Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Cp_2TiCl-catalyzed stereoselective intramolecular epoxide allylation using allyl oxygenated pronucleophiles

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Content

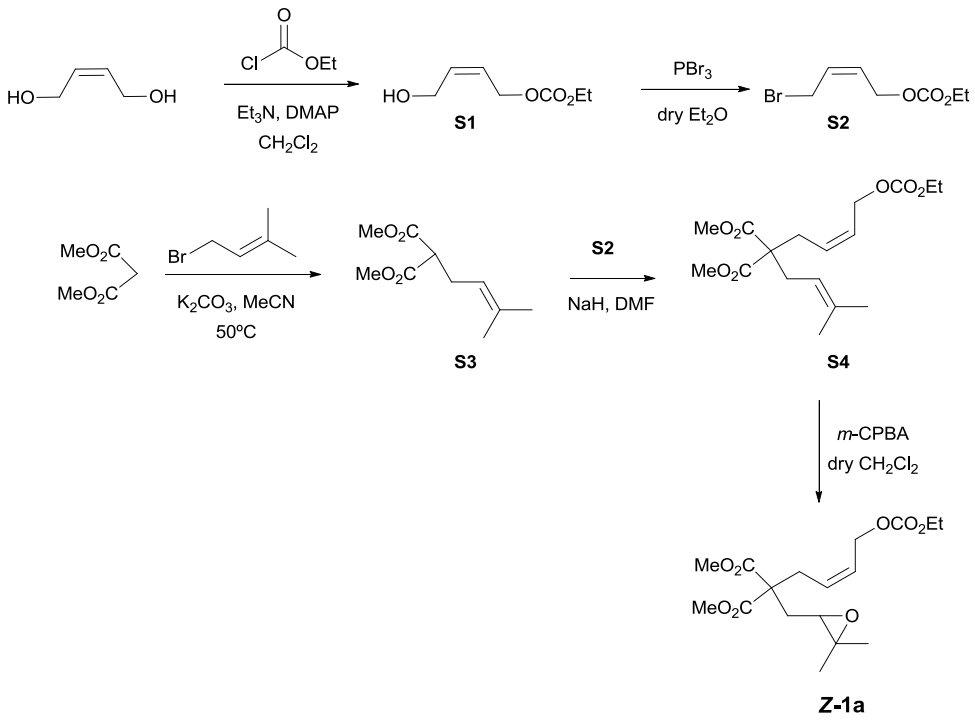
1. Experimental procedures, synthesis and characterisation data

1.1. General

Unless otherwise stated, all reagents and solvents (CH_2Cl_2, Et_2O, MeCN, EtOAc, hexane, DMF, MeOH) were purchased from commercial sources and used without further purification. Dry THF was freshly distilled over Na/benzophenone. Dry DMF and MeOH were purchased from Sigma-Aldrich. Flash column chromatography was carried out using Silica gel 60 (230-400 mesh, Scharlab, Spain) as the stationary phase. Analytical TLC was performed on aluminium sheets coated with silica gel with fluorescent indicator UV_{254} (Alugram SIL G/UV_{254}, Mackerey-Nagel, Germany) and observed under UV light (254 nm) and/or staining with Ce/Mo reagent or phosphomolybdic acid solution and subsequent heating. All ^{1}H and ^{13}C NMR spectra were recorded on Varian 300, 400 or 500 MHz spectrometers, at a constant temperature of 298 K. Chemical shifts are reported in ppm and referenced to residual solvent. Coupling constants (*J*) are reported in Hertz (Hz). Standard abbreviations indicating multiplicity were used as follows: m = multiplet, quint. = quintet, q = quartet, t = triplet, d = doublet, s = singlet, b = broad. Assignment of the ^{13}C NMR multiplicities was accomplished by DEPT techniques.

1.2. Synthesis procedures of polyfunctionalized substrates

*Synthesis of compound Z-***1a**



Compound S1: Ethyl chloroformate (7.20 mL, 76.0 mmol) was slowly added to a mixture of 2-butene-1,4-diol (10.0 g, 113 mmol), Et_3N (10.5 mL, 76 mmol) and dimethylaminopyridine (DMAP) (460 mg, 0.38 mmol) in CH_2Cl_2 (100 mL). The resulting solution was monitored by TLC and stirred at room

temperature until starting material dissapeared (5 h). Then the mixture was diluted with CH_2Cl_2, washed with water and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S1** (7.90 g, 65%) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[1]

Compound S2: Phosphorus tribromide (4.90 mL, 52.0 mmol) was slowly added to a solution of **S1** (7.90 g, 49.0 mmol) in dry Et_2O (20 mL) at 0ºC. The resulting solution was monitored by TLC and stirred at 0ºC until starting material dissapeared (about 1 h). Then the reaction mixture was slowly quenched with cold water and diluted with Et_2O, washed with water and brine and dried over anhydrous Na_2SO_4. The solvent was removed to give **S2** (8.20 g, 80%) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[2]

Compound S3: 1-bromo-3-methyl-2-butene (0.44 mL, 3.78 mmol) was added to a mixture of dimethyl malonate (0.87 mL, 7.57 mmol) and K_2CO_3 (785 mg, 5.68 mmol) in MeCN (15 mL). The mixture was stirred at 50ºC during 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **S3** (605 mg, 40%) as a colorless oil. Its spectroscopic data were identical to the reported compound.[3]

Compound S4: S2 (440 mg, 1.97 mmol) was added to a mixture of **S3** (317 mg, 1.58 mmol) and NaH (60%) (95.0 mg, 2.38 mmol) in DMF (15 mL). The resulting solution was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with HCl (10%) and brine and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **S4** (455 mg, 84%) as a yellowish oil.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.75 – 5.61 (m, 1H), 5.60 – 5.45 (m, 1H), 4.94 (t, *J* = 7.4 Hz, 1H), 4.65 (d, *J* = 6.9 Hz, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.71 (s, 6H), 2.69 (d, *J* = 7.9 Hz, 2H), 2.61 (d, *J* = 7.4 Hz, 2H), 1.69 (s, 3H), 1.60 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.2 (C), 155.0 (C), 135.9 (C), 128.6 (CH), 126.7 (CH), 117.3 (CH), 63.8 (CH_2), 63.1 (CH_2), 57.5 (C), 52.3 (CH_3), 31.3 (CH_2), 30.5 (CH_2), 25.9 (CH_3), 17.8 (CH_3), 14.2 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{17}H_{26}O_7Na$ $[M+Na]^+$: 365.1576, found: 365.1584.

Compound *Z*-1a: 3-Chloroperoxybenzoic acid (*m*-CPBA) (297 mg, 1.72 mmol) was added over a solution of **S4** (453 mg, 1.32 mmol) in dry CH_2Cl_2 (10 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 2 h). Then the reaction mixture was slowly quenched with cold water (2.5 mL) and diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give ***Z*-1a** (217 mg, 46%) as a colorless oil.

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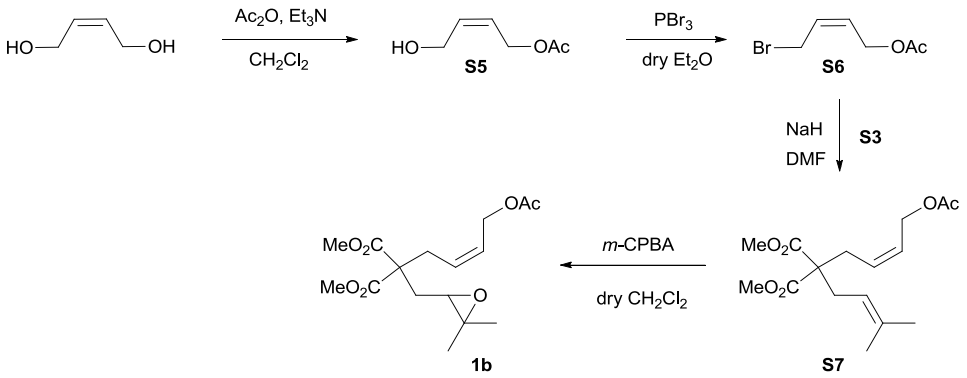
[1] A. M. Echavarren, C. Fernandez-Rivas and M. Mendez, *J. Am. Chem. Soc*., 2000, **122**, 1221-1222.

[2] D. Stolz and U. Kazmaier, *Synthesis*, 2008, 2288-2292.

[3] B. Plietker, *Angew. Chem. Int. Ed.*, 2006, **45**, 1469-1473.

