Electronic Supplementary Material (ESI) for Chemical Communications

Supporting Information

Transforming Terpene-Derived Aldehydes into 1,2-Epoxides via Asymmetric α-Chlorination: Subsequent Epoxide Opening with Carbon Nucleophiles

Philipp Winter, Jörg Swatschek, Matthieu Willot, Lea Radtke, Tobias Olbrisch, Andreas Schäfer and Mathias Christmann

TU Dortmund University

Otto-Hahn-Straße 6

D-44227 Dortmund

Germany

mathias.christmann@tu-dortmund.de

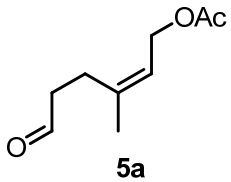
Content

I. GENERAL PROCEDURE

Solvents of HPLC grade were purchased from Fisher Scientific or VWR (Prolabo). Where dry solvents (diethyl ether, dichloromethane, toluene, DMF or THF) were required they were purified by Solvent Purification System M-BRAUN Glovebox Technology SPS-800. Dry DMPU was purchased from Aldrich or distilled from calcium hydride prior to use. Technical quality solvents for column chromatography were used after short path distillation in a rotary evaporator. Unless noted below, all other compounds are reported in literature or were supplied by Aldrich, Acros or AlfaAesar, and used without further purification. (*R*)-citronellal (*ee* = 97.5 %) was donated by Takasago. *Thin-layer chromatography* (SiO_2, *TLC*) was performed on Merck TLC silica gel 60 F_{254}. *Column chromatography* was performed on Merck silica gel 60 (0.040 – 0.063 nm), using standard flash chromatographic methods. *Optical rotations* were recorded on a Perkin Elmer polarimeter 341 at 589 nm, and were reported as $[\alpha]_D$ (concentration). The *NMR spectra* were recorded on Bruker DRX300 (300 MHz), DRX400 (400 MHz), DRX500 (500 MHz) or DRX600 (600 MHz) spectrometers and are referenced against the residual solvent peaks [$CHCl_3$: δ 7.26 ppm (^{1}H NMR) and 77.2 ppm (^{13}C NMR)]. Chemical shifts are reported in parts per million as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), coupling constant, and integration. Infrared spectra were recorded on a Nicolet Impact 400D spectrometer on potassium bromide matrix (disk or film). *Low resolution mass spectra* were performed on a Thermo TSQ mass spectrometer, Hewlett Packard 6890 series/Mass selective detector. *High resolution mass spectra* were recorded on a LTQ Orbitrap mass spectrometer coupled to an Accela HPLC-System (HPLC column: Hypersyl GOLD, 50 mm × 1 mm, 1.9 µm). All instruments are from Thermo Electron. *Chiral HPLC analysis* was performed using an Agilent 1200 series HPLC with a diode array detector. Chiral columns include Daicel Chiralpak IA (Chiral Technologies Eur., 25 cm × 4.6 mm I.D.), Chiralpak IB (Chiral Technologies Eur., 25 cm × 4.6 mm I.D.) and Daicel Chiralpak IC (Chiral Technologies Eur., 25 cm × 4.6 mm I.D.). Chiral GC analysis was performed using an Agilent 6850 series GC with a FID detector on a Hydrodex-β-6TBDM (Macherey & Nagel, 25 m x 0.25 mm) and Hydrodex-β-PM (Macherey & Nagel, 25 m x 0.25 mm).

II. Preparation of aldehydes 5a-f (starting materials for α-chlorination, table 1)

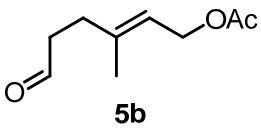
5a:



5a

a) P. R. Skaanderup, T. Jensen, *Org. Lett.* 2008, **10**, 2821–2824. b) M. Uyanik, K. Ishihara, H. Yamamoto, *Org. Lett.* 2006, **8**, 5649–5652. c) P. A. Clarke, M. Grist, M. Ebden, C. Wilson, A. J. Blake, *Tetrahedron* 2005, **61**, 353–363. d) J. Germain, P. J. Deslongchamps, *Org. Chem.* 2002, **67**, 5269–5278. e) E. Fillion, R. L. Beingessner, *J. Org. Chem.* 2003, **68**, 9485–9488. f) S. Hashimoto, A. Itoh, Y. Kitagawa, H. Yamamoto, H. Nozaki, *J. Am. Chem. Soc.* 1977, **99**, 4192–4194. g) K. Mori, *Tetrahedron* 1977, **33**, 289–294.

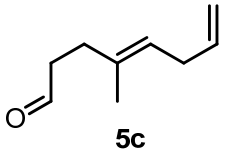
5b:



5b

a) M. Uyanik, K. Ishihara, H. Yamamoto, *Org. Lett.* 2006, **8**, 5649–5652. b) E. Marquez-Lopez, R. P. Herrera, T. Marks, W. Jacobs, D. Könning, R. M. De Figueiredo, M. Christmann, *Org. Lett.* 2009, **11**, 4116-4119.

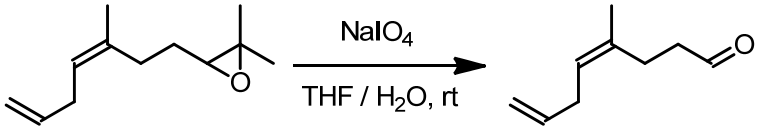
5c:



5c

P. Winter, C. Vaxelaire, C. Heinz, M. Christmann, *Chem. Commun.* 2011, **47**, 394–396.

5d:



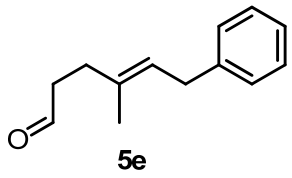
SI-1 **5d**

The epoxide **SI-1** was prepared according to the literature: P. Winter, C. Vaxelaire, C. Heinz, M. Christmann, *Chem. Commun.* 2011, **47**, 394–396.

To a stirred solution of **SI-1** (111 mg, 0.62 mmol, 1.0 eq.) in a THF/H_2O (2/1) mixture (2.6 mL) was added $NaIO_4$ (263 mg, 1.23 mmol, 2.0 eq.). After 16 h of stirring at rt, the conversion was complete (TLC: *c*-Hex/AcOEt = 5/1). The reaction was then filtrated over Celite and washed with Et_2O. The filtrate was dried with anhydrous $MgSO_4$, filtered and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, *n*-pentane:Et_2O = 20:1 to 10:1). **5d** (75 mg, 0.55 mmol, 87%) was isolated as colourless oil.

R_f = 0.63 (*c*-Hex:AcOEt = 5:1); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3436, 3079, 2969, 2916, 2822, 2720, 1726, 1638; **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 9.77 (t, *J* = 1.5 Hz, 1H), 5.78 (ddt, *J* = 17.2, 9.9, 6.1 Hz, 1H), 5.23 (t, *J* = 7.6 Hz, 1H), 5.01 (dq, *J* = 17.2, 1.5 Hz, 1H), 4.96 (dq, *J* = 9.9, 1.5 Hz, 1H), 2.76 (dd, *J* = 7.3, 6.5 Hz, 2H), 2.50 (dd, *J* = 7.6, 1.5 Hz, 2H), 2.35 (d, *J* = 7.6 Hz, 2H), 1.71 (d, *J* = 1.5 Hz, 3H); **^{13}C-NMR** (125 MHz, $CDCl_3$): δ 202.2, 137.2, 134.5, 123.8, 114.7, 42.4, 32.2, 24.4, 23.2; **HRMS** (ESI): *m/z* calculated for $C_9H_{15}O$ ($[M+H]^+$) 139.1117, found 139.1113.

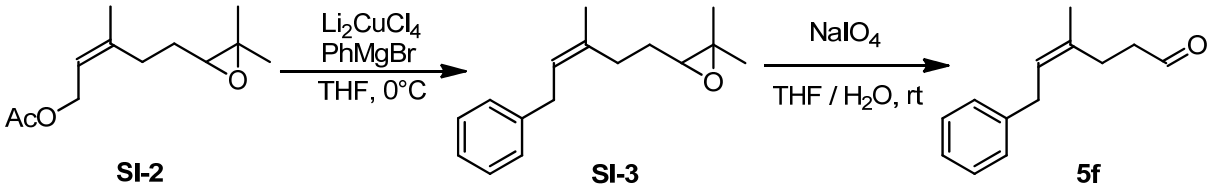
5e:



5e

P. Winter, C. Vaxelaire, C. Heinz, M. Christmann, *Chem. Commun.* 2011, **47**, 394–396.

5f:



SI-2 **SI-3** **5f**

For the preparation of **SI-2** see for: E. Fillon, R. L. Beingessner, *J. Org. Chem.* 2003, **68**, 9485-9488; M. Uyanik, K. Ishihara, H. Yamamoto, *Org. Lett.* 2006, **8**, 5649-5652.

To a solution of **SI-2** (2.25 g, 10.6 mmol) in THF (56 mL) was added dropwise Li_2CuCl_4 (4.24 mL, 0.42 mmol, 4 mol%, 0.1 M in THF) at 0 °C followed by PhMgBr (31.8 mL, 31.8 mmol, 3.0 eq., 1 M in THF) over 20 min. After a further 2 h at 0 °C, saturated aq. NH_4Cl (4.2 mL) was added and the magnesium salts dissolved with water. The aqueous phase was extracted with EtOAc (3 x 10 mL) and the combined organic phases dried over $MgSO_4$. After evaporation of all solvents, the residue was purified by flash column chromatography (SiO_2, *c*-Hex:EtOAc = 10:1), yielding **SI-3** (2.42 g, 10.5 mmol, 99 %) as a colourless oil.
$\mathbf{R_f}$ = 0.40 (*c*-Hex:EtOAc = 5:1); **IR** ($\tilde{\nu}$ / cm^{-1}) 3026, 2962, 2925, 1733, 1602, 1494, 1452, 1377; **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 7.30-7.27 (m, 2H), 7.20-7.17 (m, 3H), 5.40 (t, *J* = 7.3 Hz, 1H), 3.39 (d, *J* = 7.3 Hz, 2H), 2.75 (t, *J* = 6.1 Hz, 1H), 2.35-2.25 (m, 2H), 1.78 (d, *J* = 1.5 Hz, 3H), 1.74-1.61 (m, 2H), 1.31 (s, 3H), 1.29 (s, 3H); **^{13}C-NMR** (125 MHz, $CDCl_3$): δ 202.2, 135.3, 128.4 (2C), 128.3 (2C), 125.8, 124.5, 64.0, 58.4, 34.1, 28.6, 27.4, 24.9, 23.4, 18.7; **HRMS** (ESI) *m/z* calculated for $C_{16}H_{23}O$ ($[M+H]^+$) 231.1743, found 231.1743.

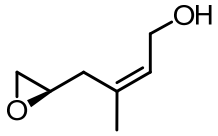
To a stirred solution of **SI-3** (2.66 g, 11.6 mmol, 1.0 eq.) in a THF/H_2O (2/1) mixture (48 mL) was added $NaIO_4$ (4.92 g, 23.1 mmol, 2.0 eq.). After 16 h of stirring at rt, the conversion was complete. The reaction was then filtrated over Celite and washed with Et_2O. The filtrate was dried with anhydrous $MgSO_4$, filtered and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, *c*-Hex:EtOAc = 20:1). **5f** (1.72 g, 9.14 mmol, 82%) was isolated as colourless oil.
$\mathbf{R_f}$ = 0.44 (*c*-Hex:EtOAc = 5:1); **IR** ($\tilde{\nu}$ / cm^{-1}) 3061, 3027, 2966, 2915, 2724, 1725; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 9.81 (t, *J* = 1.6 Hz, 1H), 7.31-7.27 (m, 2H), 7.21-7.17 (m, 3H), 5.42 (t, *J* = 7.4 Hz, 1H), 3.38 (d, *J* = 7.3 Hz, 2H), 2.58-2.53 (m, 2H), 2.49-2.45 (m, 2H), 1.78 (d, *J* = 1.25 Hz, 3H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 202.0, 141.2, 134.0, 128.4 (2C), 128.2 (2C), 125.9, 125.2, 42.2, 34.0, 24.3, 23.1; **HRMS** (ESI) *m/z* calculated for $C_{13}H_{17}O$ ($[M+H]^+$) 189.1274, found 189.1268.

III. General procedure for the synthesis of epoxides 7a-f (table 1)

To a solution of aldehyde **5a-f** (1.0 eq.) in MeCN (0.5 M) at 0 °C was added catalyst **1**·TFA (20 mol%), followed by NCS (1.1 eq.). The solution was stirred at that temperature until all starting material was consumed (TLC-control). At that point EtOH (30 Vol%) and $NaBH_4$ (2.5 eq.) were added. The white suspension was stirred 30 min and then diluted carefully with

a NaOH/EtOH/H_2O-solution (100 Vol%, solution prepared from: 12 mL EtOH, 12.5 g NaOH, 25 mL H_2O) and the medium was stirred vigorously for 1 h at rt. The reaction mixture was diluted with sat. aq. NH_4Cl (50 Vol%) and CH_2Cl_2 and the aqueous layer was further extracted with CH_2Cl_2, the organic layers dried over $MgSO_4$ and the solvents removed under reduced pressure. Purification by column chromatography (SiO_2, conditions: see below) of the crude product yielded epoxide **7a-f** as a colourless oil.

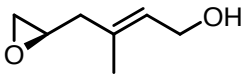
The enantiomeric excess was determined by chiral GC. In this case, D/L-proline was used instead of **1**·TFA, following the general procedure above.



7a

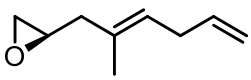
7a: yield: 64 %, 95 % *ee*; In this case, the last reaction step was performed at 0°C for 0.5 h. Otherwise, a significant amount of the cyclization product was observed.

R_f = 0.23 (*n*-pentane:Et_2O = 1:2); **$[\alpha]_D^{20}$**= –10.9 ($CHCl_3$, c = 2.87); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3450, 2902, 1723; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 5.69 (tq, *J* = 7.4, 1.5 Hz, 1H), 3.99 (d, *J* = 7.4 Hz, 2H), 3.05 (dddd, *J* = 6.5, 3.6, 3.6, 2.7 Hz, 1H), 2.82 (dd, *J* = 5.0, 3.6 Hz, 1H), 2.57 (dd, *J* = 5.0, 2.7 Hz, 1H), 2.52 (dd, *J* = 14.2, 3.6 Hz, 1H), 2.27 (dd, *J* = 14.2, 6.5 Hz, 1H), 2.12 (s_{br}, 1H), 1.82 (d, *J* = 1.5 Hz, 3H); **^{13}C-NMR** (101 MHz, $CDCl_3$): δ 135.4, 127.5, 58.2, 50.5, 47.3, 34.1, 24.6; **HRMS** (ESI): *m*/*z* calculated for $C_7H_{13}O_2$ ($[M+H]^+$) 129.0910, found 129.0905.



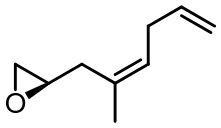
7b

7b: yield: 77 %, 95 % *ee*; **R_f** = 0.37 (*c*-Hex:AcOEt = 1:1); **$[\alpha]_D^{20}$**= +9.7 ($CHCl_3$, c = 0.93); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3467, 2922, 1712; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 5.54 (tq, *J* = 7.0, 1.2 Hz, 1H), 4.20 (dd, *J* = 5.8, 5.5 Hz, 2H), 3.02 (m, 1H), 2.79 (dd, *J* = 5.0, 4.0 Hz, 1H), 2.78 (s, 1H), 2.50 (dd, *J* = 4.8, 2.5 Hz, 1H), 2.25 (d, *J* = 5.8 Hz, 2H), 1.76 (s, 3H), OH-proton is missing; **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 135.8, 125.8, 59.3, 51.2, 47.0, 42.5, 17.1; **HRMS** (ESI): *m*/*z* calculated for $C_7H_{13}O_2$ ($[M+H]^+$) 129.0910, found 129.0905.



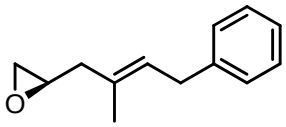
7c

7c: yield: 66 %, 92 % *ee*; $\mathbf{R_f}$ = 0.69 (*n*-pentane:Et_2O = 6:1); $\mathbf{[\alpha]_D^{20}}$= 4.14 ($CHCl_3$, c = 11.4); **IR** ($\tilde{\nu}$ / cm^{-1}) = 2921, 2980; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 5.82 (ddt, *J* = 16.9, 10.2, 6.3 Hz, 1H), 5.03 (ddt, *J* = 17.1, 5.5, 1.8 Hz, 1H), 4.98 (ddt, *J* = 10.0, 5.0, 1.5 Hz, 2H), 2.98-3.03 (m, 1H), 2.78-2.81 (m, 3H), 2.50 (dd, *J* = 5.0, 3.0 Hz, 1H), 2.28 (dd, *J* = 14.6, 6.0 Hz, 1H), 2.20 (dd, *J* = 14.6, 5.5 Hz, 1H), 1.71 (s, 3H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 16.7, 32.2, 42.5, 46.9, 51.4, 114.5, 123.9, 132.6, 136.9; **HRMS (ESI)**: *m/z* for $C_9H_{15}O$ $[M+H]^+$, calculated 139.1117, found 139.1115.



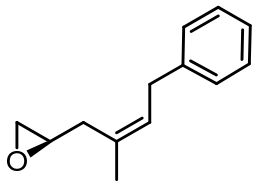
7d

7d: yield: 56 %, 94 % *ee*; $\mathbf{R_f}$ = 0.82 (*c*-Hex:AcOEt = 5:1); $\mathbf{[\alpha]_D^{20}}$= –21.0 ($CHCl_3$, c = 0.61); **IR** ($\tilde{\nu}$ / cm^{-1}) = 2974, 2918; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 5.79 (ddt, *J* = 17.1, 10.0, 6.3 Hz, 1H), 5.23 (t, *J* = 7.3 Hz, 1H), 5.02 (dq, *J* = 17.1, 1.8 Hz, 1H), 4.96 (dq, *J* = 10.0, 1.8 Hz, 1H), 2.95 (m, 1H), 2.79-2.73 (m, 3H), 2.50 (dd, *J* = 5.0, 2.8 Hz, 1H), 2.38 (dd, *J* = 14.0, 5.5 Hz, 1H), 2.20 (dd, *J* = 14.0, 5.5 Hz, 1H), 1.80 (d, *J* = 1.0 Hz, 3H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 137.3, 132.4, 124.7, 114.7, 51.3, 47.1, 34.9, 32.4, 24.5; **HRMS (ESI)**: *m/z* for $C_9H_{15}O$ $[M+H]^+$, calculated 139.1117, found 139.1113.



7e

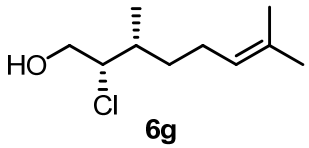
7e: yield: 53 %, 91 % *ee*; $\mathbf{R_f}$ = 0.54 (*n*-pentane:Et_2O = 10:1); $\mathbf{[\alpha]_D^{20}}$= +2.8° ($CHCl_3$, c = 0.65); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3465, 3027, 2980, 2921, 2854; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 7.31-7.26 (m, 2H), 7.21-7.18 (m, 3H), 5.49 (tq, *J* = 7.3, 1.3 Hz, 1H), 3.40 (d, *J* = 7.3 Hz, 2H), 3.02 (dddd, *J* = 6.0, 5.3, 4.0, 2.7 Hz, 1H), 2.79 (dd, *J* = 5.0, 4.0 Hz, 1H), 2.51 (dd, *J* = 5.0, 2.7 Hz, 1H), 2.30 (dd, *J* = 14.6, 6.0 Hz, 1H), 2.24 (dd, *J* = 14.6, 5.3 Hz, 1H), 1.81 (d, *J* = 1.2 Hz, 3H); **^{13}C-NMR** (101 MHz, $CDCl_3$): δ 141.3, 132.5, 128.5 (2C), 128.4 (2C), 125.9, 125.6, 51.5, 47.0, 42.6, 34.3, 17.0; **HRMS (ESI)**: *m/z* for $C_{13}H_{17}O$ $[M+H]^+$, calculated 189.1274, found 189.1271.



7f

7f: **yield:** 56 %, 93 % *ee*; $\mathbf{R_f}$ = 0.62 (*c*-Hex:EtOAc = 2:1); $\mathbf{[\alpha]_D^{20}}$ = –11.7 ($CHCl_3$, c = 1.64); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3470, 3027, 2970, 2917, 2853; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 7.29-7.23 (m, 2H), 7.19-7.16 (m, 3H), 5.47 (t, *J* = 7.5 Hz, 1H), 3.36 (d, *J* = 7.5 Hz, 2H), 3.00-2.96 (m, 1H), 2.76 (t, *J* = 4.8 Hz, 1H), 2.51 (dd, *J* = 5.0, 2.8 Hz, 1H), 2.46 (dd, *J* = 14.1, 5.8 Hz, 1H), 2.31 (dd, *J* = 14.1, 5.3 Hz, 1H), 1.82 (d, *J* = 1.3 Hz, 3H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 141.1, 131.9, 128.4 (2C), 128.3 (2C), 126.1, 125.8, 51.2, 47.0, 34.8, 34.2, 24.3. **HRMS** (ESI): *m/z* for $C_{13}H_{17}O$ $[M+H]^+$, calculated 189.1274, found 189.1271.

IV. Stepwise synthesis of epoxides 7g-h via the chloroalcohols 6g-h (table 1)

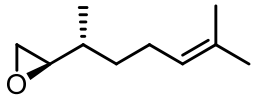


6g

To a stirred solution of (*R*)-citronellal (77 mg, 0.5 mmol, 1.0 eq.) in MeCN (1 mL) at –30 °C was added (2*R*,5*S*)-2-(*tert*-butyl)-3,5-dimethylimidazolidin-4-one-TFA-salt **1**·TFA (40 mg, 0.30 mmol, 30 mol%) and successively NCS (87 mg, 0.65 mmol, 1.3 eq.). The reaction mixture was stirred for 1.5 h, allowed to warm to 0 °C and treated with $NaBH_4$ (47 mg, 2.50 mmol, 2.5 eq.) and EtOH (0.5 mL). After stirring for 15 min at 0 °C, the reaction was quenched by the addition of sat. aq. NH_4Cl-solution (2 mL), diluted with CH_2Cl_2 (2 mL) and stirred for 5 min at RT. The layers were separated, the aqueous layer extracted with CH_2Cl_2 (3 × 5 mL), the combined organic layers dried over $MgSO_4$ and the solvents removed under reduced pressure. The crude product was purified by flash column chromatography (*n*-pentane:Et_2O = 25:1) and the desired (2*S*,3*R*)-2-chloro-3,7-dimethyloct-6-en-1-ol **6g** (69 mg, 0.36 mmol, 73%, 99% *de*) obtained as a colourless oil.

$\mathbf{R_f}$ = 0.18 (*n*-pentane:Et_2O = 5:1); $\mathbf{[\alpha]_D^{20}}$ = –1.52 ($CHCl_3$, c = 1.23); ; **IR** ($\tilde{\nu}$ / cm^{-1}): 3443, 2966, 2926, 2878, 2857, 1671, 1620, 1452, 1379, 1077, 1029, 953, 823, 666; **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 5.09 (tt, *J* = 7.1, 1.3 Hz, 1H), 4.07 (m, 1H), 3.76 (d, *J* = 6.5 Hz, 2H), 2.19 (brs, 1H), 2.01 (q, *J* = 7.6 Hz, 2H), 1.85-1.93 (m, 1H), 1.69 (s, 3H), 1.61 (s, 3H), 1.48-1.57 (m, 1H), 1.28-1.37 (m, 1H), 0.96 (d, *J* = 6.5 Hz, 3H); **^{13}C-NMR** (126 MHz, $CDCl_3$): δ

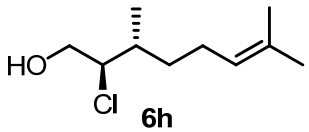
131.9, 123.8, 70.0, 65.7, 35.3, 34.2, 25.6, 25.2, 17.6, 14.5; **HRMS** (EI) *m/z* calculated for $C_{10}H_{19}OCl$ ($M^{\bullet+}$) 190.1118, found 190.1114; calculated for $C_{10}H_{19}O^{37}Cl$ ($M^{\bullet+}$) 192.1089, found 192.1082.



