °C a *Julabo* FT902 kryostat and an isopropanol bath were used. All moisture sensitive reactions were performed under Ar in flame dried glassware sealed with a rubber septum. Flash column chromatography (FCC) was performed on *Merck* 60 silica gel (40-60 µm, 230-400 mesh

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[1] Purchased from *Sigma-Aldrich*, Deisenhofen, Germany.

[2] W. G. Konfron, L. M. Baclawski, *J. Org. Chem.* **1976**, *41*, 1879.

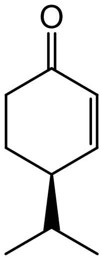
[3] H.-P. Wessel, T. Iversen, T. R. Bundle, J. Chem. Soc., Perkin Trans. 1 **1985**, 2247.

[4] S. C. Benson, P. Cai, M. Colon, M. A. Haiza, M. Tokles, J. K. Snyder, *J. Org. Chem.* **1988**, *53*, 5335.

[5] R. W. Murray, M. Singh, *Organic Synthesis* **1998,** *Coll. Vol. 9*, 288; **1997**, *Vol. 74*, 91.

ASTM), and monitored by thin layer chromatography (TLC) on *Merck* 60 F_{254} TLC-plates. For separation of diastereomers via FCC the silica gel was equilibrated with solvent mixtures containing four times higher amounts of PE than for the purification. NMR: *Bruker* AV 300 or AV 400 or ARX 400 (routine 2D spectra) and *Varian* Inova 500 or Unity Plus 600 (2D spectra, nOesy). Spectra from solutions in $CDCl_3$ (δ_C = 77.0 ppm) are calibrated relative to $SiMe_4$ (δ_H = 0.00 ppm), spectra from solutions in C_6D_6 (δ_C = 128.0 ppm) are calibrated to $SiMe_4$ (δ_H = 0.00ppm). Peak multiplicities in ^{1}H NMR spectra are abbreviated as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), and br (broad). Diastereotopic methylene protons with different chemical shifts are abbreviated as H_A and H_B. 1H and 13C NMR assignments were determined by the assistance of DEPT, ^{1}H-^{1}H COSY, HMQC and HMBC experiments. IR: *Varian* 3100 Excalibur Series with *Specac* Golden Gate Single Reflection ATR. Intensities of the bands are abbreviated as br (broad), s (strong), m (medium), and w (weak). MS: *Bruker* MicroTof (ESI). Optical rotation: *Perkin Elmer* 341 or 241. Melting point: *Stuart Scientific* SMP3. Melting points are not corrected. Elemental analysis: *Elementar-Analysensysteme* Vario EL III. GC: *Agilent* 6890; 30 m x 0.32 mm HP-5; 1.5 mL x min^{-1} H_2; start at 50 °C, 10 °C x min^{-1} to 300 °C, 15 min at 300 °C. HPLC: *Knauer* Smartline PDA detector 2600, Pump 1000, Autosampler 3900, and Manager 5000.

Preparation of *trans*- and *cis*-cryptol (11) and (*cis*-11) from *eucalyptus polybractea cryptone*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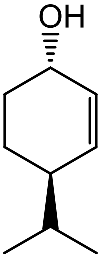
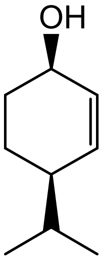

11


cis-**11**

100 ml essential oil *eucalyptus polybractea krypton*[6] were subjected to flash column chromatography (FCC) on silica gel (Et_2O:*n*-pentane (PE) = 1:4 to 1:2). The fraction with R_f= 0.34-0.30 (Et_2O:PE = 1:2) was collected and the solvent was evaporated in vacuo, yielding 12.662 g of a mixture of **9** and a sesquiterpene **ST** (**9**:**ST** = 47:53 (GC); 77% purity (GC)) as a yellowish oil.

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[6] Purchased from Martina Braun Naturprodukte, Ottersweiher, Germany (100 ml = 100 €); see: www.oshadhi.de, www.oshadhi.co.uk, www.oshadhi.jp or www.oshadhiusa.com.

$LiAlH_4$ (3.45 g) was suspended in Et_2O (240 ml) and the mixture was cooled to −78 °C. The above oil (10.49 g) in Et_2O (10 ml) was added dropwise to the suspension within 15 min.[7] Stirring was continued for 2 h 15 min before aqueous Et_2O (40 ml) was added. The flask was removed from the cooling bath and crushed ice (25 ml) was carefully added while the mixture was warmed to room temperature. Aqueous 10% H_2SO_4 solution (43 ml) was added and the solution was extracted with Et_2O (3 x 100 ml). The combined organic layers were dried over $MgSO_4$ and concentrated in vacuo. FCC on silica gel yielded 4.233 g (30.19 mmol) **11**:*cis*-**11** = 84:16 (100% purity (GC)) and 1.738 g (7.1 mmol) of the sesquiterpene as colourless oils.
A second reaction of the residual cryptone oil under the same conditions yielded 1.033 g (7.37 mmol) **11**:*cis*-**11** = 85:15. Total yield from 100 ml essential oil: 5.266 g (37.55 mmol) **11**:*cis*-**11** = 84:16.[8]

(*R*)-(−)-4-Isopropylcyclohex-2-enone ((*R*)-cryptone 9)[9]

R_f = 0.31 (Et_2O:PE = 1:2; vanillin[10]: brown-orange). t_R = 8.46 min (HP-5). HPLC Chira grom 1 (2 x 250 mm), λ = 210 nm, *i*PrOH:*n*-hexane = 1:200, 0.3 mL/min, 11.50 min ((*S*)-**9**), 14.60 min ((*R*)-**9**): 97% *ee*.

Sesquiterpene (ST)[11]

R_f = 0.33 (Et_2O:PE = 1:2; vanillin: blue-gray). R_f = 0.43 (Et_2O:PE = 1:1). t_R = 13.38 min (HP-5). ^{13}C NMR (75 MHz, $CDCl_3$): δ/ppm = 16.3; 20.2; 24.7; 26.1; 26.7; 27.4; 28.6; 29.9; 38.8; 41.7; 53.4; 54.3; 80.9; 106.2; 153.4. HR-MS (ESI, $C_{15}H_{24}O$, 244.45 g/mol): calc.: 243.1719 $[M+Na]^+$, found: m/z = 243.1721 $[M + Na]^+$.

trans-(1*S*,4*R*)- and *cis*-(1*R*,4*R*)-4-Isopropyl-cyclohex-2-enol (11)[12] and (*cis*-11)[12]

11: R_f = 0.25 (Et_2O:PE = 1:1; vanillin: gray). t_R = 7.81 min (HP-5).
cis-**11**: R_f = 0.25 (Et_2O:PE = 1:1; vanillin: gray). t_R = 7.59 min (HP-5).

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[7] Slow addition is necessary to obtain maximum diastereoselectivity of the kinetically controlled reduction.

[8] Reduction of pure synthetic (*R*)-cryptone **9** (99% *ee*) with 1.2 equiv $LiAlH_4$ at −78 °C for 2.5 h under the above conditions yielded pure **11**/*cis*-**11** in quantitative yield, which was directly used for carbamoylation without purification by FCC. FCC is here needed to separate the polar alcohols from the sesquiterpene and unpolar by-products.

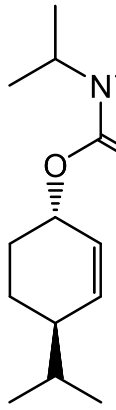
[9] a) J. Evarts, E. Torres, P. L. Fuchs, *J. Am. Chem. Soc.* **2002**, *124*, 11093; b) K. Mori, *Tetrahedron: Asymmetry* **2006**, *17*, 2133.

[10] TLC-coloring reagent: 43.0 g vanillin dissolved in 12 ml concentrated H_2SO_4 und 1 L EtOH.

[11] The structure is not yet clearly determined.

[12] Synthesis of *rac*-**9** (<5% *ee*) from (+)-nopinone and reduction to **11**/*cis*-**11**: J. M. Coxon, G. J. Hydes P. J. Steel, *Tetrahedron* **1985**, *41*, 5213.

(1*S*,4*R*)-4-Isopropylcyclohex-2-enyl *N*,*N*-diisopropylcarbamate (6)[13]



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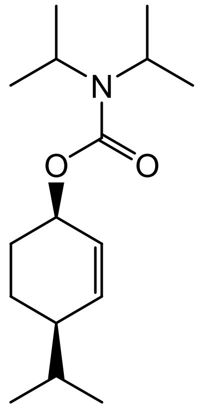
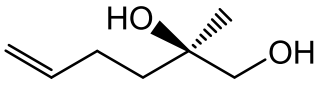


cis-**6**

NaH (1.58 g, 32.95 mmol, 1.2 equiv.) (60% in mineral oil) was suspended in THF (60 ml) at 0 °C. A solution of **11**:*cis*-**11** = 84:16 (4.62 g, 32.95 mmol) in THF (5 ml) was added to the suspension by syringe and stirring was continued for 1 h at room temperature. *N*,*N*-Diisopropylcarbamoyl chloride (*Cb*Cl)[14] (7.6 g, 46 mmol, 1.4 equiv.) was added within 5 min and the reaction mixture was exhaustively stirred and refluxed (95 °C oil bath) for 12 h. After complete consumption of the starting material (TLC) the solution was cooled to room temperature and treated with aqueous 2 M HCl solution (90 ml). The aqueous layer was extracted with diethyl ether (3 x 100 ml). The combined organic layers were washed with $NaHCO_3$ solution (90 ml), dried over $MgSO_4$, and concentrated in vacuo. FCC with Et_2O/*n*-pentane = 1:14 yielded 6.862 g (25.72 mmol, 78%) **6** and 1.081 g (4.04 mmol, 12%) *cis*-**6**.

HPLC Chiralcel OD-H (4.6 x 250 mm), λ = 200 nm, *i*PrOH:*n*-hexane = 1:600, 0.3 mL/min, 25.47 min (*ent*-**6**), 27.40 min (**6**): 97% *ee*. See pages S18-S20.

(*R*)-2-Methyl-2-hydroxyhex-5-enol (10)[15]



10

A suspension of fine powdered anhydrous copper iodide (1.124 g, 5.9 mmol, 0.1 equiv.) and (*S*)-methylglycidol (>95% *ee*) (5.195 g, 59.0 mmol) in dry THF (160 ml) was cooled to

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[13] *rac*-**6**: a) J. Becker, S. Grimme, R. Fröhlich, D. Hoppe, *Angew. Chem.* **2007**, *119*, 1672-1676; *Angew. Chem. Int. Ed.* **2007**, *46*, 1645; **6**: b) J. Becker, R. Fröhlich, O. Kataeva, D. Hoppe, *Eur. J. Org. Chem.* **2007**, 3349.

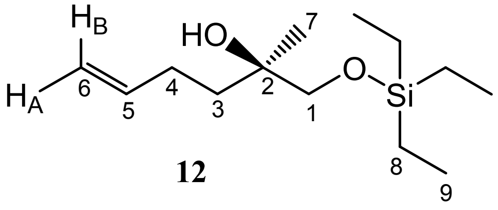
[14] D. Hoppe, R. Hanko, A. Brönneke, F. Lichtenberg, E. van Hülsen, *Chem. Ber.* **1985**, *118*, 2822.

[15] Synthesis of *ent*-**10**: M. E. Kuehne, W. G. Bornmann, I. Markó, Y. Qin, K. L. LeBoulluec, D. A. Frasier, F. Xu, T. Mulamba, C. L. Ensinger, L. S. Borman, A. E.Huot, C. Exon, F. T. Bizzarro, J. B. Cheung, S. L. Bane, *Org. Biomol. Chem.* **2003**, *1*, 2120.

−60 °C. 2 M allylmagnesium chloride solution in THF (60.5 ml, 120.95 mmol, 2.05 equiv.) was added to the stirred suspension over a period of 1 h via syringe pump. The reaction mixture was stirred for 2 h at −40 °C and then for 14 h at −20 °C. Crushed ice (100 ml) was added, the mixture was warmed to room temperature, and then treated with aqueous 2 M HCl solution (100 ml). The layers were separated, the aqueous layer was extracted with dichloromethane (3 x 50 ml), dried over $MgSO_4$ and the solution was concentrated in vacuo. The crude product was purified by FCC on silica gel (Et_2O:PE = 4:1 to 1:0) to yield 6.66 g (51.23 mmol, 87%) **10** as colourless oil.

$[\alpha]_D^{20}$ (*c* = 1.06, $CHCl_3$) = +3.8. Lit.[15]: $[\alpha]_D^{20}$ of *ent*-**10**: not reported.

(*R*)-1-Triethylsilyloxy-2-methylhex-5-en-2-ol (12)



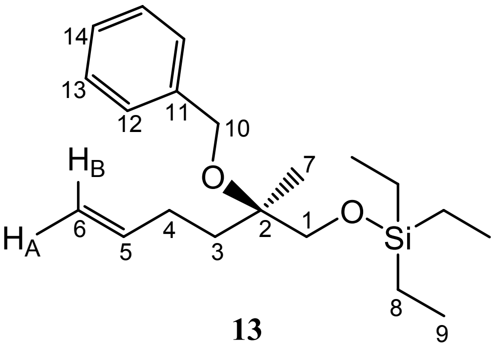
12

To a solution of imidazole (4.08 g, 60.0 mmol, 2.0 equiv.) in DMF (25 ml) was added diol **10** (3.91 g, 30.0 mmol) dissolved in DMF (5 ml). The solution was cooled to 0 °C (ice bath) and stirred for 5 min. Triethylsilyl chloride (TESCl) (4.748 g, 31.5 mmol, 1.05 equiv.) was added dropwise within 5 min. The cooling bath was removed and the solution was stirred for additional 55 min. The reaction was quenched with dist. H_2O (15 ml) and extracted with Et_2O (3 x 50 ml). The combined organic layers were dried over $MgSO_4$, concentrated in vacuo and subjected to FCC on silica gel (Et_2O:PE = 1:49 to 1:9). Evaporation of the solvent in vacuo yielded 7.259 g (29.7 mmol, 99%) silyl ether **12** as a colourless, volatile liquid.

R_f= 0.27 (Et_2O:PE = 1:9). t_R = 11.77 min (HP-5). ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 0.62 (q, $^3J_{8,9}$ = 8.0 Hz, 6H, 8-H); 0.97 (t, $^3J_{8,9}$ = 8.0 Hz, 9H, 9-H); 1.13 (s, 3H, 7-H); 1.47-1.64 (m, 2H, 3-H); 2.05-2.19 (m, 2H, 4-H); 2.39 (brs, 1H, OH); 3.38, 3.45 (2 d, $^2J_{1A,1B}$ = 9.4 Hz, 2H, 1-H); 4.93 (d, $^3J(Z)_{5,6A}$ = 10.4 Hz, 1H, 6-H_A); 5.03 (d, $^3J(E)_{5,6B}$ = 17.2 Hz, 1H, 6-H_B); 5.84 (ddt, $^3J_{4,5}$ = 6.6 Hz, $^3J(Z)_{5,6A}$ = 10.4 Hz, $^3J(E)_{5,6B}$ = 17.2 Hz, 1H, 5-H). ^{13}C NMR (400 MHz, $CDCl_3$): δ/ppm = 4.4 (CH_2, C-8); 6.7 (CH_3, C-9); 23.1 (CH_3, C-7); 28.1 (CH_2, C-4); 37.7 (CH_2, C-3); 69.9 (CH_2, C-1); 72.1 (C_q, C-2); 114.1 (CH_2, C-6); 139.1 (CH, C-5). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 2956 (s), 2912 (s), 2877 (s) ν (C_{aliph}-H). MS (ESI) m/z = 267.1738 $[M+Na]^+$;

299.2009 [M+MeOH+Na]$^+$. $C_{13}H_{28}O_2Si$ (244.45 g/mol): calc.: C 63.87, H 11.55; found: C 63.83, H 11.85. $[\alpha]_D^{20}$ (*c* = 0.95, $CHCl_3$) = −1.26.

(*R*)-[2-Benzyloxy-2-methylhex-5-enyloxy]-triethyl-silane (13)



13

To a stirred solution of **12** (7.259 g, 29.7 mmol) in Et_2O (120 ml) at 0 °C was added benzyl 2,2,2-trichloroacetimidate[16] (19.0 g, 75.2 mmol, 2.5 equiv.). A solution of trifluoromethanesulfonic acid (0.744 ml, 8.37 mmol, 0.282 equiv.) in Et_2O (30 ml) was added dropwise within 10 min and the solution was stirred for additional 30 min at 0 °C.[17] The cooling bath was removed and stirring was continued for 2 h 45 min. Saturated aqueous NH_4Cl solution (120 ml) and then dist. H_2O (100 ml) were added, the layers were separated and the aqueous layer was extracted with TBME (3 x 100 ml). The combined organic layers were dried over $MgSO_4$, the solvent was removed in vacuo and the crude product was purified by FCC on silica gel (Et_2O:PE = 1:49) to yield 8.587 g (25.67 mmol, 86%) **13** as a colourless oil.

R_f = 0.53 (Et_2O:PE = 1:19). t_R = 17.98 min (HP-5). ^1H NMR (300 MHz, $CDCl_3$): δ/ppm = 0.60 (q, $^3J_{8,9}$ = 7.7 Hz, 6H, 8-H); 0.96 (t, $^3J_{8,9}$ = 7.7 Hz, 9H, 9-H); 1.24 (s, 3H, 7-H); 1.57-1.81 (m, 2H, 3-H); 2.11-2.19 (m, 2H, 4-H); 3.52, 3.61 (2 d, $^2J_{1A,1B}$ = 10.0 Hz, 2H, 1-H); 4.50 (s, 2H, 10-H); 4.94 (d, $^3J(Z)_{5,6A}$ = 10.2 Hz, 1H, 6-H_A); 5.03 (dq, $^3J(E)_{5,6B}$ = 17.2 Hz, *J* = 1.7 Hz, 1H, 6-H_B); 5.86 (ddt, $^3J_{4,5}$ = 6.6 Hz, $^3J(Z)_{5,6A}$ = 10.2 Hz, $^3J(E)_{5,6B}$ = 17.2 Hz, 1H, 5-H); 7.22-7.40 (m, 5H, 12-H/13-H/14-H). ^{13}C NMR (75 MHz, $CDCl_3$): δ/ppm = 4.3 (CH_2, C-8); 6.8 (CH_3, C-9); 21.1 (CH_3, C-7); 27.7 (CH_2, C-4); 34.1 (CH_2, C-3); 64.0 (CH_2, C-10); 67.6 (CH_2, C-1); 77.5 (C_q, C-2); 114.0 (CH_2, C-6); 127.1. (C_q, C-11); 127.3 (CH, C-13); 128.2 (CH, C-12); 139.2 (CH, C-5); 139.7 (CH, C-14). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3066 (w), 3030 (w) $\nu(C_{arom}$-H); 2955 (s), 2912 (s), 2877 (s) $\nu(C_{aliph}$-H). HR-MS (ESI, $C_{20}H_{34}O_2Si$, 244.45 g/mol): calc.: 357.2220 [M+Na]$^+$, found: m/z = 357.2221 [M + Na]$^+$. $[\alpha]_D^{20}$ (c = 1.08, $CHCl_3$) = +0.7.

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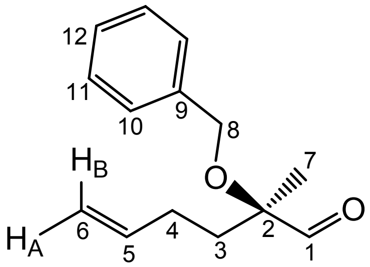
[16] H.-P. Wessel, T. Iversen, T. R. Bundle, *J. Chem. Soc.*, *Perkin Trans. 1* **1985**, 2247.

[17] The amount of acid that was needed for complete protection of the tertiary alcohol **12** is unusually high compared to other protections with Bn-TCA. Benzylation of the sodium and potassium alcoholates of **12** with benzyl bromide gave low yields. Protection of **12** with PMB-TCA proceeded smoothly with 0.3 mol% trifluoromethanesulfonic acid.

(*R*)-2-Benzyloxy-2-methylhex-5-enal (14)

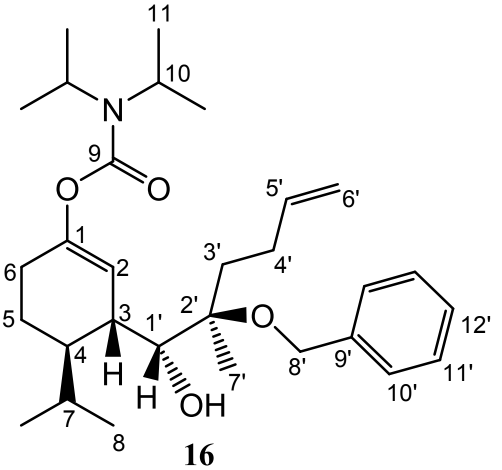


14

Oxalyl chloride (12.69 g, 100 mmol, 5.0 equiv.) was dissolved in dichloromethane (80 ml) and cooled to −60 °C. DMSO (15.63 g, 200 mmol, 10.0 equiv.) in dichloromethane (40 ml) was added dropwise over a period of 15 min, before **13** (6.69 g, 20.0 mmol) in dichloromethane (40 ml) was added within 15 min. The reaction was stirred for 14 h at −60 °C. Diisopropylethylamine (DIPEA) (51.7 g, 400 mmol, 20.0 equiv.) was then added. The cooling bath was removed and the mixture was allowed to warm to room temperature within 15 min. Stirring was continued for 30 min at room temperature and the reaction was then quenched with dist. H_2O (40 ml). The aqueous layer was extracted with dichloromethane (3 x 100 ml). The combined organic layers were washed with saturated aqueous NaCl solution (20 ml), dried over $MgSO_4$ and concentrated in vacuo. FCC on silica gel (Et_2O:PE = 1:49 to 1:30) yielded 2.211 g (16.21 mmol, 81%) aldehyde **14** as a colourless oil.