Synthesis of compound **1b**



Compound S5: Acetic anhydride (0.72 mL, 11.4 mmol) was slowly added to a mixture of 2-butene-1,4-diol (0.93 mL, 11.4 mmol) and Et_3N (1.05 mL, 11.4 mmol) in CH_2Cl_2 (40 mL). The resulting solution was stirred at room temperature for 16 h. Then the mixture was diluted with CH_2Cl_2, washed with water and brine and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S5** (470 mg, 48%) as a colorless liquid. Its spectroscopic data were identical to the reported compound.[4]

Compound S6: Phosphorus tribromide (3.50 mL, 37.0 mmol) was slowly added to a solution of **S5** (4.57 g, 35.1 mmol) in dry Et_2O (40 mL) at 0ºC. The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 1 h). Then the reaction mixture was slowly quenched with cold water and diluted with Et_2O, washed with water and dried over anhydrous Na_2SO_4. The residue was filtrated and the solvent was removed to give **S6** (4.40 g, 65%) as an oil without further purification. Its spectroscopic data were identical to the reported compound.[5]

Compound S7: S6 (282 mg, 1.46 mmol) in DMF (2 mL) was added to a mixture of **S3** (266 mg, 1.33 mmol) and NaH (60%) (80.0 mg, 2.00 mmol) in DMF (10 mL). The resulting solution was stirred at room temperature for 2 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **S7** (342 mg, 69%) as a yellowish liquid.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.72 – 5.58 (m, 1H), 5.58 – 5.44 (m, 1H), 4.93 (t, *J* = 7.4 Hz, 1H), 4.59 (d, *J* = 6.7 Hz, 2H), 3.71 (s, 6H), 2.68 (d, *J* = 7.5 Hz, 2H), 2.61 (d, *J* = 7.4 Hz, 2H), 2.05 (s, 3H), 1.69 (s, 3H), 1.60 (s, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.4 (C), 170.8 (C), 136.1 (C), 128.2 (CH), 127.3 (CH), 117.3 (CH), 60.2 (CH_2), 57.6 (C), 52.5 (CH_3), 31.3 (CH_2), 30.5 (CH_2), 26.0 (CH_3), 20.9 (CH_3), 17.9 (CH_3).

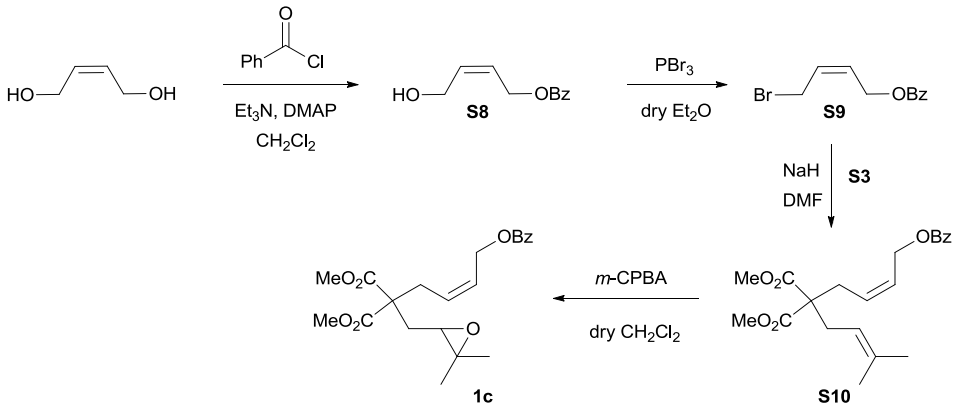
HRMS (TOF MS ES+) *m/z* calcd. for $C_{16}H_{24}O_6Na$ $[M+Na]^+$: 335.1471, found: 335.1472.

[4] A. Hamasaki, S. Maruta, A. Nakamura and M. Tokunaga, *Adv. Synth. Catal.*, 2012, **354**, 2129-2134.

[5] M. Mitchell, L. Qaio and C. H. Wong, *Adv. Synth. Catal.*, 2001, **343**, 596-599.

Compound 1b: *m*-CPBA (226 mg, 1.31 mmol) was added over a solution of **S7** (340 mg, 1.09 mmol) in dry CH_2Cl_2 (10 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **1b** (260 mg, 73%) as a yellowish oil.

Synthesis of compound **1c**



Compound S8: Benzoyl chloride (0.88 mL, 7.57 mmol) was slowly added to a mixture of Et_3N (1.05 mL, 7.57 mmol), DMAP (46.0 mg, 0.38 mmol) and 2-butene-1,4-diol (0.93 mL, 11.4 mmol) in CH_2Cl_2 (30 mL). The resulting solution was stirred at room temperature for 2 h. Then the mixture was diluted with CH_2Cl_2, washed with water and brine and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S8** (784 mg, 54%) as a colorless oil. Its spectroscopic data were identical to the reported compound.[4]

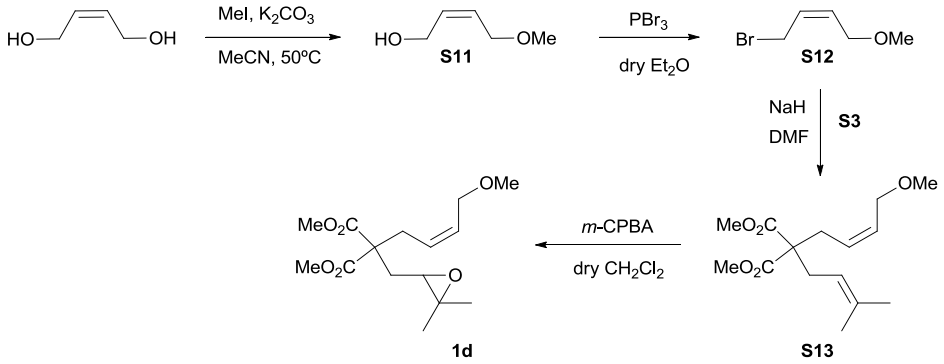
Compound S9: Phosphorus tribromide (0.40 mL, 4.29 mmol) was slowly added to a solution of **S8** (784 mg, 4.08 mmol) in dry Et_2O (15 mL) at 0ºC. The resulting solution was monitored by TLC and stirred at 0ºC until starting material dissapeared (about 40 minutes). Then the reaction mixture was slowly quenched with cold water and diluted with Et_2O, washed with water and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:98) to give **S9** (362 mg, 35%) as a colorless oil. Its spectroscopic data were identical to the reported compound.[6]

Compound S10: S9 (362 mg, 1.42 mmol) in DMF (2 mL) was added to a mixture of **S3** (258 mg, 1.29 mmol) and NaH (60%) (77.0 mg, 1.94 mmol) in DMF (7 mL). The resulting solution was stirred at room temperature for 2 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 5:95) to give **S10** (410 mg, 85%) as a yellowish oil.

[6] M. E. Ragoussi, S. M. Walker, A. Piccanello, B. M. Kariuki, P. N. Horton, N. Spencer and J. S. Snaith, *J. Org.Chem.*, 2010, **75**, 7347-7357.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 8.02 (d, *J* = 7.5 Hz, 2H), 7.58 – 7.49 (t, *J* = 7.6 Hz, 1H), 7.46 – 7.37 (t, *J* = 7.6 Hz, 1H), 5.84 – 5.73 (m, 1H), 5.62 – 5.49 (m, 1H), 4.94 (t, *J* = 7.4 Hz, 1H), 4.83 (d, *J* = 6.7 Hz, 2H), 3.70 (s, 6H), 2.75 (d, *J* = 7.7 Hz, 2H), 2.62 (d, *J* = 7.4 Hz, 2H), 1.67 (s, 3H), 1.58 (s, 3H).
^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.5 (C), 166.5 (C), 136.2 (C), 133.0 (CH), 130.2 (C), 129.7 (CH), 128.4 (CH), 127.4 (CH), 117.4 (CH), 60.8 (CH_2), 57.7 (C), 52.6 (CH_3), 31.4 (CH_2), 30.7 (CH_2), 26.1 (CH_3), 18.0 (CH_3).
HRMS (TOF MS ES+) *m/z* calcd. for $C_{21}H_{26}O_6Na$ $[M+Na]^+$: 397.1627, found: 397.1629.
Compound 1c: *m*-CPBA (227 mg, 1.32 mmol) was added over a solution of **S10** (410 mg, 1.10 mmol) in dry CH_2Cl_2 (10 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **1c** (305 mg, 71%) as a yellowish oil.

Synthesis of compound **1d**



Compound S11: Iodomethane (0.70 mL, 11.4 mmol) was slowly added to a mixture of 2-butene-1,4-diol (1.40 mL, 17.0 mmol) and K_2CO_3 (3.14 g, 22.7 mmol) in MeCN (20 mL). The mixture was stirred at 50ºC during 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S11** (590 mg, 34%) as a yellowish liquid. Its spectroscopic data were identical to the reported compound.[7]
Compound S12: Phosphorus tribromide (0.38 mL, 4.05 mmol) was slowly added to a solution of **S11** (394 mg, 3.86 mmol) in dry Et_2O (20 mL) under Ar atmosphere at 0ºC. The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 40 minutes). Then the reaction mixture was slowly quenched with cold water and diluted with Et_2O, washed with water and dried over anhydrous Na_2SO_4. The residue was filtrated and the solvent was removed to give **S12** (250 mg, 40%) as a yellowish oil without further purification.
^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.91 – 5.78 (m, 1H), 5.72 – 5.60 (m, 1H), 4.02 (d, *J* = 6.2 Hz, 2H), 3.98 (d, *J* = 8.4 Hz, 2H), 3.32 (s, 3H).