7g

To a stirred solution of (2*S*,3*R*)-2-chloro-3,7-dimethyloct-6-en-1-ol **6g** (381 mg, 2.00 mmol, 1.0 eq.) in MeCN (2 mL) was added a NaOH/EtOH/H_2O-solution (8 mL) and the reaction mixture was stirred for 2 h at rt. After addition of *n*-pentane (5 mL) the layers were separated, the aqueous layer extracted with *n*-pentane (3 x 5 mL), the combined organic layers dried over Na_2SO_4 and the solvents removed under reduced pressure. The crude product was purified by flash column chromatography (*n*-pentane:Et_2O = 100:1) and the desired (*R*)-2-((*R*)-6-methylhept-5-en-2-yl)oxirane **7g** (302 mg, 1.97 mmol, 98%, 98% *de*) obtained as a colourless oil.

R_f = 0.38 (*n*-pentane:Et_2O = 15:1); **$[\alpha]_D^{20}$** = +6.92 ($CHCl_3$, *c* = 0.96); **IR** ($\tilde{\nu}$ / cm^{-1}): 3043, 2965, 2919, 2856, 1483, 1457, 1412, 1376, 1258, 1115, 985, 964, 931, 916, 882, 836, 736, 489; **^{1}H -NMR** (500 MHz, $CDCl_3$): δ 5.08 (tt, *J* = 7.1, 1.2 Hz, 1H), 2.65-2.71 (m, 2H), 2.44 (dd, *J* = 5.0, 2.8 Hz, 1H), 1.97-2.11 (m, 2H), 1.65 (s, 3H), 1.58 (s, 3H), 1.51-1.57 (m, 1H), 1.26-1.36 (m, 2H), 0.91 (d, *J* = 6.6 Hz, 3H); **^{13}C-NMR** (126 MHz, $CDCl_3$): δ 131.3, 124.3, 56.8, 45.4, 35.5, 34.6, 25.6, 25.3, 17.5, 15.4; **HRMS** (ESI) *m/z* calculated for $C_{10}H_{17}$ ([M-H_2O]$^+$) 137.13248, found 137.3218; calculated for $C_{10}H_{19}O$ ([M+H]$^+$) 155.1430, found 155.1429.

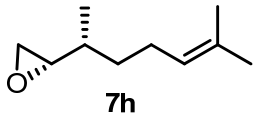


6h

Applying the enantiomeric catalyst *ent* **1**·TFA under the same reaction conditions (see **6g**) and the same scale (2*R*,3*R*)-2-chloro-3,7-dimethyloct-6-en-1-ol **6h** (67 mg, 0.35 mmol, 70%, >99% *de*) was obtained as a colourless oil.

R_f = 0.18 (*n*-pentane:Et_2O = 5:1); **$[\alpha]_D^{20}$** = +16.71 ($CHCl_3$, *c* = 0.75); **IR** ($\tilde{\nu}$ / cm^{-1}): 3375, 2965, 2928, 2877, 2858, 1455, 1379, 1259, 1199, 1071, 1031, 987, 953, 824, 669; **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 5.09 (t, *J* = 7.1 Hz, 1H), 3.98 (ddd, *J* = 8.3, 5.1, 3.8 Hz, 1H), 3.71-3.85 (m, 2H), 2.04-2.13 (m, 2H), 1.88-1.99 (m, 2H), 1.69 (s, 3H), 1.61 (s, 3H), 1.52-1.60 (m, 1H),

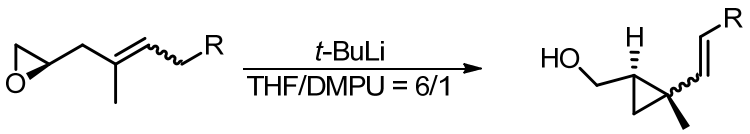
1.27-1.35 (m, 1H), 1.03 (d, J = 6.9 Hz, 3H); **^{13}C-NMR** (126 MHz, $CDCl_3$): δ 132.0, 123.9, 71.0, 64.9, 36.3, 32.7, 25.7, 25.3, 17.7, 16.3; **HRMS** (EI) *m/z* calculated for $C_{10}H_{19}OCl$ ($M^{\bullet+}$) 190.1119, found 190.1122; calculated for $C_{10}H_{19}O^{37}Cl$ ($M^{\bullet+}$) 192.1089, found 192.1077.



7h

Applying the same reaction conditions and the same scale (see **7g**) (*S*)-2-((*R*)-6-methylhept-5-en-2-yl)oxirane **7h** (252 mg, 1.64 mmol, 72%, 97% *de*) was obtained as a colourless oil.
R_f = 0.38 (*n*-pentane:Et_2O = 15:1); **$[\alpha]_D^{20}$** = +2.77 ($CHCl_3$, c = 0.94); **IR** ($\tilde{\nu}$ / cm^{-1}): 3044, 2965, 2922, 2855, 1483, 1454, 1375, 929, 916, 892, 856, 833, 426, 406; **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 5.09 (tt, J = 7.1, 1.2 Hz, 1H), 2.76 (dd, J = 4.9, 4.0 Hz, 1H), 2.67-2.71 (m, 1H), 2.53 (dd, J = 5.0, 2.8 Hz, 1H), 1.97-2.10 (m, 2H), 1.69 (s, 3H), 1.61 (s, 3H), 1.40-1.49 (m, 1H), 1.26-1.35 (m, 2H), 1.04 (d, J = 6.4 Hz, 3H); **^{13}C-NMR** (126 MHz, $CDCl_3$): δ 131.6, 124.2, 56.9, 46.8, 35.7, 33.6, 25.6, 25.5, 17.6, 17.0; **HRMS** (ESI) *m/z* calculated for $C_{10}H_{19}O$ ($[M+H]^+$) 155.1430, found 155.1429

V. Synthesis of substituted cyclopropanes 8-10 from epoxides 7c-f and i



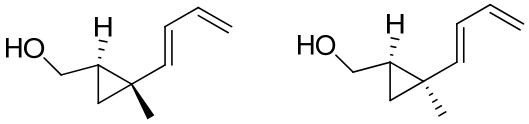
7c-f,i **8-10**

General procedure:

t-BuLi (1.2 eq., 1.6 M in *n*-pentane) was added dropwise to a stirred solution of epoxide **7c-f,i** (1.0 eq.) in THF/DMPU (6/1, 0.2 M) at −78 °C. After 30 min, the orange solution was warmed slowly to rt and quenched after a further 30 min with sat. aq. NH_4Cl. The aqueous phase was extracted with EtOAc, the combined organic phases washed with brine and dried over $MgSO_4$. After evaporation of all solvents, the residue was purified by flash column chromatography (SiO_2, conditions: see below).

Characterization of cyclopropane 8

Using epoxide **7d**, an inseparable 10:1 mixture favouring the *trans*-isomer (97 % isolated yield) was obtained. Epoxide **7c** yielded in an inseparable 1:1 mixture of the *trans*- and *cis*-isomer (90 % isolated yield).



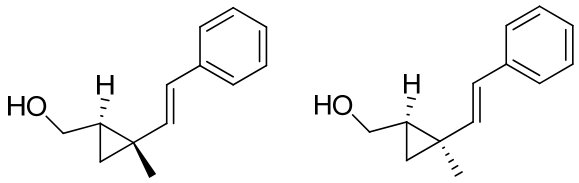
***trans*-8** ***cis*-8**

***trans*-8:** (as a diastereomeric mixture of 10:1, only main isomer): $\mathbf{R}_f$ = 0.42 (*c*-Hex:AcOEt = 2:1); $[\alpha]_D^{20}$ = –26.2° ($CHCl_3$, c = 0.32); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3443, 2994, 2957, 2926, 2877, 1645; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 6.29 (dt, *J* = 17.1, 10.3 Hz, 1H), 6.04 (dd, *J* = 15.3, 10.3 Hz, 1H), 5.33 (d, *J* = 15.3 Hz, 1H), 5.10 (dd, *J* = 17.1, 1.3 Hz, 1H), 4.94 (dd, *J* = 10.3, 1.3 Hz, 1H), 3.81 (dd, *J* = 11.5, 6.3 Hz, 1H), 3.59 (dd, *J* = 11.5, 8.5 Hz, 1H), 1.27 (s, 3H), 1.24 (m, 1H), 0.86 (dd, *J* = 9.0, 4.8 Hz, 1H), 0.53 (dd, *J* = 5.8, 4.8 Hz, 1H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 143.4, 137.2, 126.7, 114.6, 63.4, 28.5, 21.9, 19.8, 16.0; **HRMS (ESI)**: *m/z* for $C_9H_{15}O$ $[M+H]^+$, calculated 139.1117, found 139.1112.

***cis*-8:** $\mathbf{R}_f$ = 0.42 (*c*-Hex:AcOEt = 2:1); **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 6.34 (dt, *J* = 16.9, 10.4 Hz, 1H), 6.14 (dd, *J* = 15.3, 10.4 Hz, 1H), 5.62 (d, *J* = 15.3 Hz, 1H), 5.12 (dd, *J* = 17.0, 1.7 Hz, 1H), 4.97 (dd, *J* = 10.1, 1.7 Hz, 1H), 3.74 (dd, *J* = 11.4, 6.2 Hz, 1H), 3.48 (dd, *J* = 11.6, 8.7 Hz, 1H), 1.23 (s, 3H), 1.25 (m, 1H), 0.83 (dd, *J* = 9.4, 4.9 Hz, 1H), 0.66 (dd, *J* = 5.4, 5.2 Hz, 1H); **^{13}C-NMR** (125 MHz, $CDCl_3$): δ 137.4, 137.2, 130.3, 115.0, 63.7, 30.3, 23.5, 19.9, 16.0.

Characterization of cyclopropane 9

Using epoxide **7f**, an inseparable 8:1 mixture favouring the *trans*-isomer (69 % isolated yield) was obtained. Epoxide **7e** yielded in an inseparable 1:1 mixture of the *trans*- and *cis*-isomer (61 % isolated yield, 70 % brsm).



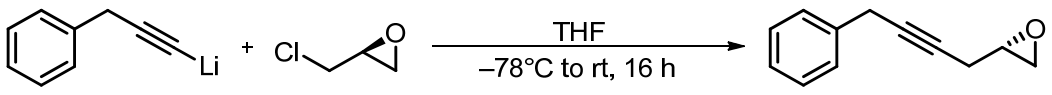
trans-8 *cis*-8

trans-8: (as a diastereomeric mixture of 8:1, only main isomer)**:** $\mathbf{R_f}$ = 0.43 (*c*-Hex:EtOAc = 2:1); $\mathbf{[\alpha]_D^{20}}$ = –67.9 ($CHCl_3$, c = 1.10); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3438, 3059, 3024, 2954, 2926, 2876, 1644; **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 7.30-7.23 (m, 4H), 7.16-7.13 (m, 1H), 6.31 (d, *J* = 16.1 Hz, 1H), 5.80 (d, *J* = 16.1 Hz, 1H), 3.82 (dd, *J* = 11.5, 6.3 Hz, 1H), 3.60 (dd, *J* = 11.5, 8.5 Hz, 1H), 1.34 (s, 3H), 1.31-1.28 (m, 1H), 0.92 (dd, *J* = 9.0, 4.8 Hz, 1H), 0.56 (t, *J* = 5.8 Hz, 1H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 138.9, 137.6, 128.5 (2C), 126.7, 125.7 (2C), 125.4, 63.3, 28.3, 22.1, 19.5, 16.0; **HRMS** (ESI): *m/z* for $C_{13}H_{17}O$ $[M+H]^+$, calculated 171.1168, found 171.1166.

cis-8: $\mathbf{R_f}$ = 0.43 (*c*-Hex:EtOAc = 2:1); **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 7.36-7.27 (m, 4H), 7.23-7.17 (m, 1H), 6.47 (d, *J* = 15.8 Hz, 1H), 6.16 (d, *J* = 15.8 Hz, 1H), 3.87 (dd, *J* = 11.5, 5.0 Hz, 1H), 3.64 (dd, *J* = 11.3, 8.8 Hz, 1H), 1.38 (s, 3H), 1.37-1.33 (m, 1H), 0.97 (dd, *J* = 8.8, 4.8 Hz, 1H), 0.79 (t, *J* = 5.3 Hz, 1H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 137.5, 133.0, 129.0, 128.5 (2C), 126.9, 125.8 (2C), 63.6, 30.1, 23.6, 22.4, 19.7.

Synthesis and characterization of epoxide 7i and cyclopropane 10

Alkyne SI-4



SI-4

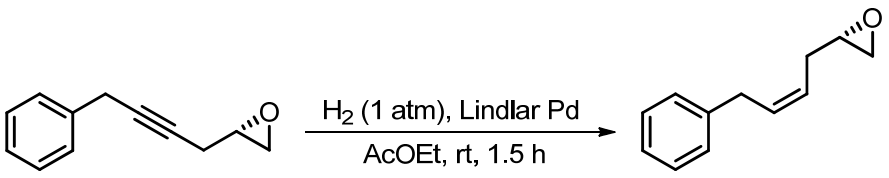
To a stirred solution of (3-phenylprop-1-ynyl)lithium[1] (267 mg, 2.19 mmol, 1 eq.) in dry THF (10.9 mL) under argon atmosphere at –78°C was added slowly (*S*)-(+)-epichlorhydrin (171 µL, 2.19 mmol, 1.0 eq.). The solution was allowed to warm slowly to rt. After 16 h, the reaction was quenched with an aqueous saturated NH_4Cl solution and extracted 3 times with Et_2O. The organic phases were dried with anhydrous $MgSO_4$, filtered and concentrated under

[1]A. Maercker, J. Fischenich, *Tetrahedron* 1995, **51**, 10209-10218.

reduced pressure. The crude product was purified by flash column chromatography (SiO_2, *n*-Pentane:Et_2O = 10:1). Highly volatile **SI-4** (75.2 mg, 437 µmol, 20 %) was isolated as yellow oil in a *n*-pentane:Et_2O solution.

R_f = 0.21 (*c*-Hex:AcOEt = 20:1); **$[\alpha]_D^{20}$** = –1.3 (Et_2O, c = 0.96); **IR** ($\tilde{\nu}$ / cm^{-1}) = 3459, 2960, 1714, 1643, 1360, 1094; **^{1}H-NMR** (500 MHz, $CDCl_3$): δ 7.29-7.22 (m, 4H), 7.16 (m, 1H), 3.52 (t, *J* = 2.3 Hz, 2H), 3.05 (m, 1H), 2.72 (dd, *J* = 4.7, 4.0 Hz, 1H), 2.61 (dd, *J* = 4.7, 2.5 Hz, 1H), 2.59 (ddt, *J* = 17.1, 4.5, 2.4 Hz, 1H), 2.59 (ddt, *J* = 17.1, 5.0, 2.5 Hz, 1H); **^{13}C-NMR** (125 MHz, $CDCl_3$): δ 137.1, 128.6 (2C), 127.9 (2C), 126.6, 80.3, 76.6, 50.3, 46.5, 25.2, 22.7, **HRMS** (ESI): *m/z* for $C_{12}H_{13}O$ $[M+H]^+$, calculated 173.0957, found 173.0961.

Epoxide 7i

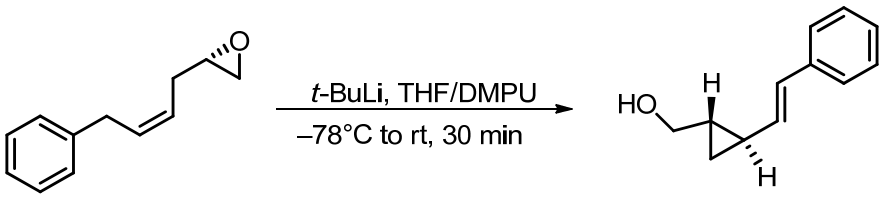


SI-4 **7i**

To a stirred solution of **SI-4** (10 mg, 59.2 µmol, 1.0 equiv.) in AcOEt (0.67 mL) under argon atmosphere was added Lindlar Pd (1.7 mg). The solution was put under H_2 atmosphere through a quadruple cycle vacuum/H_2 atmosphere. After 1.5 h of stirring at rt, the solution was filtered under celite, washed with Et_2O and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, *n*-pentane:Et_2O = 10:1). Highly volatile **7i** (5.0 mg, 28.7 µmol, 48%) was isolated as colorless liquid in a *n*-pentane:Et_2O solution.

R_f = 0.59 (*c*-Hex:AcOEt = 5:1); **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 7.28 (m, 2H), 7.20 (m, 3H), 5.74 (m, 1H), 5.57 (m, 1H), 3.42 (d, *J* = 7.5 Hz, 2H), 3.01 (m, 1H), 2.77 (dd, *J* = 4.8, 4.3 Hz, 1H), 2.54 (dd, *J* = 4.8, 2.8 Hz, 1H), 2.49 (m, 1H), 2.43 (m, 1H); **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 140.6, 131.4 (2C), 128.6 (2C), 128.5, 127.2 (2C), 51.7, 46.8, 34.3, 33.7.

Cyclopropane 10



7i **10**

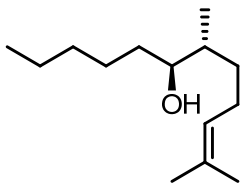
To a stirred solution of **7i** (7.2 mg, 41.3 µmol, 1.0 eq.) in a dry mixture THF/DMPU (6/1, 0.21 mL) under argon atmosphere at –78°C was added *t*-BuLi (1.6 M in *n*-pentane, 31.0 µL, 49.6 µmol, 1.2 equiv.). After 30 min of stirring at –78°C, the solution was quenched with an aqueous saturated NH_4Cl-solution and extracted 3 times with Et_2O. The organic phases were dried with anhydrous $MgSO_4$, filtered and concentrated under reduced pressure. The crude product was purified by flash column chromatography (SiO_2, *n*-pentane:Et_2O = 5:1 to 1:1). cyclopropane **10** (5.3 mg, 30.4 µmol, 74%, *d.r.* = 6:1) was isolated as colorless oil.
R_f = 0.45 (*c*-Hex:AcOEt = 2:1); **$[\alpha]_D^{20}$** = +45.1 ($CHCl_3$, c = 0.37); **^{1}H-NMR** (400 MHz, $CDCl_3$): δ 7.32-7.17 (m, 5H), 6.47 (d, *J* = 15.7 Hz, 1H), 5.80 (dd, *J* = 15.7, 8.8 Hz, 1H), 3.57 (d, *J* = 7.0 Hz, 2H), 1.55-1.47 (m, 1H), 1.32-1.25 (m, 1H), 0.80 (t, *J* = 7.0 Hz, 2H), OH-proton is missing; **^{13}C-NMR** (100 MHz, $CDCl_3$): δ 137.4, 132.7, 128.4 (2C), 128.0, 126.7 (2C), 125.6, 66.2, 23.4, 20.3, 12.1.

The analytical data (^{1}H-NMR, ^{13}C-NMR, $[\alpha]_D^{20}$) of compound **10** match with previously published results according to *Charette et al*.[2] However, the absolute configuration of the cyclopropane clearly depends on the regioselective epichlorhydrin opening. In our case, we expect in the first step an epoxide opening, followed by an intramolecular chlorine displacement.

[2] A. B. Charette, C. Molinaro and C. Brochu, *J. Am. Chem. Soc.* 2001, **123**, 12168-12175.

VI. Synthesis of (–)-*cis*-aerangis lactone (12)

Alcohol 11

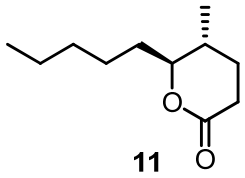


11

To a stirred suspension of CuCN (17.9 mg, 0.20 mmol, 20 mol%) and epoxide *ent*-**7h** (154 mg, 1.00 mmol, 1.0 eq.) in THF (1.4 mL) at −30 °C under Argon was added und dropwise *n*-BuLi (1.26 mL, 1.6 M in n-hexane, 2.00 mmol, 2.0 eq.). The reaction mixture was stirred for 5 h, allowed to warm to RT and quenched with aqueous saturated NH_4Cl solution. The layers were separated and the organic phase was extracted with EtOAc (3 ×10 mL). The combined organic layers were dried over $MgSO_4$ and the solvents removed under reduced pressure. The crude product was purified by flash column chromatography (*n*-pentane:EtOAc = 220:1) and the desired alcohol **11** (152 mg, 0.72 mmol, 72%) was obtained as a slightly yellow oil.

$\mathbf{R}_f$ = 0.29 (*n*-pentane:EtOAc = 15:1); $\mathbf{[\alpha]_D^{20}}$ = −5.9 ($CHCl_3$, c = 1.04); **IR** ($\tilde{\nu}$ / cm^{-1}): 828, 943, 983, 1013, 1082, 1118, 1378, 1458, 2857, 2928, 2959, 3377; **^{1}H-NMR** (500 MHz, $CDCl_3$) δ 5.07 - 5.12 (m, 1 H), 3.47 - 3.51 (m, 1 H), 1.91 - 2.08 (m, 2 H), 1.68 (s, 3 H), 1.60 (s, 3 H), 1.37 - 1.53 (m, 6 H), 1.25 - 1.36 (m, 5 H), 1.16 - 1.25 (m, 1 H), 0.85 - 0.92 (m, 6 H); **^{13}C-NMR** (125 MHz, $CDCl_3$) δ 131.3, 124.6, 75.0, 37.7, 34.4, 33.4, 31.9, 25.9, 25.7, 25.6, 22.6, 17.6, 14.0, 13.5; **HRMS** (ESI): *m/z* for $C_{14}H_{29}O$ $[M+H]^+$, calculated 213.2213, found 213.2213.