R_f = 0.26 (Et_2O:PE = 1:19). t_R = 13.40 min (HP-5). ^{1}H NMR (400 MHz, $CDCl_3$): δ/ppm = 1.34 (s, 3H, 7-H); 1.72-1.90 (m, 2H, 3-H); 2.08-2.21 (m, 2H, 4-H); 4.45, 4.49 (2 d, $^3J_{8A,8B}$ = 11.2 Hz, 2H, 8-H), 4.97 (dq, $^3J(Z)_{5,6A}$ = 10.1 Hz, J = 1.4 Hz, 1H, 6-H_A); 5.04 (dq, $^3J(E)_{5,6B}$ = 17.1 Hz, J = 1.7 Hz, 1H, 6-H_B); 5.80 (ddt, $J_{4,5}$ = 6.6 Hz, $^3J(Z)_{5,6A}$ = 10.1 Hz, $^3J(E)_{5,6B}$ = 17.1 Hz, 1H, 5-H); 7.27-7.38 (m, 5H, 12-H/13-H/14-H), 9.67 (s, 1H, 1-H). ^{13}C NMR (100 MHz, $CDCl_3$): δ/ppm = 18.3 (CH_3, C-7); 27.2 (CH_2, C-4); 34.3 (CH_2, C-3); 66.1 (CH_2, C-8); 82.4 (C_q, C-2); 115.0 (CH_2, C-6); 127.4 (CH, C-11); 127.7 (CH, C-12); 128.4 (CH, C-10); 137.8 (CH, C-5); 138.2 (C_q, C-9); 204.9 (CH, C-1). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3067 (w), 3032 (w) ν(C_{arom}-H); 2979 (m), 2937 (m), 2867 (s) ν(C_{aliph}-H); 1734 ν(C=O). MS (ESI) m/z = 241.1203 $[M+Na]^+$; 273.1463 $[M+MeOH+Na]^+$. $C_{14}H_{18}O_2$ (218.29 g/mol) calc.: C 77.03, H 8.31; found: C 76.80, H 8.43. $[\alpha]_D^{20}$ (c = 1.03, $CHCl_3$) =+19.5.

[3*R*,4*R*,3(1*R*,2*R*)]- and [3*R*,4*R*,3(1*S*,2*R*)]-3-[2-Benzyloxy-1-hydroxy-2-methylhex-5-enyl]-4-isopropylcyclohex-1-enyl *N*,*N*-diisopropylcarbamate (16) and (17)



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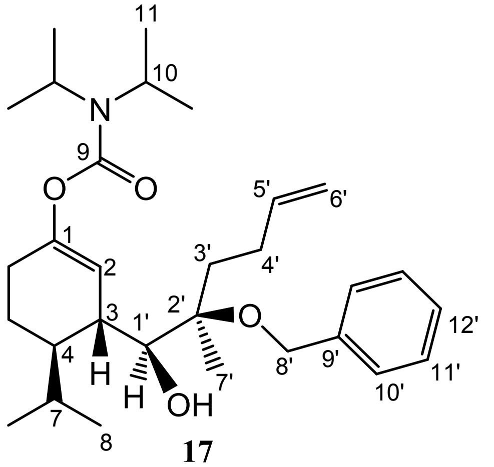

17

To a stirred solution of **6** (134 mg, 0.50 mmol) and TMCDA (89 mg, 0.525 mmol, 1.05 equiv.) in Et_2O (4 ml) at −78 °C 1.22 M *s*BuLi solution (0.43 ml, 0.525 mmol, 1.05 equiv.) was added dropwise. After 2 h a 1.74 M solution of ClTiPT[18,19]in toluene (0.50 ml, 0.85 mmol, 1.74 equiv.) was added over a period of 5 min and stirring at −78 °C was continued for 2 h, while the solution turned deep black. Then aldehyde **14** (273 mg, 1.25 mmol, 2.5 equiv.) in toluene (0.5 ml) was added dropwise. The reaction was warmed to room temperature over a period of 13.5 h and then quenched with saturated aqueous NH_4Cl solution (0.50 ml). Et_2O (10 ml) was added and the mixture was stirred for 10 min at room temperature. The precipitate was decanted and the reaction mixture was filtered through a Büchner funnel. The white solid filter cake (TiO_2) was washed with Et_2O (10 ml). The filtrate was concentrated in vacuo and then subjected to FCC on silica gel (Et_2O:PE = 1:30, then 1:3) to yield 97 mg (0.20 mmol, 40%) **16**:**17** = 83:17[20] as an inseparable mixture and 188 mg (0.86 mmol, 69%) aldehyde **14**[21] as colourless oils.

An analogous reaction (0.50 mmol scale), but shorter transmetallation for 1 h at −78 °C, yielded 95 mg (0.196 mmol, 39%) **16**:**17** = 83:17, and 167 mg (0.77 mmol, 61%) aldehyde **14**. Transmetallation with 1.74 equiv ClTiPT for 3 h at −45 °C and addition of 2.0 equiv. **14** at −78 °C, before warming to room temperature within 16 h, yielded 42 mg (0.086 mmol, 35%) **16**:**17** = 83:17 and 75 mg (0.344 mmol, 69%) aldehyde **14** (0.25 mmol scale).

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[18] Preparation of 2.3 ml 1.74 M ClTiPT solution in toluene: 853 mg (3.0 mmol) tetraisopropoxytitanium(IV) (TiPT) and 190 mg (1.0 mmol) $TiCl_4$ were dissolved in 2 ml dry toluene under Ar at room temperature 1 h before the transmetallation reaction.

[19] Transmetallation with $ClTi(NEt_2)_3$ and homoaldol reaction with aldehyde **14** led to mixtures of the homoaldol products **16**/**17** and their corresponding ketones, which arose from loss of C(O)N*i*Pr_2 of **16**/**17**.

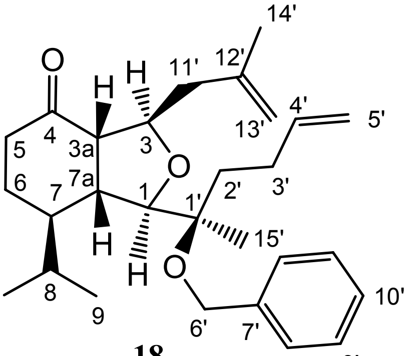
[20] The diastereomeric ratio was determined by integration of the olefinic protons in the ^1H NMR spectra.

[21] The reisolated aldehyde **14** was essentially pure and was reused in further homoaldol reactions.

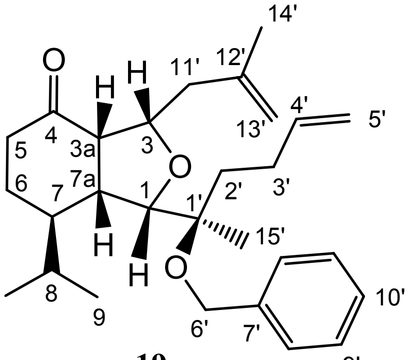
16: R_f = 0.28 (Et_2O:PE = 1:2). t_R = 25.69 min (HP-5). ^{1}H-NMR (500 MHz, C_6D_6): δ/ppm = 0.76, 0.89 (2 d, $^3J_{7,8}$ = 6.8 Hz, 6H, 8-H); 1.05 (brs, 12H, 11-H); 1.14 (s, 3H, 7’-H); 1.44-1.51 (m, 2H, 4-H/5-H_A); 1.71-1.81 (m, 2H, 3’-H_A/7-H); 1.91-2.01 (m, 2H, 3’-H_B/5-H_B); 2.09-2.20 (m, 3H, 4’-H_A/6-H); 2.27 (m, 1H, 4’-H_B), 2.83 (brdd, $^3J_{1',3}$ = $^3J_{3,4}$ = 7.1 Hz, 1H, 3-H); 3.17 (d, J = 8.6 Hz, 1H, OH); 3.58 (d, $^3J_{1',3}$ = 7.1 Hz, 1H, 1’-H); 3.67, 3.82 (2 brs, 2H, 10-H); 4.34, 4.44 (2 d, $^2J_{8'A,8'B}$ = 11.5 Hz, 2H, 8’-H); 4.96 (dq, $^3J(Z)_{5',6'A}$ = 10.4 Hz; J = 1.9 Hz, 1H, 6’-H_A); 5.06 (dq, $^3J(E)_{5',6B'}$ = 17.2 Hz, J = 1.9 Hz, 1H, 6’-H_B); 5.73 (d, J = 4.5 Hz, 1H, 2-H); 5.82 (ddt, $^3J_{4',5'}$ = 6.6 Hz; $^3J(Z)_{5',6'A}$ = 10.4 Hz; $^3J(E)_{5',6'B}$ = 17.2 Hz, 1H, 5’-H); 7.11 (t, $^3J_{11',12'}$ = 7.5 Hz, 1H, 12’-H); 7.21 (dd, $^3J_{10',11'}$ = 7.3 Hz, $^3J_{11',12'}$ = 7.5 Hz, 2H, 11’-H); 7.34 (d, $^3J_{10',11'}$ = 7.3 Hz, 2H, 10’-H). ^{13}C-NMR (500 MHz, C_6D_6): δ/ppm = 18.3, 22.1 (CH_3, C-8); 20.45, 21.35 (CH_3, C-11); 20.8 (CH_3, C-7’); 21.6 (CH_2, C-5); 26.4 (CH_2, C-6); 28.3 (CH, C-7); 29.2 (CH_2, C-4’); 35.2 (CH_2, C-3’); 38.6 (CH, C-3); 44.5 (CH, C-4); 46.1, 46.6 (CH, C-10); 64.2 (CH_2, C-8’); 78.7 (CH, C-1’); 80.5 (C_q, C-2’); 114.1 (CH_2, C-6’); 114.2 (CH, C-2); 127.1, (CH, C-12’); 127.4 (CH, C-11’); 128.4 (CH, C-10’); 139.5 (CH, C-5’); 140.5 (C_q, C-9’); 151.8 (C_q, C-1); 154.1 (C_q, C-9). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3467 ν(OH); 3087 (w), 3066 (w), 3030 (w) $\nu(C_{arom}$-H); 2962 (m), 2934 (m), 2872 (w) $\nu(C_{aliph}$-H); 1701 (s) ν(C=O). MS (ESI) m/z = 508.3395 $[M+Na]^+$. $C_{30}H_{47}NO_4$ (485.70 g/mol, mixture of diastereomers): calc.: C 74.19, H 9.75, N 2.88; found: C 74.15, H 9.92, N 2.60. $[\alpha]_D^{20}$ (c = 0.81, $CHCl_3$, **16**:**17** = 88:12) = +51.4.

17: R_f = 0.28 (Et_2O:PE = 1:2). t_R = 25.63 min (HP-5). ^{1}H-NMR (500 MHz, C_6D_6): δ/ppm = 0.76, 0.89 (2 d, $^3J_{7,8}$ = 6.8 Hz, 6H, 8-H); 1.05 (brs, 12H, 11-H); 1.19 (s, 3H, 7’-H); 1.44-1.51 (m, 2H, 4-H/5-H_A); 1.59-1.65 (m, 2H, 3’-H); 1.71-1.81 (m, 1H, 7-H); 1.91-2.01 (m, 1H, 5-H_B); 2.09-2.20 (m, 3H, 4’-H_A/6-H); 2.27 (m, 1H, 4’-H_B), 3.00 (brdd, $^3J_{1',3}$ = $^3J_{3,4}$ = 6.4 Hz, 1H, 3-H); 3.28 (brs, 1H, OH); 3.64 (brs, 1H, 1’-H); 3.67, 3.82 (2 brs, 2H, 10-H); 4.31, 4.36 (2 d, $^2J_{8'A,8'B}$ = 11.4 Hz, 2H, 8’-H); 4.97 (dq, $^3J(Z)_{5',6'A}$ = 10.2 Hz; J = 1.9 Hz, 1H, 6’-H_A); 5.07 (dq, $^3J(E)_{5',6B'}$ = 17.0 Hz, J = 1.9 Hz, 1H, 6’-H_B); 5.60 (d, J = 4.7 Hz, 1H, 2-H); 5.82 (ddt, $^3J_{4',5'}$ = 6.6 Hz; $^3J(Z)_{5',6'A}$ = 10.2 Hz; $^3J(E)_{5',6'B}$ = 17.0 Hz, 1H, 5’-H); 7.10 (m, 1H, 12’-H); 7.21 (m, 2H, 11’-H); 7.33 (m, 2H, 10’-H). ^{13}C-NMR (500 MHz, C_6D_6): δ/ppm = 18.7, 22.0 (CH_3, C-8); 20.45, 21.35 (CH_3, C-11); 19.6 (CH_3, C-7’); 21.5 (CH_2, C-5); 26.1 (CH_2,C-6); 28.2 (CH,C-7); 28.3 (CH_2, C-4’); 35.3 (CH_2, C-3’); 38.0 (CH, C-3); 45.0 (CH, C-4); 46.1, 46.6 (CH, C-10); 64.0 (CH_2, C-8’); 77.9 (CH, C-1’); 80.4 (C_q, C-2’); 114.1 (CH_2, C-6’); 114.2 (CH, C-2); 127.1, (CH, C-12’); 127.5 (CH, C-11’); 128.3 (CH, C-10’); 139.4 (CH, C-5’); 140.3 (C_q, C-9’); 151.9 (C_q, C-1); 154.2 (C_q, C-9).

[1*R*,3*R*,3a*S*,7*R*,7a*R*,1(1*R*)]- and [1*S*,3*S*,3a*S*,7*R*,7a*R*,1(1*R*)]-1-(2-Benzyloxyhex-5-en-2-yl)-7-isopropyl-3-(2-methylallyl)-hexahydroisobenzofuran-4(1*H*)-one (18) and (19)



18



19

To a stirred solution of **16**:**17** = 83:17 (192 mg, 0.45 mmol) and freshly distilled 3-methyl-3-butenal diethyl acetal (**8**)[22] (107 mg, 0.945 mmol, 2.10 equiv.) in dichloromethane (1.65 ml) at 0 °C, BF_3•OEt_2 (107 µl, 0.855 mmol, 1.90 equiv.) was added through a syringe within 1 min. The green solution was stirred for 35 min at 0 °C. The reaction was quenched with saturated aqueous NaCl solution (1.5 ml), diluted with dichloromethane (10 ml) and the aqueous layer was extracted with dichloromethane (3 x 10 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ solution (1.5 ml), dried with $MgSO_4$, and concentrated in vacuo. The crude product was purified by FCC on silica gel (Et_2O:PE = 1:12) to yield 24 mg (0.06 mmol, 13%) **19** and 136 mg (0.32 mmol, 71%) **18** as colourless oils.

18: R_f= 0.41 (Et_2O:PE = 1:4). t_R = 23.86 min (HP-5). ^1H NMR (500 MHz, $CDCl_3$): δ/ppm = 0.72, 1.00 (2 d, $^3J_{8,9}$ = 6.7 Hz, 6H, 9-H); 1.21 (s, 3H, 15’-H); 1.47 (m, 1H, 6-H_A); 1.60 (tt, $^3J_{7,7a} = J$ = 10.7 Hz, J = 2.8 Hz, 1H, 7-H); 1.68-1.75 (m, 2H, 3’-H); 1.76 (s, 3H, 14’-H); 1.80 (m, 1H, 8-H); 1.95 (m, 1H, 6-H_B); 2.09-2.19 (m, 2H, 2’-H); 2.21-2.23 (m, 2H, 11’-H); 2.35-2.39 (m, 2H, 5-H); 2.56 (ddd, $^3J_{1,7a}$ = 2.3 Hz, $^3J_{3a,7a}$ = 7.9 Hz, $^3J_{7,7a}$ = 10.7 Hz, 1H, 7a-H); 2.74 (dd, $^3J_{3,3a}$ = 9.8 Hz, $^3J_{3a,7a}$ = 7.9 Hz, 1H, 3a-H); 3.96 (d, $^3J_{1,7a}$ = 2.3 Hz, 1H, 1-H); 4.16 (m, 1H, 3-H); 4.45, 4.53 (2 d, $^2J_{6'A,6'B}$ = 11.2 Hz, 2H, 6’-H); 4.75, 4.78 (2 s, 2H, 13’-H); 4.94 (d, $^3J(Z)_{4',5'A}$ = 10.2 Hz, 1H, 5’-H_A); 5.02 (d, $^3J(E)_{4',5'B}$ = 17.1 Hz, 1H, 5’-H_B); 5.84 (ddt, $^3J_{3',4'}$ = 6.6 Hz, $^3J(Z)_{4',5'A}$ = 10.2 Hz, $^3J(E)_{4',5'B}$ = 17.1 Hz, 1H, 4’-H); 7.23-7.33 (m, 5H, 8’-H/9’-H/10’-H). nOesy correlations[23] are depicted on page S26.^{13}C NMR (500 MHz, $CDCl_3$): δ/ppm = 15.7, 20.0 (CH_3, C-9); 22.0 (CH_3, C-14’); 23.2 (CH_3, C-15’); 23.9 (CH_2, C-6); 27.5 (CH, C-8); 28.8 (CH_2, C-2’); 34.7 (CH_2, C-3’); 38.7 (CH_2, C-5); 42.6 (CH_2, C-11’); 42.9 (CH, C-7); 46.1 (CH, C-7a); 58.8 (CH, C-3a); 64.5 (CH_2, C-6’); 78.6 (C_q, C-1’); 80.0 (CH, C-3);

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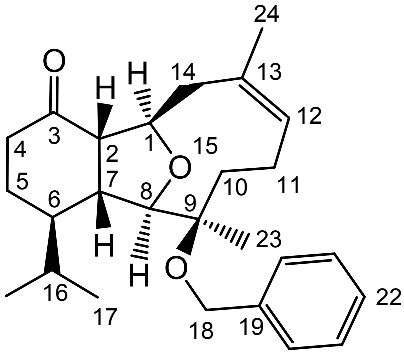
[22] J. W. Conforth, M. E. Firth, *J. Chem. Soc.* **1958**, 1091.

[23] K. Scott, J. Keller, Q. N. Vau, A. J. Shaka, *J. Magn. Reson.* **1997**, *125*, 302.

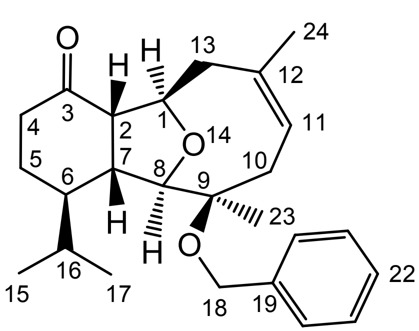
89.1 (CH, C-1); 112.3 (CH$_2$, C-13’); 114.2 (CH, C-5’); 127.1 (CH, C-10’); 127.3 (CH, C-9’); 128.2 (CH, C-8’); 139.0 (CH, C-4’); 139.6 (C$_q$, C-7’); 143.2 (C$_q$, C-12’); 211.2 (C$_q$, C-4). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3074 (w), 3030 (w), ν(C$_{\mathrm{arom}}$-H); 2959 (m), 2871 (w) ν(C$_{\mathrm{aliph}}$-H); 1705 (s) ν(C=O). HR-MS (ESI, $C_{28}H_{40}O_3$, 424.62 g/mol): calc.: 447.2870 [M+Na]$^+$, found: m/z = 447.2876 [M+Na]$^+$. $[\alpha]_{\mathrm{D}}^{20}$ (c = 0.97, CDCl$_3$) = –18.9.