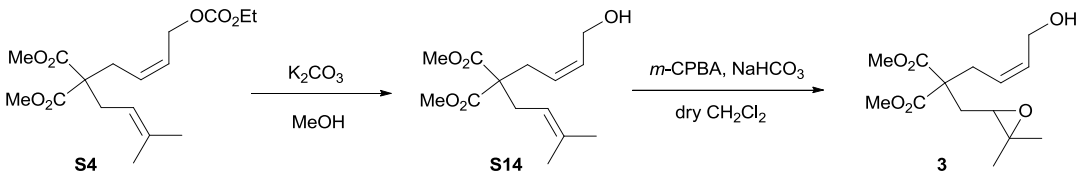
[7] E. Tayama, S. Otoyama and W. Isaka, *Chem. Commun.*, 2008, 4216-4218.

^{13}C-NMR (100 MHz, $CDCl_3$) δ(ppm): 131.1 (CH), 128.3 (CH), 67.4 (CH_2), 58.3 (CH_2), 26.5 (CH_3).

Compound S13: S12 (250 mg, 1.52 mmol) in DMF (2 mL) was added to a mixture of **S3** (276 mg, 1.38 mmol) and NaH (60%) (83.0 mg, 2.07 mmol) in DMF (15 mL). The resulting solution was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was filtrated and the solvent was removed to give **S13** (303 mg, 77%) as an oil without further purification. Its spectroscopic data were identical to the reported compound.[8]

Compound 1d: *m*-CPBA (219 mg, 1.27 mmol) was added over a solution of **S13** (300 mg, 1.06 mmol) in dry CH_2Cl_2 (10 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 2 h). Then the reaction mixture was slowly quenched with cold water (2.5 mL) and diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **1d** (170 mg, 54%) as a yellowish oil.

Synthesis of compound **3**



Compound S14: K_2CO_3 (888 mg, 6.42 mmol) was added over a solution of **S4** (733 mg, 2.14 mmol) in MeOH (12 mL). The mixture was stirred at room temperature until starting material dissappeared (about 2 h). Then K_2CO_3 was filtrated and the resulting mixture was quenched with cold water. MeOH was removed and the residue was diluted with EtOAc, washed with water and brine and dried over anhydrous Na_2SO_4. The solvent was removed to give **S14** (410 mg, **72%**) as a colorless liquid.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.82 – 5.68 (m, 1H), 5.50 – 5.34 (m, 1H), 4.95 (t, *J* = 7.9 Hz, 1H), 4.15 (t, *J* = 5.9 Hz, 2H), 3.72 (s, 6H), 2.66 (d, *J* = 8.5 Hz, 2H), 2.62 (d, *J* = 7.9 Hz, 2H), 1.70 (s, 3H), 1.61 (s, 3H), 1.47 (t, *J* = 5.8 Hz, 1H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.6 (C), 135.9 (C), 132.5 (CH), 125.4 (CH), 117.3 (CH), 58.0 (CH_2), 57.8 (C), 52.4 (CH_3), 31.4 (CH_2), 30.4 (CH_2), 25.9 (CH_3), 17.8 (CH_3).

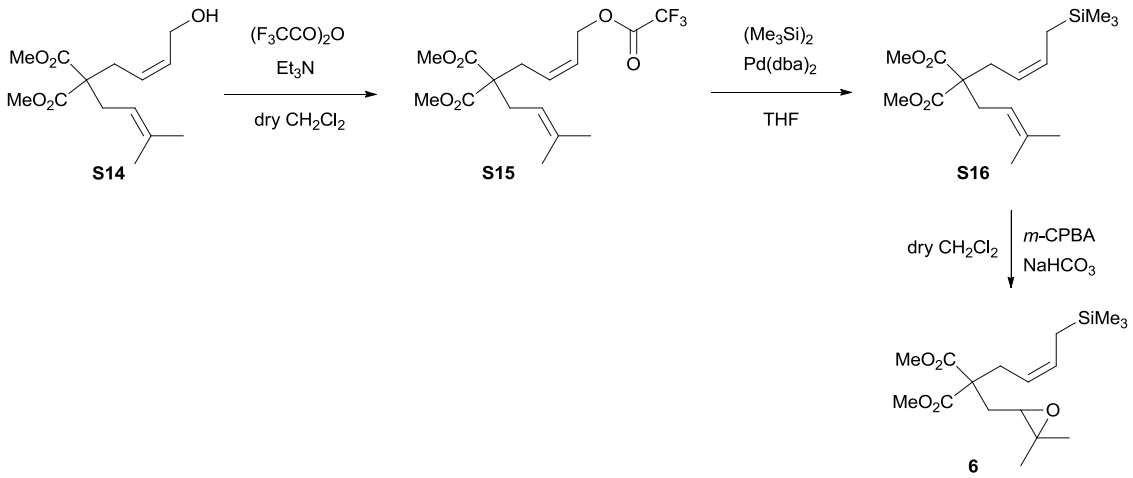
HRMS (TOF MS ES+) *m/z* calcd. for $C_{14}H_{22}O_5Na$ $[M+Na]^+$: 293.1365, found: 293.1362.

Compound 3: *m*-CPBA (96.4 mg, 0.56 mmol) was added to a mixture of **S14** (160 mg, 0.56 mmol) and $NaHCO_3$ (94.0 mg, 1.12 mmol) in dry CH_2Cl_2 (10 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was slowly quenched with cold water (2.5 mL) and diluted with CH_2Cl_2,

[8] S. Porcel, V. Lopez-Carrillo, C. Garcia-Yebra and A. M. Echavarren, *Angew. Chem. In. Ed.*, 2008, **47**, 1883-1886.

washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 3:7) to give **3** (87.0 mg, 55%) as a colorless oil.

Synthesis of compound **6**



Compound S15: Trifluoroacetic anhydride (0.25 mL, 1.81 mmol) was added to a mixture of **S14** (407 mg, 1.51 mmol) and Et_3N (0.25 mL, 1.81 mmol) in dry CH_2Cl_2 (10 mL) under Ar atmosphere. The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 2 h). Then the reaction mixture was slowly quenched with cold water and diluted with CH_2Cl_2, washed with water and brine and dried over anhydrous Na_2SO_4. The solvent was removed and compound **S15** (523 mg, 95%) was used for the next step withouth any further purification.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.74 – 5.60 (m, 2H), 4.93 (t, *J* = 6.8 Hz, 1H), 4.86 (d, *J* = 5.6 Hz, 2H), 3.72 (s, 6H), 2.70 (d, *J* = 6.8 Hz, 2H), 2.62 (d, *J* = 7.4 Hz, 2H), 1.70 (s, 3H), 1.60 (s, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.5 (C), 136.6 (C), 131.3 (CH), 124.6 (CH), 117.3 (CH), 63.6 (CH_2), 57.6 (C), 52.8 (CH_3), 31.7 (CH_2), 30.8 (CH_2), 26.1 (CH_3), 18.1 (CH_3), (two carbon signals were not observed).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{16}H_{22}O_6F_3$ $[M+H]^+$: 367.1368, found: 367.1360.

Compound S16: Hexamethyldisilane (0.47 mL, 2.32 mmol) was added to a mixture of **S15** (425 mg, 1.16 mmol) and $Pd(dba)_2$ (68.0 mg, 0.12 mmol) in THF (10 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 16 h). The solvent was removed and the residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 5:95) to give **S16** (210 mg, 56%) as a yellowish oil.

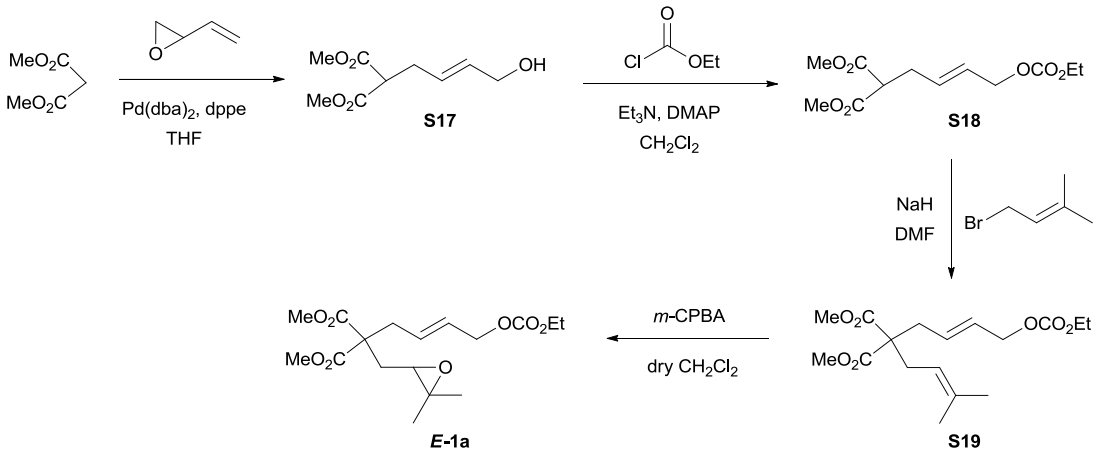
^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.56 – 5.39 (m, 2H), 5.14 – 5.02 (m, 1H), 5.02 – 4.92 (m, 1H), 3.69 (s, 6H), 2.67 – 2.52 (m, 4H), 1.69 (s, 3H), 1.60 (s, 3H), 1.41 (d, *J* = 8.0 Hz, 2H), -0.02 (s, 9H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.8 (C), 135.5 (C), 131.3 (CH), 121.8 (CH), 117.8 (CH), 58.2 (C), 52.3 (CH_3), 35.9 (CH_2), 30.9 (CH_2), 26.1 (CH_3), 23.1 (CH_2), 17.9 (CH_3), -1.9 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{17}H_{31}O_4Si$ $[M+H]^+$: 327.1992, found: 327.1983.