(–)-*cis*-aerangis lactone (12)



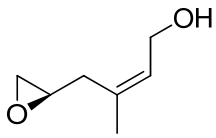
11

Ozone was bubbled through a stirred solution of alcohol **9** (250 mg, 1.18 mmol, 1.0 eq.) in CH_2Cl_2 (45 mL) at -78°C until a blue colour appeared. Subsequently, air was blown through the mixture until the blue colour disappeared. PPh_3 (926 mg, 3.53 mmol, 3.0 eq.) was added, the solution was allowed to warm to rt and stirred for 2 h. The solvent was removed under

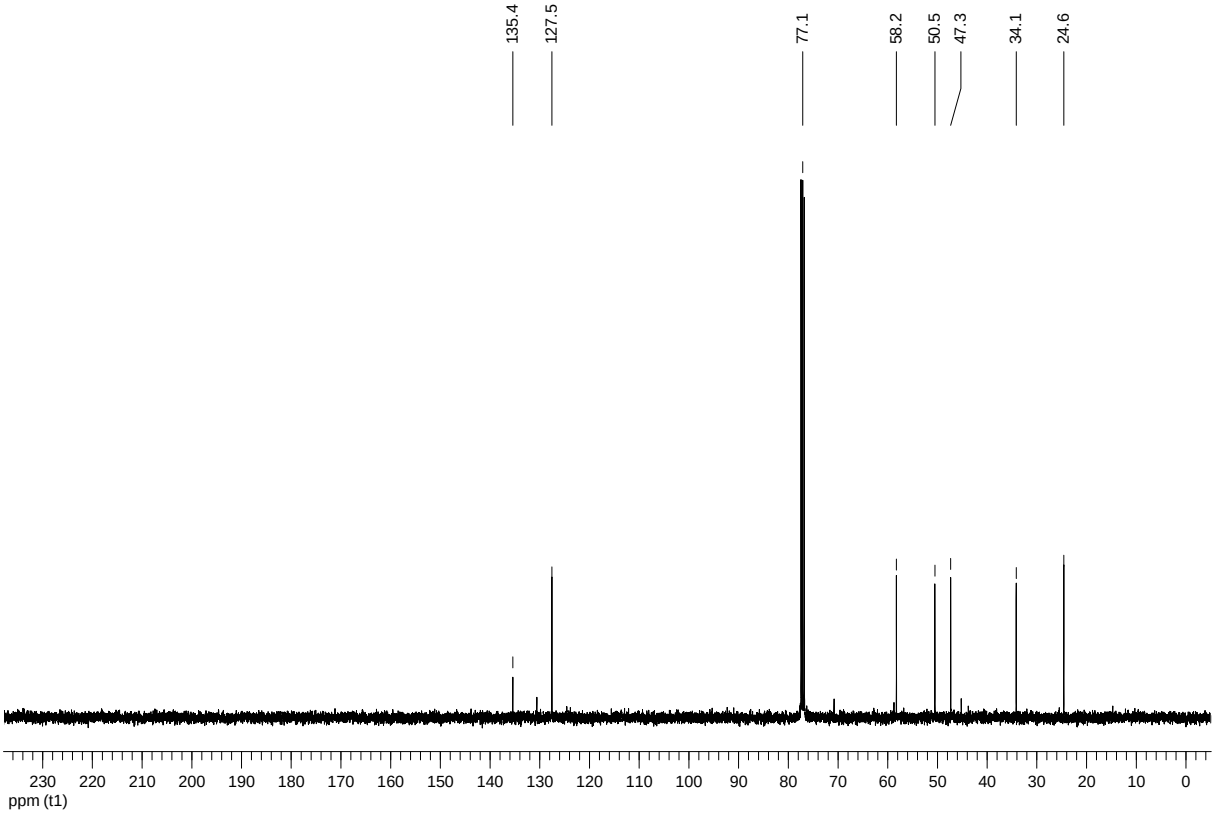
reduced pressure. The crude product was filtrated over SiO_2 (rinsed with *n*-pentane:Et_2O = 15:1) and used in the next step without further purification.

To a stirred solution of IBX (602 mg, 2.15 mmol, 2.6 eq.) in DMSO (4.3 mL) was added a solution of the crude lactole (not shown) DMSO (1.0 mL). After 1 h of stirring at rt the reaction was cooled to 0 °C and quenched by the addition of H_2O. The white solid was filtered and washed with Et_2O (3 × 10 mL). The layers were separated, the aqueous phase extracted with Et_2O (3 × 10 mL) and the combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the crude product purified by flash column chromatography (*n*-pentane:EtOAc = 5:1), yielding (–)-*cis*-aerangis lactone (**12**) (87 mg, 0.48 mmol, 41% over two steps) as a light yellow oil.

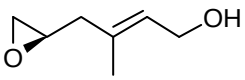
R_f = 0.30 (*n*-pentane:EtOAc = 5:1); **$[\alpha]_D^{20}$** = −57.8 ($CHCl_3$, c = 1.0); **IR** ($\tilde{\nu}$ / cm^{-1}): 732, 909, 995, 1070, 1097, 1123, 1204, 1244, 1344, 1380, 1462, 1735, 2872, 2934, 3465; **^{1}H-NMR** (500 MHz, $CDCl_3$) δ 4.25 (ddd, *J* = 8.6, 4.4, 3.1 Hz, 1 H), 2.50 (t, *J* = 7.3 Hz, 2 H), 1.94 - 2.05 (m, 2 H), 1.58 - 1.68 (m, 2 H), 1.41 - 1.55 (m, 2 H), 1.22 - 1.34 (m, 5 H), 0.93 (d, *J* = 6.9 Hz, 3 H), 0.86 (t, *J* = 6.7 Hz, 3 H); **^{13}C-NMR** (125 MHz, $CDCl_3$) δ 172.0, 82.9, 31.8, 31.5, 29.2, 26.6, 25.9, 25.1, 22.4, 13.9, 12.3; **HRMS** (ESI): *m/z* for $C_{11}H_{20}O_2$ $[M+H]^+$, calculated 184.1463, found 184.1462.