19: R_{f} = 0.47 (Et$_2$O:PE = 1:4). t$_{\mathrm{R}}$ = 23.71 min (HP-5). ^{1}H NMR (500 MHz, CDCl$_3$): δ/ppm = 0.50, 0.91 (2 d, $^3J_{8,9}$ = 6.9 Hz, 6H, 9-H); 1.18 (s, 3H, 15’-H); 1.44 (ddt, $^3J_{5\mathrm{AB},6\mathrm{A}}$ = 4.4 Hz, $^3J_{5\mathrm{AB},6\mathrm{A}}$ = $^3J_{6\mathrm{A},7}$ = 12.9 Hz, $^3J_{6\mathrm{A},6\mathrm{B}}$ = 17.2 Hz, 1H, 6-H$_{\mathrm{A}}$); 1.61-1.69 (m, 2H, 2’-H$_{\mathrm{A}}$/7-H); 1.77 (s, 3H, 14’-H); 1.81 (m, 1H, 2’-H$_{\mathrm{B}}$); 1.89-1.96 (m, 2H, 6-H$_{\mathrm{B}}$/8-H); 2.11-2.17 (m, 2H, 3’-H$_{\mathrm{A}}$/11’-H); 2.22 (m, 1H, 3’-H$_{\mathrm{B}}$); 2.28 (brdd, $^3J_{3,11'\mathrm{B}}$ = 3.1 Hz, $^2J_{11'\mathrm{A},11'\mathrm{B}}$ = 14.4 Hz, 1H, 11’-H$_{\mathrm{B}}$); 2.33-2.41 (m, 2H, 5-H); 2.53-2.59 (d and m, $^3J_{3,3\mathrm{a}}$ = 8.9 Hz, 2H, 3a-H/7a-H); 3.95 (d, $^3J_{1,7\mathrm{a}}$ = 2.1 Hz, 1H, 1-H); 4.17 (ddd, $^3J_{3,3\mathrm{a}}$ = 8.9 Hz, $^3J_{3\mathrm{a},11'\mathrm{A}}$ = 3.1 Hz, $^3J_{3\mathrm{a},11'\mathrm{B}}$ = 12.1 Hz, 1H, 3-H); 4.39, 4.42 (2 d, $^2J_{6'\mathrm{A},6'\mathrm{B}}$ = 14.4 Hz, 2H, 6’-H); 4.77, 4.80 (2 s, 2H, 13’-H); 4.94 (d, $^3J(Z)_{4',5'\mathrm{A}}$ = 10.1 Hz, 1H, 5’-H$_{\mathrm{A}}$); 5.02 (dq, $^3J(E)_{4',5'\mathrm{B}}$ = 17.1 Hz, J = 1.7 Hz, 1H, 5’-H$_{\mathrm{B}}$); 5.84 (ddt, $^3J_{3',4'}$ = 6.6 Hz, $^3J(Z)_{4',5'\mathrm{A}}$ = 10.1 Hz, $^3J(E)_{4',5'\mathrm{B}}$ = 17.1 Hz, 1H, 4’-H); 7.25-7.34 (m, 5H, 8’-H/9’-H/10’-H). nOesy correlations[13] are depicted on page S28. ^{13}C NMR (500 MHz, CDCl$_3$): δ/ppm = 15.7, 22.0 (CH$_3$, C-9); 19.0 (CH$_3$, C-15’); 23.4 (CH$_3$, C-14’); 24.1 (CH$_2$, C-6); 26.7 (CH, C-8); 27.4 (CH$_2$, C-3’); 34.0 (CH$_2$, C-2’); 39.1 (CH$_2$, C-5); 42.3 (CH$_2$, C-11’); 43.5 (CH, C-7); 45.6 (CH, C-7a); 58.8 (CH, C-3a); 63.8 (CH$_2$, C-6’); 78.2 (C$_q$, C-1’); 79.4 (CH, C-3); 86.4 (CH, C-1); 112.5 (CH$_2$, C-13’); 114.2 (CH$_2$, C-5’); 127.2 (CH, C-10’); 127.6 (CH, C-9’); 128.1 (CH, C-8’); 139.0 (CH, C-4’); 139.1 (C$_q$, C-7’); 143.0 (C$_q$, C-12’); 211.3 (C$_q$, C-4). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3075 (w), 3031 (w), ν(C$_{\mathrm{arom}}$-H); 2957 (s), 2870 (m) ν(C$_{\mathrm{aliph}}$-H); 1705 (s) ν(C=O). MS (ESI) m/z = 447.2865 [M+Na]$^+$. $C_{28}H_{40}O_3$ (424.62 g/mol) calc.: C 79.20, H 9.50; found: C 79.05, H 9.66. $[\alpha]_{\mathrm{D}}^{20}$ (c = 1.12, CDCl$_3$) = +1.96.

(1*R*,2*S*,7*R*,8*R*,9*R*)-9-Benzyloxy-6-isopropyl-9,13-dimethyl-15-oxa-tricyclo[6.6.$1^{1,8}$.$0^{2,7}$] pentadec-12-en-3-one (21) and (1*R*,2*S*,7*R*,8*R*,9*R*)-9-Benzyloxy-6-isopropyl-9,12-dimethyl-14-oxa-tricyclo[6.5.$1^{1,8}$.$0^{2,7}$]tetradec-11-en-3-one (22)



21



22

18 (100 mg, 0.236 mmol) was dissolved in dry benzene (degassed with Ar) (150 ml) and the solution was exhaustively refluxed (110 °C oil bath) under Ar. The second generation Grubbs catalyst **20**[24] (20.0 mg, 0.0236 mmol, 0.1 equiv.), dissolved in dry benzene (10 ml) was added to the refluxing solution by syringe within 2 min. After 1 h 20 min the solution was cooled to room temperature, opened to air, and stirring was continued for 1 h. The reaction mixture was concentrated in vacuo to a volume of 2 ml and the crude product was purified by FCC on silica gel (Et_2O:PE = 1:14) to yield 42 mg (0.106 mmol, 45%) **21** as a colourless solid and 15 mg (0.039 mmol, 17%) **22** as a colourless oil.

21: R_f= 0.27 (Et_2O:PE = 1:4). M. p. = 61.5 °C (Et_2O). t_R = 24.69 min (HP-5). ^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 0.75, 0.89 (2 d, $^3J_{16,17}$ = 6.6 Hz, 6H, 17-H); 1.39 (s, 3H, 23-H); 1.60-1.64 (m, 3H, 10-H_A/14-H_A/16-H); 1.77 (s, 3H, 24-H); 1.80-2.03 (m, 5H, 5-H_A/6-H/10-H_B/ 11-H_A/14-H_B); 2.28 (m, 1H, 4-H_A); 2.39 (m, 1H, 4-H_B); 2.54 (m, 1H, 5-H_B); 2.70 (d, $^2J_{11A,11B}$ = 14.5 Hz, 1H, 11-H_B); 2.83 (dd, $^3J_{1,2}$ = 4.8 Hz, $^3J_{2,7}$ = 8.3 Hz, 1H, 2-H); 2.99 (dt, $^3J_{2,7}$ = 8.3 Hz, $^3J_{6,7}$ = $^3J_{7,8}$ = 6.6 Hz, 1H, 7-H); 3.78 (d, $^3J_{7,8}$ = 6.6 Hz, 1H, 8-H); 4.39, 4.44 (2 d, $^2J_{18A,18B}$ = 11.1 Hz, 2H, 18-H); 4.60 (brs, 1H, 1-H); 5.56 (brs, 1H, 12H); 7.22-7.32 (m, 5H, 20-H/21-H/22-H). nOesy correlations[13] are depicted on page S30. ^{13}C NMR (500 MHz, $CDCl_3$): δ/ppm = 17.5, 21.7 (CH_3, C-17); 22.7 (CH_3, C-23); 22.9 (CH_2, C-14); 23.0 (CH_2, C-5); 27.5 (CH_3, C-24); 28.6 (CH, C-6); 34.1 (CH_2, C-10); 37.2 (CH_2, C-11); 37.9 (CH_2, C-4); 41.0 (CH, C-16); 45.8 (CH, C-7); 53.9 (CH, C-2); 63.6 (CH_2, C-18); 76.9 (CH, C-1); 78.6 (C_q, C-9); 88.8 (CH, C-8); 127.1 (CH, C-22); 127.3 (CH, C-21); 128.1 (CH, C-20); 129.5 (C_q, C-13); 131.3 (CH, C-12); 139.4 (C_q, C-19); 211.3 (C_q, C-3). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3088 (w), 3064 (w),

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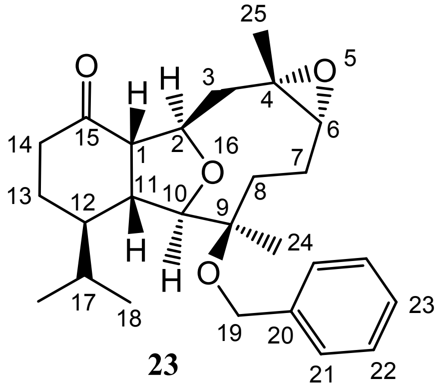
[24] M. Scholl, S. Ding, C. W. Lee, R. H. Grubbs, *Org. Lett.* **1999**, *1*, 953.

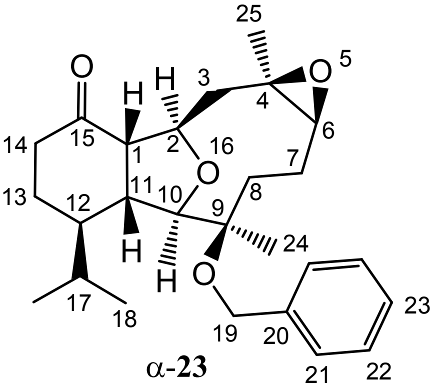
3030 (w), ν(C_{arom}-H); 2957 (s), 2929 (m), 2870 (m) ν(C_{aliph}-H); 1708 (s) ν(C=O). MS (ESI) m/z = 419.2559 $[M+Na]^+$. $C_{26}H_{36}O_3$ (396.56 g/mol) calc.: C 78.75, H 9.15; found: C 78.47, H 9.12. $[\alpha]_D^{20}$ (c = 0.96, $CHCl_3$) = –26.6.

22: R_f= 0.18 (Et_2O:PE = 1:4). t_R = 22.79 min (HP-5). ^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 0.60 (d, $^3J_{15,16}$ = 6.6 Hz, 3H, 15-H); 0.71 (d, $^3J_{16,17}$ = 6.6 Hz, 3H, 17-H); 1.27 (brs, 1H, 6-H); 1.39 (s, 3H, 23-H); 1.69-1.77 (m, 3H, 5-H/16-H); 1.80 (s, 3H, 24-H); 2.00 (dd, $^3J_{1,13A}$ = 5.6 Hz, $^2J_{13A,13B}$ = 14.6 Hz, 1H, 13-H_A); 2.22 (dt, $^2J_{4A,4B}$ = 16.7 Hz, $^3J_{4A,5A}$ = $^3J_{4A,5B}$ = 6.0 Hz, 1H, 4-H_A); 2.28-2.35 (m, 2H, 4-H_B/10-H_A); 2.42 (dd, $^2J_{10A,10B}$ = 14.3 Hz, $^3J_{10B,11}$ = 9.0 Hz, 1H, 10-H_B); 2.48 (d, $^3J_{2,7}$ = 9.0 Hz, 1H, 2-H); 2.70 (brd, $^2J_{13A,13B}$ = 14.6 Hz, 1H, 13-H_B); 3.44 (m, 1H, 7-H); 3.67 (d, $^3J_{7,8}$ = 7.0 Hz, 1H, 8-H); 4.46, 4.51 (2 d, $^2J_{18A,18B}$ = 10.5 Hz, 2H, 18-H); 4.96 (dd, $^3J_{1,13A}$ = 5.6 Hz, $^3J_{1,13B}$ = 3.5 Hz, 1H, 1-H); 5.56 (t, $^3J_{10,11}$ = 9.0 Hz, 1H, 11-H); 7.25-7.35 (m, 5H, 20-H/21-H/22-H). nOesy correlations[13] are depicted on page S32. ^{13}C NMR (500 MHz, $CDCl_3$): δ/ppm = 18.8, 21.3 (CH_3, C-15/C-17); 21.2 (CH_2, C-5); 26.2 (CH_3, C-23); 26.7 (CH_3, C-24); 28.3 (CH, C-16); 32.1 (CH_2, C-10); 36.9 (CH_2, C-4); 38.7 (CH_2, C-13); 43.0 (CH, C-6); 43.8 (CH, C-7); 55.1 (CH, C-2); 64.6 (CH_2, C-18); 79.9 (CH, C-1); 82.7 (C_q, C-9); 90.2 (CH, C-8); 124.1 (CH, C-11); 127.3 (CH, C-22); 128.1 (CH, C-21); 128.2 (CH, C-20); 136.5 (C_q, C-12); 139.0 (C_q, C-19); 211.8 (C_q, C-3). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3089 (w), 3064 (w), 3030 (w), ν(C_{arom}-H); 2960 (s), 2928 (m), 2907 (m), 2872 (m) ν(C_{aliph}-H); 1707 (s) ν(C=O). HR-MS (ESI, $C_{25}H_{34}O_3$, 382.54 g/mol): calc.: 405.2400 $[M+Na]^+$, found: m/z = 405.2405 $[M+Na]^+$. $[\alpha]_D^{20}$ (c = 0.56, $CHCl_3$) = –27.3.

(1*S*,2*R*,4*S*,6*R*,9*R*,10*R*,11*R*)- and (1*S*,2*R*,4*R*,6*S*,9*R*,10*R*,11*R*)-9-Benzyloxy-12-isopropyl-4,9-dimethyl-5,16-dioxa-tetracyclo [9.4.1^{2,10}.0^{4,6}.0^{1,11}]hexadeca-15-one (23) and (α-23)



23



α-**23**

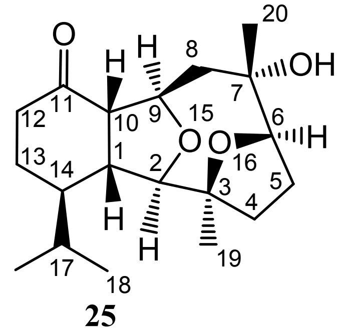
21 (25.0 mg, 0.063 mmol) in abs. acetone (0.3 ml) was cooled to −20 °C and a 0.071 M solution of dimethyldioxirane in acetone[5] (0.975 ml, 0.069 mmol, 1.1 equiv.) was added dropwise by syringe. The solution was stirred for 30 min at −20 °C until completion of the reaction (TLC) and was then warmed to room temperature and opened to air. The magnetic stirring bar was washed with Et_2O (2 ml) and the solution was concentrated in vacuo. Purification by FCC on silica gel (Et_2O:PE = 1:2) yielded 21.0 mg (0.051 mmol, 81%) **23** and 2.2 mg (0.005 mmol, 8%) α-**23** as colourless oils.

23: R_f= 0.20 (Et_2O:PE = 1:2). t_R = 25.97 min (HP-5). ^1H NMR (600 MHz, $CDCl_3$): δ/ppm = 0.75, 0.93 (2 d, $^3J_{17,18}$ = 6.6 Hz, 6H, 18-H); 1.25 (s, 3H, 24-H); 1.32 (s, 3H, 25-H); 1.58-1.66 (m, 2H, 12-H/13-H_A); 1.82-2.04 (m, 6H, 3-H_A/7-H_A/8-H/13-H_B/17-H); 2.06-2.13 (m, 2H, 3-H_B/7-H_B,); 2.33-2.43 (m, 2H, 14-H); 2.77 (dd, $^3J_{6,7A}$ = 11.2 Hz, $^3J_{6,7B}$ = 3.3 Hz, 1H, 6-H); 2.81 (dt, $^3J_{1,11}$ = 7.2 Hz, $^3J_{10,11}$ = $^3J_{11,12}$ = 4.6 Hz, 1H, 11-H); 3.24 (t, $^3J_{1,2}$ = $^3J_{1,11}$= 7.2 Hz, 1H, 1-H); 3.87 (d, $^3J_{10,11}$ = 4.6 Hz, 1H, 10-H); 4.42, 4.45 (2 d, $^2J_{19A,19B}$ = 11.0 Hz, 2H, 19-H); 4.60 (brs, 1H, 2-H); 7.24-7.27 (m, 3H, 21-H/23-H); 7.28-7.34 (m, 2H, 22-H). nOesy correlations[13] are depicted on page S34.^{13}C NMR (100 MHz, $CDCl_3$): δ/ppm = 16.6, 21.8 (CH_3, C-18); 22.8 (CH_3, C-24); 23.4 (CH_2, C-13); 25.7 (CH_2, C-7); 26.6 (CH_3, C-25); 28.4 (CH, C-17); 29.9 (CH_2, C-8); 38.1 (CH_2, C-14); 38.9 (CH_2, C-3); 41.2 (CH, C-12); 46.4 (CH, C-11); 53.2 (CH, C-1); 59.9 (C_q, C-4); 64.1 (CH_2, C-19); 65.4 (CH, C-6); 76.6 (CH, C-2); 78.6 (C_q, C-9); 89.6 (CH, C-10); 127.4 (CH, C-23); 127.6 (CH, C-22); 128.3 (CH, C-21); 138.9 (C_q, C-20); 210.7 (C_q, C-15). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3064 (w), 3032 (w), ν(C_{arom}-H); 2958 (s), 2930 (s), 2871 (s) ν(C_{aliph}-H); 1709 (s) ν(C=O). HR-MS (ESI, $C_{26}H_{36}O_4$, 412.26 g/mol): calc.: 435.2506 $[M+Na]^+$, found: m/z = 435.2504 $[M+Na]^+$. $[\alpha]_D^{20}$ (c = 1.30, $CDCl_3$) = +39.0.

α-**23**: R_f= 0.11 (Et_2O:PE = 1:2). t_R = 25.73 min (HP-5). ^1H NMR (500 MHz, $CDCl_3$): δ/ppm = 0.82, 0.98 (2 d, $^3J_{17,18}$ = 6.8 Hz, 6H, 18-H); 1.17 (s, 3H, 25-H); 1.35 (s, 3H, 24-H); 1.46-1.52 (m, 3H, 7-H_A/12-H/13-H_A); 1.70 (dd, $^3J_{2,3A}$ = 11.4 Hz, $^3J_{3A,3B}$ = 12.5 Hz, 1H, 3-H_A); 1.80-1.94 (m, 4H, 8-H/13-H_B/17-H); 1.99 (dd, $^3J_{2,3B}$ = 4.8 Hz, $^3J_{3A,3B}$ = 12.5 Hz, 1H, 3-H_B); 2.12 (m, 1H, 7-H_B); 2.38-2.43 (m, 2H, 14-H); 2.77 (dd, $^3J_{6,7A}$ = 10.6 Hz, $^3J_{6,7B}$ = 4.5 Hz, 1H, 6-H); 2.79 (m, 1H, 11-H); 3.06 (t, $^3J_{1,2}$ = $^3J_{1,11}$= 7.6 Hz, 1H, 1-H); 3.84 (brs, 1H, 10-H); 4.18 (ddd, $^3J_{1,2}$ = 7.6 Hz, $^3J_{2,3A}$ = 11.4 Hz, $^3J_{2,3B}$ = 4.8 Hz, 1H, 2-H); 4.25, 4.40 (2 d, $^2J_{19A,19B}$ = 11.4 Hz, 2H, 19-H); 7.26-7.35 (m, 5H, 21-H/22-H/23-H). nOesy correlations[13] are depicted on page S36.^{13}C NMR (500 MHz, $CDCl_3$): δ/ppm = 15.6, 21.8 (CH_3, C-18); 22.1 (CH_3, C-24); 23.1 (CH_2, C-13); 23.9 (CH_2, C-7); 24.6 (CH_3, C-25); 28.6 (CH, C-17); 29.3 (CH_2, C-8); 38.4 (CH_2, C-14); 39.7 (CH_2, C-3); 42.2 (CH, C-12); 47.5 (CH, C-11); 58.8 (CH, C-1); 60.7 (C_q, C-4); 64.4 (CH, C-6); 64.8 (CH_2, C-19); 78.0 (CH, C-2); 79.9 (C_q, C-9); 91.1 (CH, C-10);

127.1 (CH, C-23); 127.5 (CH, C-22); 128.5 (CH, C-21); 138.6 (C_q, C-20); 211.1 (C_q, C-15). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3091, 3061 (w), 3031 (w), ν(C_{arom}-H); 2960 (s), 2928 (s), 2872 (m) ν(C_{aliph}-H); 1706 (s) ν(C=O). HR-MS (ESI, $C_{26}H_{36}O_4$, 412.26 g/mol): calc.: 435.2506 $[M+Na]^+$, found: m/z = 435.2497 $[M+Na]^+$. $[\alpha]_D^{20}$ (c = 0.22, $CDCl_3$) = −76.6.

(1*R*,2*R*,3*R*,6*S*,7*S*,9*R*,10*S*,14*R*)-14-Isopropyl-3,7-dimethyl-15,16-dioxa-tetracyclo[8.4.1^{2,9}.1^{3,6}.0^{1,10}]hexadeca-11-on (25)



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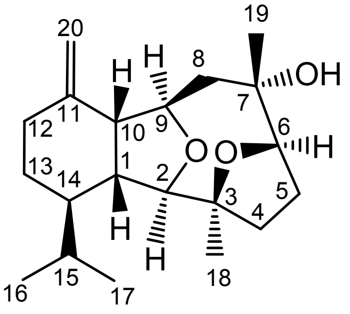
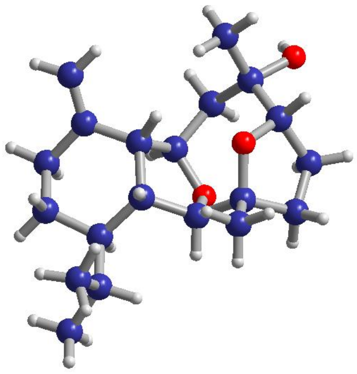
23 (16.4 mg, 0.040 mmol) was dissolved in ethyl acetate (4 ml) in a Schlenk tube under Ar. 10% Pd on activated charcoal (8 mg, 20 mol%) was added and the tube was purged with Ar. The tube was flushed with hydrogen (1 bar) and the reaction mixture was stirred for 1 h 15 min until complete consumption of the starting material (TLC). The suspension was filtered and the filter was washed with ethyl acetate (5 ml). The solution was concentrated to a volume of 0.5 ml and the crude product was subjected to FCC on silica gel (Et_2O:PE = 8:1) to yield 11.7 mg (0.036 mmol, 81%) **25** as a colourless solid.