Compound 6: *m*-CPBA (130 mg, 0.75 mmol) was added over a solution of **S16** (205 mg, 0.63 mmol) in dry CH_2Cl_2 (8 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 2 h). Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **6** (104 mg, 48%) as a colorless oil.

*Synthesis of compound **E**-**1a***



Compound S17: 1,3-Butadiene monoxide (0.61 mL, 7.57 mmol) was added to a mixture of dimethyl malonate (0.87 mL, 7.57 mmol), $Pd(dba)_2$ (217 mg, 0.38 mmol) and dppe (151 mg, 0.38 mmol) in THF (15 mL). The resulting mixture was stirred at room temperature for 3 h and then solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S17** (539 mg, 33%) as a yellowish liquid. Its spectroscopic data were identical to the reported compound.[9]

Compound S18: Ethyl chloroformate (0.68 mL, 7.11 mmol) was slowly added to a mixture of **S17** (1.20 g, 5.93 mmol), Et_3N (0.99 mL, 7.11 mmol) and dimethylaminopyridine (DMAP) (362 mg, 2.96 mmol) in CH_2Cl_2 (20 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 3 h). Then the mixture was diluted with CH_2Cl_2, washed with water and dried over anhydrous Na_2SO_4. The residue was filtrated and the solvent was removed to give **S18** (1.60 g, 97%) as an oil without further purification. Its spectroscopic data were identical to the reported compound.[10]

Compound S19: 1-bromo-3-methyl-2-butene (0.38 mL, 3.25 mmol) was added to a mixture of **S18** (742 mg, 2.71 mmol) and NaH (60%) (162 mg, 4.06 mmol) in DMF (10 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and

[9] Z. Zhang, S. D. Lee, A. S. Fisher and R. A. Widenhoefer, *Tetrahedron*, 2009, **65**, 1794-1798.

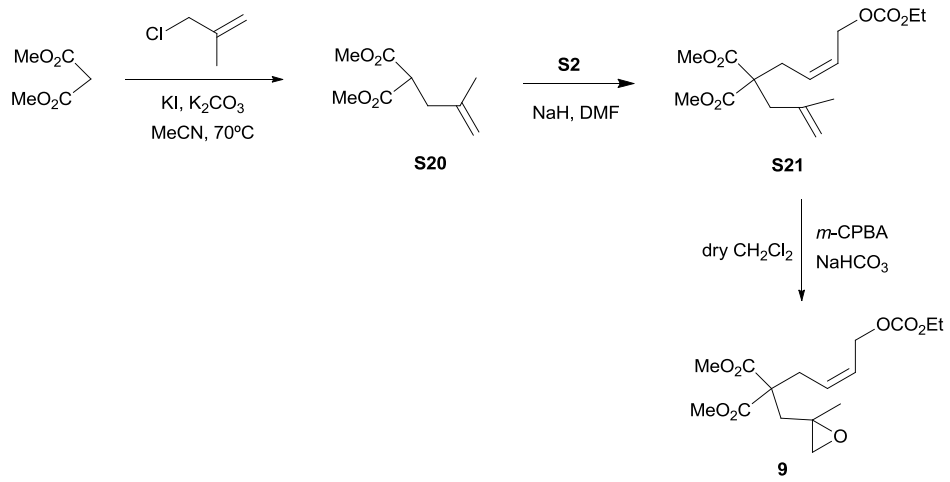
[10] A. G. Campaña, B. Bazdi, N. Fuentes, R. Robles, J. M. Cuerva, J. E. Oltra, S. Porcel and A. M. Echavarren, *Angew. Chem. In. Ed*., 2008, **47**, 7515-7519.

dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **S19** (520 mg, 56%) as a yellowish oil. Compound **S19** was obtained as a 1:0.2 mixture of *E*:*Z* isomers.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.70 – 5.58 (m, 2H), 4.93 (t, *J* = 7.0 Hz, 1H), 4.65 (d, *J* = 7.5 Hz, 2H, *Z*-isomer), 4.54 (d, *J* = 3.8 Hz, 2H, *E*-isomer), 4.19 (q, *J* = 7.1 Hz, 2H), 3.70 (s, 6H), 2.68 (d, *J* = 7.5 Hz, 2H, *Z*-isomer), 2.65 – 2.53 (m, 4H, *E*-isomer), 1.69 (s, 3H), 1.60 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H).

Compound *E*-1a: *m*-CPBA (315 mg, 1.82 mmol) was added over a solution of **S19** (520 mg, 1.52 mmol) in dry CH_2Cl_2 (10 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 1 h). Then the reaction mixture was slowly quenched with cold water (2.5 mL) and diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give ***E*-1a** (420 mg, 77%) as a colorless oil. Compound ***E*-1a** was obtained as a 1:0.2 mixture of *E*:*Z* isomers.

Synthesis of compound **9**



Compound S20: 3-Chloro-2-methylpropene (0.78 mL, 7.95 mmol) was added to a mixture of dimethyl malonate (1.00 g, 7.57 mmol), K_2CO_3 (1.25 g, 9.04 mmol) and KI (63.0 mg, 0.38 mmol) in MeCN (15 mL). The mixture was stirred at 70^{o}C during 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 5:95) to give **S20** (620 mg, 72%) as a colorless oil. Its spectroscopic data were identical to the reported compound.[11]

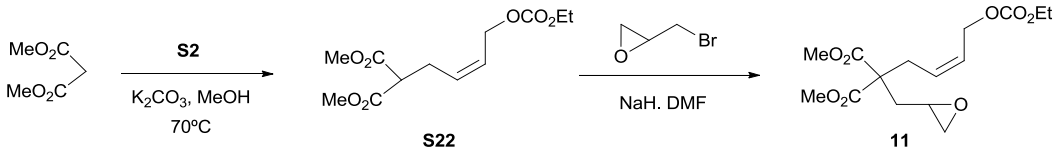
Compound S21: S2 (822 mg, 3.39 mmol) in DMF (5 mL) was added to a mixture of **S20** (623 mg, 3.35 mmol) and NaH (60%) (201 mg, 5.03 mmol) in dry DMF (5 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with EtOAc, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane,

[11] A. M. Gomez, M. D. Company, S. Valverde and J. C. Lopez, *Org. Lett.*, 2004, **4**, 383-386.

1:9) to give **S21** (830 mg, 76%) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[10]

Compound 9: *m*-CPBA (467 mg, 2.70 mmol) was added to a mixture of **S21** (444 mg, 1.35 mmol) and $NaHCO_3$ (454 mg, 5.41 mmol) in dry CH_2Cl_2 (20 mL). The mixture was stirred at room temperature for 48 h. Then mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **9** (87.0 mg, 55%) as a colorless oil.

Synthesis of compound **11**

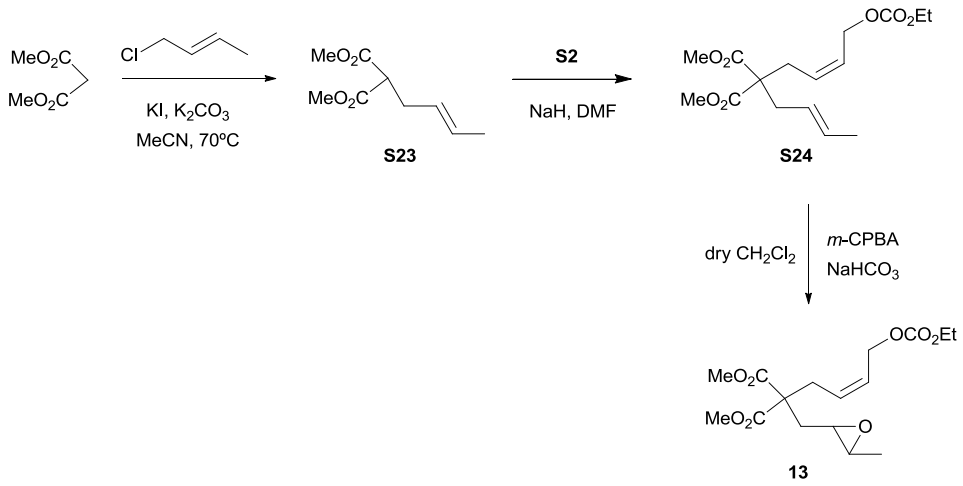


Compound S22: S2 (1.69 g, 7.57 mmol) was added to a mixture of dimethyl malonate (0.86 mL, 7.57 mmol) and K_2CO_3 (1.57 g, 11.4 mmol) in MeCN (15 mL). The mixture was stirred at 70ºC during 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **S22** (1.90 g, 92%) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[12]

Compound 11: Epibromohydrin (0.14 mL, 1.61 mmol) was added to a mixture of **S22** (400 mg, 1.47 mmol) and NaH (60%) (70.3 mg, 1.76 mmol) in DMF (15 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with Et_2O, washed with brine and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **11** (100 mg, 22%) as a colorless oil.