7a

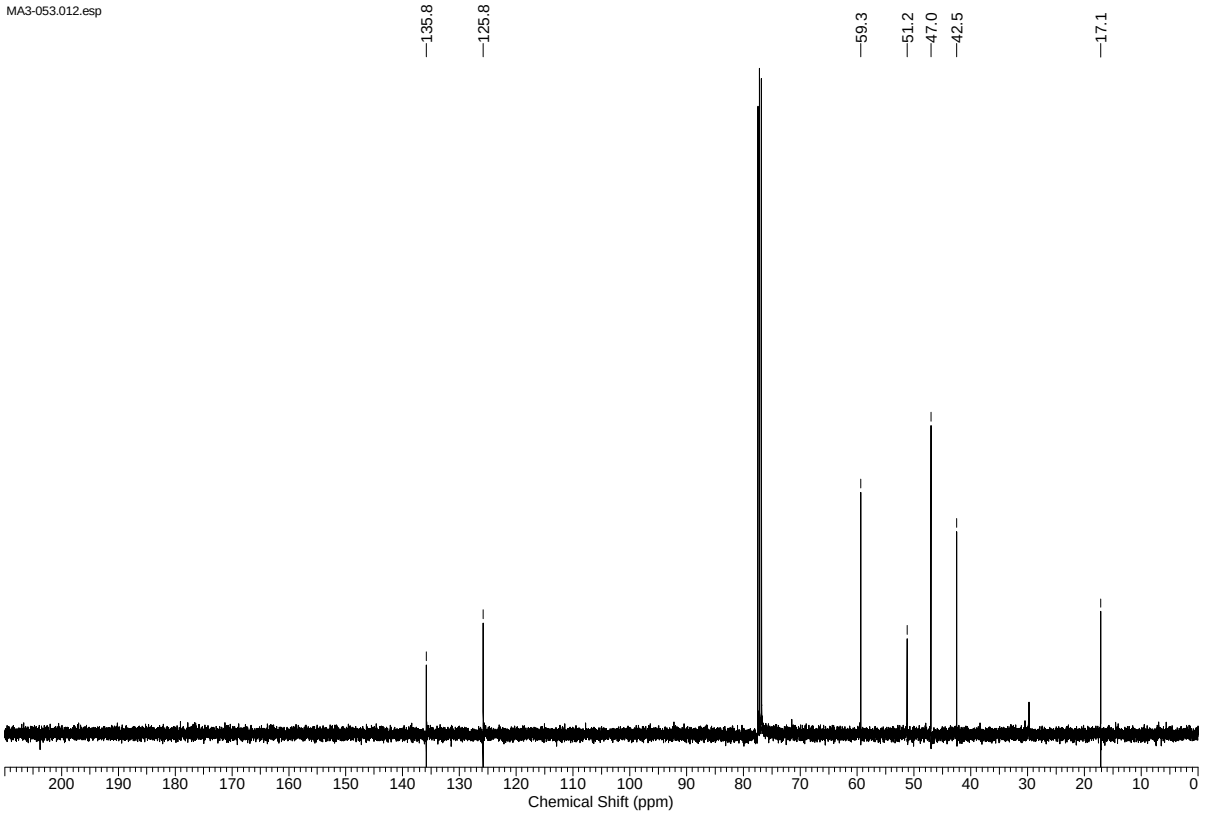


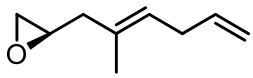
MA3-053.011.esp



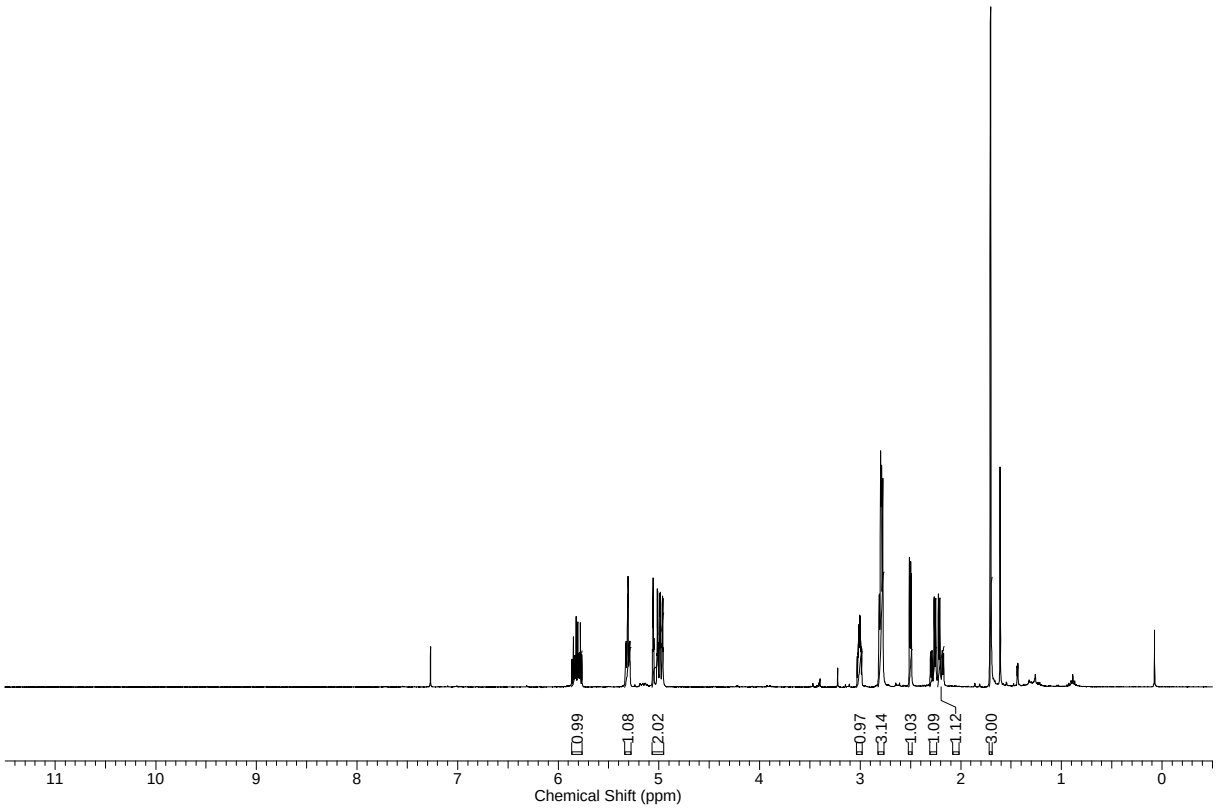
7b

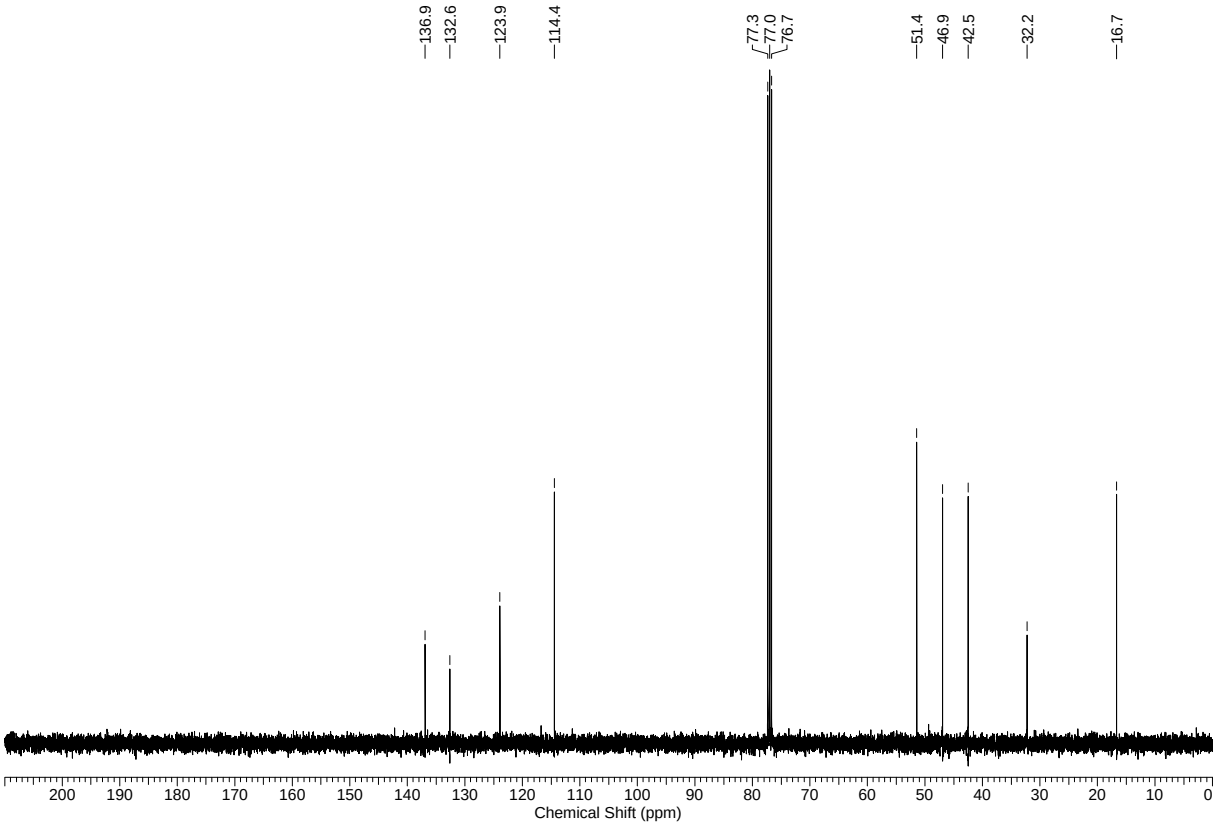
MA3-053.012.esp



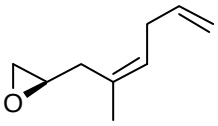


7c



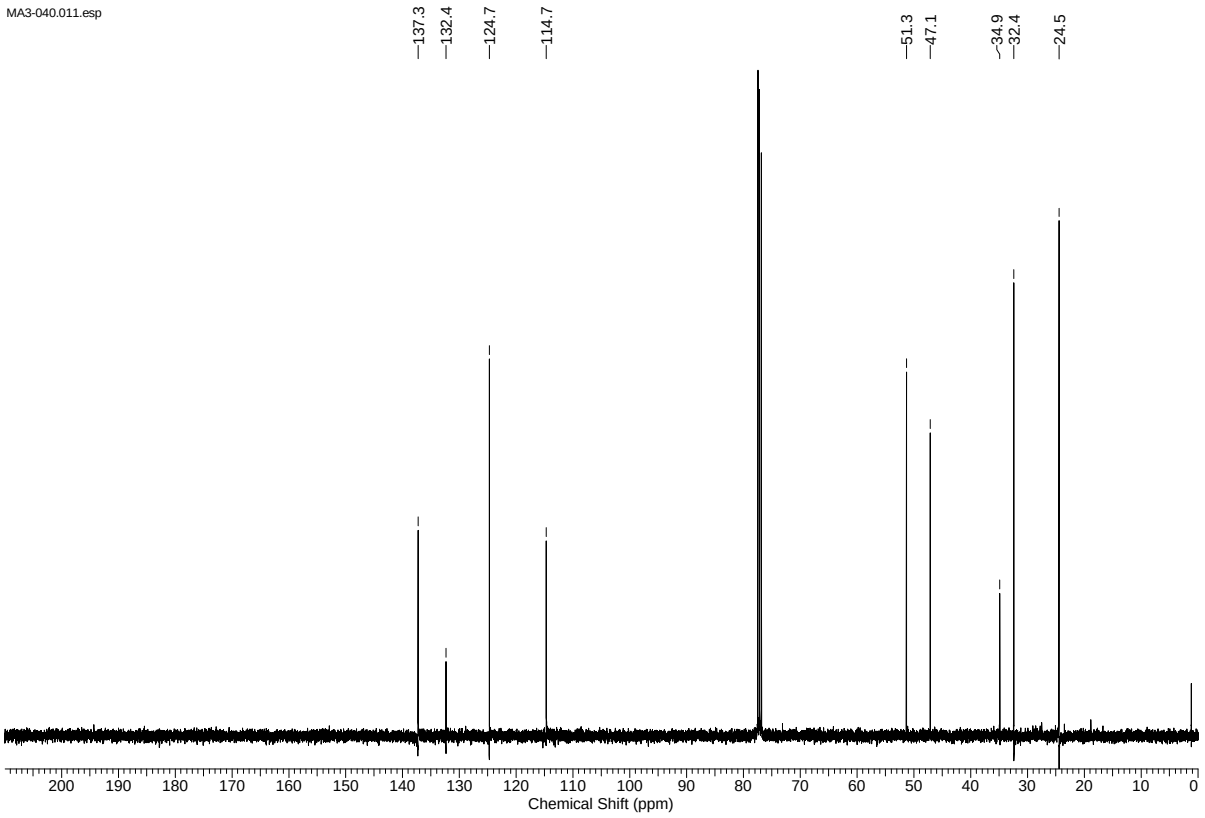


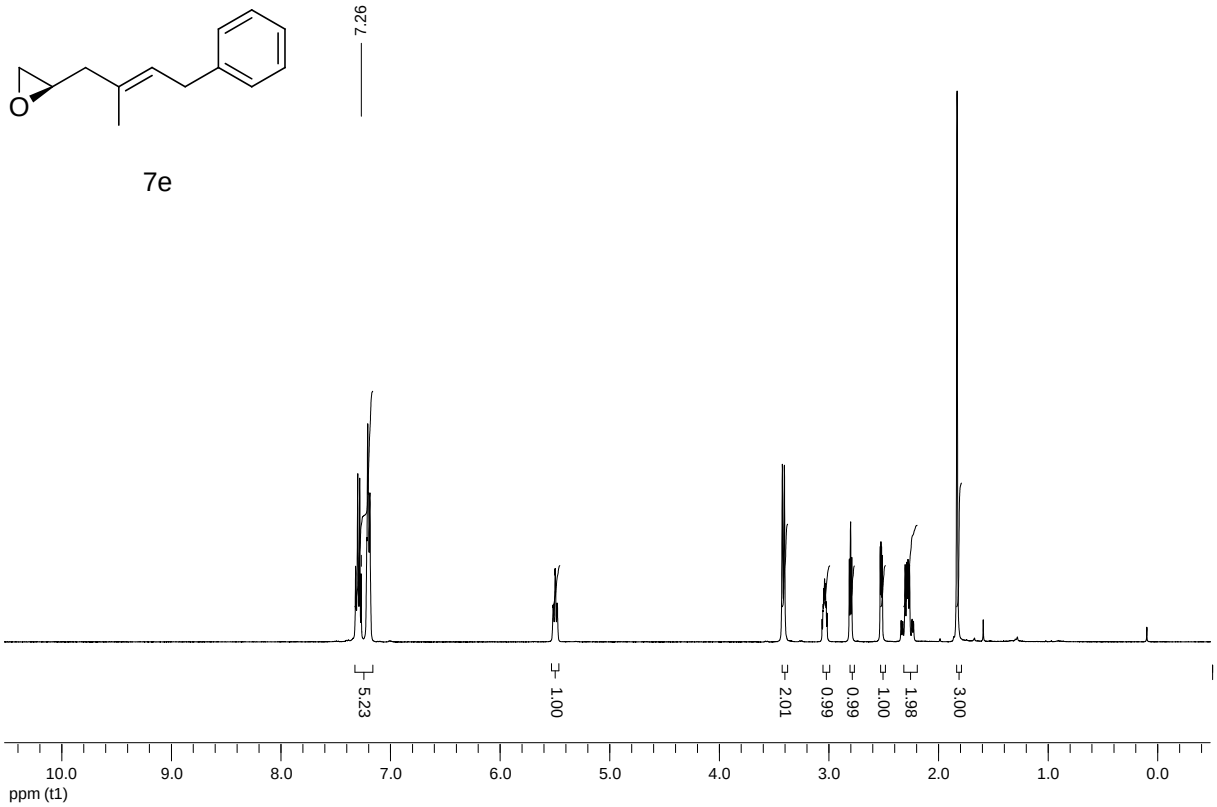
MA3-040.010.esp



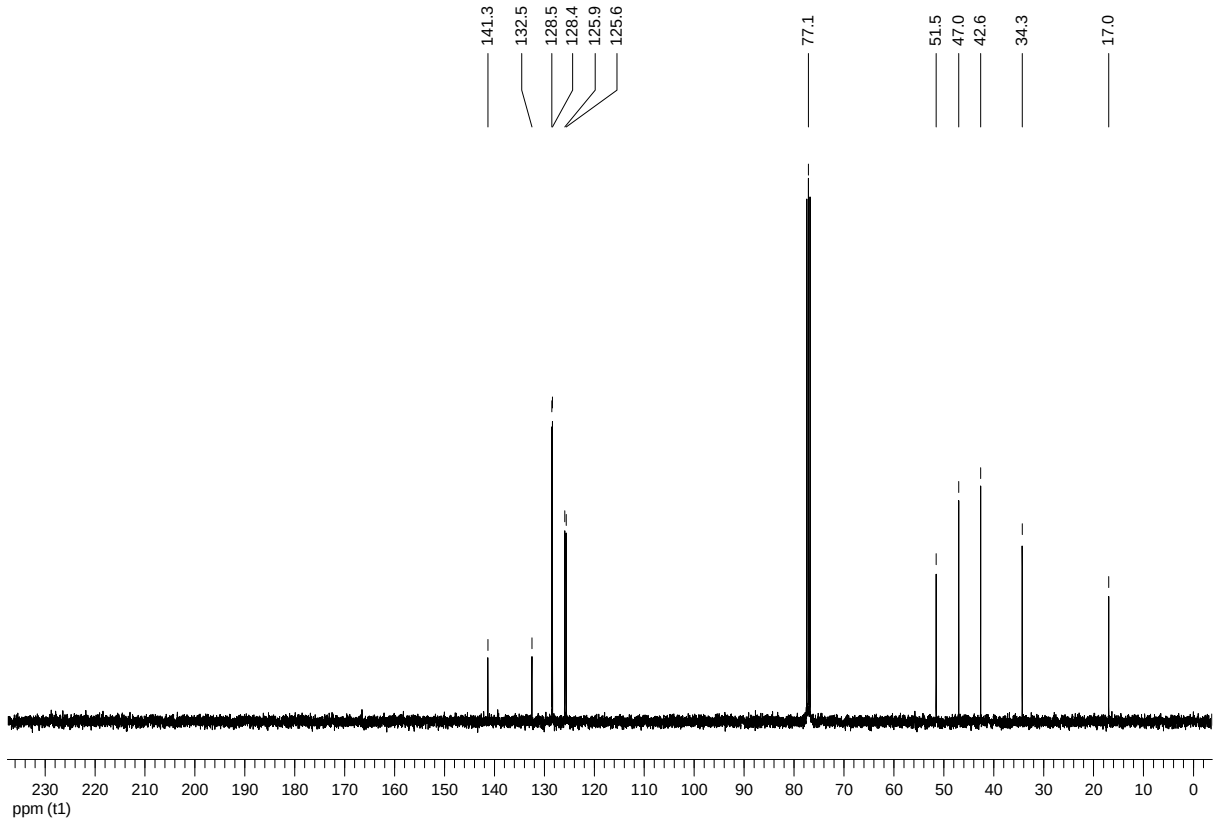
7d

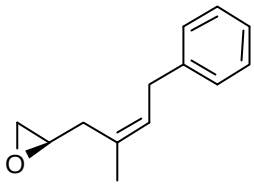
MA3-040.011.esp



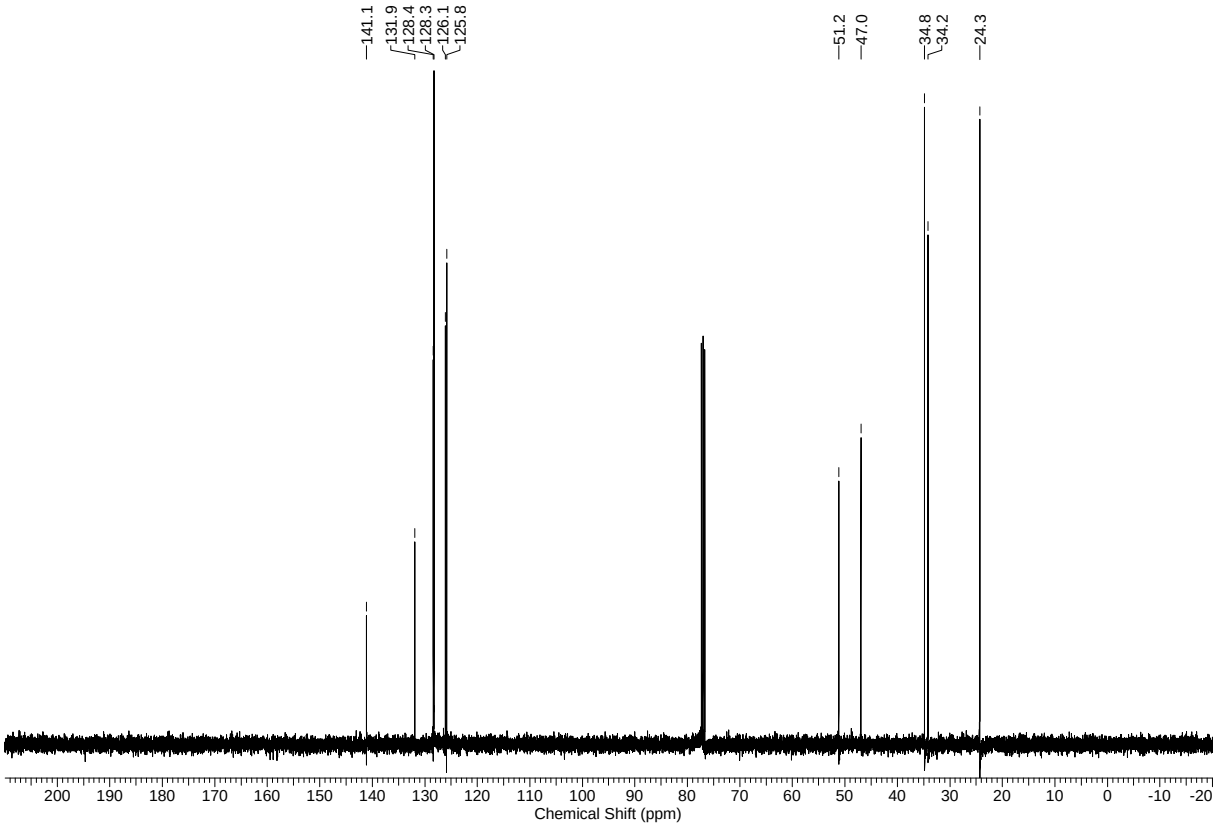


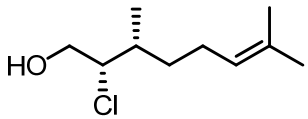
7e



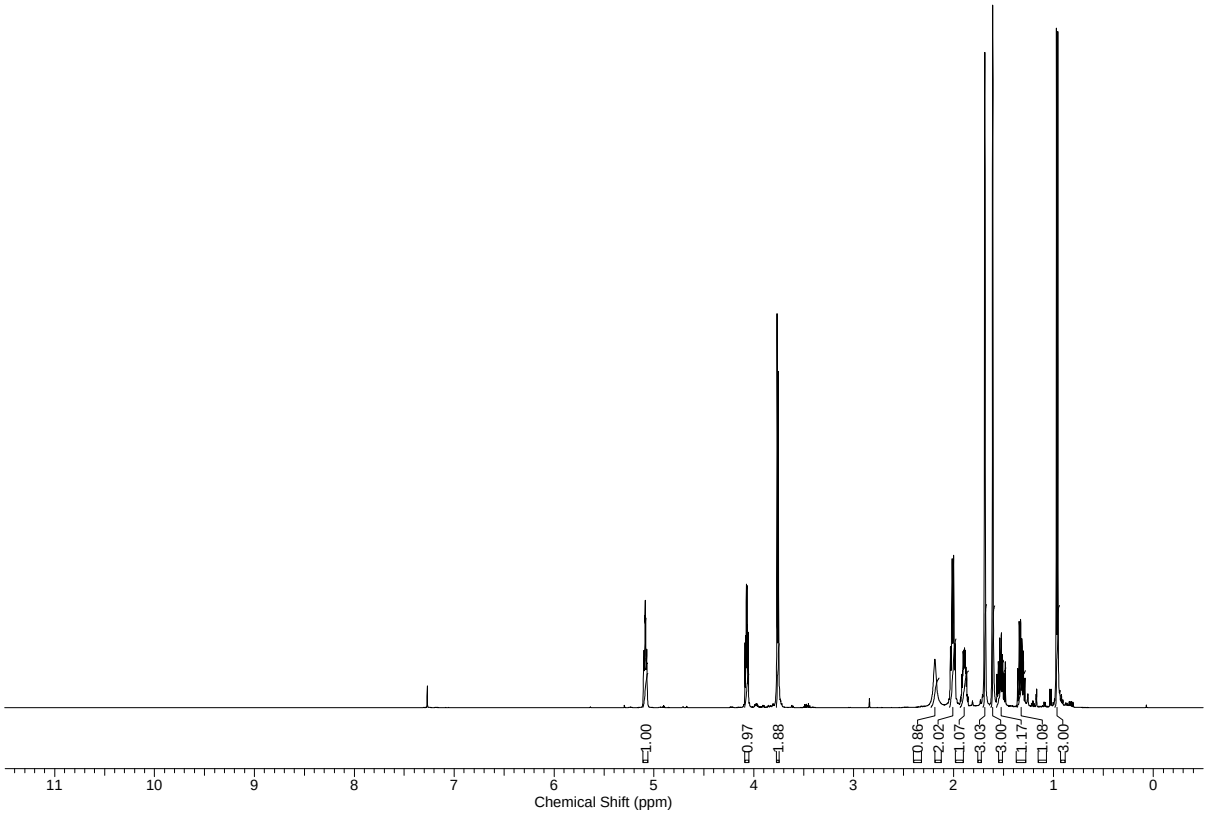


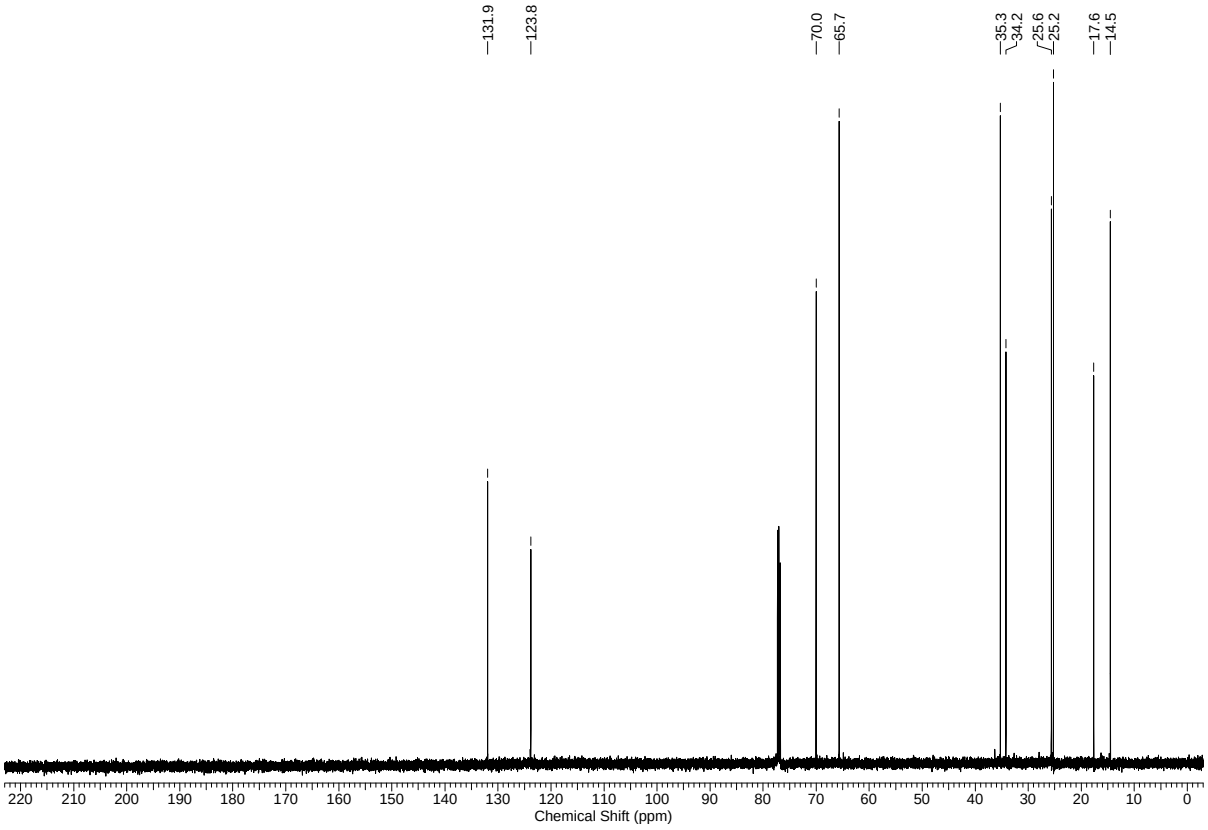
7f

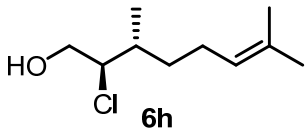




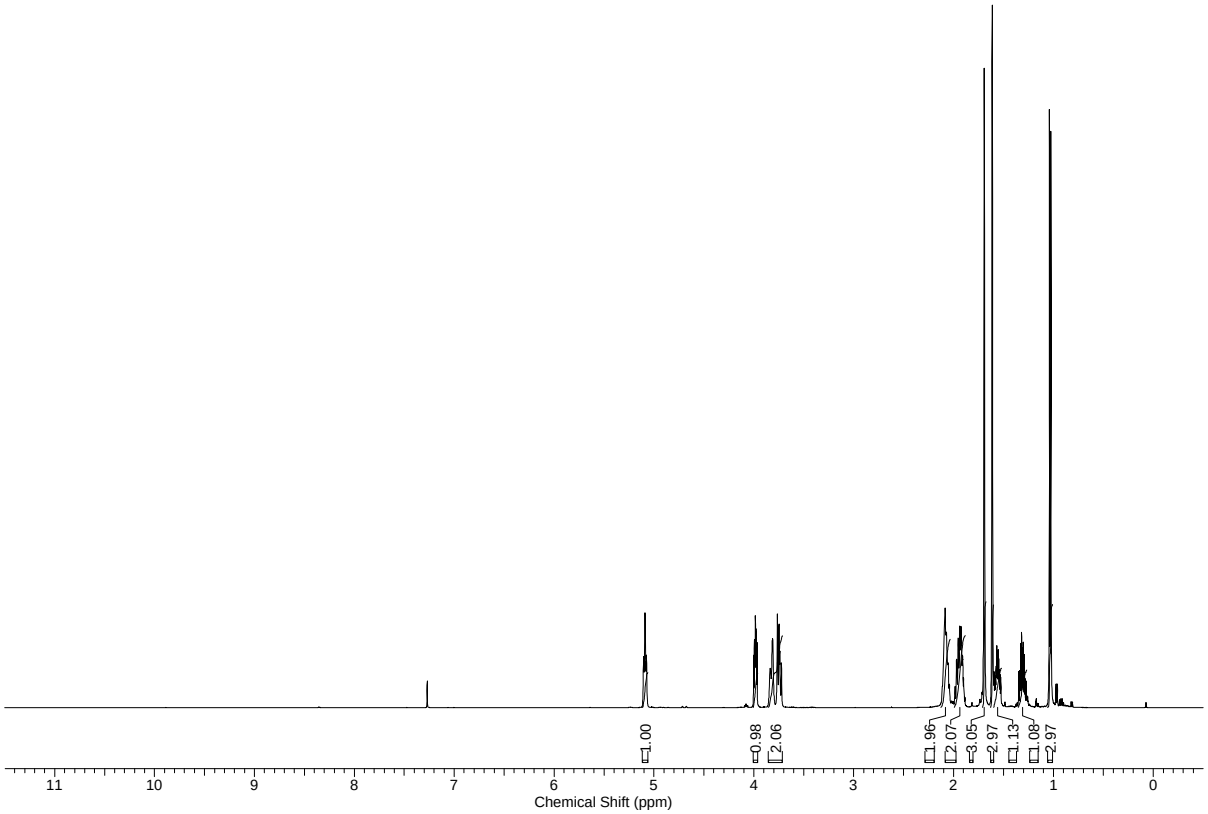
6g

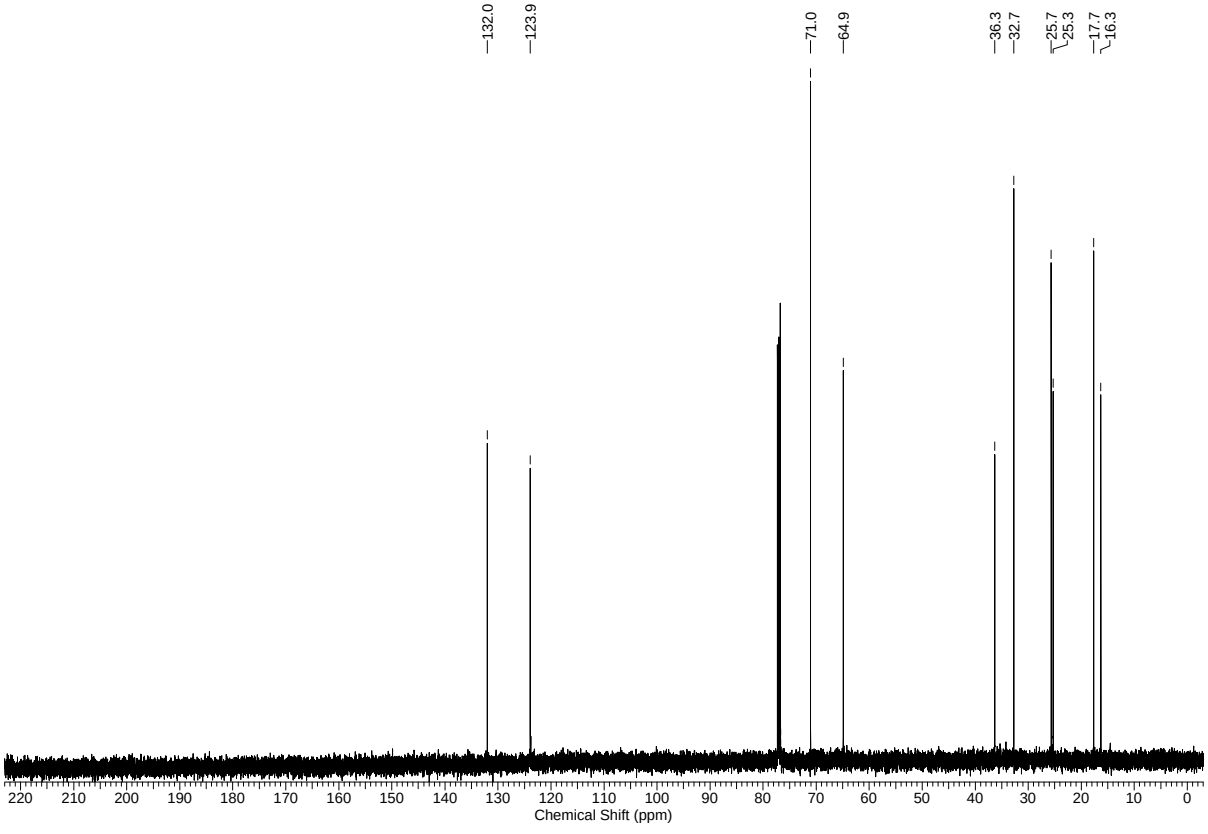


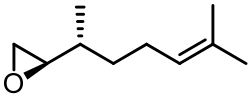




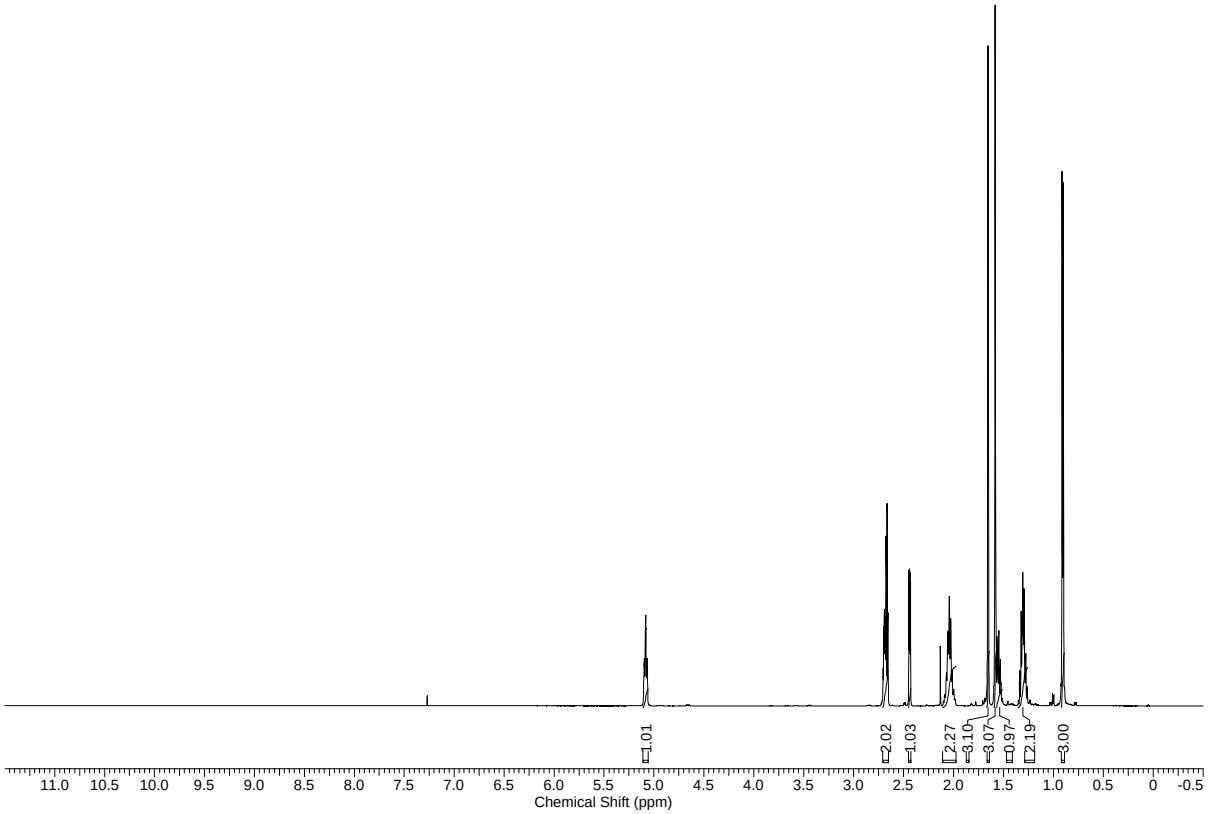
6h

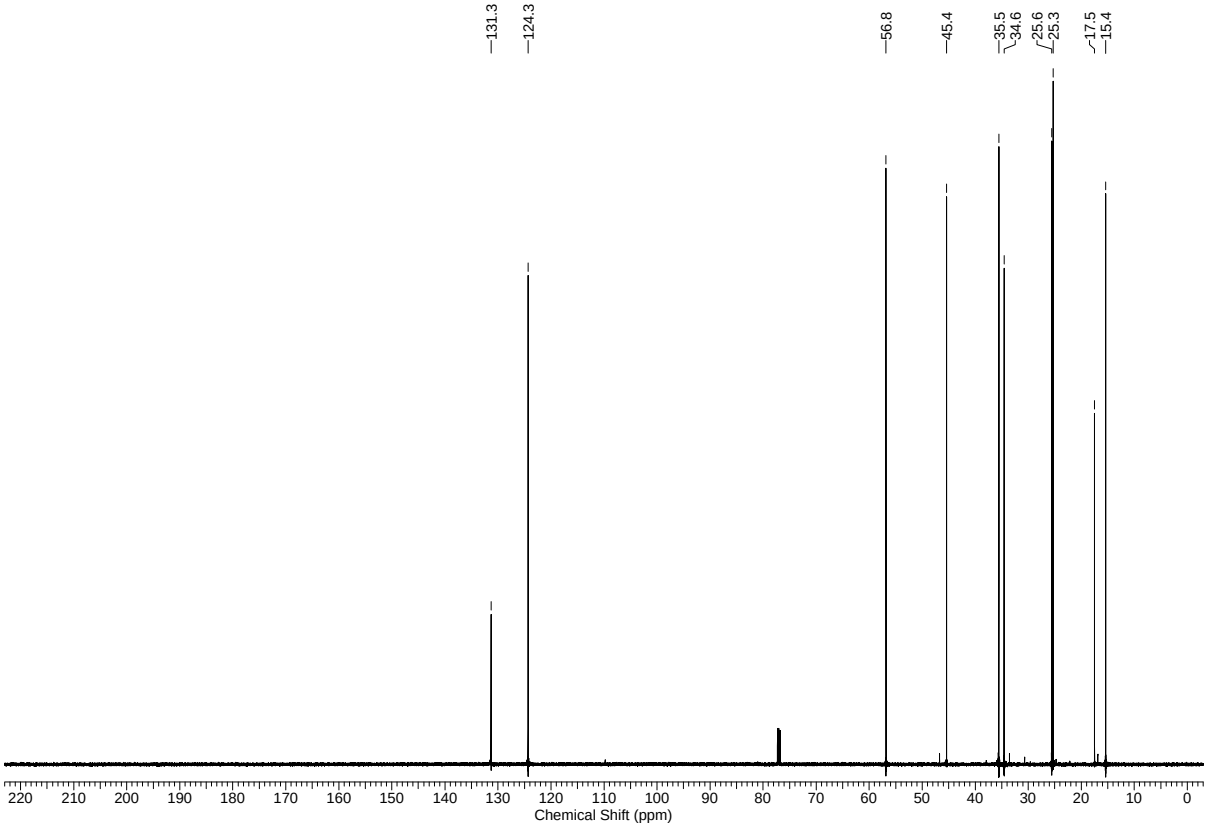


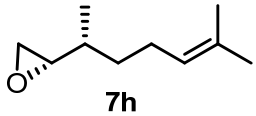