R_f = 0.15 (Et_2O:PE = 8:1). M. p. = 148.1 °C (Et_2O). t_R = 21.11 min (HP-5). ^{1}H-NMR (600 MHz, $CDCl_3$): δ/ppm = 0.81, 1.01 (2 d, $^3J_{17,18}$ = 6.9 Hz, 6H, 18-H); 1.19 (s, 3H, 19-H); 1.41-1.46 (m, 3H, 13-H_A/14-H); 1.52 (s, 3H, 20-H); 1.73 (brs, 1H, OH); 1.75-1.83 (m, 2H, 4-H); 1.86 (dd, $^2J_{8A,8B}$ = 15.2 Hz, $^3J_{8A,9}$ = 3.3 Hz, 1H, 8-H_A); 1.91 (m, 1H, 13-H_B); 2.00 (m, 1H, 5-H_A); 2.17 (ddd, $^2J_{12A,12B}$ = 12.6 Hz, $^3J_{12A,13A}$ = 2.8 Hz, $^3J_{12A,13B}$ = 9.1 Hz, 1H, 12-H_A); 2.33 (dd, $^2J_{8A,8B}$ = 15.2 Hz, $^3J_{8B,9}$ = 4.6 Hz, 1H, 8-H_B); 2.36-2.41 (m, 2H, 5-H_B/12-H_B); 2.57 (dd, $^3J_{1,10}$ = 8.3 Hz, $^3J_{1,14}$ = 10.7 Hz, 1H, 1-H); 3.59 (t, $^3J_{1,10}$ = $^3J_{9,10}$ = 8.3 Hz, 1H, 10-H); 3.79 (brs, 1H, 2-H); 4.06 (t, $^3J_{5A,6}$ = $^3J_{5B,6}$ = 7.6 Hz, 1H, 6-H); 4.28 (ddd, $^3J_{8A,9}$ = 3.3 Hz, $^3J_{8B,9}$ = 4.6 Hz, $^3J_{9,10}$ = 8.3 Hz, 1H, 9-H). nOesy correlations[13] are depicted on page S38. ^{13}C-NMR (600 MHz, $CDCl_3$): δ/ppm = 15.4, 21.9 (CH_3, C-18); 23.0 (CH_2, C-13); 24.1 (CH_3, C-19); 27.8 (CH_2, C-5); 28.6 (CH, C-17); 31.5 (CH_3, C-20); 38.0 (CH_2, C-12); 38.1 (CH_2, C-4); 42.3 (CH, C-14); 43.0 (CH_2, C-8); 46.9 (CH, C-1); 54.0 (CH, C-10); 74.1 (C_q, C-3); 79.7 (CH, C-9); 85.6 (C_q, C-7); 87.0 (CH, C-6); 90.1 (CH, C-2); 211.8 (C_q, C-11). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3549 (s) ν(OH); 2999 (w), 2942 (m), 2963 (m), 2913 (m), 2884 (m), 2861 (m) ν(C_{aliph}-H); 1692 (s) ν(C=O). HR-MS (ESI, $C_{19}H_{30}O_4$, 322.44 g/mol): calc.: 345.2036 $[M+Na]^+$, found: m/z = 345.2042 $[M+Na]^+$. $[\alpha]_D^{20}$ (c = 0.45, $CDCl_3$) = −18.7.

(1*R*,2*R*,3*R*,6*S*,7*S*,9*R*,10*R*,14*R*)-14-Isopropyl-3,7-dimethyl-11-methylene-15,16-dioxa-tetracyclo[8.4.1^{2,9}.1^{3,6}.0^{1,10}]hexadecane (Vigulariol, 1)



1



To a stirred suspension of methyltriphenylphosphonium bromide (51 mg, 0.143 mmol, 4.0 equiv.) in toluene (1 ml) was added a 1 M NaHMDS solution in THF (0.125 ml, 0.125 mmol, 3.5 equiv.). The mixture was heated to 80 °C for 20 min. To the orange solution of the ylide was added **25** (11.5 mg, 0.036 mmol) in toluene (0.75 ml) and stirring at 80 °C was continued for 45 min. The reaction was cooled to room temperature and quenched with 1 drop of dist. H_2O. The mixture was transferred to an equilibrated silica gel column and the reaction flask was washed with Et_2O, which was also transferred to the column. FCC on silica gel (Et_2O:PE = 8:1) yielded 10.6 mg (0.033 mmol, 93%) **1** as a colourless crystalline solid.

Attempts to obtain suitable crystals for X-ray crystal structure analysis by slow evaporation of solvent from a saturated solution of **1** in Et_2O, *n*-pentane, *n*-pentane/Et_2O mixtures, and ethyl acetate only led to the formation of fine needles (like winter window ice crystals). Complete evaporation of solvent from a solution of **1** in Et_2O in a 10 ml flask at 42 °C in vacuo (900 mbar) resuted in the formation of several suitable single crystals of **1**, which were harvested from the surrounding needles. The relative configuration of **1** was directly proven by X-ray crystal structure analysis[25] (page S42) and nOesy correlations[13] (page S40). The absolute

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[25] X-ray crystal structure analysis for (+)-**1**: formula $C_{20}H_{32}O_3$, $M = 320.46$, colorless crystal 0.20 x 0.08 x 0.08 mm, $a = 9.0189(1)$, $b = 10.6042(1)$, $c = 9.7714(1)$ Å, $\beta = 97.051(1)°$, $V = 927.45(2)$ Å^3, $\rho_{calc} = 1.148$ g cm^{-3}, $\mu = 0.589$ mm^{-1}, empirical absorption correction ($0.891 \leq T \leq 0.954$), $Z = 2$, monoclinic, space group $P2_1$ (No. 4), $\lambda = 1.54178$ Å, $T = 223$ K, ω and φ scans, 5758 reflections collected (±*h*, ±*k*, ±*l*), $[(\sin\theta)/\lambda] = 0.60$ Å^{-1}, 2252 independent ($R_{int} = 0.079$) and 2049 observed reflections [$I \geq 2\,\sigma(I)$], 213 refined parameters, $R = 0.058$, $wR^2 =$

configuration of **1** is also prooven due to the specific optical rotation and HPLC measurements of the starting materials **6** and **9**, whose absolute ablosute configurations were previously determined by X-ray crystal structure analysis with anomalous dispersion of a corresponding hexahydroisobenzofuran-4(1*H*)-one.[13b] The Flack-parameter of the X-ray analysis fitted better to **1** (F = 0.1 (4)) than to *ent*-**1** (F = 0.8 (4)), which can only be seen as a hint for the absolute configuration in the absence of a heavy atom.

R_f = 0.31 (Et_2O:PE = 8:1). M. p. = 141.7 °C (Et_2O). t_R = 19.85 min (HP-5). ^{1}H NMR (500 MHz, $CDCl_3$): δ/ppm = 0.76 (d, $^3J_{15,16}$ = 6.9 Hz, 3H, 16-H); 0.96 (d, $^3J_{15,17}$ = 6.9 Hz, 3H, 17-H); 1.00 (dt, $^3J_{12A,13A}$ = 13.0 Hz, $^3J_{12B,13A}$ = 3.0 Hz, $^3J_{13A,14}$ = 13.0 Hz, 1H, 13-H_A); 1.18 (s, 3H, 18-H); 1.25 (m, 1H, 14-H); 1.53 (s, 3H, 19-H); 1.68-1.74 (m, 2H, 13-H_B/15-H); 1.77 (dt, $^2J_{4A,4B}$ = 12.5 Hz, $^3J_{4A,5A}$ = 9.6 Hz, $^3J_{4A,5B}$ = 9.6 Hz, 1H, 4-H_A); 1.85 (dd, $^2J_{8A,8B}$ = 15.0 Hz, $^3J_{8A,9}$ = 3.0 Hz, 1H, 8-H_A); 1.90 (brs, 1H, OH); 1.99 (m, 1H, 5-H_A); 2.05 (tt, $^2J_{12A,12B}$ = $^2J_{12A,13A}$ = 13.0 Hz, $^3J_{12A,13B}$ = $^3J_{12A,20A}$ = 1.8 Hz, 1H, 12-H_A); 2.14-2.19 (m, 2H, 1-H, 4-H_B); 2.24 (dt, 1H, $^2J_{12A,12B}$ = 13.0 Hz, $^3J_{12B,13A}$ = 3.0 Hz, $^3J_{12B,13B}$ = 3.0 Hz, 12-H_B); 2.27 (dd, $^2J_{8A,8B}$ = 15.1 Hz, $^3J_{8B,9}$ = 4.6 Hz, 1H, 8-H_B); 2.43 (m, 1H, 5-H_B); 3.64 (s, 1H, 2-H); 3.68 (t, $^3J_{1,10}$ = $^3J_{9,10}$ = 8.1 Hz, 1H, 10-H); 4.06 (ddd, $^3J_{8A,9}$ = 3.0 Hz, $^3J_{8B,9}$ = 4.6 Hz, $^3J_{9,10}$ = 8.1 Hz, 1H, 9-H); 4.08 (t, $^3J_{5A,6}$ = $^3J_{5B,6}$ = 7.5 Hz, 1H, 6-H); 4.70 (t, $^3J_{12A,20A}$ = 1.8 Hz, $^3J_{20A,20B}$ = 1.8 Hz, 1H, 20-H_A); 4.70 (t, J = 1.8 Hz, $^3J_{20A,20B}$ = 1.8 Hz, 1H, 20-H_B). nOesy correlations[13] are depicted on page S39.^{13}C NMR (500 MHz, $CDCl_3$): δ/ppm = 15.4, 22.0 (CH_3, C-16/C-17); 23.9 (CH_3, C-18); 24.9 (CH_2, C-13); 27.9 (CH_2, C-5); 29.0 (CH, C-15); 31.3 (CH_2, C-12); 31.9 (CH_3, C-19); 38.5 (CH_2, C-4); 42.2 (CH_2, C-8); 43.0 (CH, C-14); 45.8 (CH, C-1); 47.5 (CH, C-10); 74.5 (C_q, C-7); 80.6 (CH, C-9); 85.8 (C_q, C-3); 87.1 (CH, C-6); 90.0 (CH, C-2); 109.9 (CH_2, C-20); 148.0 (C_q, C-11). IR ($\tilde{\nu}$/cm^{-1}, ATR) = 3454 (m) ν(OH); 2994 (w), 2972 (m), 2958 (s), 2927 (s), 2906 (m), 2865 (m), ν(C_{aliph}-H); 1646 (m) ν(C=C). HR-MS (ESI, $C_{20}H_{32}O_3$, 320.47 g/mol): calc.: 343.2244 $[M+Na]^+$, found: m/z = 345.2249 $[M+Na]^+$. $[\alpha]_D^{20}$ (c = 0.24, $CHCl_3$) = +4.2.

0.161, Flack parameter 0.1(4), max. residual electron density 0.23 (−0.20) e Å^{-3}, hydrogen atoms calculated and refined as riding atoms.
Data set was collected with a Nonius KappaCCD diffractometer. Programs used: data collection COLLECT (Nonius B.V., 1998), data reduction Denzo-SMN (Z. Otwinowski, W. Minor, *Methods in Enzymology*, **1997**, *276*, 307-326), absorption correction Denzo (Z. Otwinowski, D. Borek, W. Majewski, W. Minor, *Acta Cryst.* **2003**, *A59*, 228-234), structure solution SHELXS-97 (G.M. Sheldrick, *Acta Cryst.* **1990**, *A46*, 467-473), structure refinement SHELXL-97 (G.M. Sheldrick, Universität Göttingen, 1997), graphics SCHAKAL (E. Keller, Universität Freiburg, 1997). CCD 663250 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge at www.ccdc.cam.ac.uk/conts/retrieving.html [or from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: (internat.) +44(1223)336-033, E-mail: deposit@ccdc.cam.ac.uk].

HPLC of *rac*-6 (< 5% *ee*)[12]
AK Hoppe e. r. Report

User: JBK

Data File: C:\EZChrom Elite\Enterprise\Projects\Uni Münster\KGO\Data\JBK\Cryptol\OCb 1130F1 rac\1130f1rac_10µl#2_ODH_iPr_Hex_1_600 2007-04-27
Method: C:\EZChrom Elite\Enterprise\Projects\Uni Münster\KGO\Method\untitled.met
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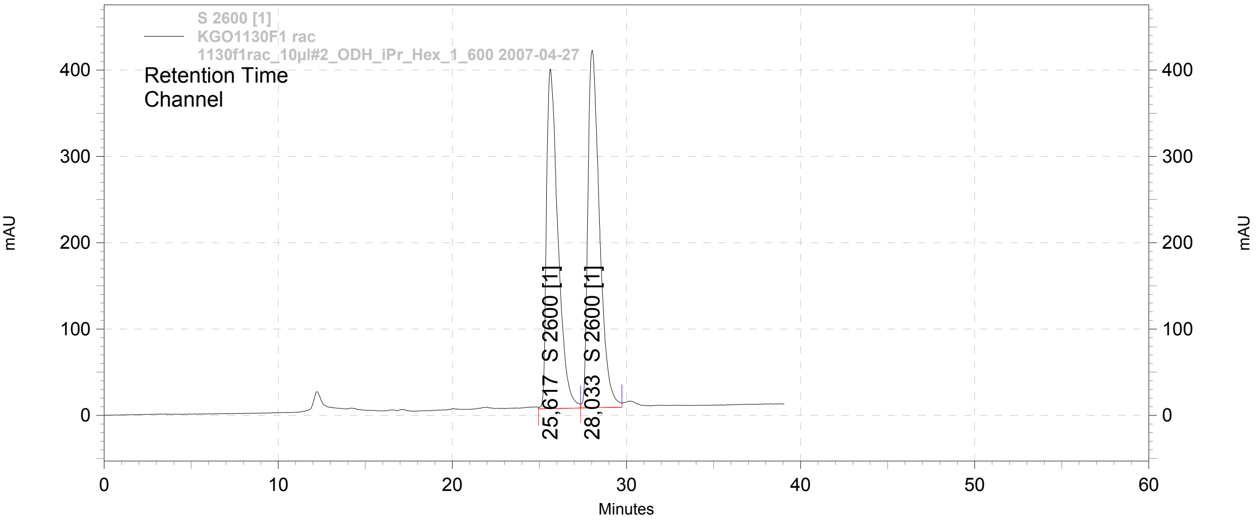

S 2600 [1] Results

Retention Time	Height	Height %	Area	Area %
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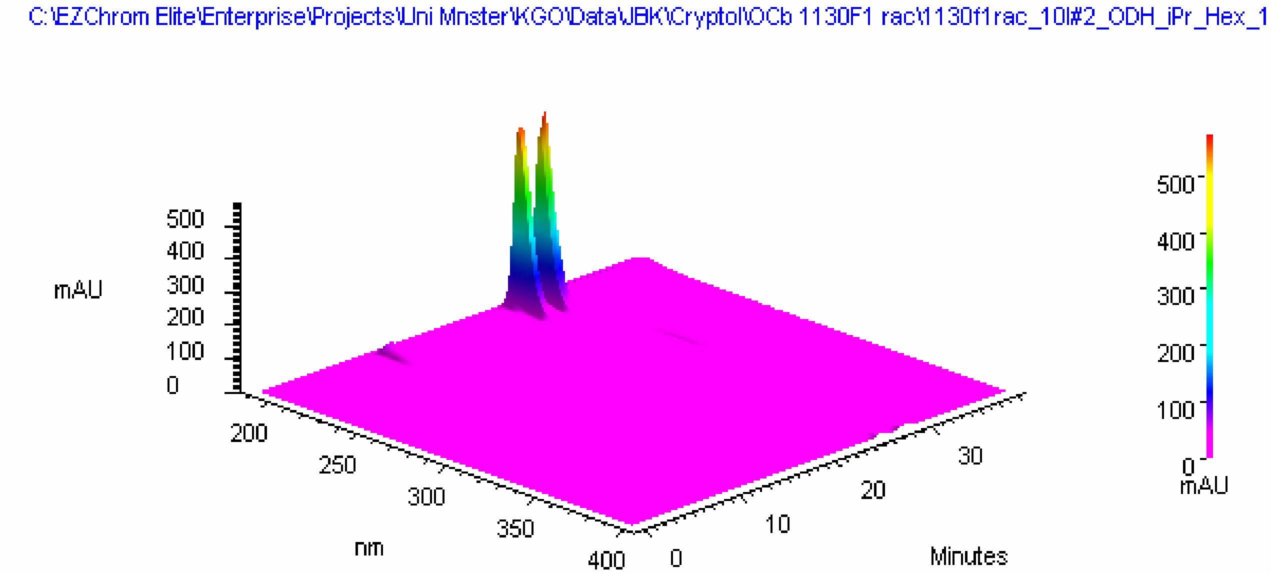
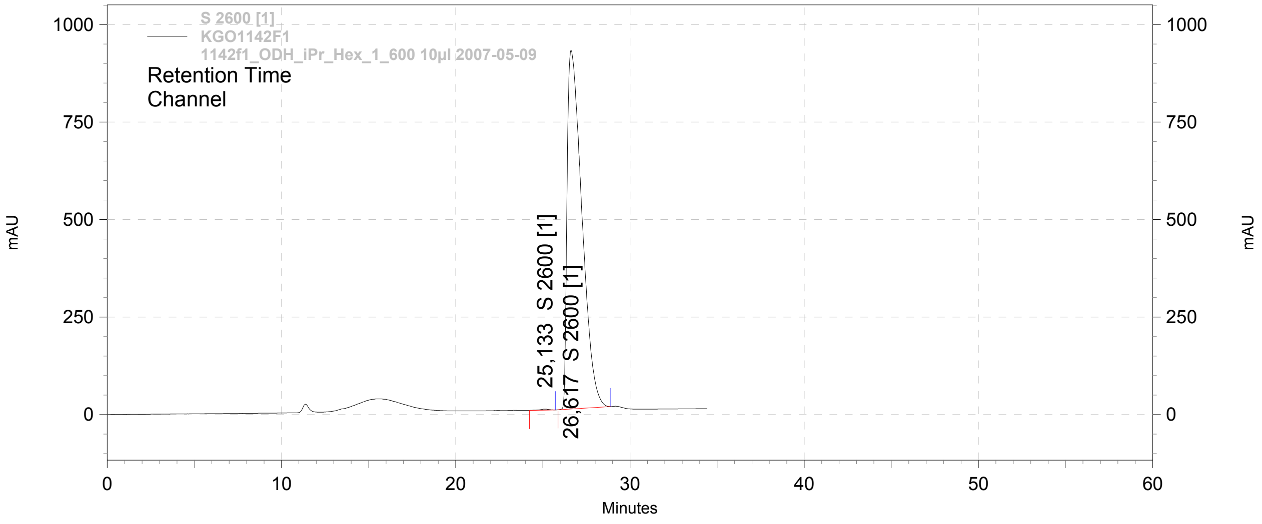
28.033	413999	51.28	19295635	51.83
Totals	807408	100.00	37229756	100.00



HPLC of fully synthetic 6
AK Hoppe e. r. Report

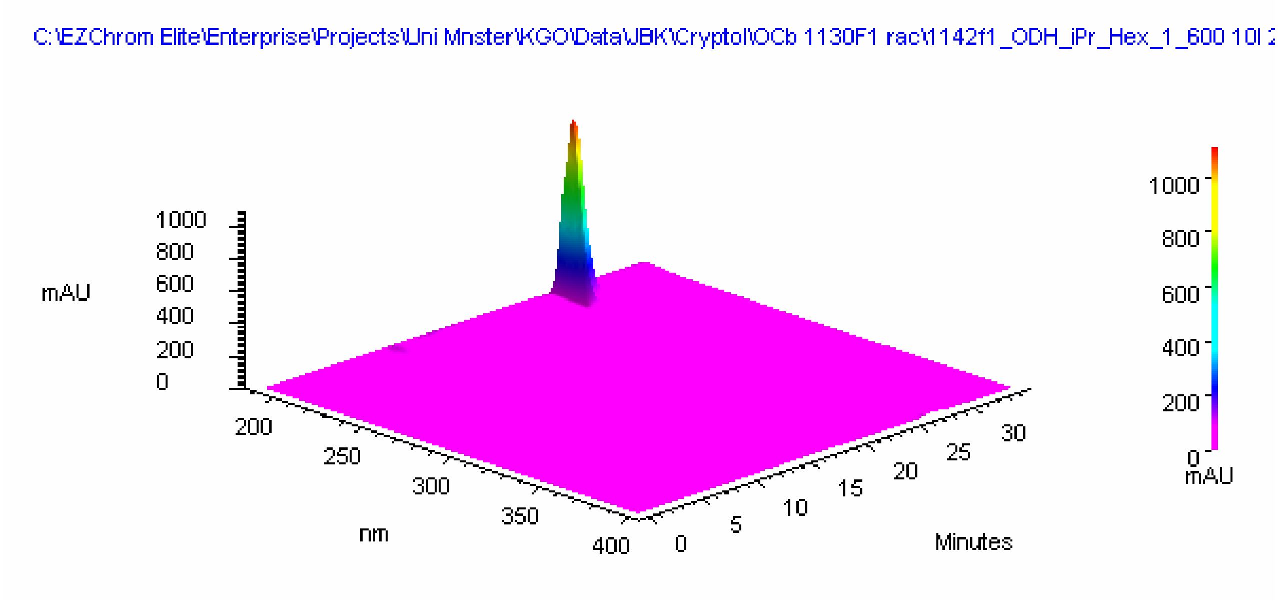
User: JBK

Data File: C:\EZChrom Elite\Enterprise\Projects\Uni Münster\KGO\Data\JBK\Cryptol\OCb 1130F1 rac\1142f1_ODH_iPr_Hex_1_600 10µl 2007-05-09
Method: C:\EZChrom Elite\Enterprise\Projects\Uni Münster\KGO\Method\untitled.met
Acquired: 09.05.2007 13:13:38 Printed: 03.10.2007 13:02:52
Sequenz: {Sequence Name}
Vial: 81 Inj. Vol: 10 Int. Wavelenght: 200 nm