[12] A. G. Campaña, N. Fuentes, E. Gomez-Bengoa, C. Mateo, J. E. Oltra, A. M. Echavarren and J. M. Cuerva, *J. Org. Chem.*, 2007, **72**, 8127-8130.

Synthesis of compound **13**



Compound S23: Crotyl chloride (70%) (2.22 mL, 15.9 mmol) was added to a mixture of dimethyl malonate (1.74 mL, 15.1 mmol), K_2CO_3 (2.50 g, 18.2 mmol) and KI (126 mg, 0.76 mmol) in MeCN (15 mL). The mixture was stirred at 70ºC during 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **S23** (2.30 g, 82%) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[13]

Compound S24: S2 (1.00 g, 4.49 mmol) in DMF (5 mL) was added to a mixture of **S23** (760 mg, 4.09 mmol) and NaH (60%) (245 mg, 6.13 mmol) in dry DMF (6 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **S24** (855 mg, 64%) as a yellowish oil.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.79 – 5.63 (m, 1H), 5.61 – 5.45 (m, 2H), 5.30 – 5.15 (m, 1H), 4.65 (d, *J* = 6.7 Hz, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.71 (s, 6H), 2.68 (d, *J* = 7.1 Hz, 2H), 2.57 (d, *J* = 7.3 Hz, 2H), 1.65 (d, *J* = 6.3 Hz, 3H), 1.30 (t, *J* = 7.1 Hz, 3H).

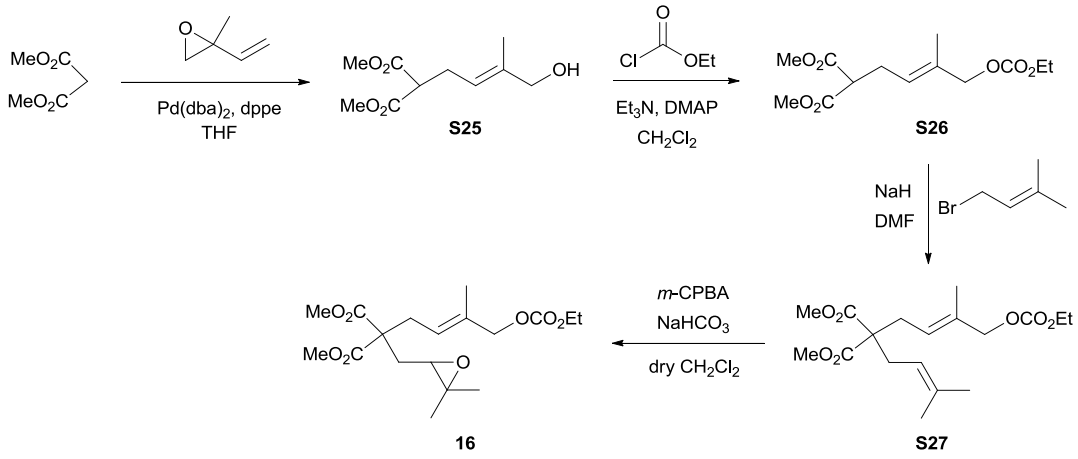
^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 170.9 (C), 154.9 (C), 130.0 (CH), 128.3 (CH), 126.6 (CH), 124.2 (CH), 63.8 (CH_2), 63.0 (CH_2), 57.4 (C), 52.3 (CH_3), 35.8 (CH_2), 30.3 (CH_2), 17.8 (CH_3), 14.1 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{16}H_{25}O_7$ $[M+H]^+$: 329.1600, found: 329.1603.

Compound 13: *m*-CPBA (162 mg, 0.94 mmol) was added to a mixture of **S24** (309 mg, 0.94 mmol) and $NaHCO_3$ (158 mg, 1.88 mmol) in dry CH_2Cl_2 (10 mL). The mixture was stirred at room temperature for 48 h. Then mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **13** (215 mg, 66%) as a yellowish oil.

[13] F. Glorius and A. Pfaltz, *Org. Lett.*, 1999, **1**, 141-144.

Synthesis of compound **16**



Compound S25: Isoprene monoxide (97%) (0.77 mL, 7.57 mmol) was added to a mixture of dimethyl malonate (97%) (0.89 mL, 7.57 mmol), $Pd(dba)_2$ (221 mg, 0.38 mmol) and dppe (151 mg, 0.38 mmol) in THF (8 mL). The resulting mixture was stirred at room temperature for 3 h and then solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S25** (539 mg, 33%) as a colorless liquid. Its spectroscopic data were identical to the reported compound.[14]

Compound S26: Ethyl chloroformate (0.24 mL, 2.49 mmol) was slowly added to a mixture of **S25** (539 mg, 2.49 mmol), Et_3N (0.70 mL, 4.99 mmol) and DMAP (152 mg, 1.25 mmol) in CH_2Cl_2 (15 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with water and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **S26** (447 mg, 62%) as a colorless oil. Its spectroscopic data were identical to the reported compound.[14]

Compound S27: 1-bromo-3-methyl-2-butene (0.22 mL, 1.86 mmol) was added to a mixture of **S26** (447 mg, 1.55 mmol) and NaH (60%) (93.0 mg, 2.33 mmol) in DMF (10 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **S27** (472 mg, 86%) as a yellowish oil.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.30 (t, *J* = 7.2 Hz, 1H), 4.88 (t, *J* = 7.2 Hz, 1H), 4.44 (s, 2H), 4.14 (q, *J* = 7.1 Hz, 2H), 3.66 (s, 6H), 2.59 (d, *J* = 7.2 Hz, 2H), 2.54 (d, *J* = 7.2 Hz, 2H), 1.64 (s, 3H), 1.62 (s, 3H), 1.54 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H).

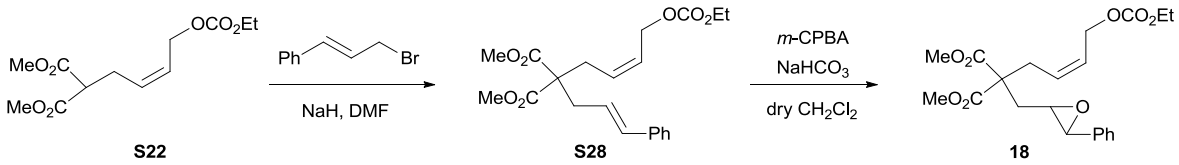
^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.6 (C), 155.1 (C), 135.8 (C), 133.4 (C), 123.5 (CH), 117.5 (CH), 73.1 (CH_2), 63.9 (CH_2), 57.5 (C), 52.4 (CH_3), 31.2 (CH_2), 30.7 (CH_2), 26.0 (CH_3), 17.8 (CH_3), 14.3 (CH_3), 13.9 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{18}H_{29}O_7$ $[M+H]^+$: 357.1913, found: 357.1914.

[14] C. Fernandez-Rivas, M. Mendez, C. Nieto-Oberhuber and A. M. Echavarren, *J. Org. Chem.*, 2002, **67**, 5197-5201.

Compound 16: *m*-CPBA (176 mg, 1.02 mmol) was added to a mixture of **S27** (363 mg, 1.02 mmol) and $NaHCO_3$ (171 mg, 2.04 mmol) in dry CH_2Cl_2 (10 mL). The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 4 h). Then mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **16** (227 mg, 61%) as a colorless oil.

Synthesis of compound **18**



Compound S28: S22 (300 mg, 1.09 mmol) was slowly added to a mixture of cinnamyl bromide (216 mg, 1.09 mmol) and NaH (60%) (48.0 mg, 1.20 mmol) in DMF (10 mL) under Ar atmosphere. The resulting solution was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The solvent was removed and compound **S28** (325 mg, 76%) was used for the next step withouth any further purification.