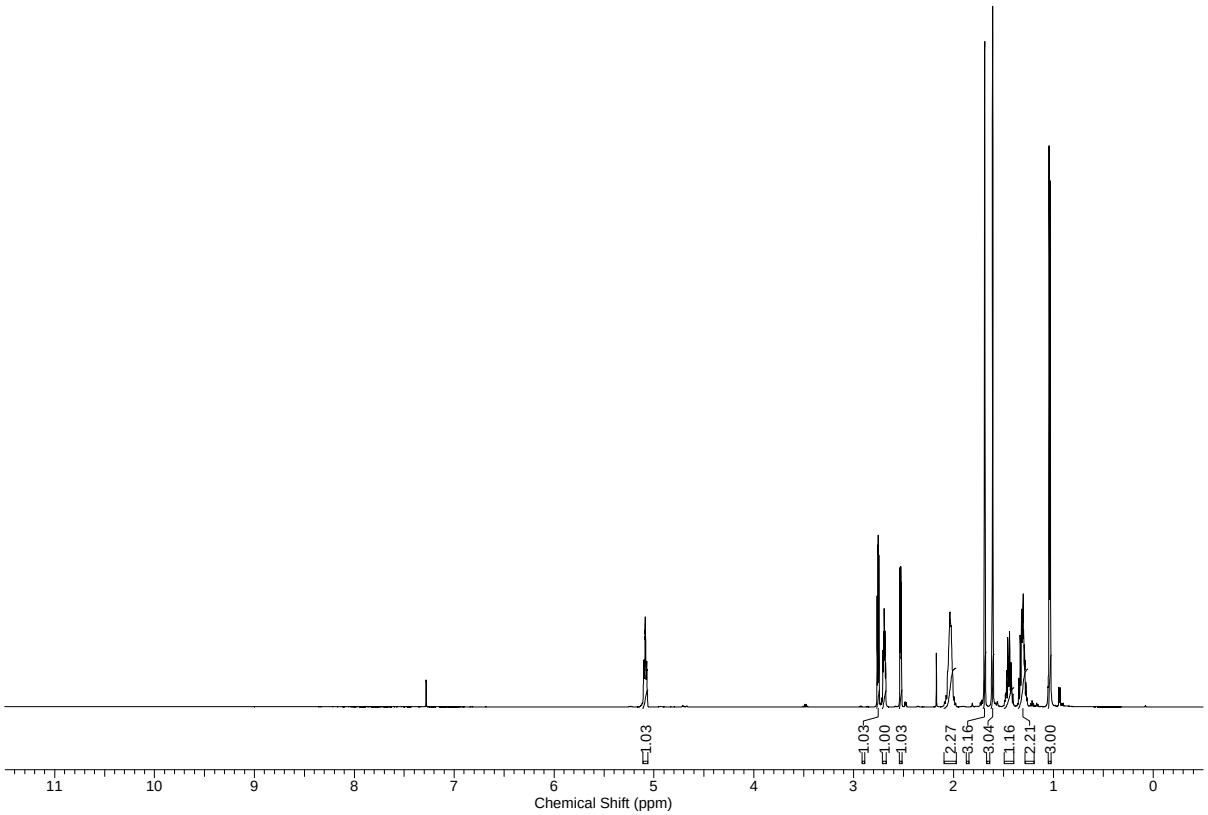
7g

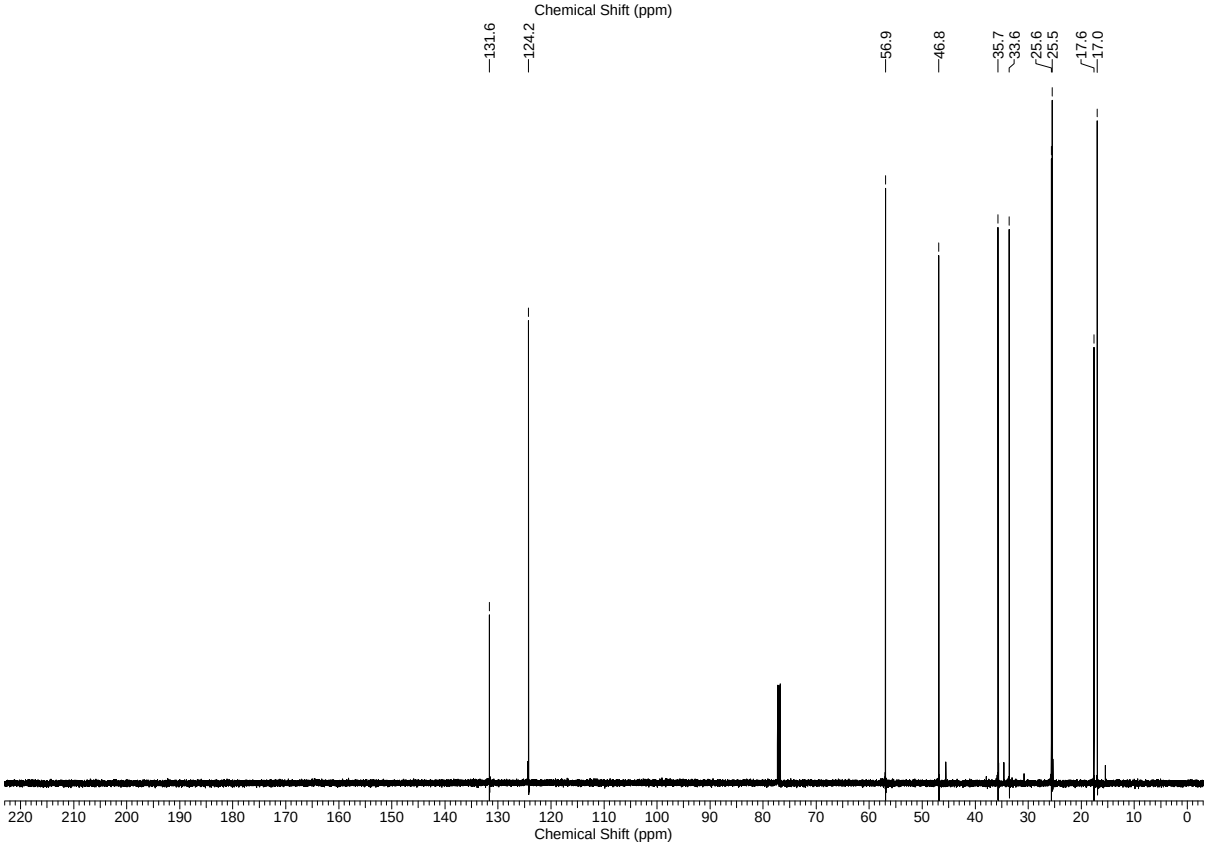

1.01
2.02
1.03
2.27
3.10
3.07
0.97
2.19
3.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0 -0.5
Chemical Shift (ppm)


131.3
124.3
56.8
45.4
35.5
34.6
25.6
25.3
17.5
15.4
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
Chemical Shift (ppm)

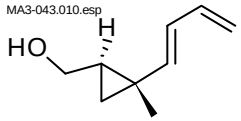


7h



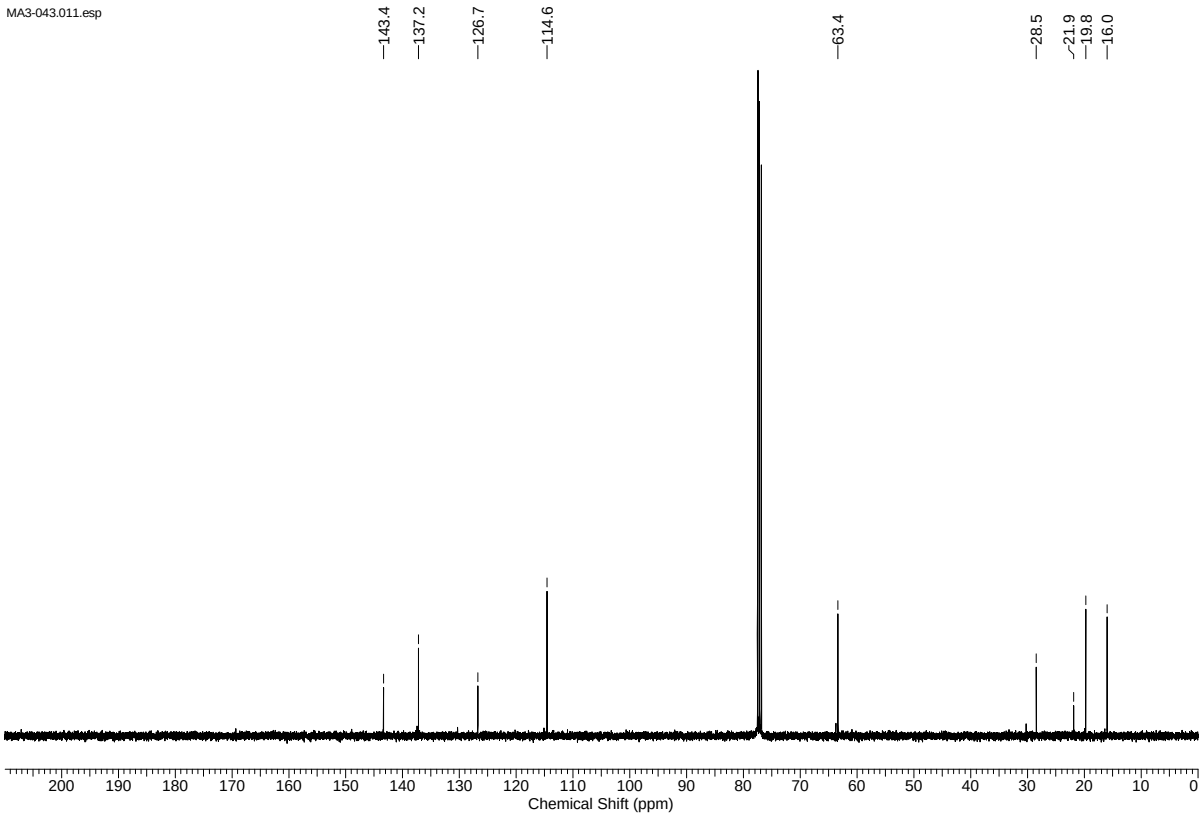


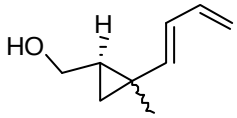
MA3-043.010.esp



***trans*-8**

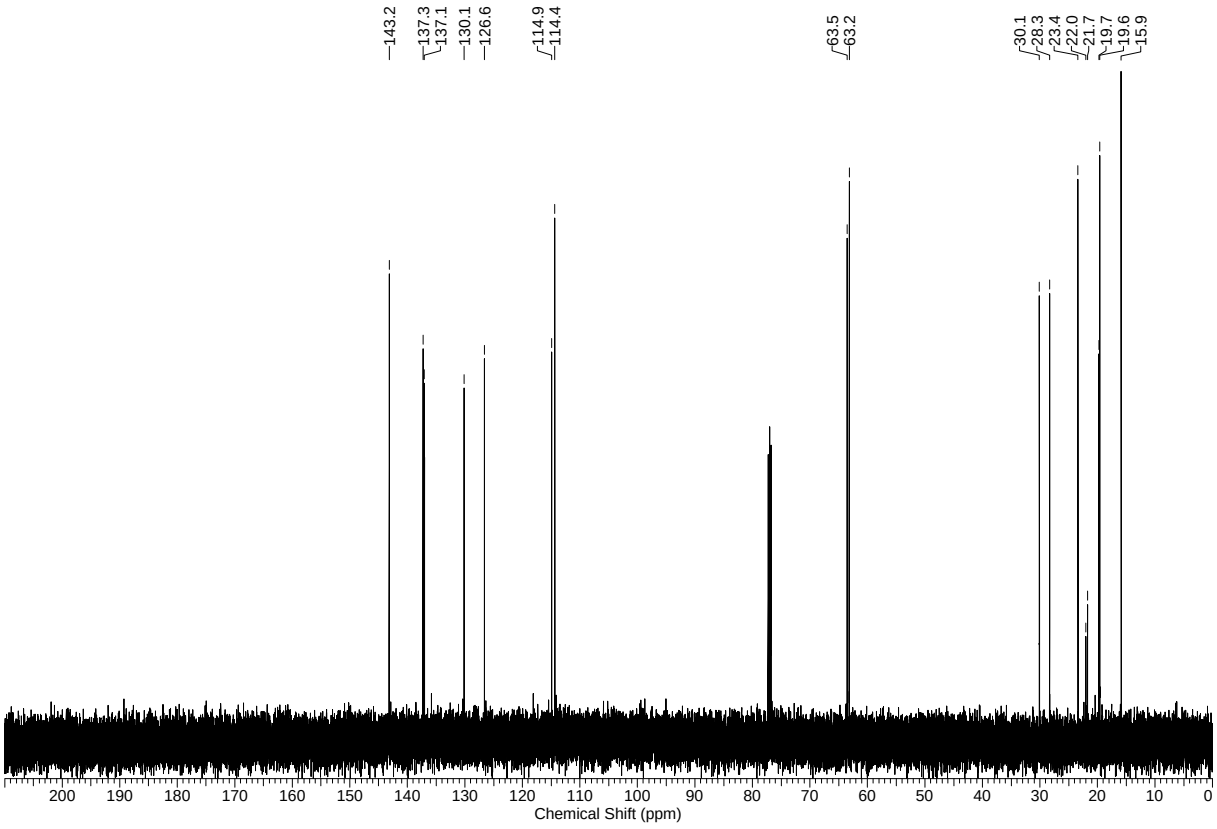
MA3-043.011.esp

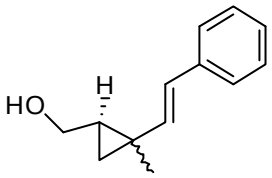



HO
H

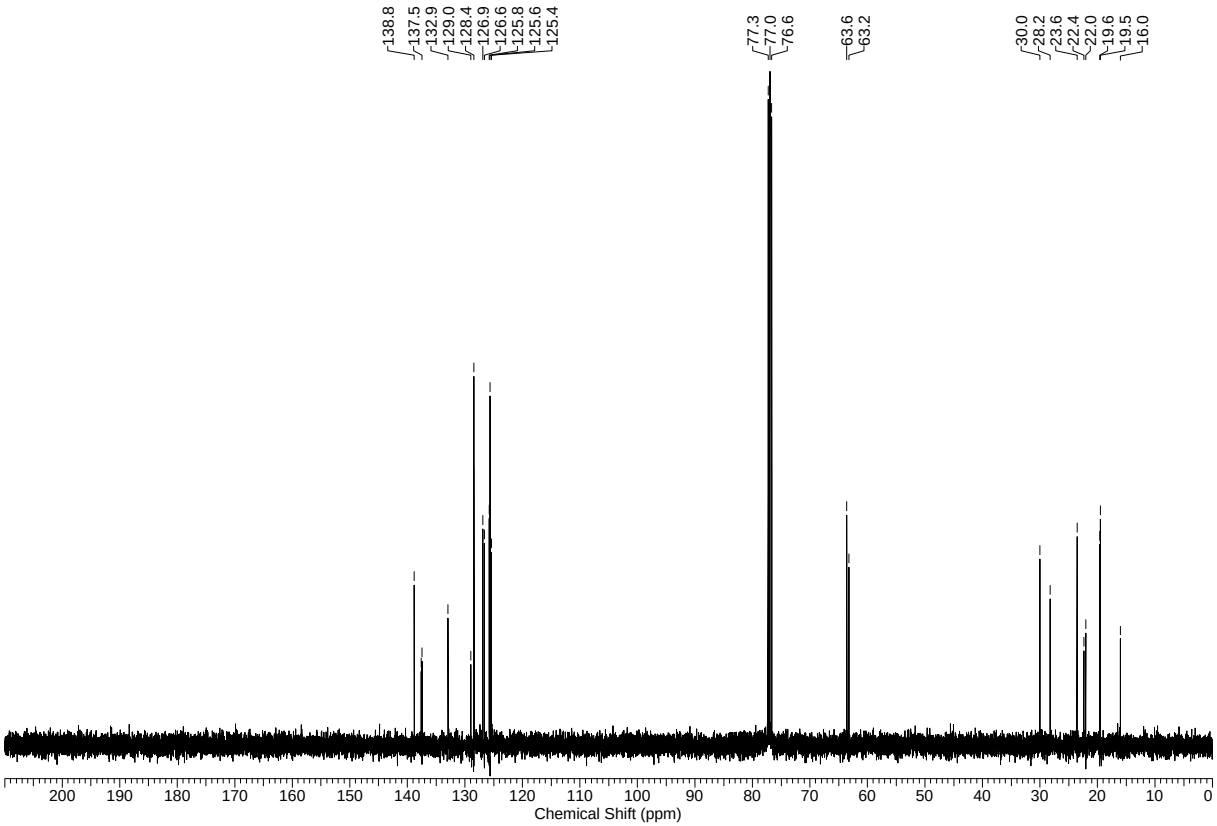
8

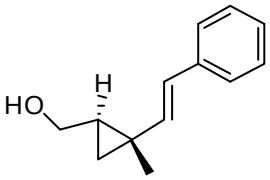
1.96
1.03
0.83
1.00
1.84
1.85
0.86
7.65
1.96
1.03
11
10
9
8
7
6
5
4
3
2
1
0
Chemical Shift (ppm)


143.2
137.3
137.1
130.1
126.6
114.9
114.4
63.5
63.2
30.1
28.3
23.4
22.0
21.7
19.7
19.6
15.9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)