S 2600 [1] Results

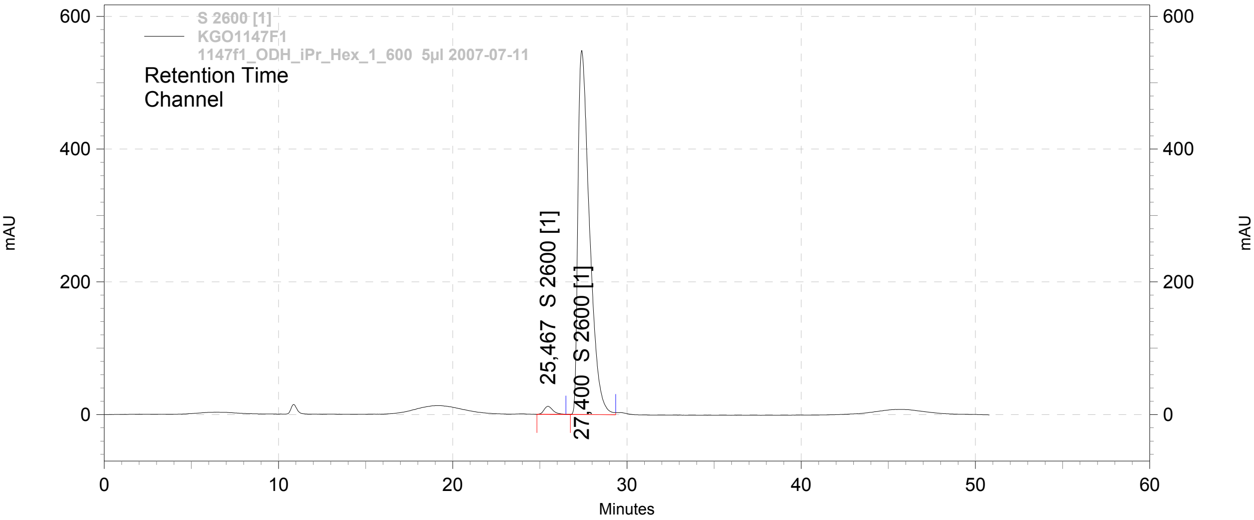
Retention Time	Height	Height %	Area	Area %
25.133	2451	0.27	91182	0.17
26.617	919882	99.73	54042863	99.83
				99.7% *ee*
Totals	922333	100.00	54134045	100.00



HPLC of partial synthetic 6
AK Hoppe e. r. Report

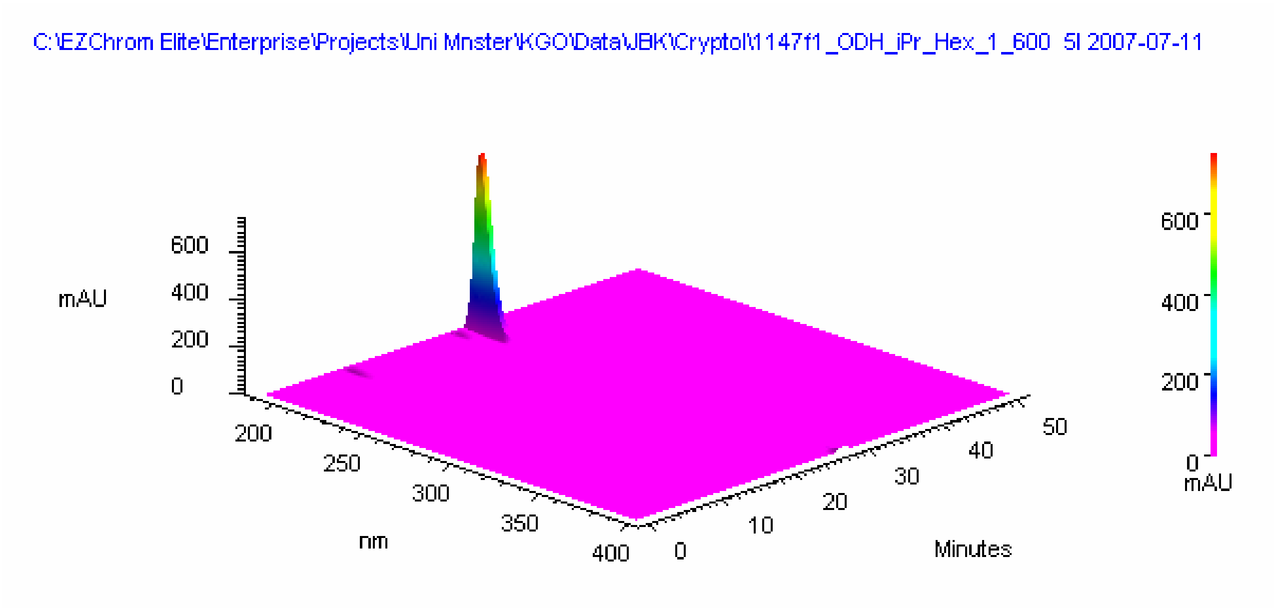
User: JBK

Data File: C:\EZChrom Elite\Enterprise\Projects\Uni Münster\KGO\Data\JBK\Cryptol\1147f1_ODH_iPr_Hex_1_600 5µl 2007-07-11
Method: C:\EZChrom Elite\Enterprise\Projects\Uni Münster\KGO\Method\untitled.met
Acquired: 13.07.2007 13:04:24 Printed: 03.10.2007 13:19:29
Sequenz: {Sequence Name}
Vial: 5 Inj. Vol: 5 Int. Wavelenght: 200 nm

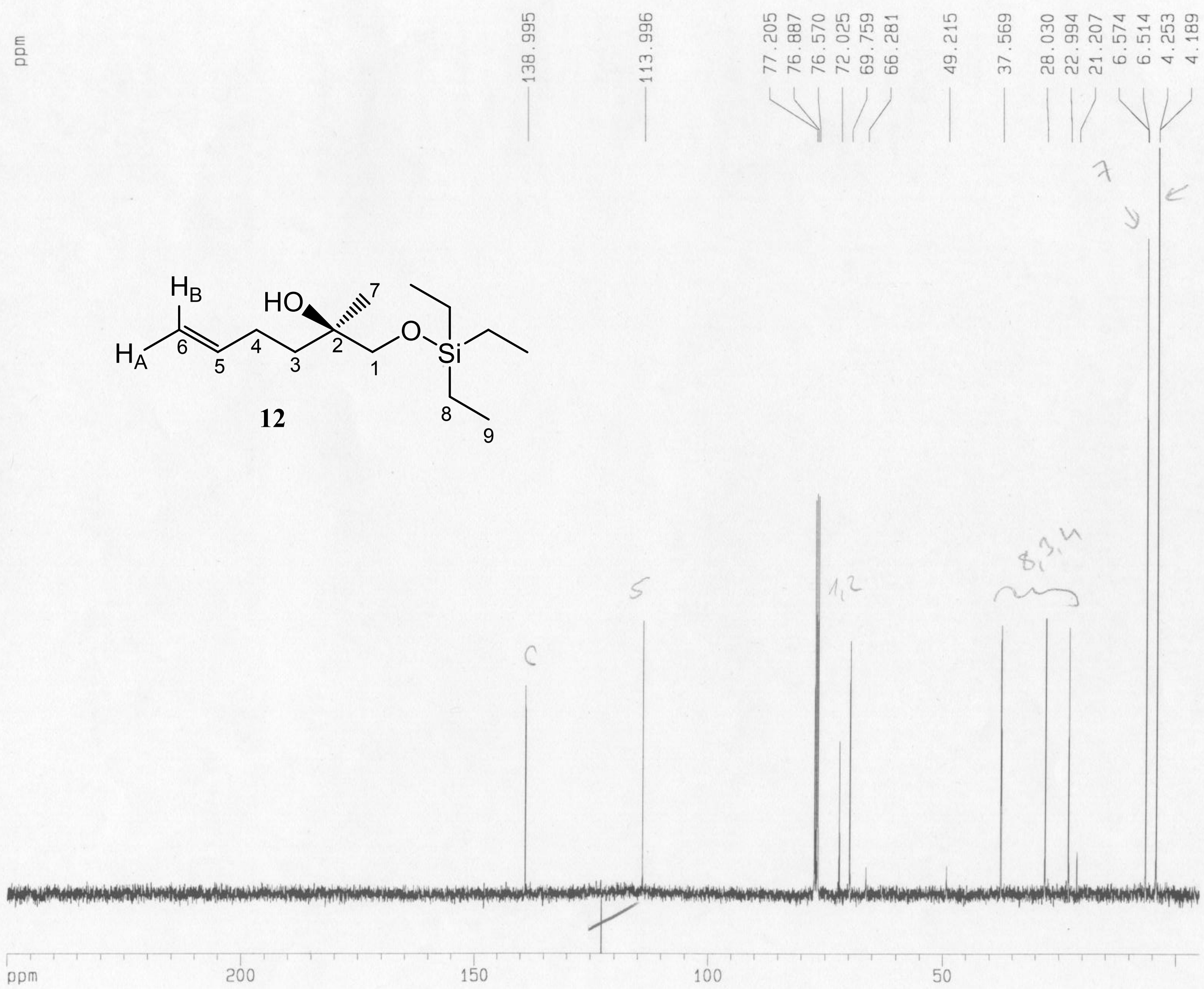


S 2600 [1] Results

Retention Time	Height	Height %	Area	Area %
25.467	12140	2.16	431097	1.67
27.400	548720	97.84	25393202	98.33
				96.7% *ee*
Totals	560860	100.00	25824299	100.00



becker jbk d6 1
A_13c CDCl3 z klaube 1



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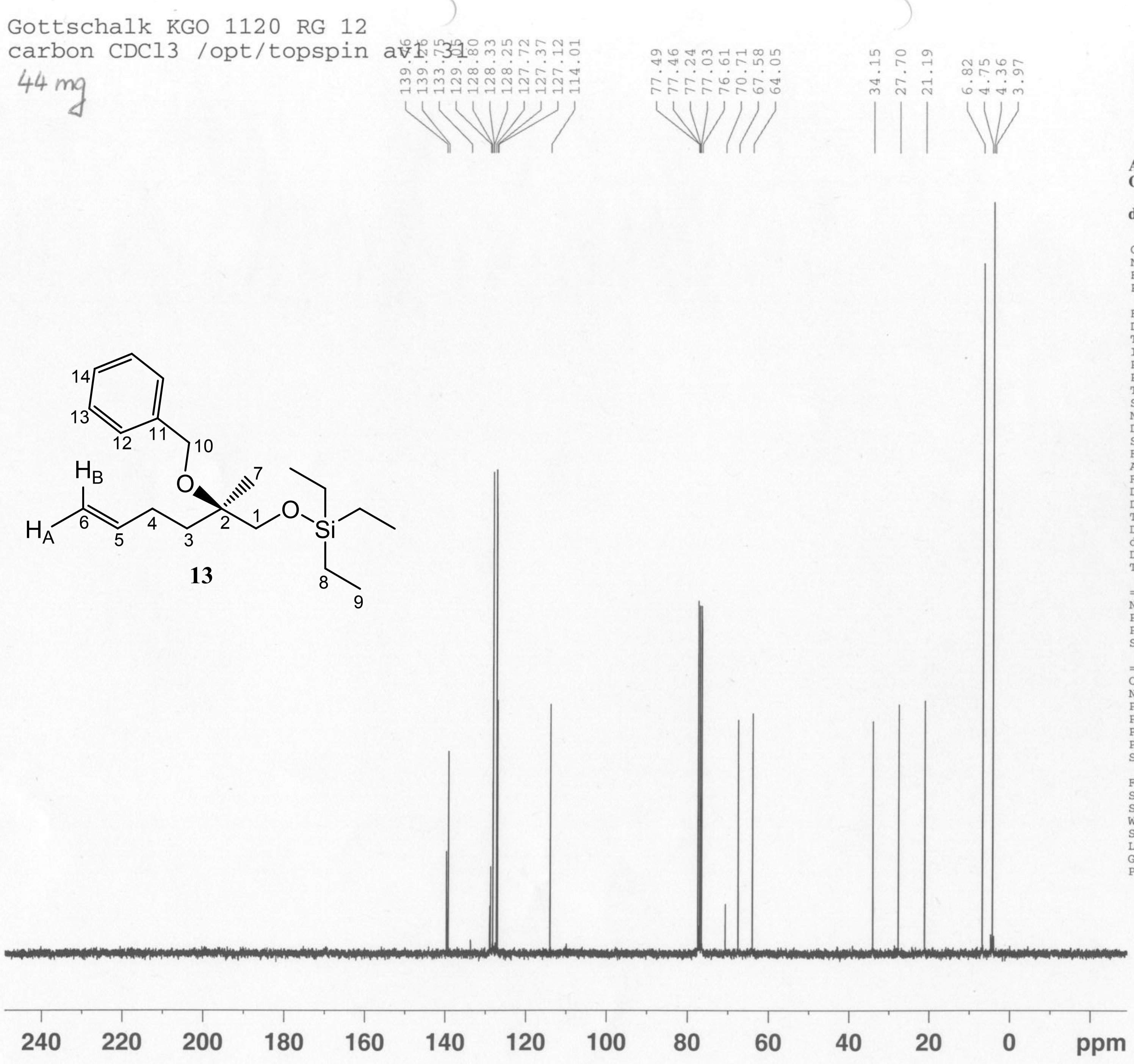
Current Data Parameters
NAME          Nov28-2006
EXPNO                 11
PROCNO                 1

F2 - Acquisition Parameters
Date_           20061128
Time               10.11
INSTRUM            spect
PROBHD   5 mm Multinuc
PULPROG           zgpg30
TD                 65536
SOLVENT            CDCl3
NS                  1024
DS                     2
SWH           26315.789 Hz
FIDRES         0.401547 Hz
AQ            1.2452340 sec
RG                 32768
DW                19.000 usec
DE                 23.75 usec
TE                 300.0 K
HL1                    2 dB
D1            0.69999999 sec
CPDPRG           waltz16
P31               100.00 usec
S4                    27 dB
D11           0.0300000 sec
S2                    22 dB
P1                 11.80 usec
SF01         100.6262008 MHz
NUCLEUS              13C

F2 - Processing parameters
SI                 65536
SF           100.6138810 MHz
WDW                   EM
SSB                    0
LB                  1.00 Hz
GB                     0
PC                  1.40

1D NMR plot parameters
CX                 20.00 cm
F1P              250.000 ppm
F1              25153.47 Hz
F2P               -5.000 ppm
F2               -503.07 Hz
PPMCM           12.75000 ppm/cm
HZCM          1282.82690 Hz/cm
```

Gottschalk KGO 1120 RG 12
carbon CDCl3 /opt/topspin av1 31
44 mg



13

AV300
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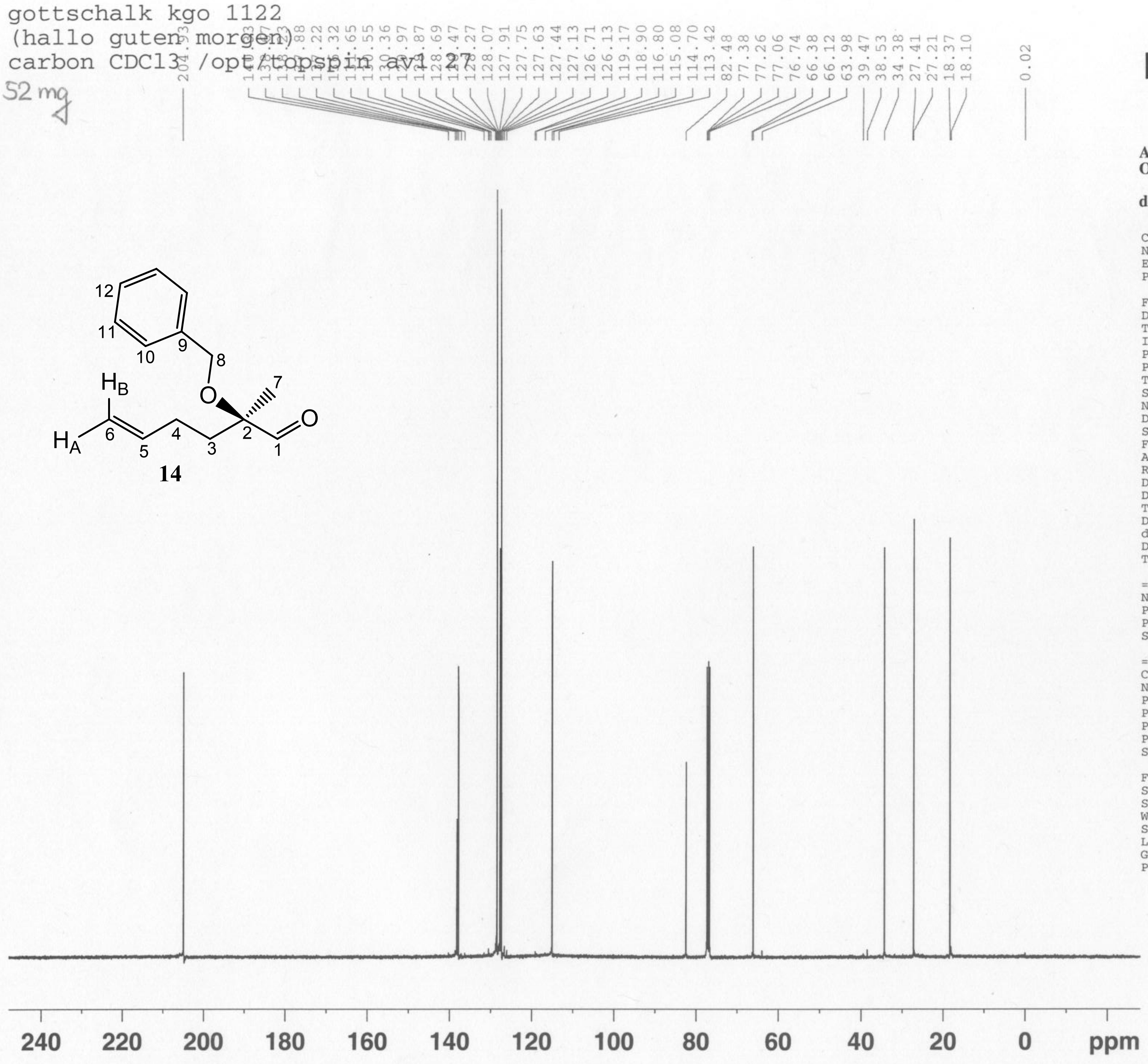
```
Current Data Parameters
NAME             Mar23-2007
EXPNO                   311
PROCNO                    1

F2 - Acquisition Parameters
Date_              20070323
Time                  17.08
INSTRUM               spect
PROBHD   5 mm PABBO BB-
PULPROG             zgpg30
TD                    65536
SOLVENT               CDCl3
NS                     1024
DS                        4
SWH               21008.404 Hz
FIDRES             0.320563 Hz
AQ                1.5598068 sec
RG                    32800
DW                   23.800 usec
DE                     9.00 usec
TE                    300.0 K
D1               0.50000000 sec
d11              0.03000000 sec
DELTA            0.40000001 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                    13C
P1                     8.60 usec
PL1                   -2.00 dB
SFO1             75.4760505 MHz

======== CHANNEL f2 ========
CPDPRG2             waltz16
NUC2                     1H
PCPD2                 80.00 usec
PL12                  16.39 dB
PL13                  22.00 dB
PL2                   -1.00 dB
SFO2            300.1312005 MHz

F2 - Processing parameters
SI                   131072
SF               75.4677490 MHz
WDW                      EM
SSB                       0
LB                     1.00 Hz
GB                        0
PC                     1.40
```



14

AV400
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```
Current Data Parameters
NAME             Mar23-2007
EXPNO                    11
PROCNO                    1

F2 - Acquisition Parameters
Date_              20070323
Time                  14.44
INSTRUM               spect
PROBHD   5 mm PABBI 1H/
PULPROG              zgpg30
TD                    65536
SOLVENT               CDCl3
NS                     5000
DS                        4
SWH               27777.777 Hz
FIDRES             0.423855 Hz
AQ                1.1796980 sec
RG                     2050
DW                   18.000 usec
DE                     9.00 usec
TE                    300.0 K
D1               1.00000000 sec
d11              0.03000000 sec
DELTA            0.89999998 sec
TD0                       1

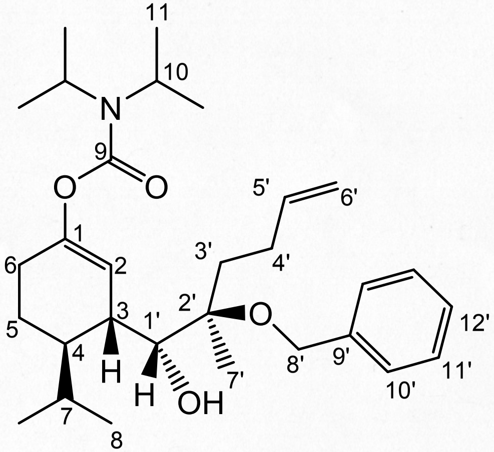
======== CHANNEL f1 ========
NUC1                    13C
P1                    12.20 usec
PL1                   -5.00 dB
SFO1            100.6238359 MHz

======== CHANNEL f2 ========
CPDPRG2             waltz16
NUC2                     1H
PCPD2                 80.00 usec
PL12                  19.54 dB
PL13                  20.00 dB
PL2                   -1.50 dB
SFO2            400.1316005 MHz

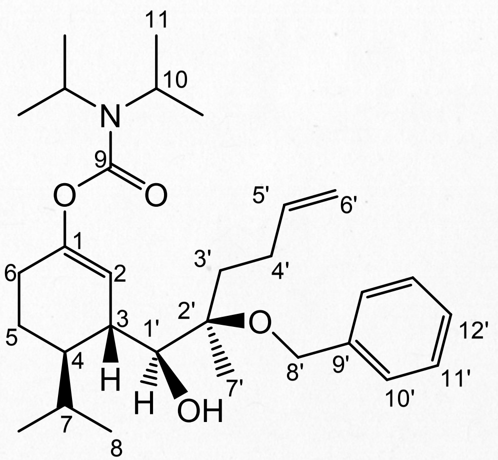
F2 - Processing parameters
SI                   131072
SF              100.6127690 MHz
WDW                      EM
SSB                       0
LB                     1.00 Hz
GB                        0
PC                     1.40
```