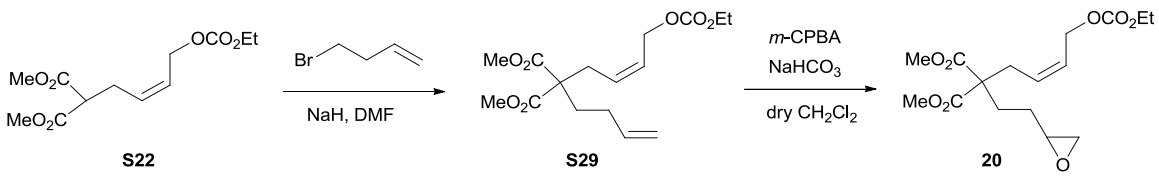
^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 7.40 – 7.15 (m, 5H), 6.43 (d, *J* = 15.7 Hz, 1H), 6.09 – 5.93 (m, 1H), 5.77 – 5.63 (m, 2H), 4.56 (d, *J* = 3.6 Hz, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.72 (s, 6H), 2.78 (d, *J* = 7.1 Hz, 2H), 2.69 (d, *J* = 4.6 Hz, 2H), 1.30 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.1 (C), 155.0 (C), 137.1 (C), 134.4 (CH), 130.1 (CH), 128.6 (CH), 128.3 (CH), 127.6 (CH), 126.3 (CH), 123.6 (CH), 67.7 (CH_2), 64.1 (CH_2), 58.0 (C), 52.6 (CH_3), 36.6 (CH_2), 35.9 (CH_2), 14.4 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{21}H_{27}O_7$ $[M+H]^+$: 391.1757, found: 391.1746.

Compound 18: *m*-CPBA (106 mg, 0.62 mmol) was added to a mixture of **S28** (200 mg, 0.51 mmol) and $NaHCO_3$ (43.0 mg, 0.51 mmol) in dry CH_2Cl_2 (8 mL). The resulting solution was stirred at room temperature for 48 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **18** (88.0 mg, 42%) as a yellowish oil.

Synthesis of compound **20**



Compound S29: 4-Bromo-1-butene (0.74 mL, 7.30 mmol) was added to a mixture of **S22** (1.00 g, 3.65 mmol) and NaH (60%) (292 mg, 7.30 mmol) in DMF (15 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **S29** (742 mg, 62%) as a yellowish oil.

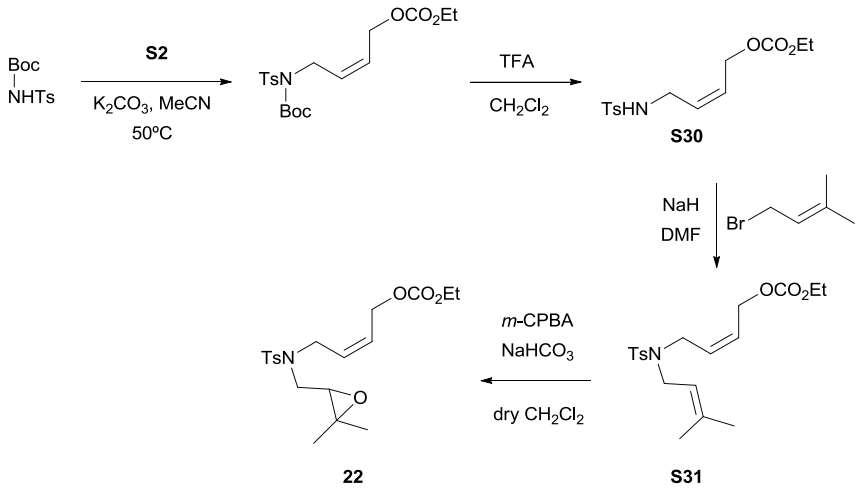
^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.70 – 5.63 (m, 2H), 5.02 (d, *J* = 18.7 Hz, 1H), 4.97 (d, *J* = 11.0 Hz, 1H), 4.54 (d, *J* = 4.4 Hz, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.71 (s, 6H), 2.67 (d, *J* = 5.4 Hz, 2H), 2.05 – 1.87 (m, 4H), 1.30 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.3 (C), 154.8 (C), 137.2 (CH), 130.0 (CH), 127.9 (CH), 115.1 (CH_2), 67.5 (CH_2), 63.9 (CH_2), 57.3 (C), 52.3 (CH_3), 35.7 (CH_2), 31.8 (CH_2), 28.3 (CH_2), 14.2 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{16}H_{25}O_7$ $[M+H]^+$: 329.1600, found: 329.1590.

Compound 20: *m*-CPBA (556 mg, 3.23 mmol) was added to a mixture of **S29** (265 mg, 0.81 mmol) and $NaHCO_3$ (136 mg, 1.62 mmol) in dry CH_2Cl_2 (10 mL). The resulting solution was stirred at room temperature for 48 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **20** (167 mg, 60%) as a colorless oil.

Synthesis of compound **22**



Compound S30: **S2** (2.47 g, 11.1 mmol) was added to a mixture of *N*-(*tert*-butoxycarbonyl)-*p*-toluenesulfonamide (3.00 g, 11.1 mmol) and K_2CO_3 (1.83 g, 13.3 mmol) in MeCN (22 mL). The mixture was stirred at 50ºC for 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was dissolved in CH_2Cl_2 (15 mL) and trifluoroacetic acid (TFA) (2.2 mL) was added. The resulting solution was monitored by TLC and stirred at room temperature until starting material dissapeared (about 3 h). Then the mixture was diluted with CH_2Cl_2 and neutralized with $NaHCO_{3,sat}$, washed with brine and dried over anhydrous

Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S30** (2.68 g, 61%, 2 steps) as a yellow oil. Its spectroscopic data were identical to the reported compound.[15]

Compound S31: 1-bromo-3-methyl-2-butene (0.36 mL, 3.11 mmol) was added to a mixture of **S30** (811 mg, 2.59 mmol) and NaH (60%) (155 mg, 3.88 mmol) in DMF (15 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **S31** (805 mg, 82%) as a yellowish oil.

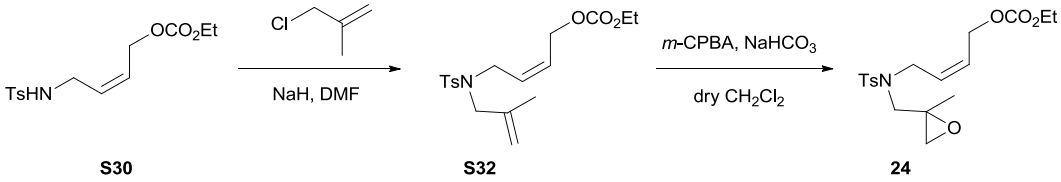
^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 7.69 (d, *J* = 8.2 Hz, 2H), 7.30 (d, *J* = 8.2 Hz, 2H), 5.74 – 5.62 (m, 1H), 5.61 – 5.48 (m, 1H), 4.98 (t, *J* = 7.0 Hz, 1H), 4.60 (d, *J* = 6.6 Hz, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.85 (d, *J* = 6.6 Hz, 1H), 3.78 (d, *J* = 7.0 Hz, 1H), 2.43 (s, 3H), 1.66 (s, 3H), 1.58 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 154.8 (C), 143.1 (C), 137.1 (C), 137.0 (C), 130.1 (CH), 129.5 (CH), 127.0 (CH), 126.2 (CH), 118.6 (CH), 63.9 (CH_2), 62.6 (CH_2), 44.9 (CH_2), 43.5 (CH_2), 25.5 (CH_3), 21.3 (CH_3), 17.6 (CH_3), 14.1 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{19}H_{28}NO_5S$ $[M+H]^+$: 382.1688, found: 382.1678.

Compound 22: *m*-CPBA (163 mg, 0.93 mmol) was added to a mixture of **S31** (355 mg, 0.93 mmol) and $NaHCO_3$ (156 mg, 1.86 mmol) in dry CH_2Cl_2 (10 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **22** (238 mg, 65%) as a yellowish oil.

Synthesis of compound **24**



Compound S32: 3-Chloro-2-methylpropene (0.70 mL, 6.84 mmol) was added to a mixture of **S30** (1.79 g, 5.70 mmol) and NaH (60%) (205 mg, 8.55 mmol) in DMF (15 mL). The mixture was stirred at room temperature for 48 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **S32** (509 mg, 25%) as a yellowish oil.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 7.70 (d, *J* = 8.1 Hz, 2H), 7.30 (d, *J* = 8.1 Hz, 2H), 5.66 (dt, *J* = 11.1, 5.4 Hz 1H), 5.48 (dt, J = 11.1, 6.9 Hz, 1H), 4.88 (s, 1H), 4.83 (s, 1H), 4.59 (d, *J* = 6.8 Hz, 2H), 4.18 (q, *J* = 7.1 Hz, 2H), 3.85 (d, *J* = 6.9 Hz, 2H), 3.69 (s, 2H), 2.43 (s, 3H), 1.71 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H).