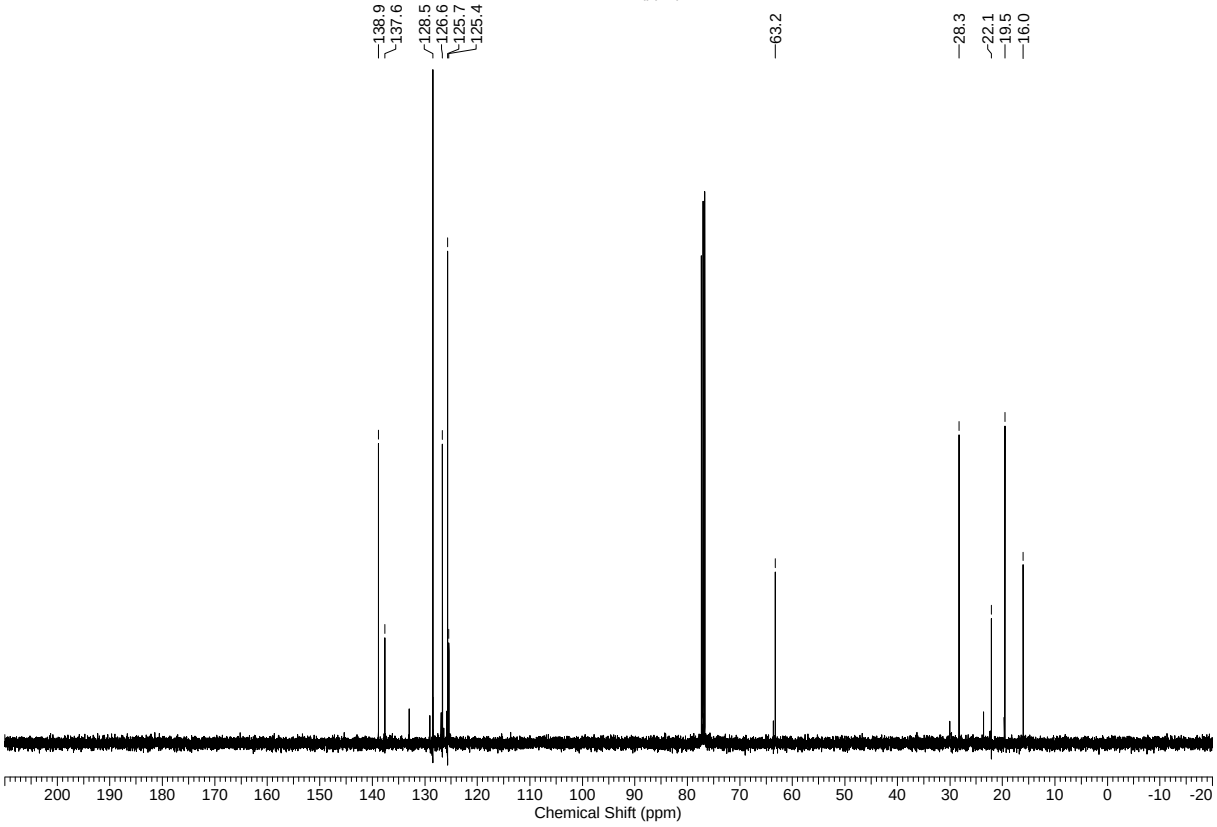


9

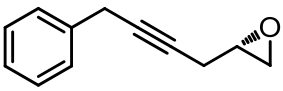




***trans*-9**

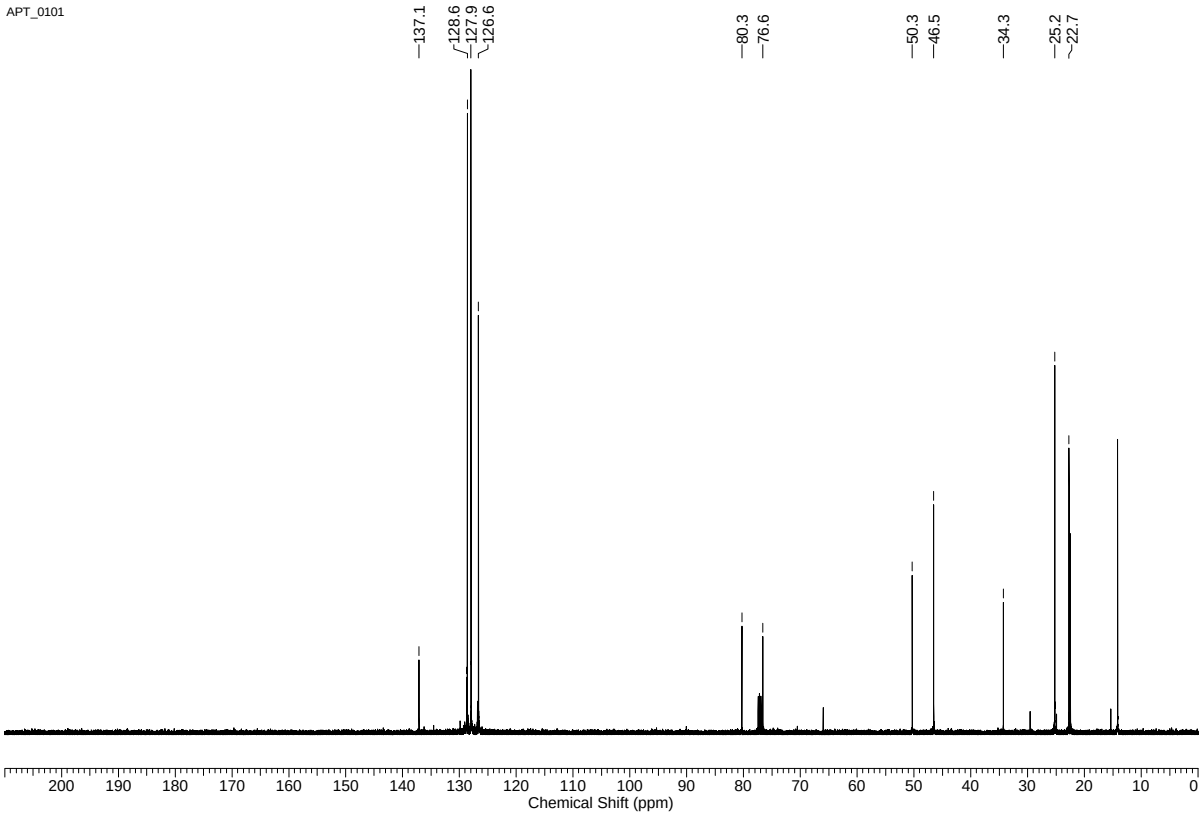


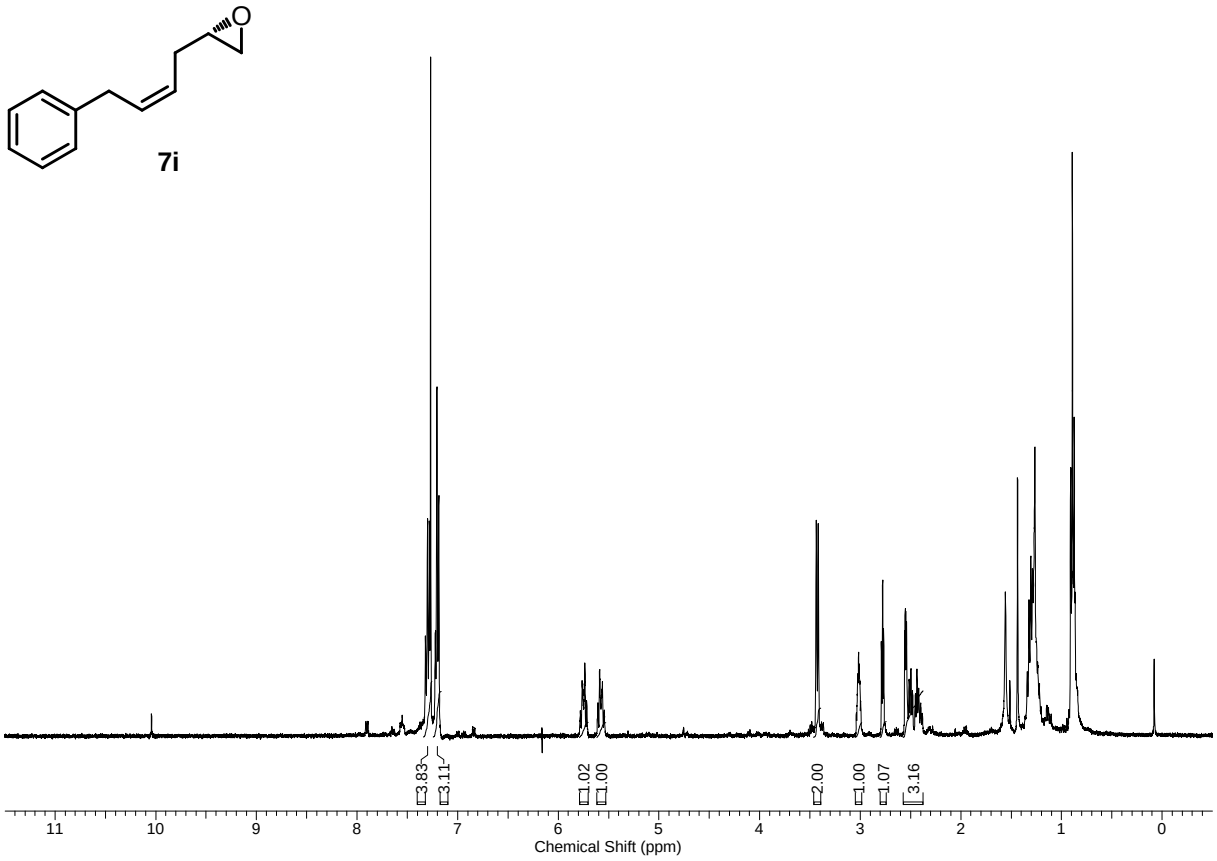
PROTON_0101

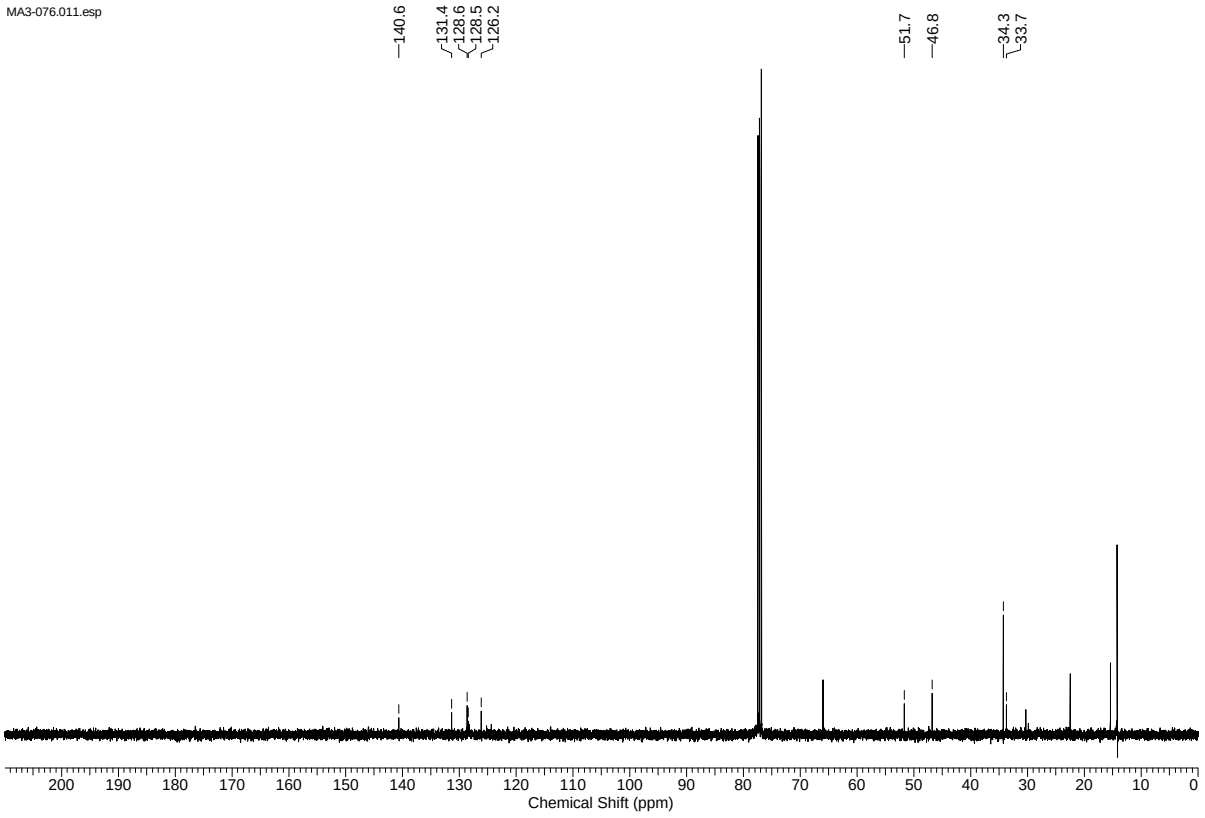


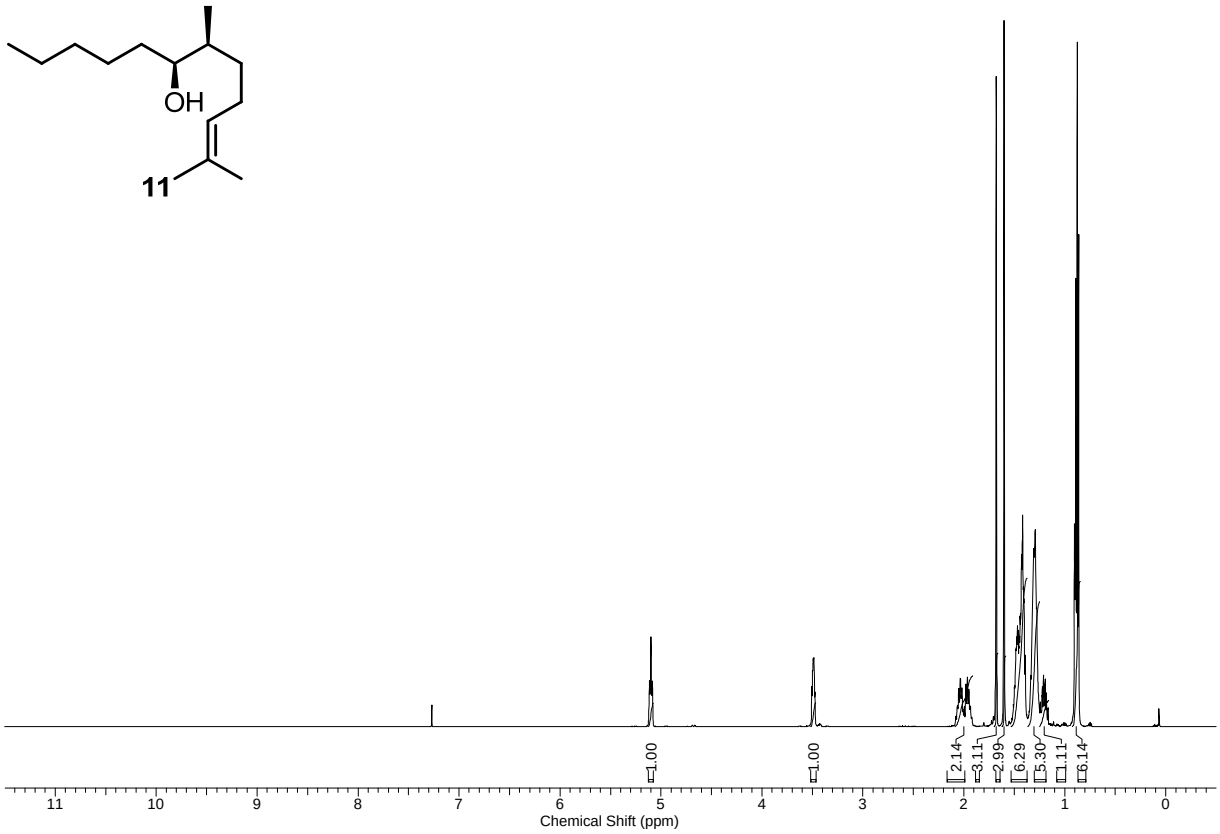
SI-4

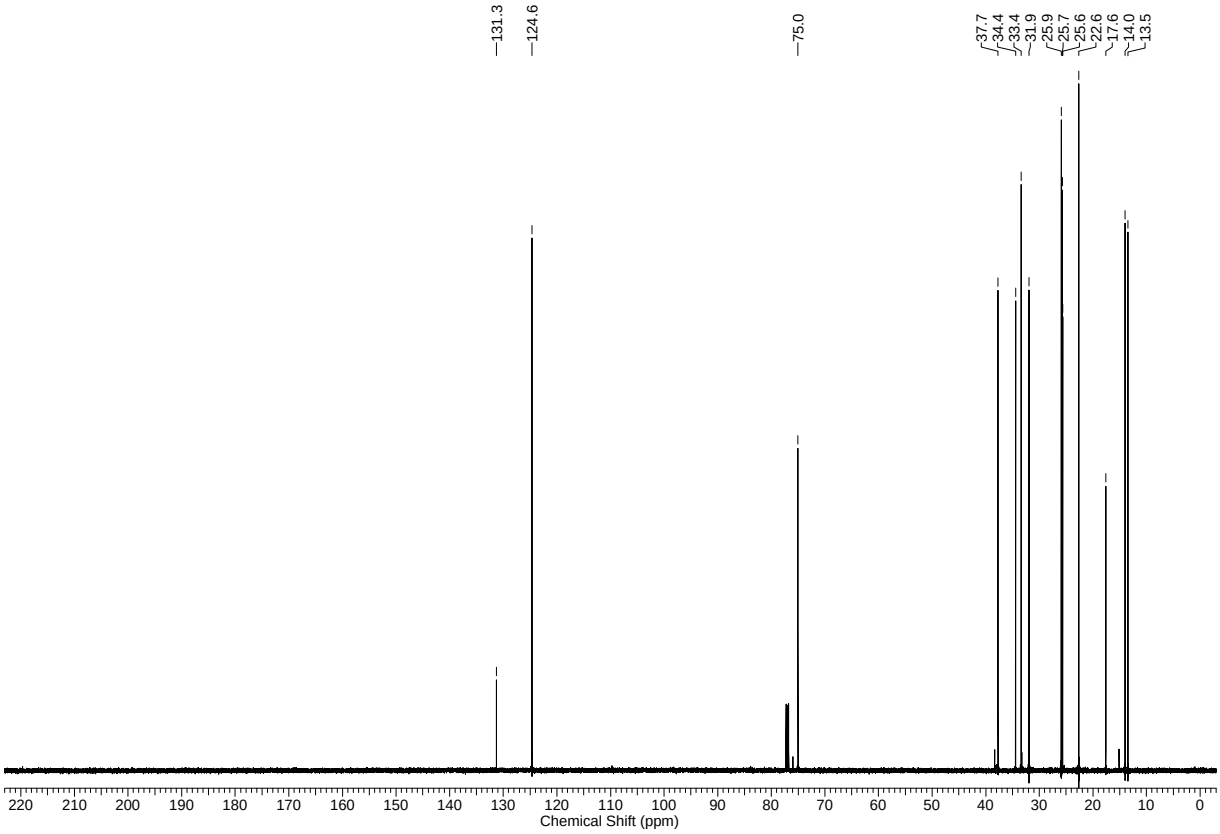
APT_0101

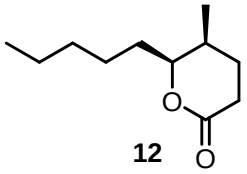



7i
3.83
3.11
1.02
1.00
2.00
1.00
1.07
3.16
Chemical Shift (ppm)

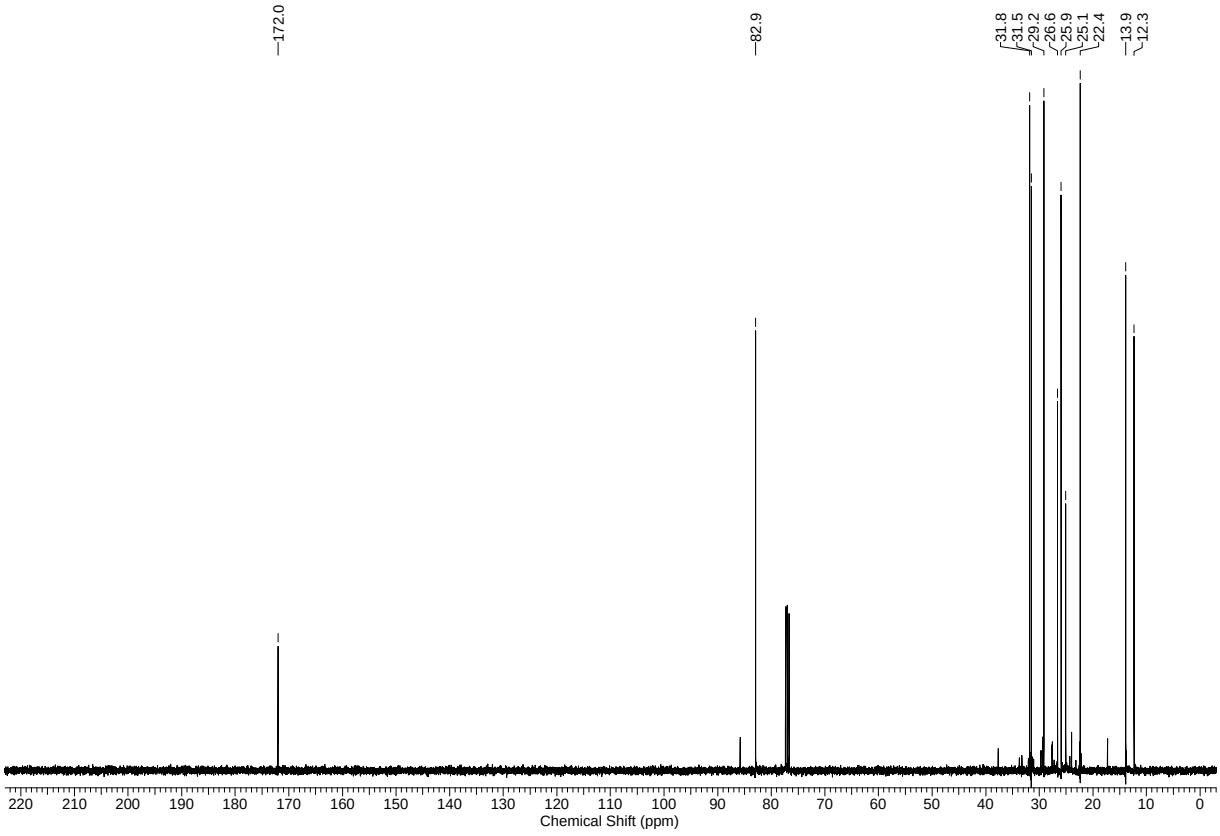

MA3-076.011.esp
140.6
131.4
128.6
128.5
126.2
51.7
46.8
34.3
33.7
Chemical Shift (ppm)



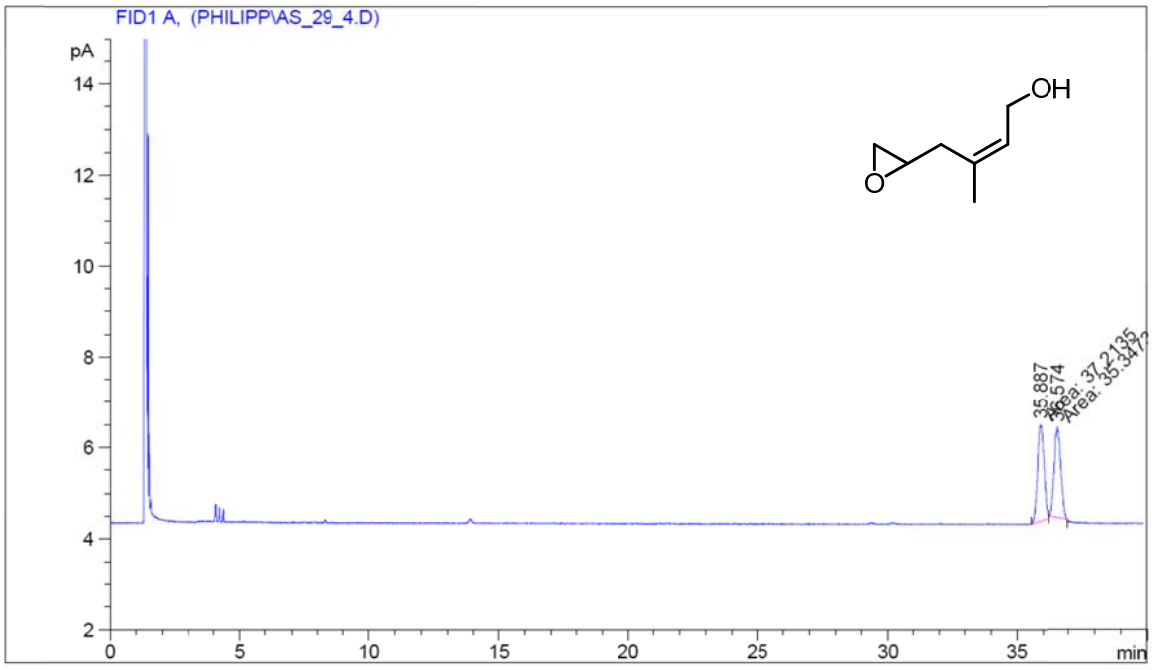




12



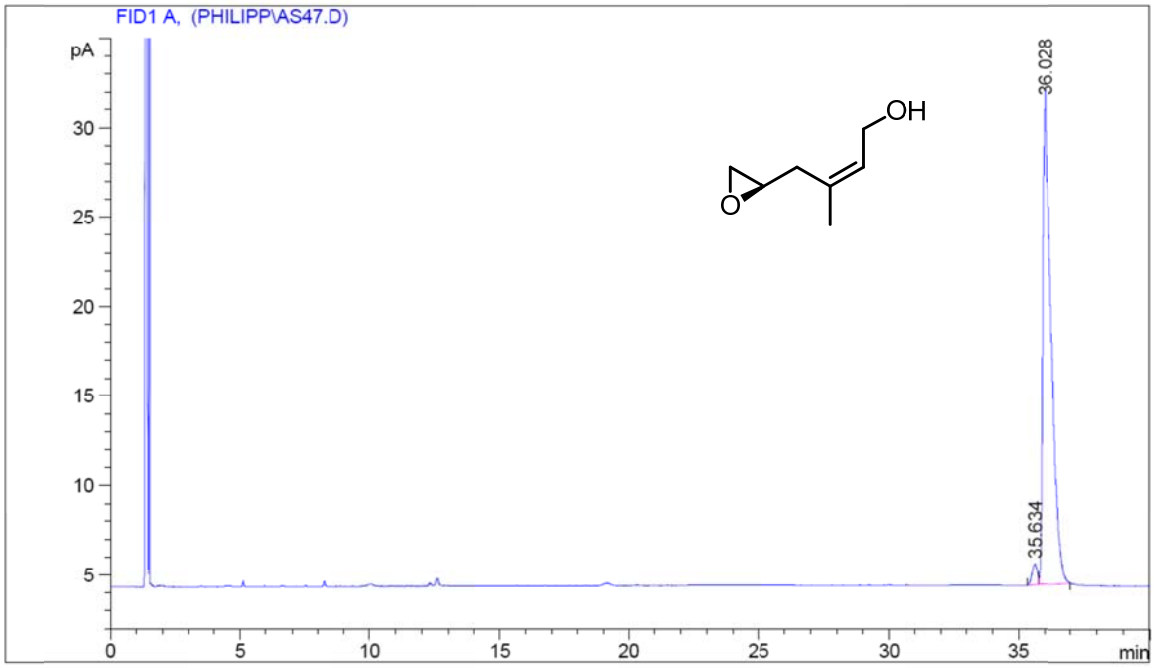
```
Data File C:\CHEM32\2\DATA\PHILIPP\AS_29_4.D
Sample Name: AS_29

==========================================================================
Acq. Operator    : Bokelmann
Acq. Instrument  : GC 6850                          Location : Vial 1
Injection Date   : 23-Nov-10, 14:20:35                   Inj :   1
                                                  Inj Volume : 0.2 µl
Acq. Method      : C:\CHEM32\2\METHODS\140°_60MIN.M
Last changed     : 11/23/2010 2:18:16 PM by Bokelmann
                   (modified after loading)
Analysis Method  : C:\CHEM32\2\METHODS\100°_60MIN.M
Last changed     : 1/18/2011 10:50:02 AM by Bokelmann
                   (modified after loading)
Sample Info      : MN Hydrodex-ß-6tDBM
                   140 °C isotherm
                   1.1 mL/min He
                   50:1 split
```




```
==========================================================================
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	35.887	MM	0.2915	37.21351	2.12794	51.28596
2	36.574	MM	0.2936	35.34731	2.00632	48.71404

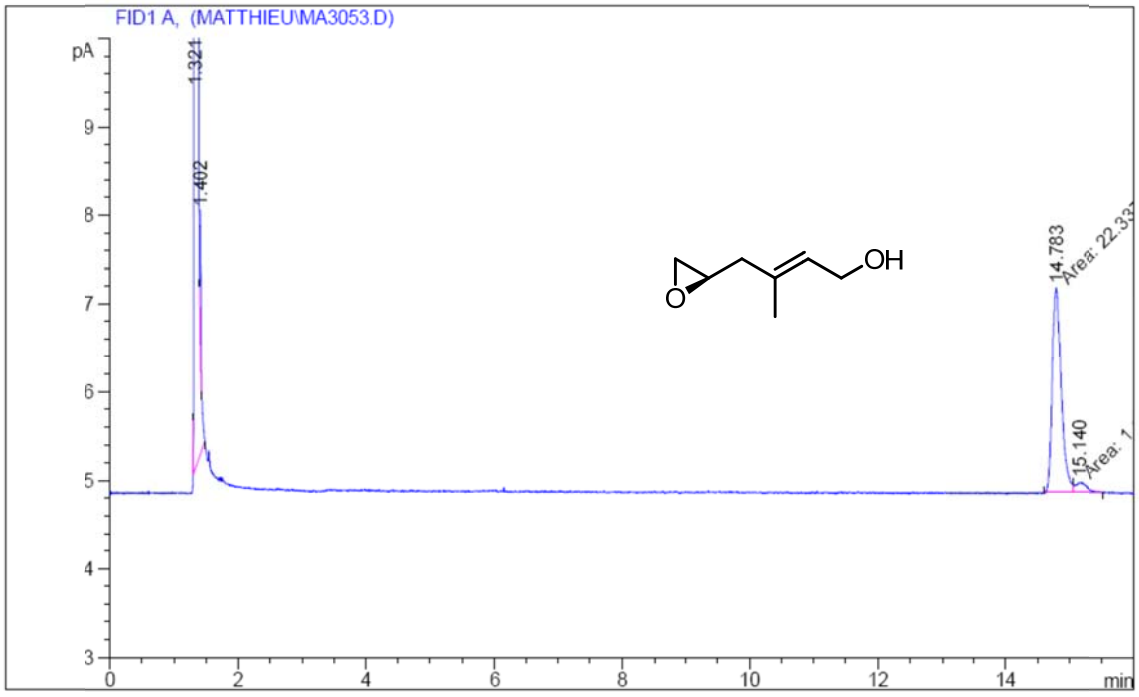
```
Data File C:\CHEM32\2\DATA\PHILIPP\AS47.D
Sample Name: AS47