kb_jbk-c28212_121007_298k_1h

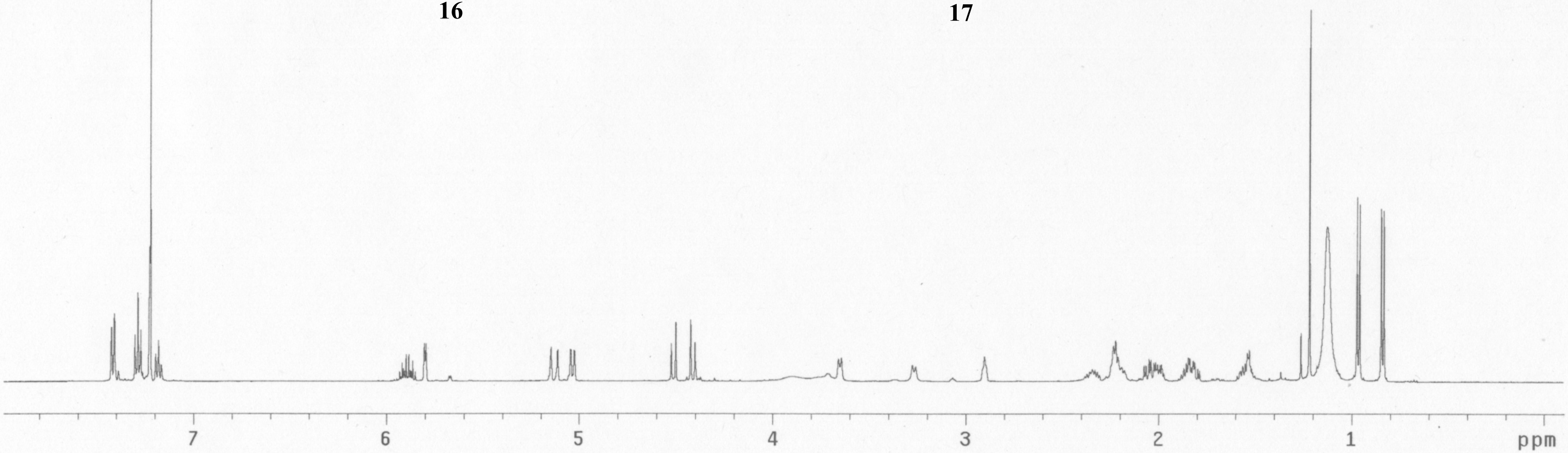
500 MHz, probe: bb

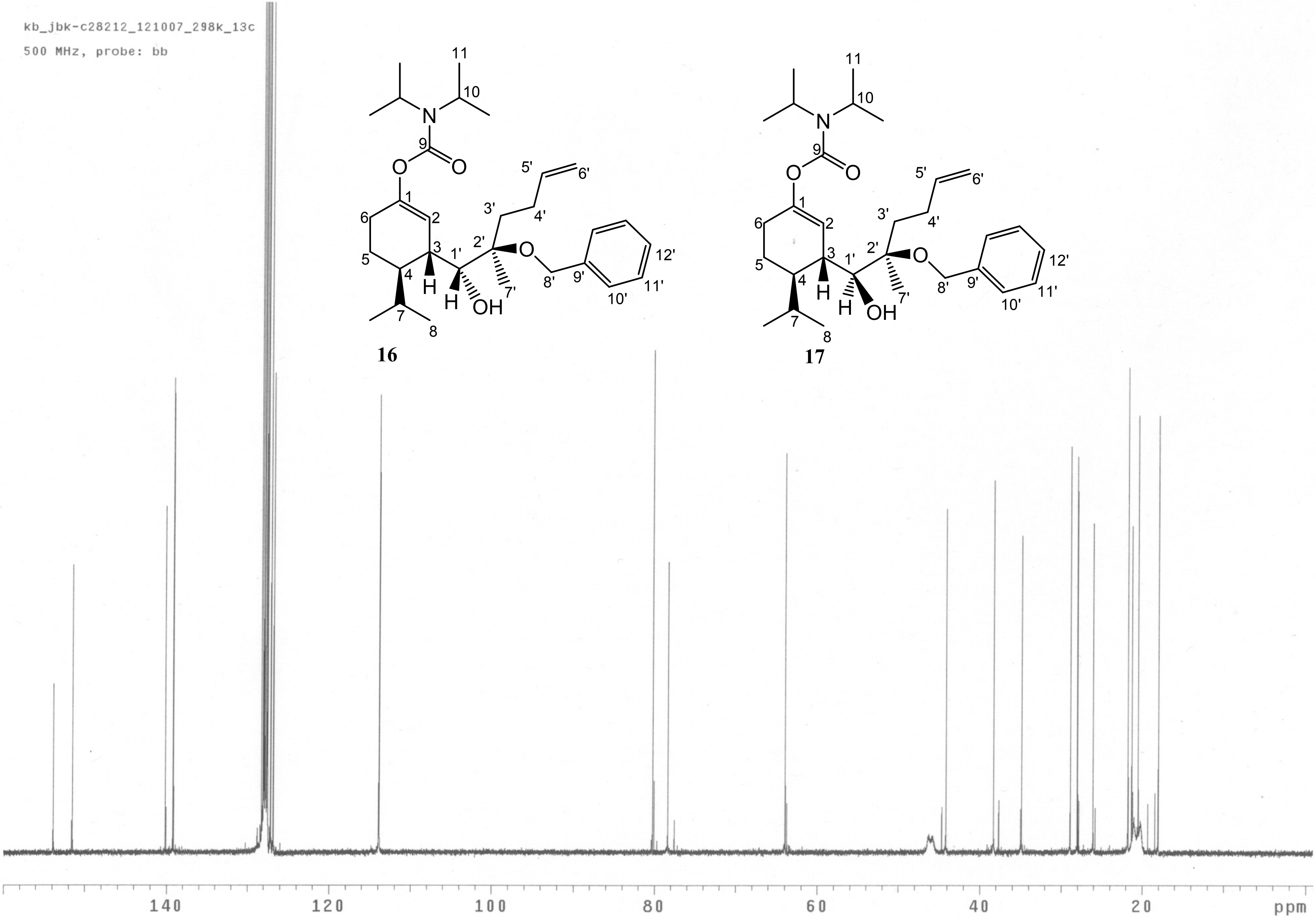


16



17



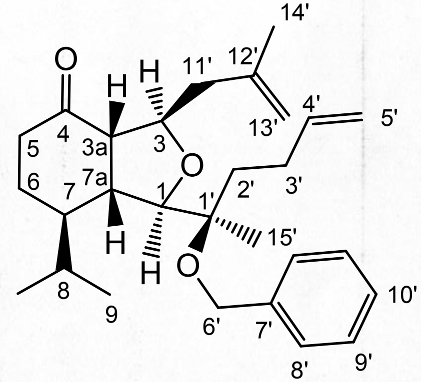

kb_jbk-c28212_121007_298k_13c
500 MHz, probe: bb
1
2
3
4
5
6
7
8
9
10
11
1'
2'
3'
4'
5'
6'
7'
8'
9'
10'
11'
12'
O
N
H
OH
140
120
100
80
60
40
20
ppm

16

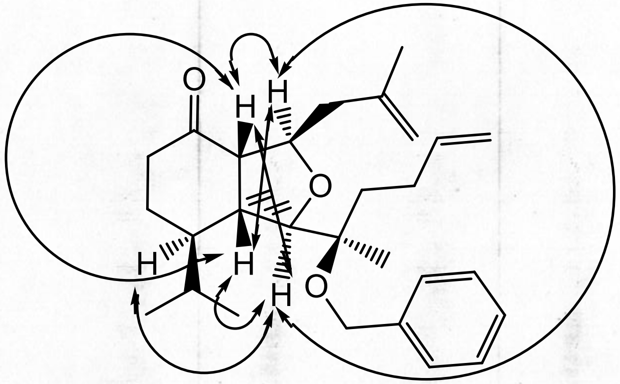
17

jbk-c2952_250707_298k_1h

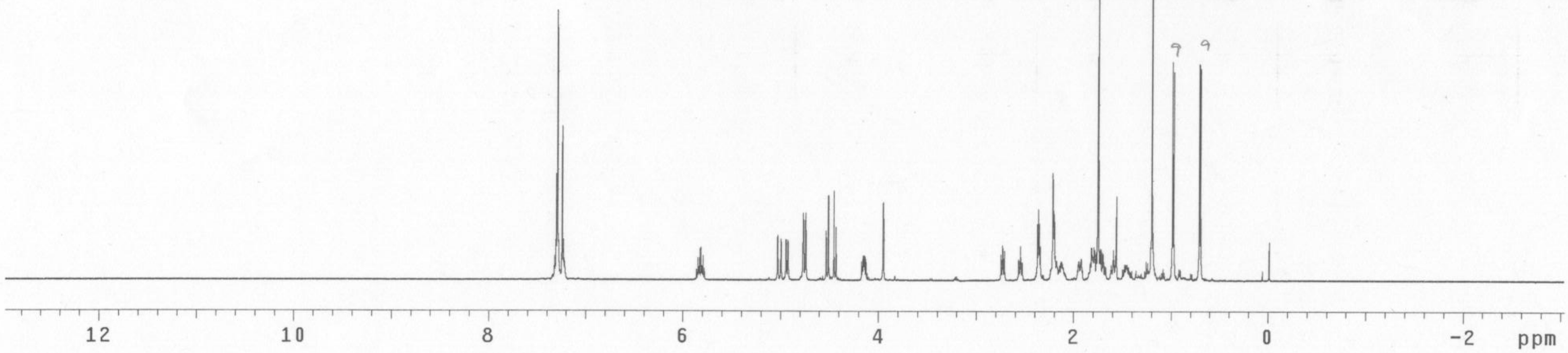
500 MHz, probe: bb



18

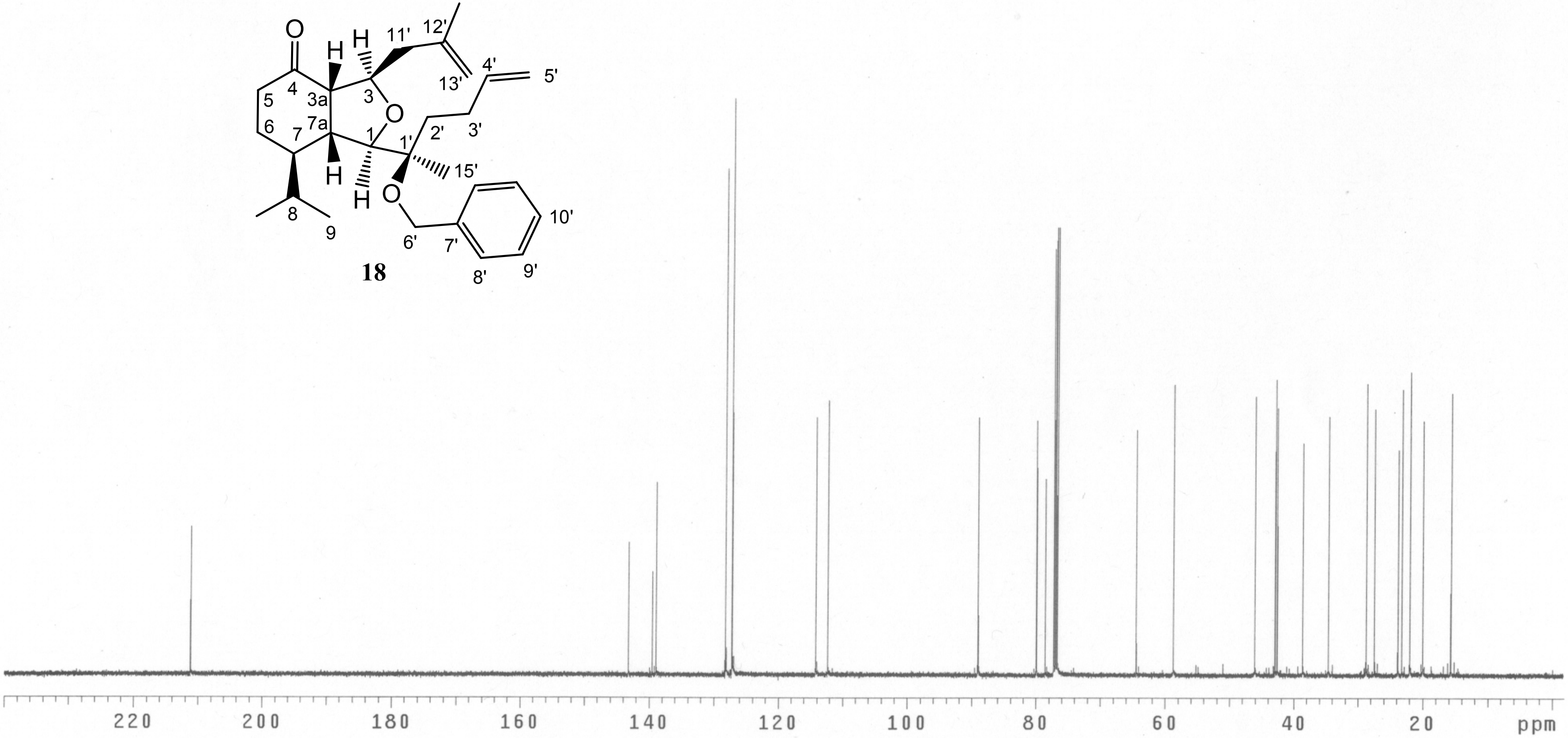


nOe



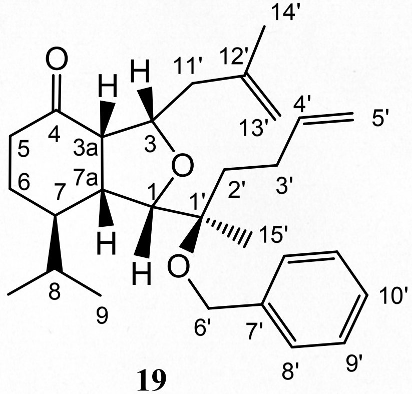
jbk-c2952_250707_298k_13c

500 MHz, probe: bb

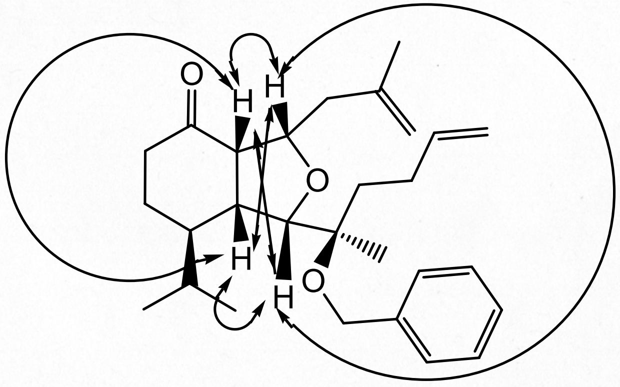


18

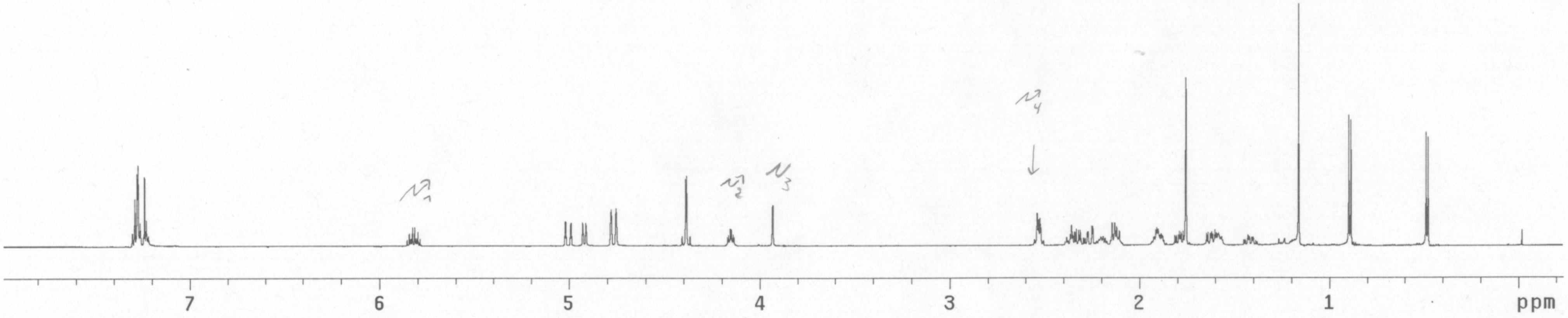
kb_jbk-c2974_091007_298k_1h
600 MHz, probe: id



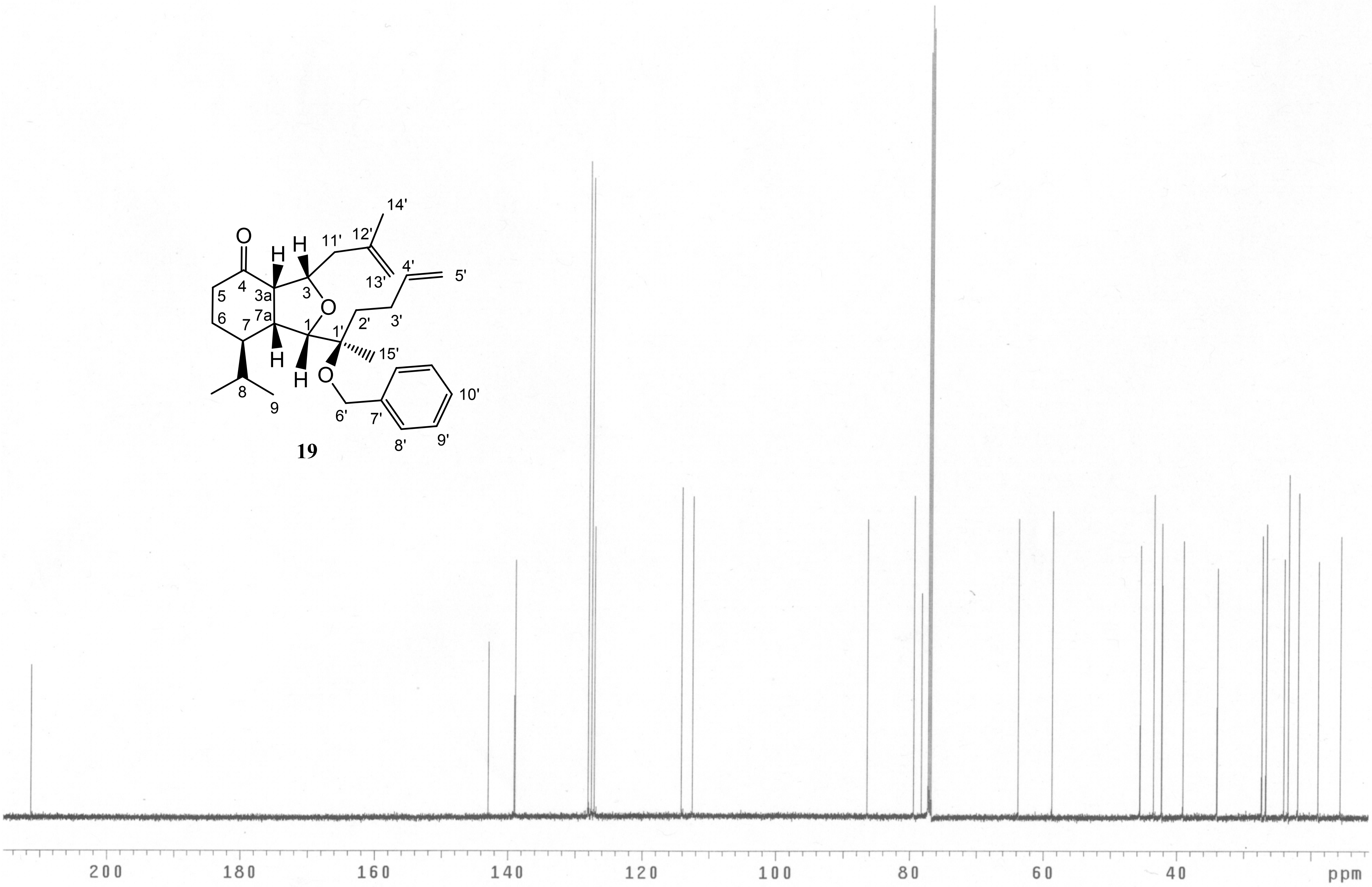
19



nOe

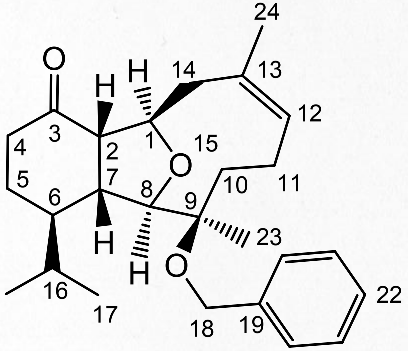


kb_jbk-c2974_091007_298k_13c
600 MHz, probe: id

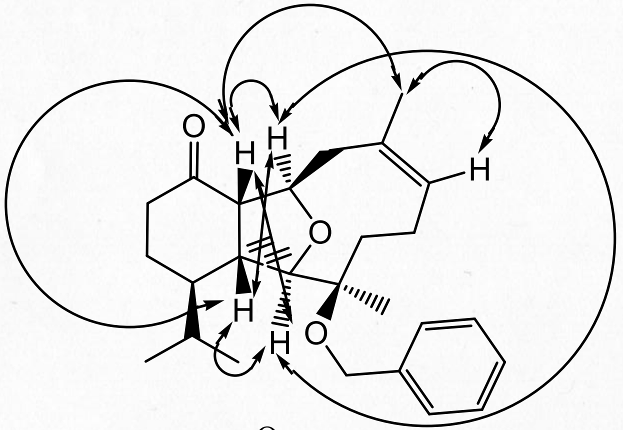


19

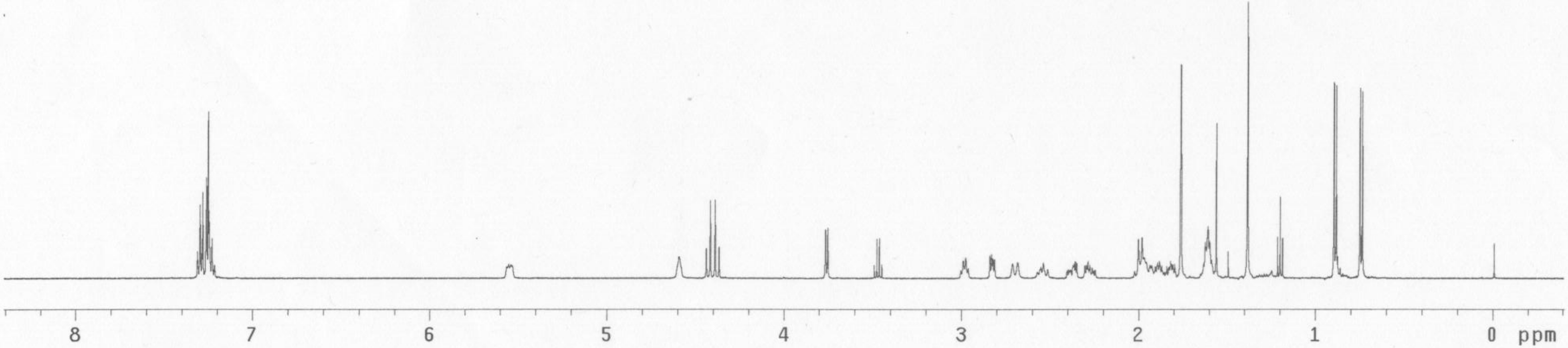
jbk-c304_020807_298k_1h
500 MHz, probe: bb