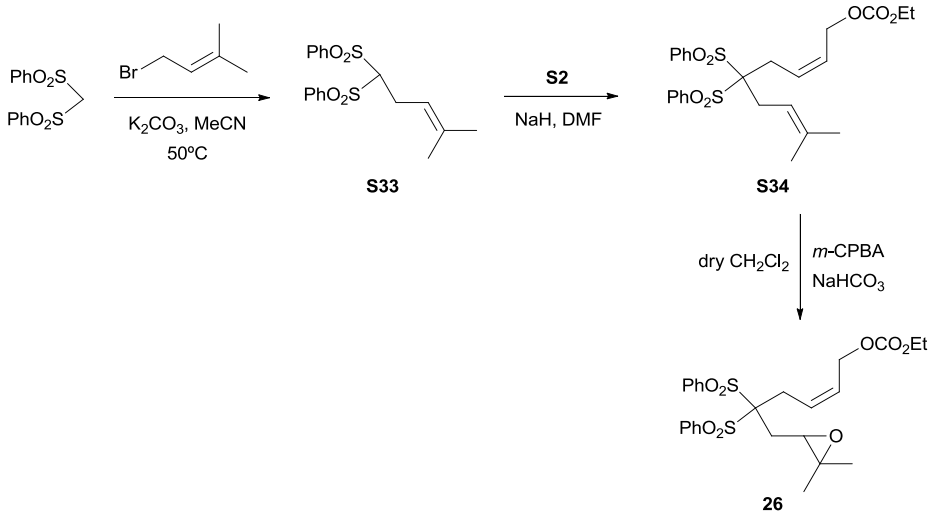
[15] R. E. Estevez, J. Justicia, B. Bazdi, N. Fuentes, M. Paradas, D. Choquesillo-Lazarte, J. M. Garcia-Ruiz, R. Robles, A. Gansäuer, J. M. Cuerva and J. E. Oltra, *Chem. Eur. J.* 2009, **15**, 2774-2791.

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 154.9 (C), 143.3 (C), 140.3 (C), 137.0 (C), 129.7 (CH), 129.4 (CH), 127.2 (CH), 126.6 (CH), 114.6 (CH_2), 64.1 (CH_2), 62.6 (CH_2), 53.6 (CH_2), 43.6 (CH_2), 21.5 (CH_3), 19.7 (CH_3), 14.2 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{18}H_{25}NO_5SNa$ $[M+Na]^+$: 390.1351, found: 390.1333.

Compound 24: *m*-CPBA (239 mg, 1.39 mmol) was added to a mixture of **S32** (509 mg, 1.39 mmol) and $NaHCO_3$ (233 mg, 2.77 mmol) in dry CH_2Cl_2 (50 mL). The mixture was stirred at room temperature for 4 days. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **24** (407 mg, 77%) as a yellowish oil.

Synthesis of compound **26**



Compound S33: 1-bromo-3-methyl-2-butene (0.27 mL, 2.26 mmol) was added to a mixture of bis(phenylsulfonyl)methane (670 mg, 2.26 mmol) and K_2CO_3 (467 mg, 3.39 mmol) in MeCN (20 mL). The mixture was stirred at 50ºC for 16 h. Then K_2CO_3 was filtrated and the solvent was removed to give **S34** (810 mg, 97%) as an oil without further purification. Its spectroscopic data were identical to the reported compound.[16]

Compound S34: S2 (759 mg, 3.40 mmol) in DMF (5 mL) was added to a mixture of **S33** (827 mg, 2.27 mmol) and NaH (60%) (136 mg, 3.40 mmol) in dry DMF (8 mL). The mixture was stirred at room temperature for 16 h. Then the mixture was diluted with Et_2O, washed with brine and HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **S34** (860 mg, 75%) as a yellowish oil.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 8.05 (d, *J* = 7.7 Hz, 2H), 7.70 (t, *J* = 7.7 Hz, 1H), 7.58 (t, *J* = 7.7 Hz, 2H), 5.93 (d, *J* = 9.2, 6.4 Hz, 1H), 5.79 (d, *J* = 9.2, 6.7 Hz, 1H), 5.35 – 5.23 (m, 1H), 4.60 (d, *J* = 6.6 Hz,

[16] C. Nieto-Oberhuber, P. Perez-Galan, E. Herrero-Gomez, T. Lauterbach, C. Rodriguez, S. Lopez, C. Bour, A. Rosellón, D. J. Cárdenas and A. M. Echavarren, *J. Am. Chem. Soc*., 2008, **130**, 269-279.

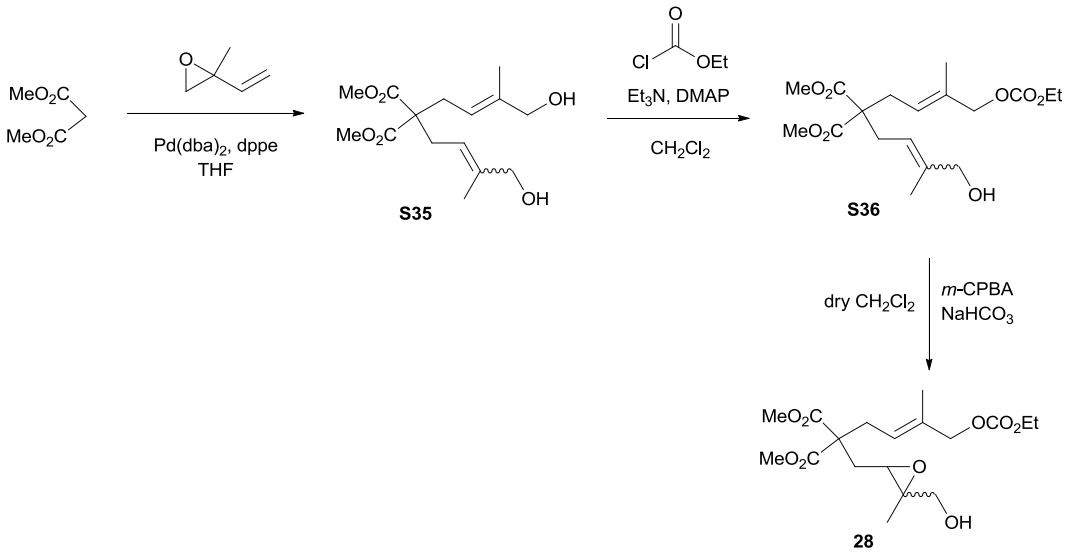
2H), 4.21 (q, *J* = 7.1 Hz, 2H), 3.04 (d, *J* = 6.3 Hz, 2H), 2.95 (d, *J* = 6.0 Hz, 2H), 1.71 (s, 3H), 1.55 (s, 3H), 1.54 (s, 3H), 1.32 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 154.9 (C), 137.0 (C), 136.5 (C), 134.6 (CH), 131.4 (CH), 128.5 (CH), 126.9 (CH), 126.1 (CH), 114.8 (CH), 90.3 (C), 64.1 (CH_2), 63.0 (CH_2), 27.7 (CH_2), 27.1 (CH_2), 26.0 (CH_3), 18.2 (CH_3), 14.3 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{25}H_{31}O_7S_2$ $[M+H]^+$: 507.1511, found: 507.1494.

Compound 26: *m*-CPBA (164 mg, 0.95 mmol) was added to a mixture of **S34** (482 mg, 0.95 mmol) and $NaHCO_3$ (160 mg, 1.90 mmol) in dry CH_2Cl_2 (10 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 2:8) to give **26** (380 mg, 76%) as a colorless oil.

Synthesis of compound **28**



Compound S35: Isoprene monoxide (3.70 mL, 37.9 mmol) was added to a mixture of dimethyl malonate (1.74 mL, 15.1 mmol), $Pd(dba)_2$ (220 mg, 0.38 mmol) and dppe (151 mg, 0.38 mmol) in THF (15 mL). The resulting mixture was stirred at room temperature for 3 h and then solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:1) to give **S35** (2.20 g, 49%) as a colorless liquid. Compound **S35** was obtained as a 1:1 mixture of *E*,*E*:*E*,*Z* isomers.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.28 (t, *J* = 7.6 Hz, 2H, *E*-isomer), 5.25 (t, *J* = 7.4 Hz, 1H, *E*-isomer), 5.10 (t, *J* = 8.1 Hz, 1H, *Z*-isomer), 4.07 (s, 4H, *Z*-isomer), 3.98 (s, 4H, *E*-isom er), 3.72 (s, 6H, *E*-isomer), 3.71 (s, 6H, *Z*-isomer), 2.66 (d, *J* = 7.5 Hz, 4H, both isomers), 1.79 (s, 6H, *Z*-isomer) 1.65 (s, 6H, *E*-isomer).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.9 (C), 171.8 (C), 138.9 (C), 138.8 (C), 138.7 (C), 120.4 (CH), 118.4 (CH), 68.1 (CH_2), 60.7 (CH_2), 57.7 (C), 57.5 (C), 52.6 (CH_3), 52.5 (CH_3), 30.7 (CH_2), 30.5 (CH_2), 30.4 (CH_2), 21.4 (CH_3), 13.8 (CH_3), 13.7 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{15}H_{24}O_6Na$ $[M+Na]^+$: 323.1471, found: 323.1473.