==========================================================================
Acq. Operator    : Bokelmann
Acq. Instrument : GC 6850                          Location : Vial 1
Injection Date   : 10-Dec-10, 09:03:57                  Inj :   1
                                                  Inj Volume : 0.2 µl
Acq. Method      : C:\CHEM32\2\METHODS\AS_140_1_1ML_40MIN.M
Last changed     : 12/10/2010 9:01:20 AM by Bokelmann
                   (modified after loading)
Analysis Method : C:\CHEM32\2\METHODS\100°_60MIN.M
Last changed     : 1/18/2011 10:52:52 AM by Bokelmann
                   (modified after loading)
Sample Info      : MN Hydrodex-ß-6tDBM
                   140 °C isotherm
                   1.1 ml/min He
                   50:1 split
```




```
==========================================================================
```

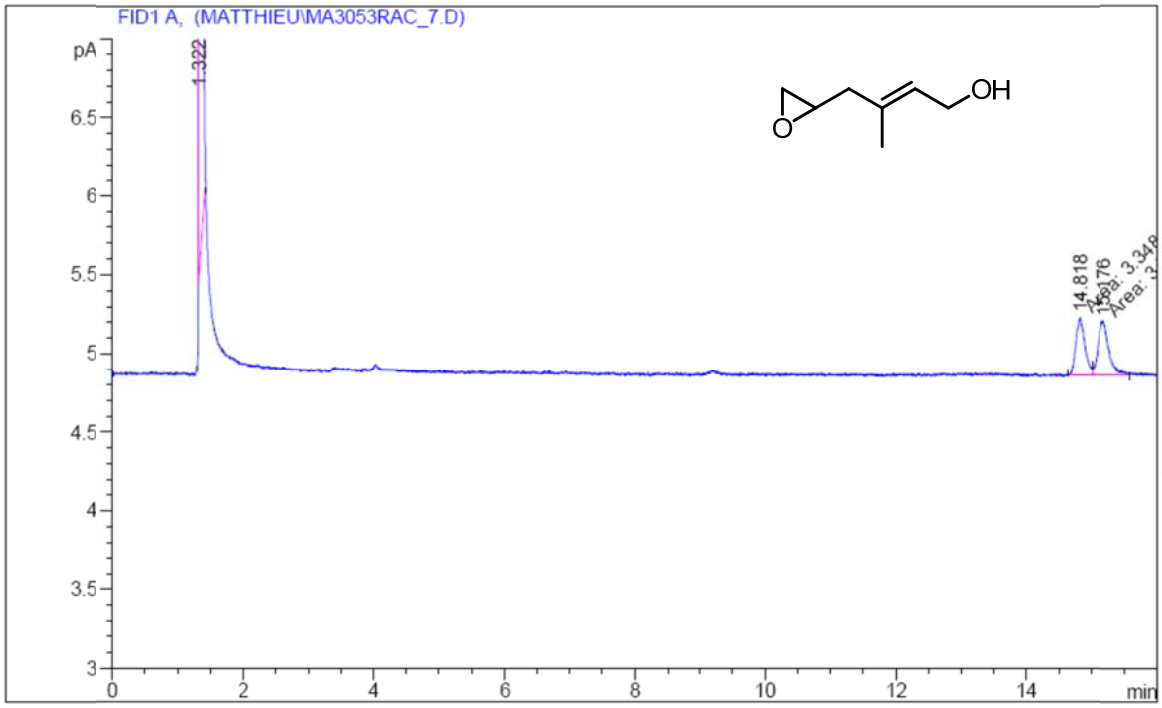
Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	35.634	BV	0.1780	16.87003	1.20027	2.63862
2	36.028	VB	0.2709	622.47986	27.62294	97.36138

```
==========================================================================
Acq. Operator    : Bokelmann
Acq. Instrument : GC 6850                          Location : Vial 5
Injection Date  : 25-Mar-11, 14:15:43                   Inj :   1
                                                  Inj Volume : 0.2 µl
Acq. Method      : C:\CHEM32\2\METHODS\110°_120MIN.M
Last changed     : 3/25/2011 2:14:33 PM by Bokelmann
                   (modified after loading)
Analysis Method : C:\CHEM32\2\METHODS\SÄULENEINBAU.M
Last changed     : 7/8/2011 12:49:57 PM by Bokelmann
                   (modified after loading)
Sample Info      : MN-Lipodex E
                   110 oC isotherm
                   1.1 mL/min He
                   50:1 split
```

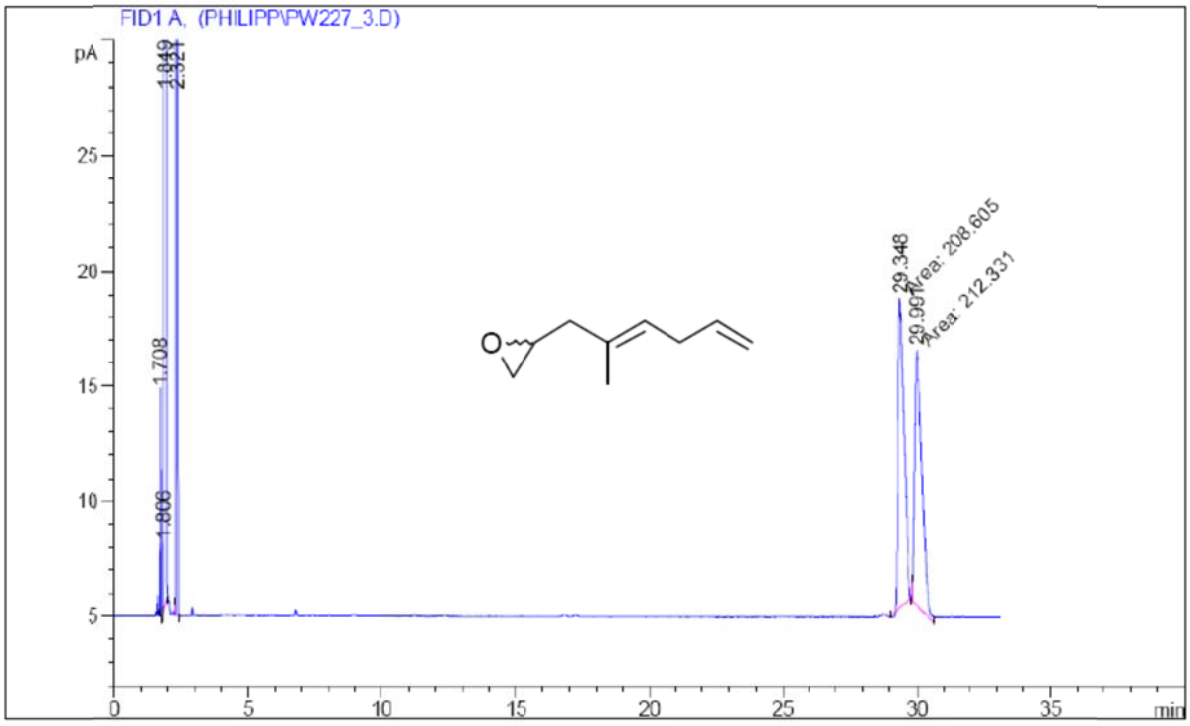


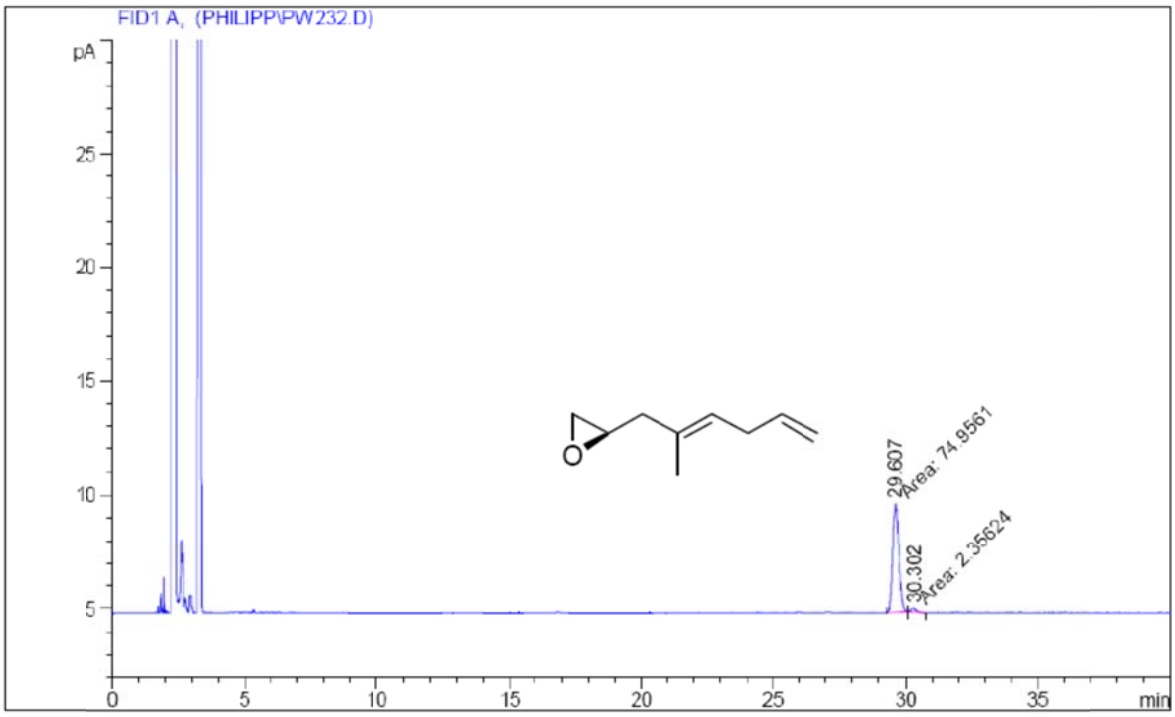
Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	1.321	BB S	0.0160	2.97646e4	2.88246e4	99.91683
2	1.402	BB X	0.0146	1.26667	1.44766	0.00425
3	14.783	MF	0.1615	22.33759	2.30494	0.07499
4	15.140	FM	0.1875	1.17177	1.04148e-1	0.00393