21

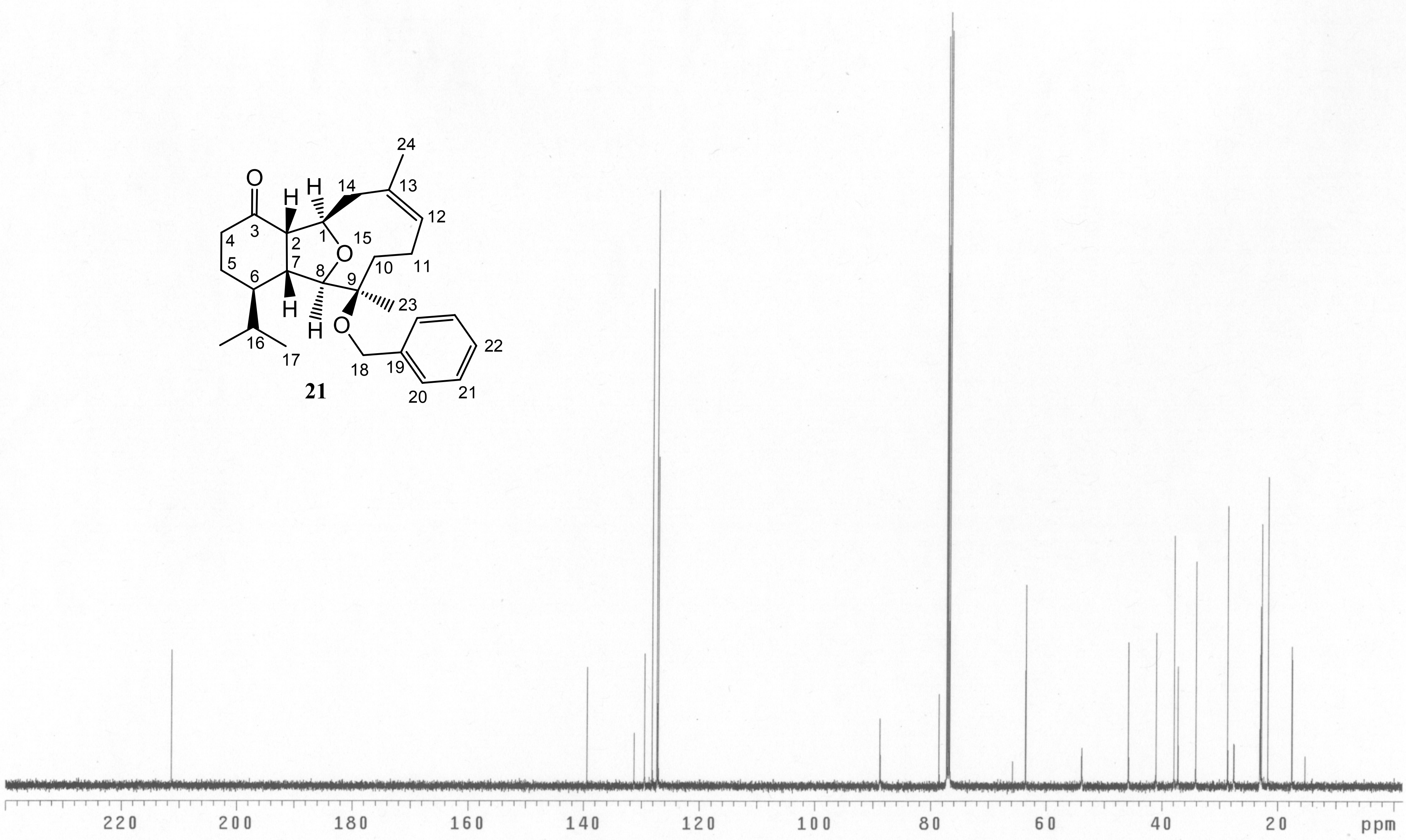


nOe



jbk-c304_020807_298k_13c

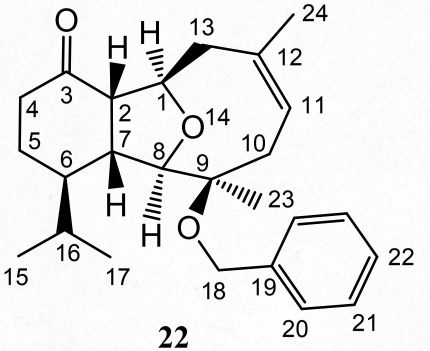
500 MHz, probe: bb



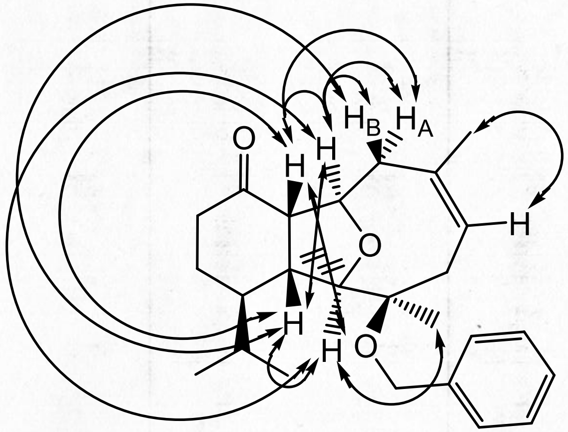
21

kb_jbkc3013_230407_298k_1h

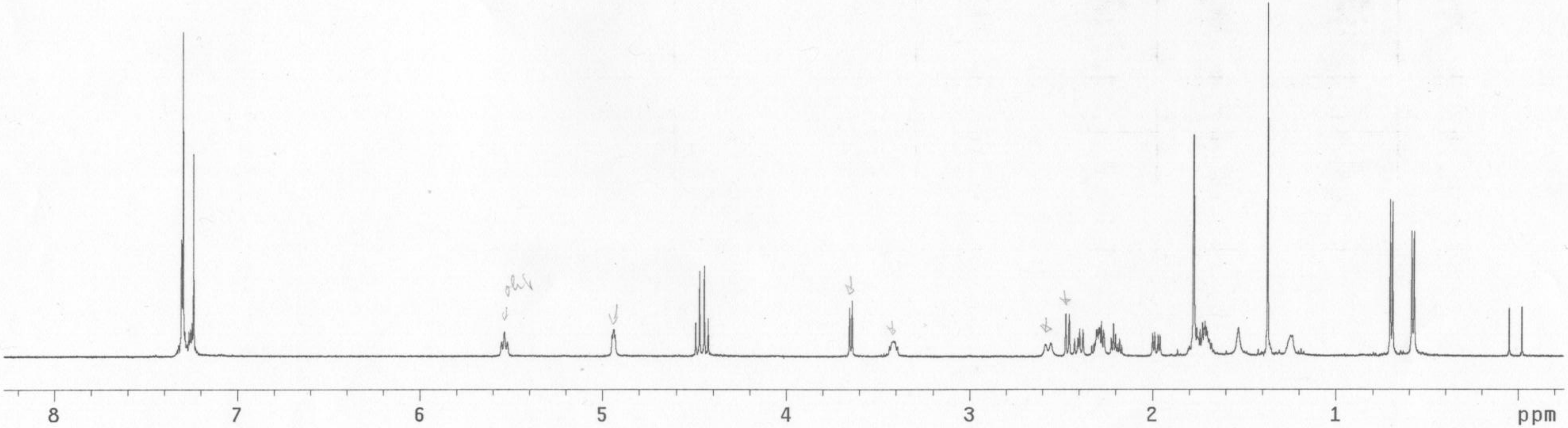
500 MHz, probe: bb



22

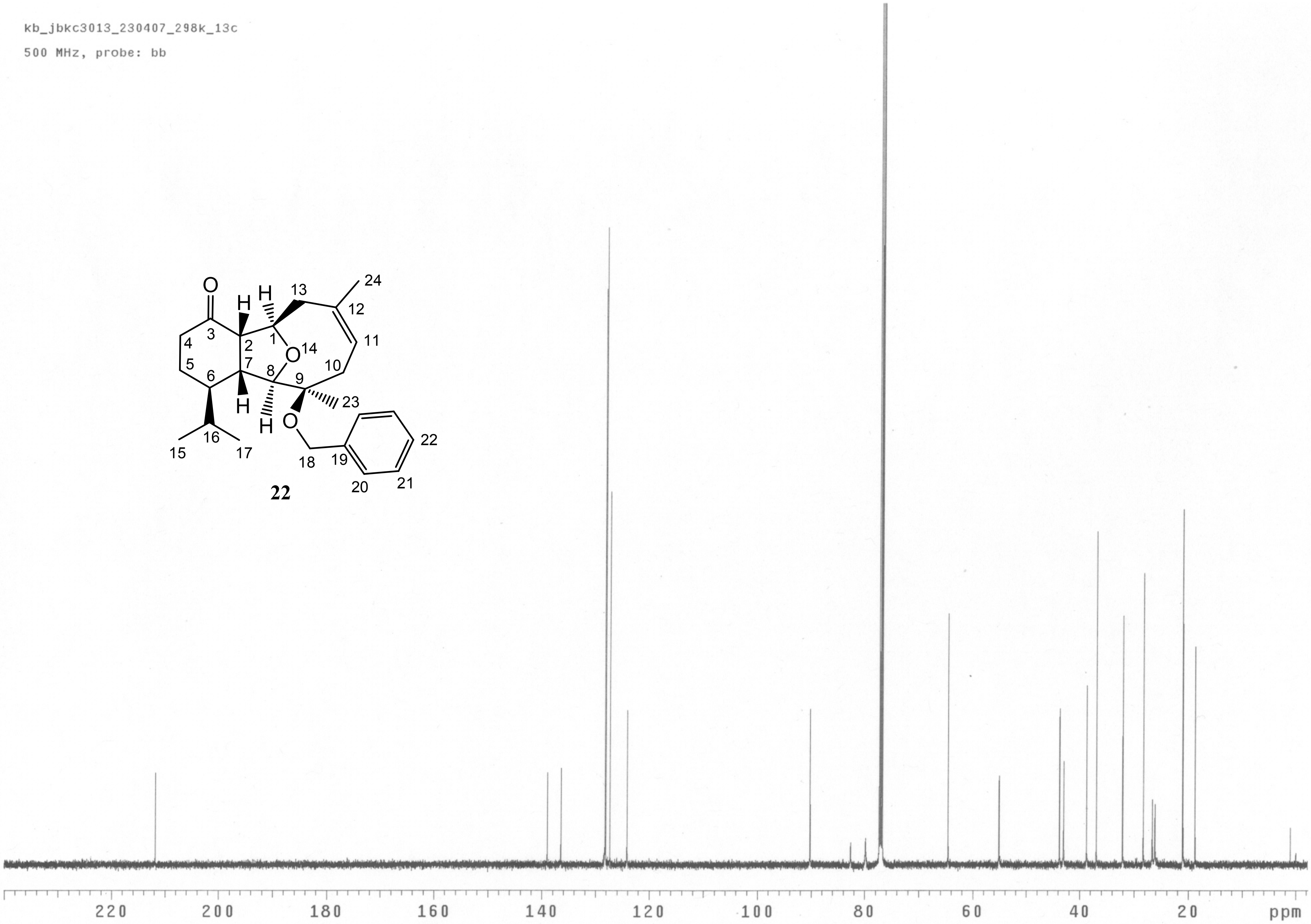


nOe



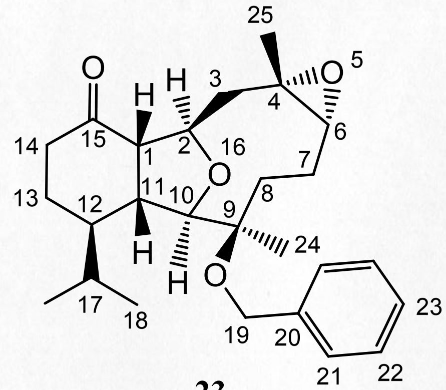
kb_jbkc3013_230407_298k_13c

500 MHz, probe: bb

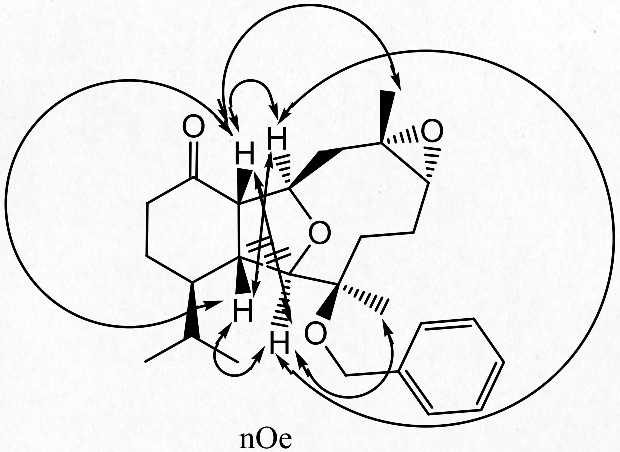


22

kb_jbk-c332_040907_298k_1h
600 MHz, probe: id



23



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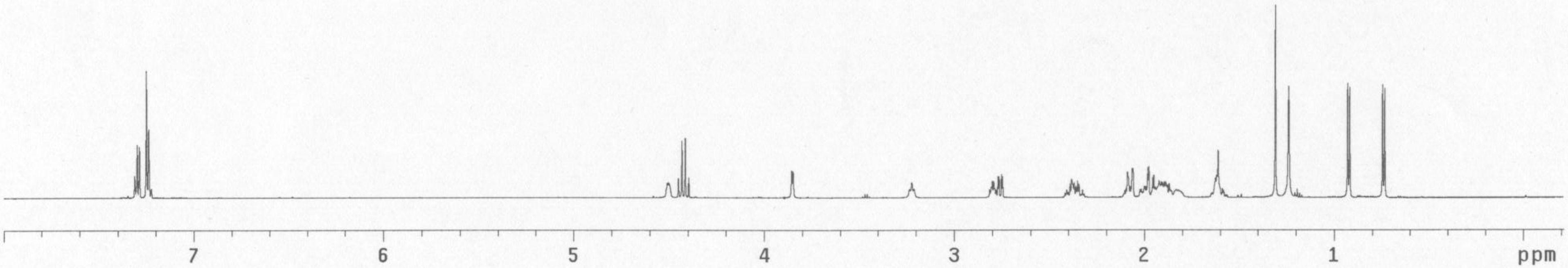
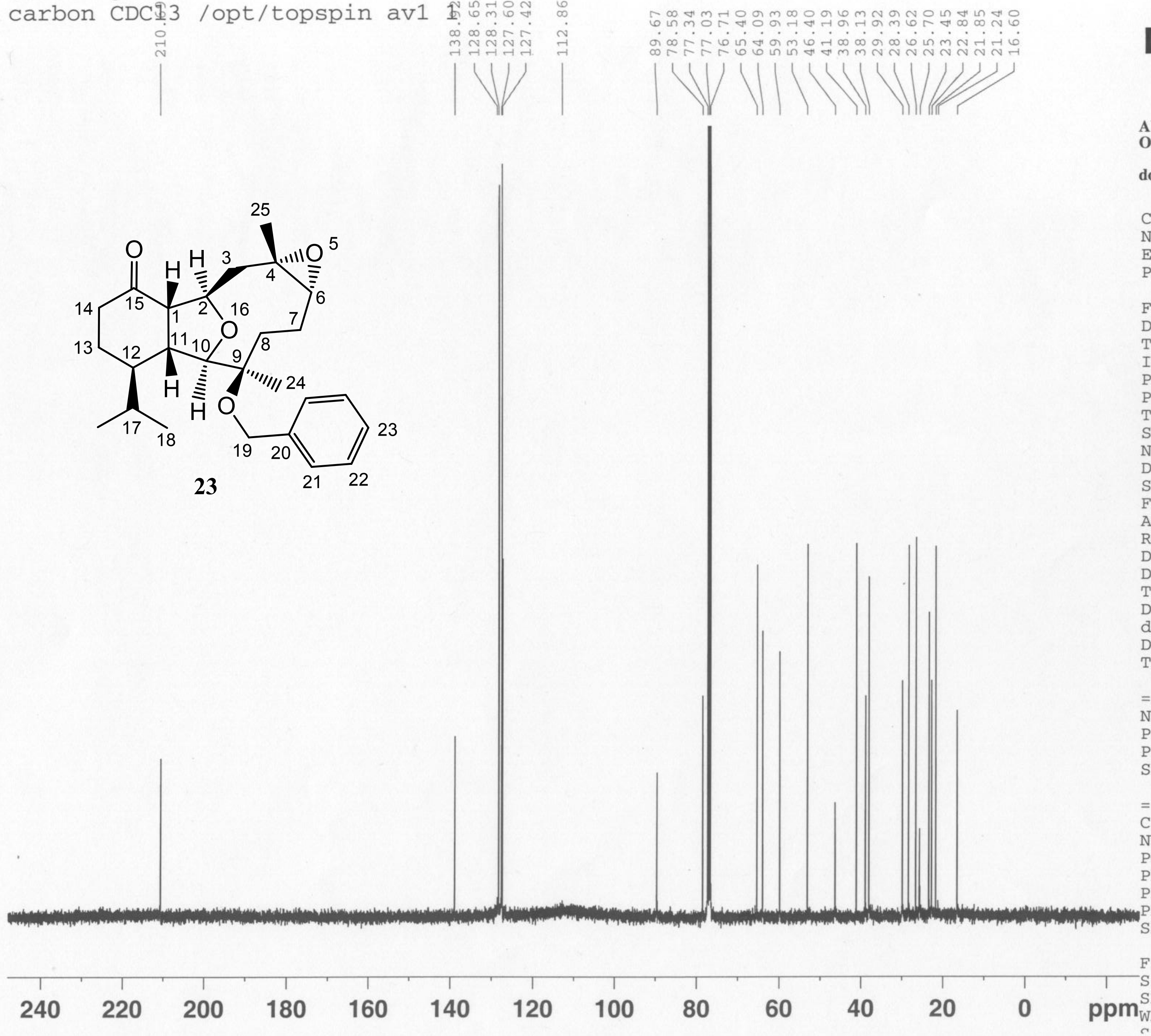


```
becker jbk c 32 2
carbon CDCl3 /opt/topspin av1 1
```



23

AV400
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```
Current Data Parameters
NAME             Sep03-2007
EXPNO                    11
PROCNO                    1

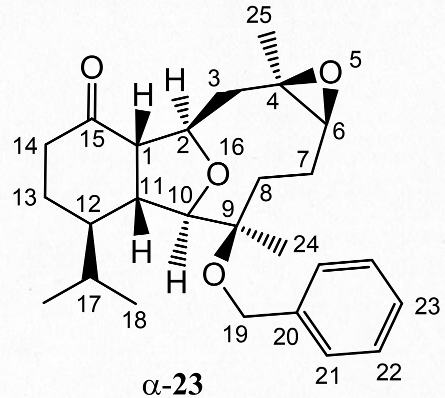
F2 - Acquisition Parameters
Date_              20070903
Time                   9.28
INSTRUM               spect
PROBHD   5 mm PABBI 1H/
PULPROG             zgpg30
TD                    65536
SOLVENT               CDCl3
NS                     3028
DS                        4
SWH              27777.777 Hz
FIDRES            0.423855 Hz
AQ               1.1796980 sec
RG                     1150
DW                   18.000 usec
DE                     9.00 usec
TE                    294.4 K
D1             1.00000000 sec
d11            0.03000000 sec
DELTA          0.89999998 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                    13C
P1                    12.20 usec
PL1                   -5.00 dB
SFO1           100.6238359 MHz

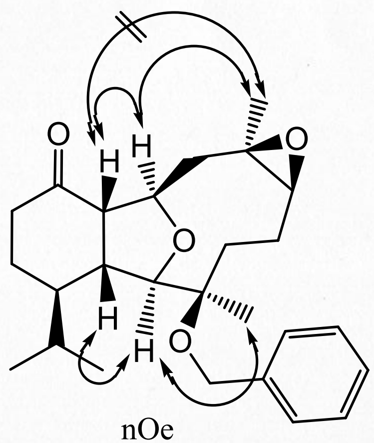
======== CHANNEL f2 ========
CPDPRG2             waltz16
NUC2                     1H
PCPD2                 80.00 usec
PL12                  18.50 dB
PL13                  20.00 dB
PL2                   -1.50 dB
SFO2           400.1316005 MHz