```
==========================================================================
Acq. Operator    : Bokelmann
Acq. Instrument  : GC 6850                          Location : Vial 3
Injection Date   : 25-Mar-11, 13:58:03                   Inj :   1
                                                  Inj Volume : 0.2 µl
Acq. Method      : C:\CHEM32\2\METHODS\110°_120MIN.M
Last changed     : 3/25/2011 1:56:28 PM by Bokelmann
Analysis Method  : C:\CHEM32\2\METHODS\SÄULENEINBAU.M
Last changed     : 7/8/2011 12:48:37 PM by Bokelmann
                   (modified after loading)
Sample Info      : MN-Lipodex E
                   110 oC isotherm
                   1.1 mL/min He
                   50:1 split
```

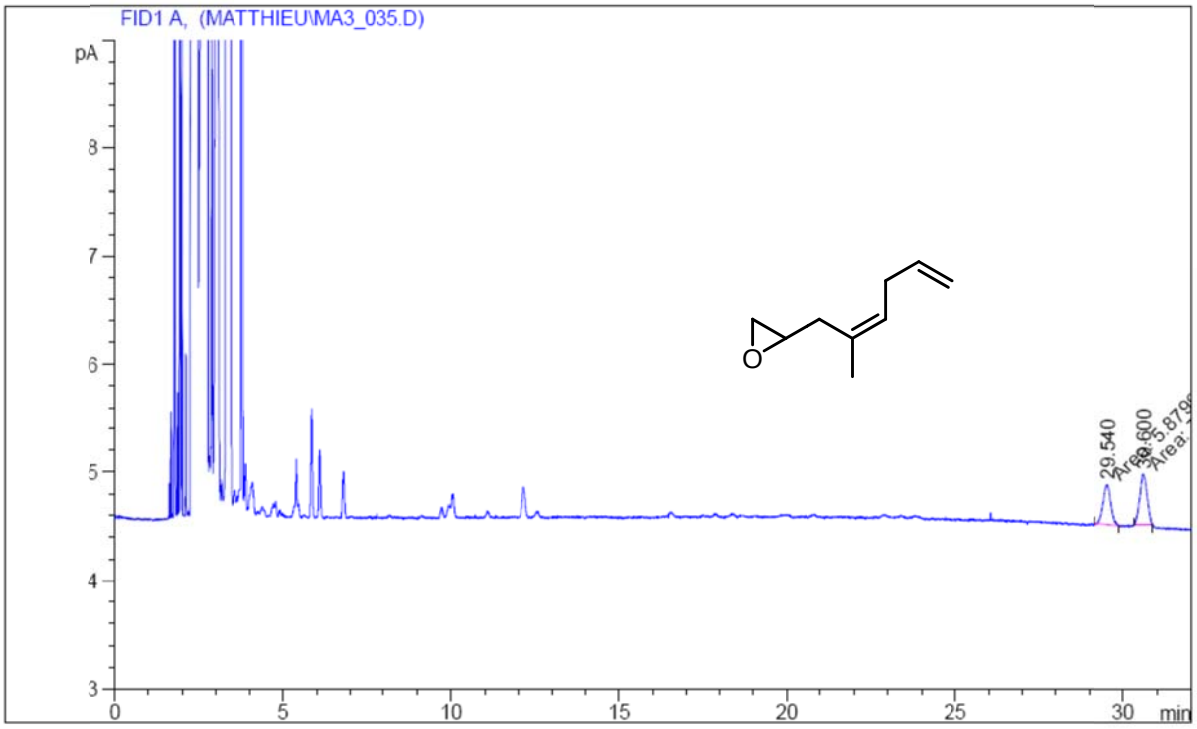


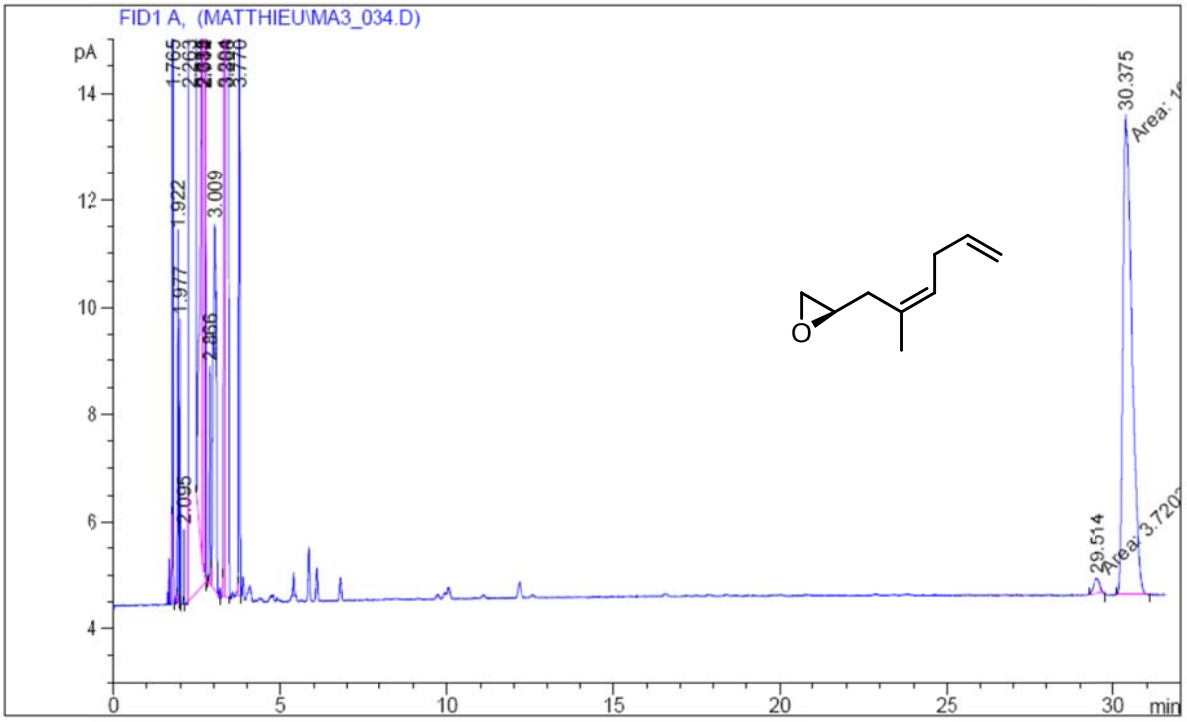
Sample Info : MN Hydrodex-ß-6TDBM
80°C
0.9ml/min He
100:1 split





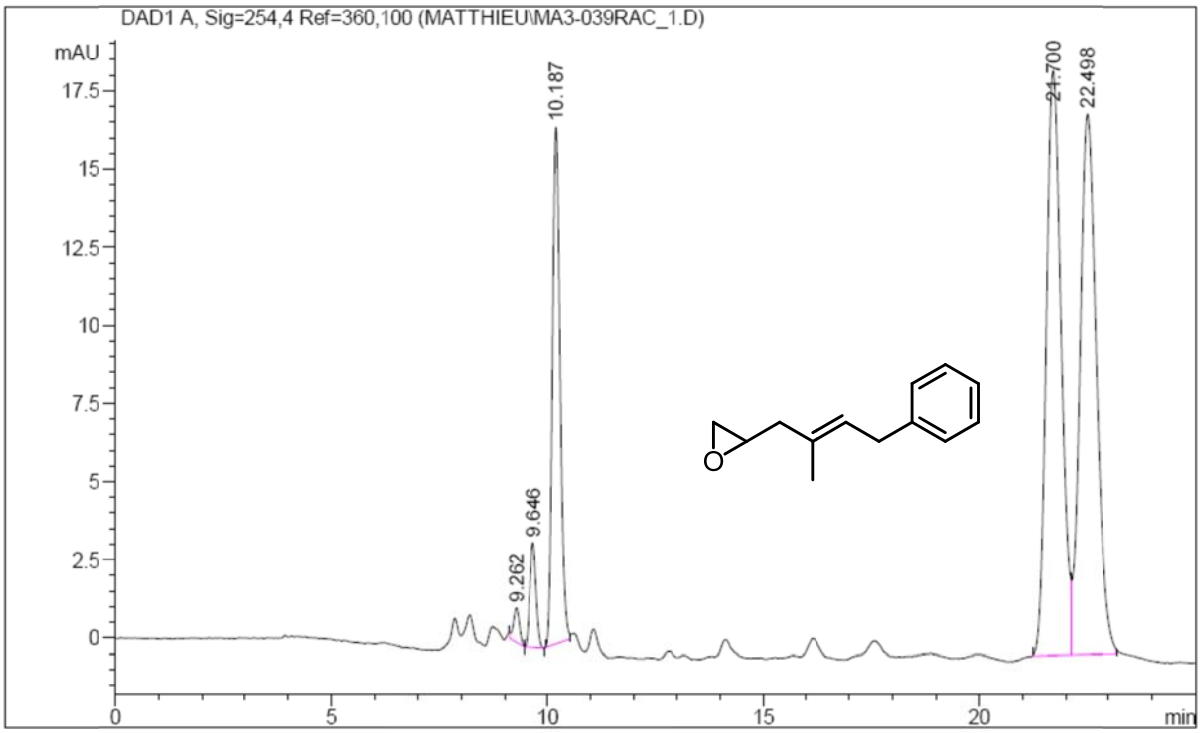
Sample Info : MN-Hydrodex-ß-TBDM
80 oC isotherm
0.9 mL/min He
100:1 split

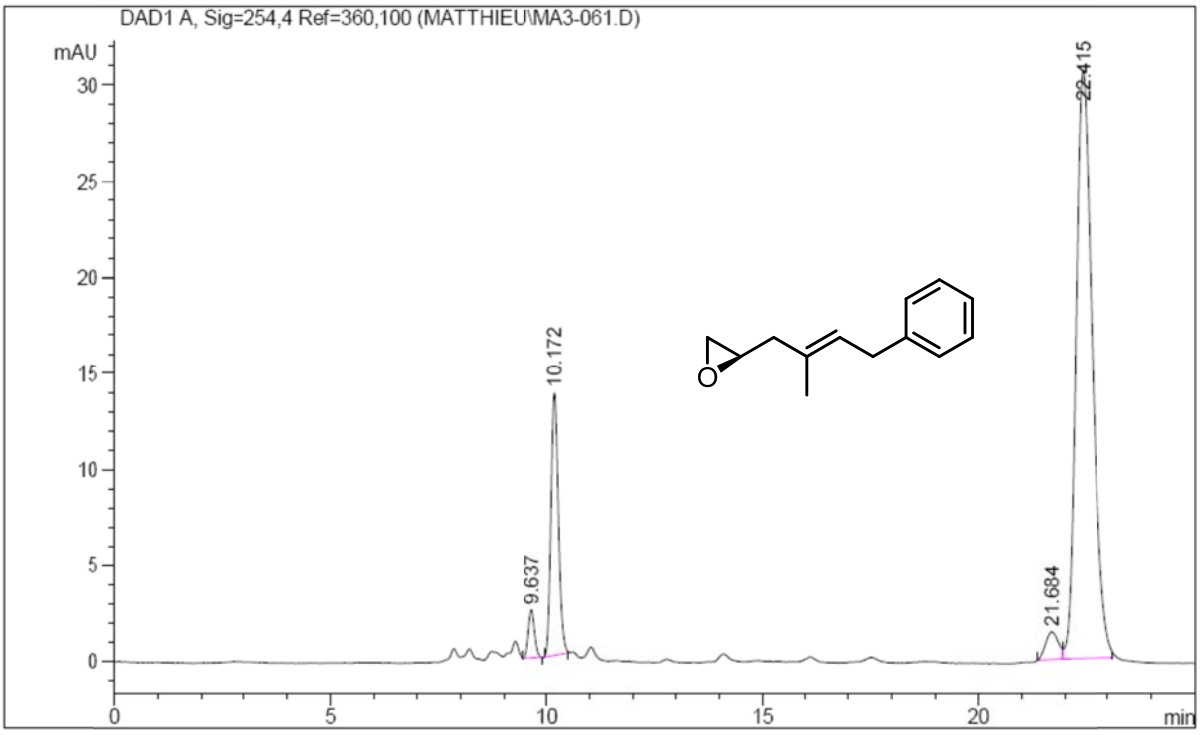




14	29.514	MM	0.2219	3.72033	2.79484e-1	0.00400
15	30.375	MM	0.3061	164.38243	8.95164	0.17671

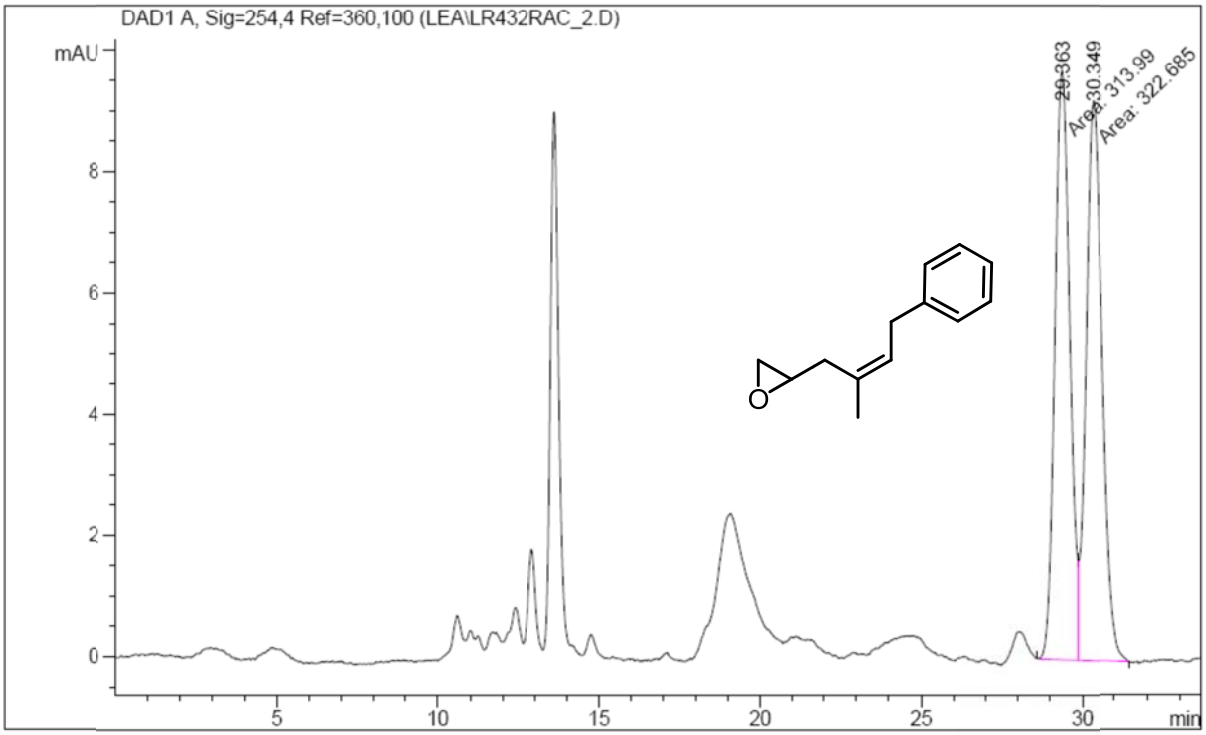
Sample Info : 99/1 n-Heptan/IPA
0.4 mL/min
DAICEL OD-H, 10°C

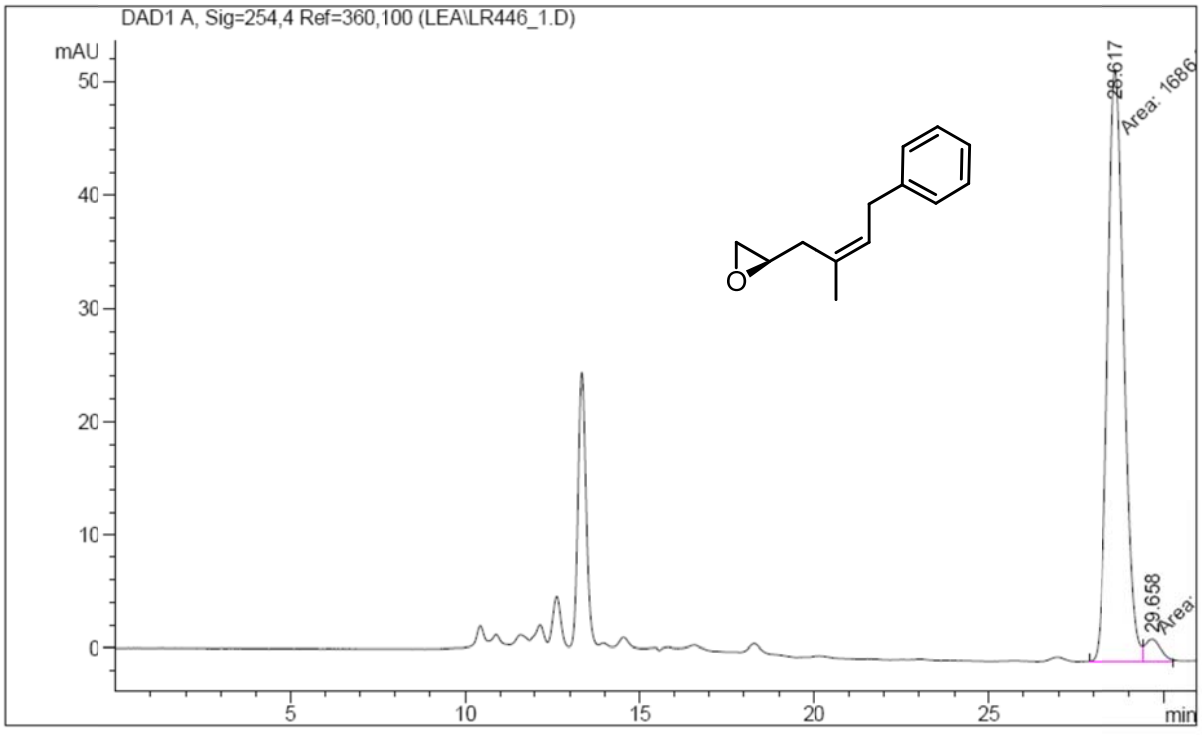




3	21.684	BV	0.2850	30.30472	1.45524	2.9575
4	22.415	VB	0.4031	806.09460	30.62465	78.6682

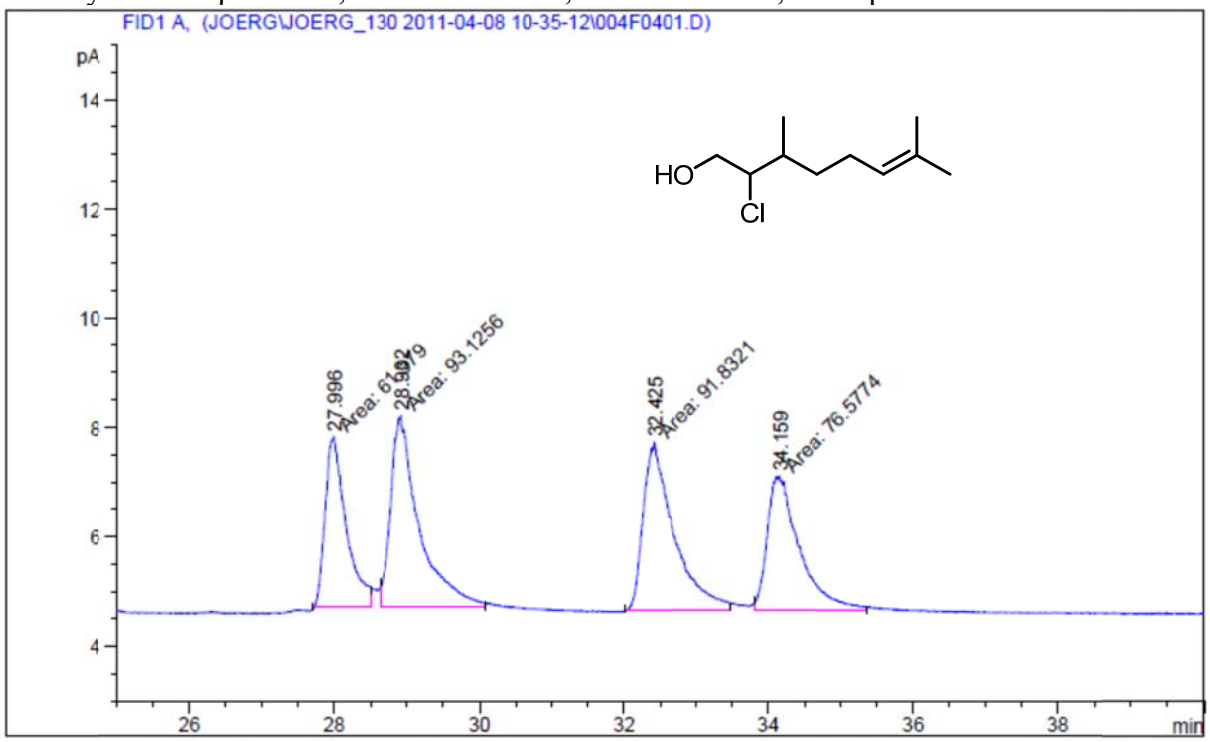
Sample Info : 99/1 n-Heptan/IPA
0.3 mL/min
DAICEL OD-H, 10°C



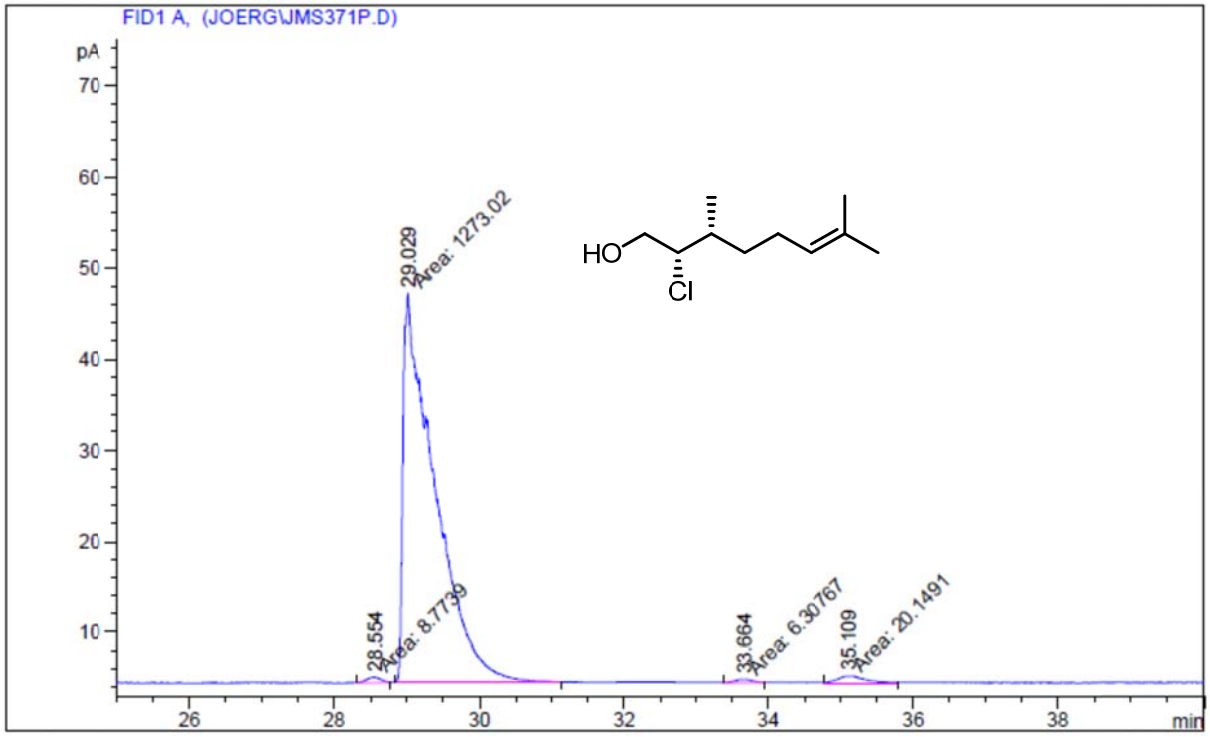


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.617	MF	0.5384	1686.79858	52.21662	96.4868
2	29.658	FM	0.5137	61.41845	1.99262	3.5132

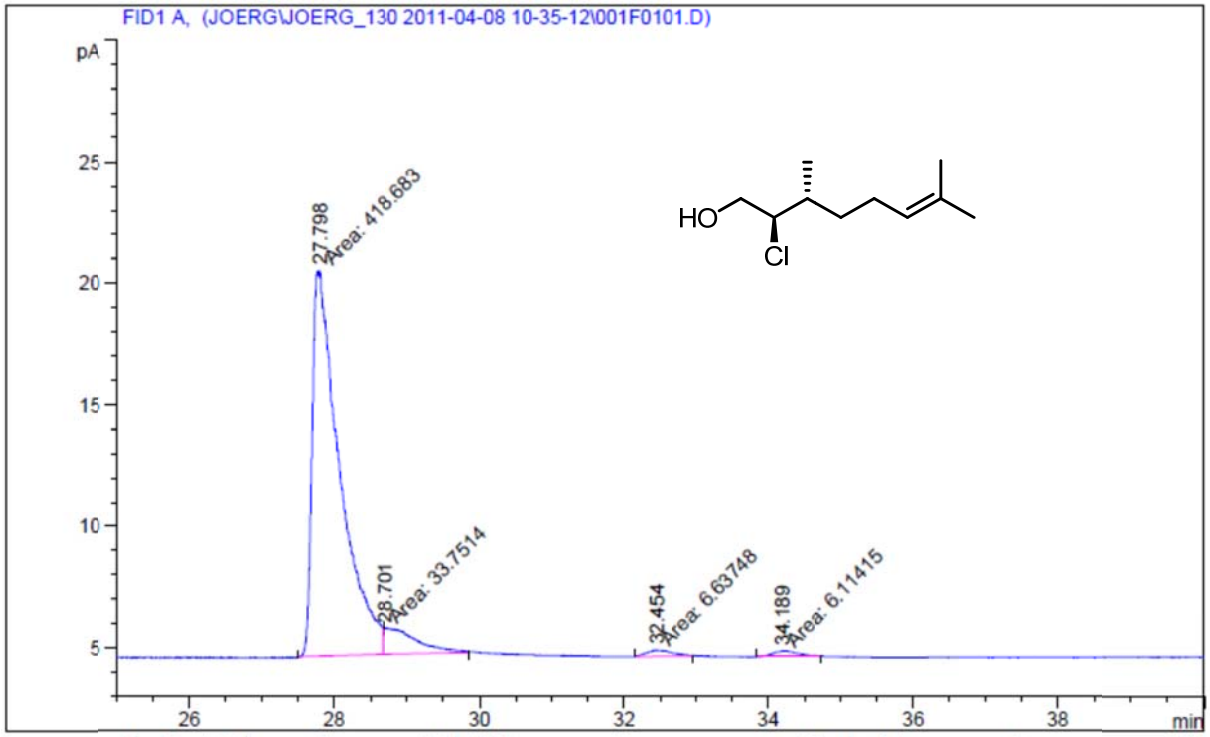
MN-Hydrodex-6β-TBDM, 130 °C isotherm, 1.1 mL/min He, 50:1 split



Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	27.996	MF	0.3324	61.97901	3.10809	19.15806
2	28.932	FM	0.4440	93.12556	3.49553	28.78563
3	32.425	MF	0.4968	91.83212	3.08085	28.38582
4	34.159	FM	0.5190	76.57735	2.45937	23.67049

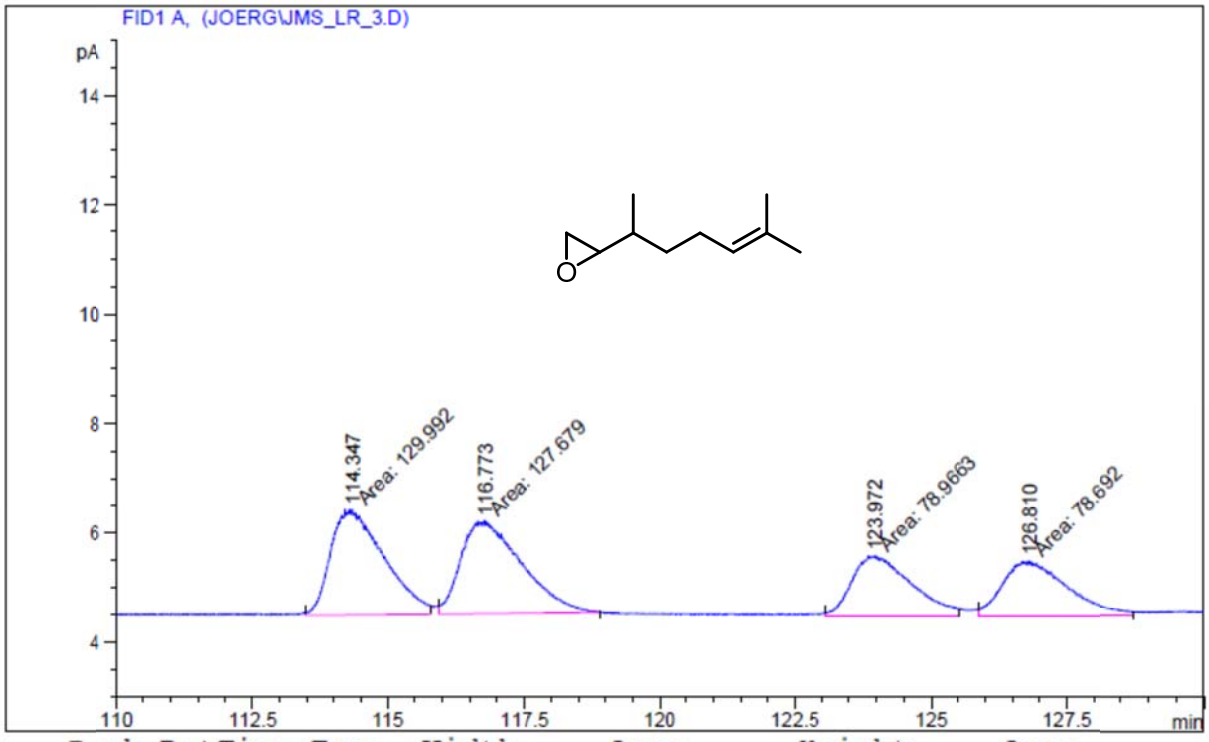


Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	28.554	MM	0.2427	8.77390	6.02431e-1	0.67066
2	29.029	MM	0.4961	1273.02063	42.76980	97.30704
3	33.664	MM	0.2792	6.30767	3.76507e-1	0.48214
4	35.109	MM	0.4400	20.14915	7.63148e-1	1.54016

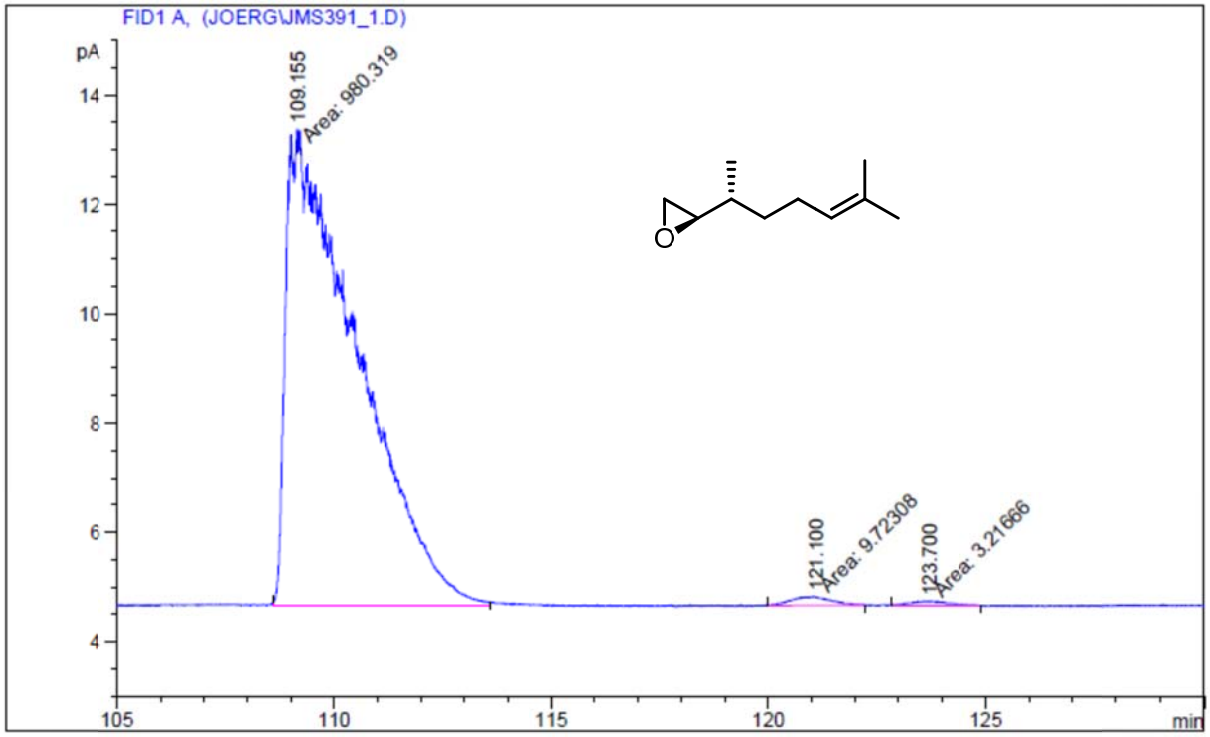


Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	27.798	MF	0.4379	418.68307	15.93680	90.00334
2	28.701	FM	0.5123	33.75143	1.09801	7.25547
3	32.454	MM	0.4119	6.63748	2.68592e-1	1.42684
4	34.189	MM	0.4189	6.11415	2.43264e-1	1.31435

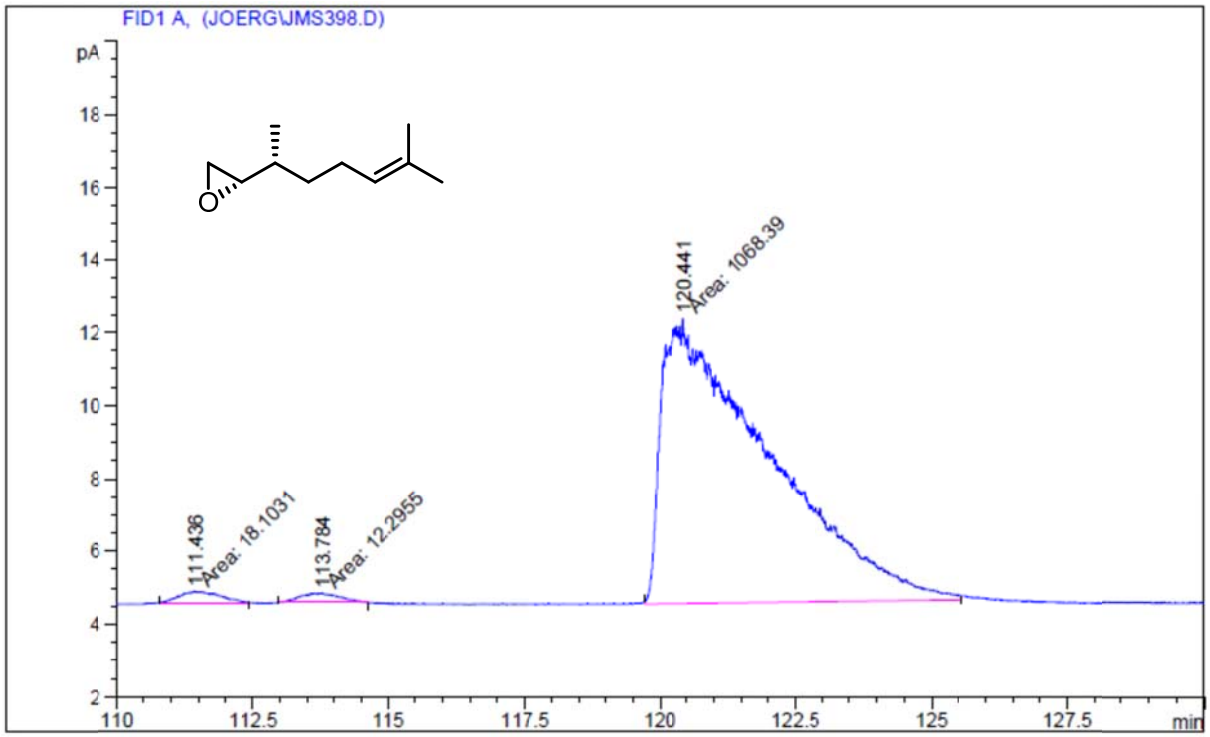
MN-Hydrodex-6β-TBDM, 60 °C isotherm, 1.1 mL/min He, 30:1 split



Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	114.347	MF	1.1233	129.99190	1.92875	31.29854
2	116.773	FM	1.2576	127.67868	1.69206	30.74158
3	123.972	MF	1.2167	78.96628	1.08170	19.01295
4	126.810	FM	1.3113	78.69205	1.00016	18.94692



Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	109.155	MM	1.8721	980.31866	8.72734	98.69724
2	121.100	MM	0.9696	9.72308	1.67125e-1	0.97891
3	123.700	MM	0.8221	3.21666	6.52089e-2	0.32385



Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	111.436	MM	0.8957	18.10306	3.36846e-1	1.64755
2	113.784	MM	0.7933	12.29549	2.58324e-1	1.11901
3	120.441	MM	2.2674	1068.38904	7.85339	97.23345