F2 - Processing parameters
SI                   131072
SF             100.6127690 MHz
WDW                      EM
```

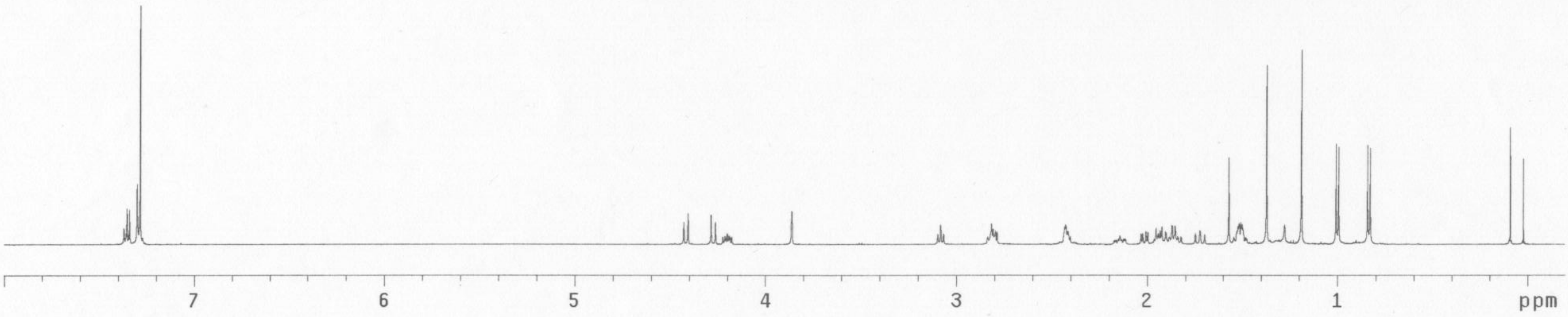
kb_jbk-c332_140907_298k_1h
500 MHz, probe: id



α-**23**

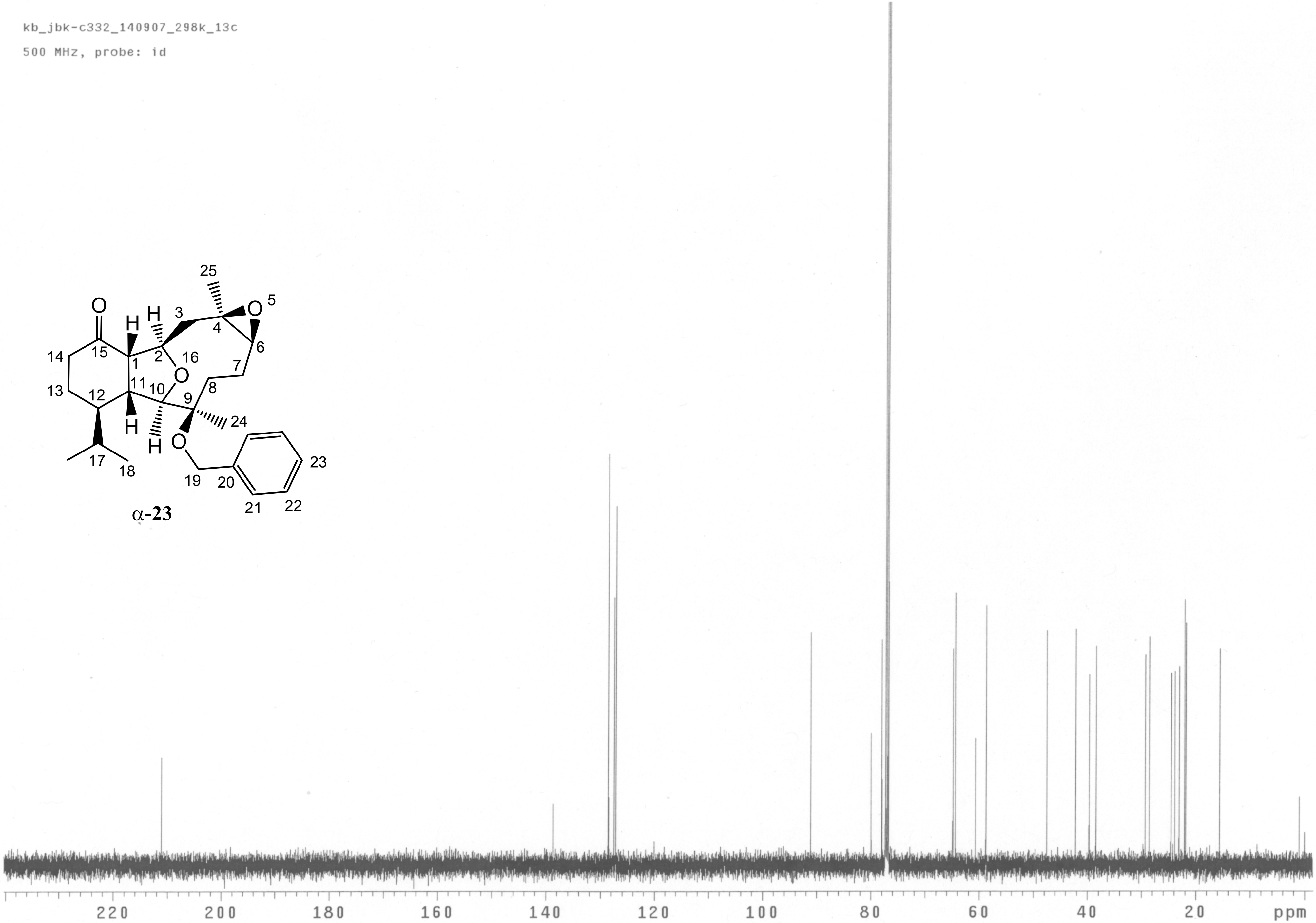


nOe

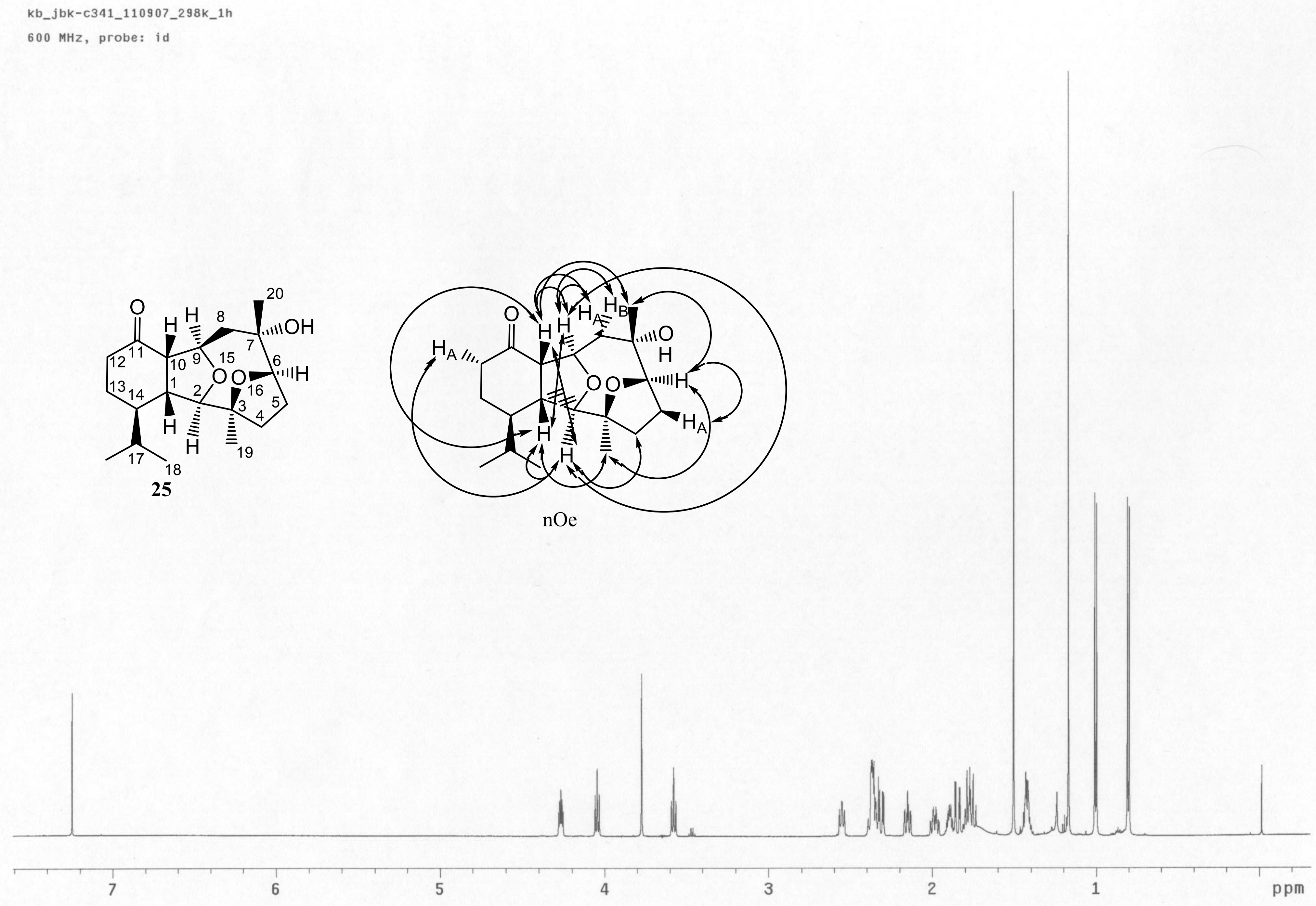


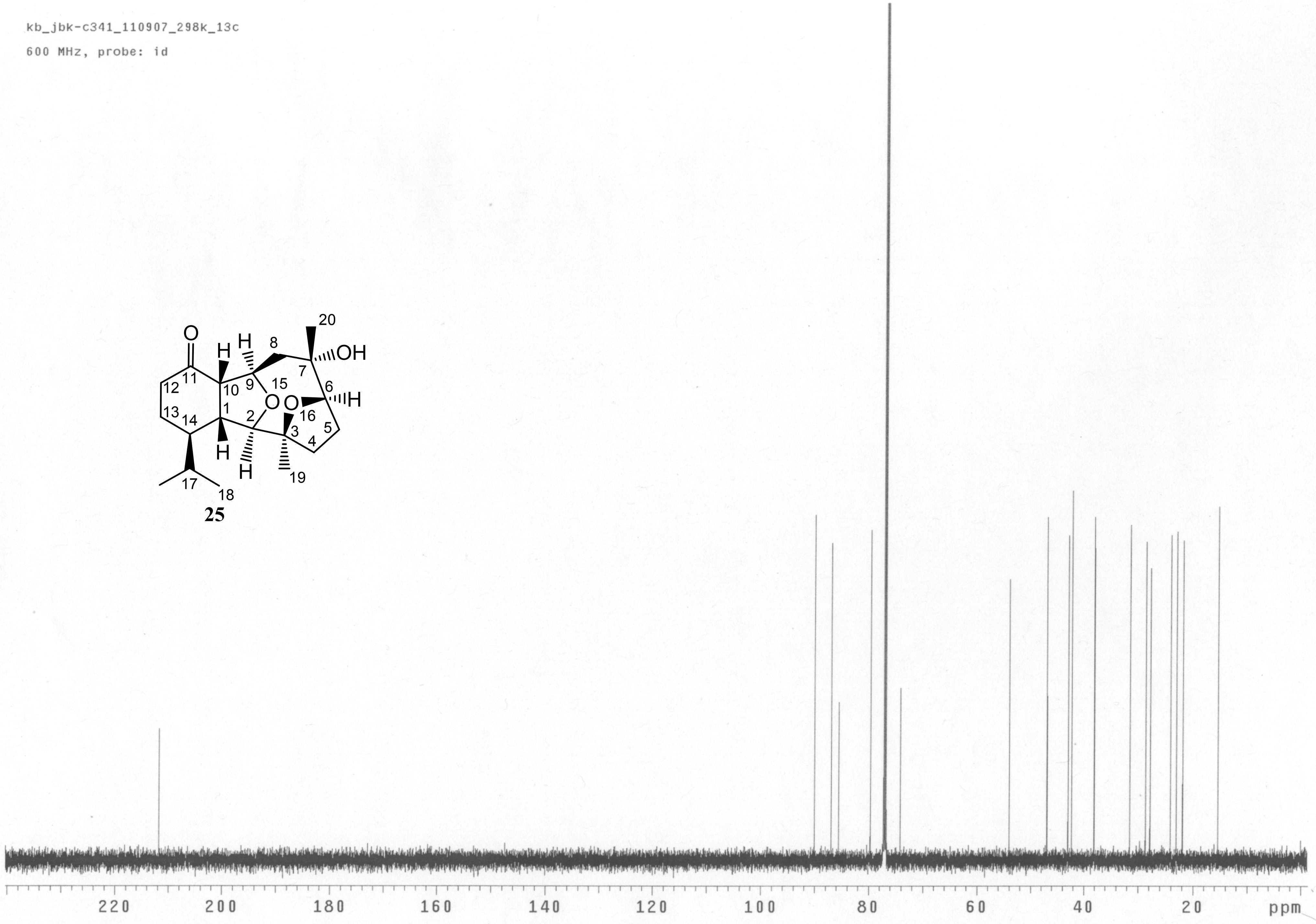
kb_jbk-c332_140907_298k_13c

500 MHz, probe: id



α-**23**

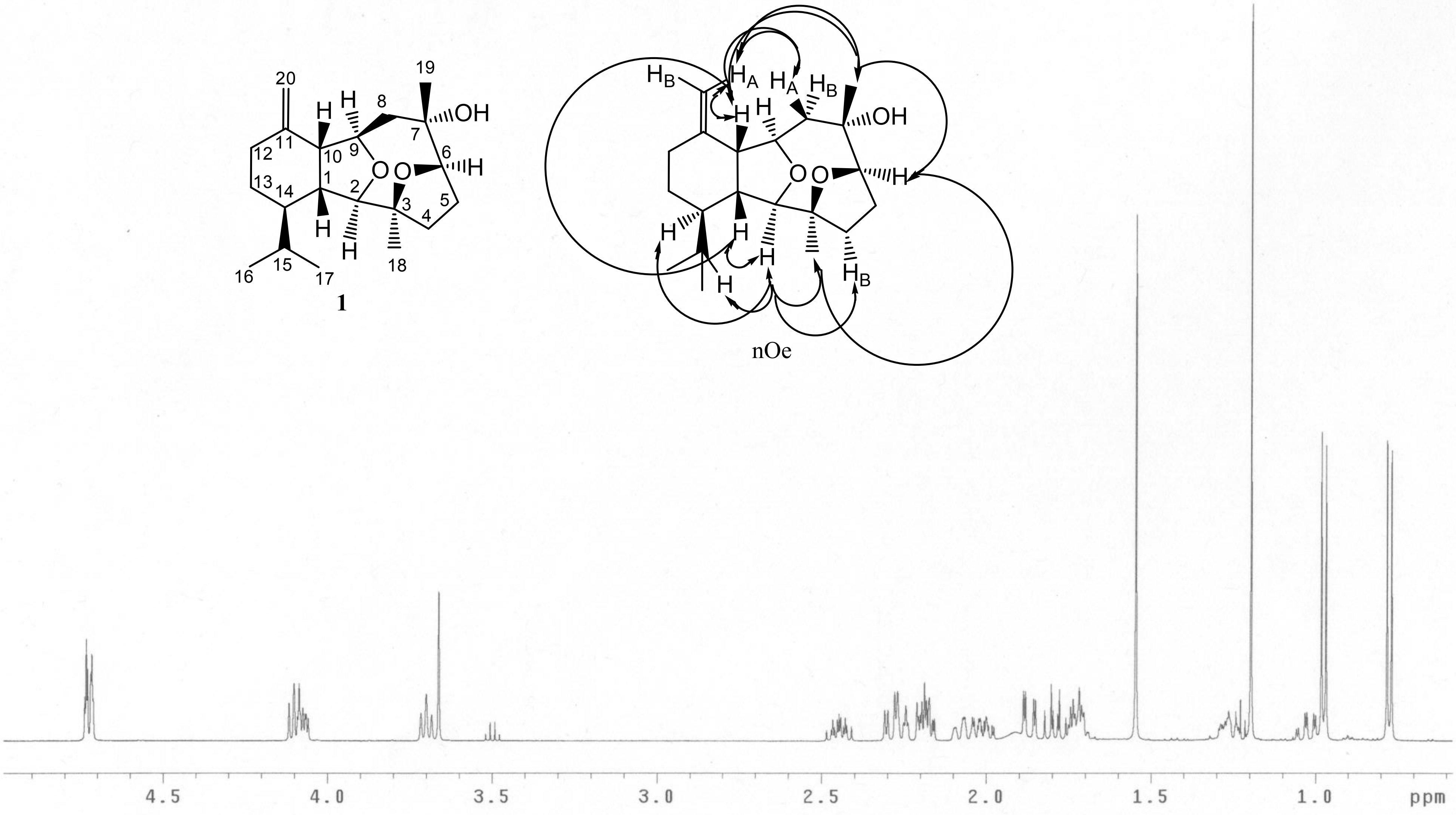

kb_jbk-c341_110907_298k_1h
600 MHz, probe: id
O
H
H
8
20
7
OH
12
11
10
9
15
O
O
6
H
16
13
14
1
2
3
5
4
H
H
19
17
18
25
O
H
H
H_A
H_B
O
H
H_A
O
O
H
H
H
H_A
nOe
7
6
5
4
3
2
1
ppm

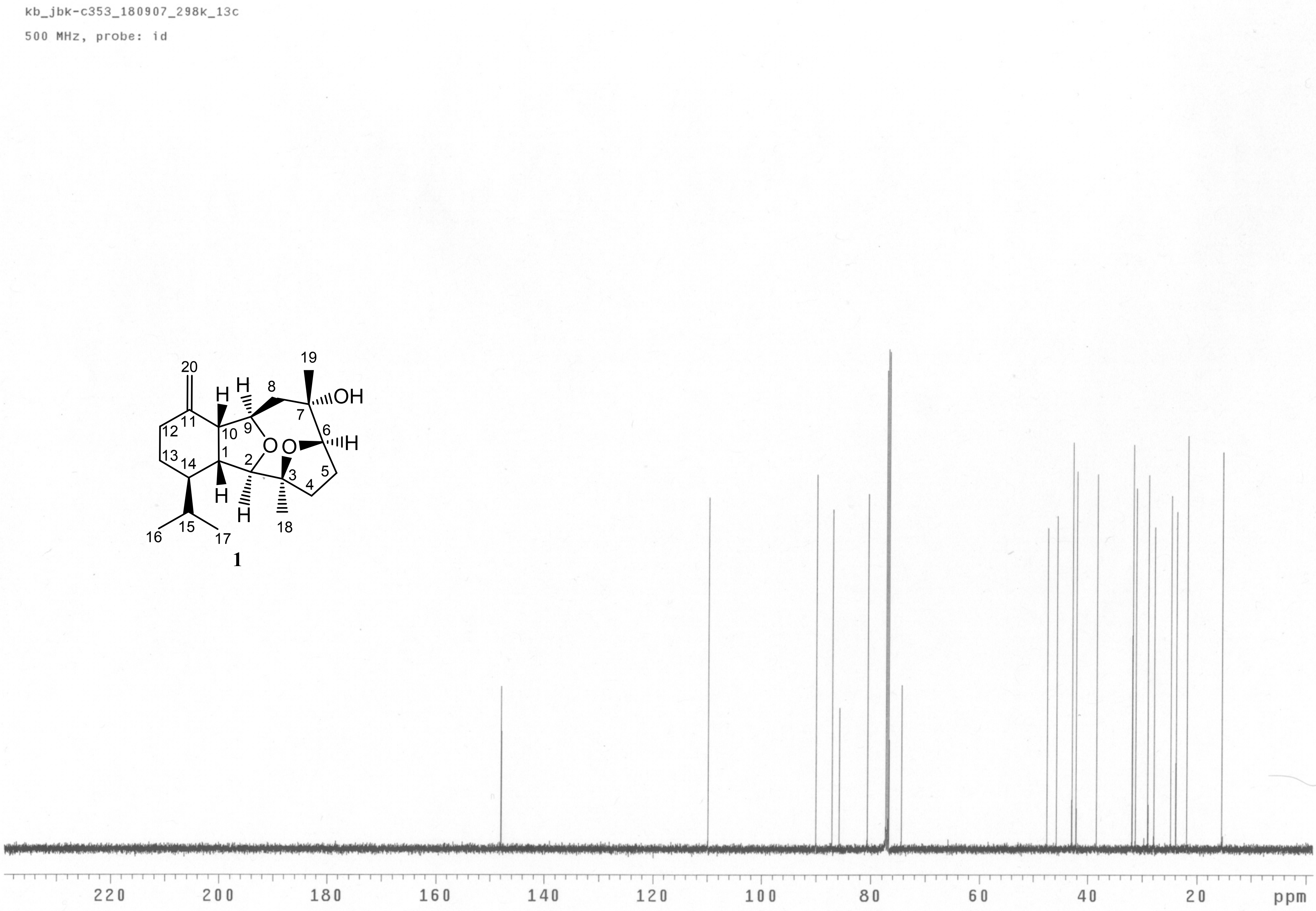


kb_jbk-c341_110907_298k_13c
600 MHz, probe: id
O
H
H
8
20
OH
11
12
10
9
15
7
6
H
O
O
16
13
14
1
2
3
5
4
H
H
19
17
18
220
200
180
160
140
120
100
80
60
40
20
ppm

25

kb_jbk-c353_180907_298k_1h
500 MHz, probe: id




kb_jbk-c353_180907_298k_13c
500 MHz, probe: id
20
H
H
8
19
OH
11
12
10
9
7
6
H
13
14
1
2
O
O
3
5
4
H
H
18
16
15
17
1
220
200
180
160
140
120
100
80
60
40
20
ppm