Compound S36: Ethyl chloroformate (0.68 mL, 7.07 mmol) was slowly added to a mixture of **S35** (2.12 g, 7.07 mmol), Et_3N (0.98 mL, 7.07 mmol) and DMAP (43.0 mg, 0.35 mmol) in CH_2Cl_2 (100 mL). The mixture was stirred at room temperature for 16 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with HCl (10%) and brine and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **S36** (772 mg, 30%) as a yellowish liquid. Compound **S36** was obtained as a 2:1 mixture of *E*:*Z* isomers.

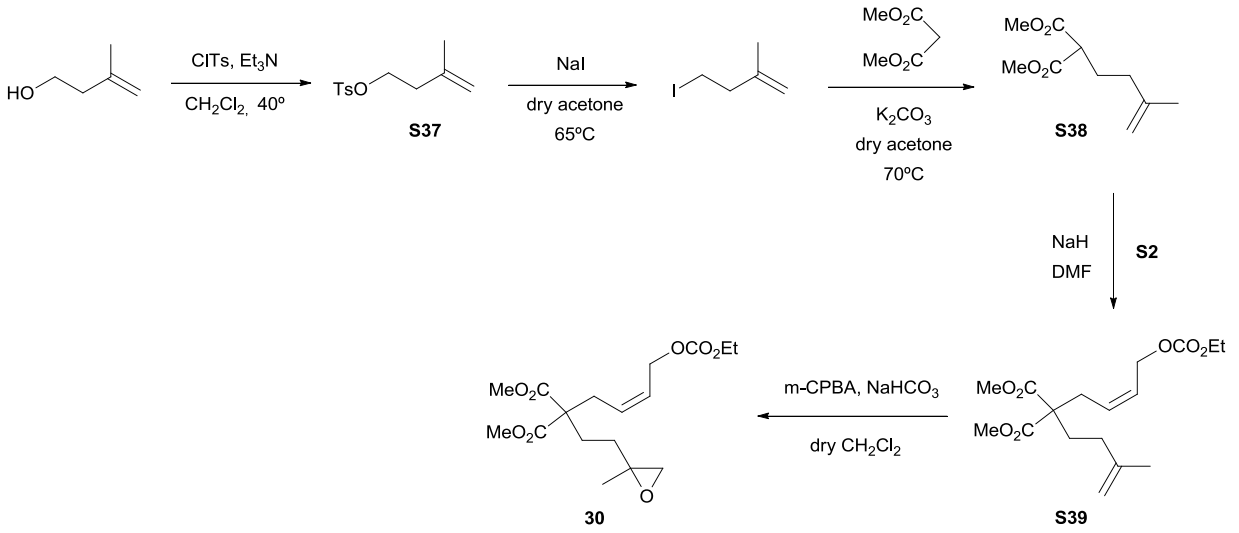
^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.28 (t, *J* = 7.2 Hz, 1H), 5.18 (t, *J* = 7.1 Hz, 1H, *E*-isomer), 5.04 (t, *J* = 7.1 Hz, 1H, *Z*-isomer), 4.42 (s, 2H), 4.13 (q, *J* = 7.1 Hz, 2H), 4.00 (s, 2H, *Z*-isomer), 3.90 (s, 2H, *E*-isomer), 3.65 (s, 6H, *E*-isomer), 3.64 (s, 6H, *Z*-isomer), 2.58 (d, *J* = 6.7 Hz, 4H), 1.73 (s, 3H, *Z*-isomer) 1.60 (s, 3H), 1.57 (s, 3H, *E*-isomer), 1.24 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.5 (C), 171.4 (C), 155.0 (C), 139.1 (C), 139.0 (C), 133.7 (C), 133.6 (C), 123.1 (CH), 123.0 (CH), 120.5 (CH), 118.3 (CH), 72.9 (CH_2), 72.8 (CH_2), 68.2 (CH_2), 64.0 (CH_2), 63.9 (CH_2), 61.0 (CH_2), 57.6 (C), 57.4 (C), 52.5 (CH_3), 52.4 (CH_3), 31.0 (CH_2), 30.8 (CH_2), 30.7 (CH_2), 30.6 (CH_2), 21.6 (CH_3), 14.2 (CH_3), 14.0 (CH_3), 13.9 (CH_3), 13.7 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{18}H_{28}O_8Na$ $[M+Na]^+$: 395.1682, found: 395.1683.

Compound 28: *m*-CPBA (138 mg, 0.80 mmol) was added to a mixture of **S36** (248 mg, 0.67 mmol) and $NaHCO_3$ (56.0 mg, 0.67 mmol) in dry CH_2Cl_2 (6 mL). The mixture was stirred at room temperature for 48 h. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 4:6) to give **28** (212 mg, 82%) as a yellowish oil.

Synthesis of compound **30**



Compound S37: *p*-Toluenesulfonyl chloride (2.32 g, 12.2 mmol) was added to a mixture of 3-methyl-3-buten-1-ol (1.18 mL, 11.6 mmol) and Et_3N (2.41 mL, 17.4 mmol) in CH_2Cl_2 (15 mL). The resulting solution was monitored by TLC and stirred at 40ºC until starting material dissapeared (about 4 h). Then mixture was diluted with CH_2Cl_2, washed with water and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **S37** (1.84 g, 66%) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[17]

Compound S38: NaI (1.54 g, 10.3 mmol) was added over a solution of **S37** (1.23 g, 5.13 mmol) in dry acetone (25 mL). The resulting solution was monitored by TLC and stirred at 65ºC until starting material disappeared (about 6 h). Then NaI was filtrated and dimethyl malonate (0.60 mL, 5.13 mmol) and K_2CO_3 (1.06 g, 7.68 mmol) were added. The mixture was stirred at 70ºC during 16 h. Then K_2CO_3 was filtrated and the solvent was removed. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 5:95) to give **S38** (322 mg, 31%, 2 steps) as a yellowish oil. Its spectroscopic data were identical to the reported compound.[18]

Compound S39: S2 (190 mg, 0.83 mmol) in DMF (2 mL) was added to a mixture of **S38** (150 mg, 0.75 mmol) and NaH (60%) (45.0 mg, 1.13 mmol) in dry DMF (5 mL). The mixture was stirred at room temperature for 3 h. Then the mixture was diluted with Et_2O, washed with HCl (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 1:9) to give **S39** (175 mg, 68%) as a colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 5.69 – 5.58 (m, 1H), 5.53 – 5.40 (m, 1H), 4.67 (d, *J* = 5.1 Hz, 2H), 4.67 (d, *J* = 5.1 Hz, 2H), 4.12 (q, *J* = 7.1 Hz, 2H), 3.65 (s, 6H), 2.67 (d, *J* = 7.6 Hz, 2H), 2.02 – 1.89 (m, 2H), 1.88 – 1.76 (m, 2H), 1.65 (s, 3H), 1.23 (t, *J* = 7.1 Hz, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.3 (C), 155.0 (C), 144.4 (C), 128.4 (CH), 127.9 (CH), 110.4 (CH_2), 64.1 (CH_2), 63.0 (CH_2), 57.1 (C), 52.4 (CH_3), 32.1 (CH_2), 30.8 (CH_2), 30.7 (CH_2), 22.3 (CH_3), 14.2 (CH_3).

HRMS (TOF MS ES+) *m/z* calcd. for $C_{17}H_{27}O_7$ $[M+H]^+$: 343.1757, found: 343.1764.

Compound 30: *m*-CPBA (177 mg, 1.02 mmol) was added to a mixture of **S39** (175 mg, 0.51 mmol) and $NaHCO_3$ (43.0 mg, 0.51 mmol) in dry CH_2Cl_2 (5 mL). The mixture was stirred at room temperature for 4 days. Then the reaction mixture was diluted with CH_2Cl_2, washed with NaOH (10%) and dried over anhydrous Na_2SO_4. The residue was submitted to flash chromatography (SiO_2, EtOAc:Hexane, 15:85) to give **30** (105 mg, 58%) as a colorless oil.

[17] A. K. Ghosh and D. R. Nicponski, *Org. Lett.*, 2011, **13**, 4328-4331.

[18] K. Tanabe, A. Fujie, N. Ohmori, Y. Hiraga, S. Kojima and K. Ohkata, *Bull. Chem. Soc. Jpn*., 2007, **80**, 1597-1604.

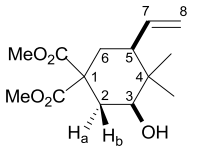
2. Cp_2TiCl-catalyzed intramolecular epoxide allylation

2.1. General procedure

Rigorously deoxygenated dry THF (10 mL) was added to a previously deoxygenated mixture of Cp_2TiCl_2 (0.2 mmol), Mn (8.0 mmol) under Ar atmosphere, and the suspension was stirred at room temperature until it turned green (about 10 min). A solution of the previously synthesized polyfunctionalized substrate (1.0 mmol) in THF (2 mL), Me_3SiCl (4.0 mmol) and 2,4,6-collidine (6.0 mmol) were then added. The reaction mixture was stirred at room temperature for 16 h and then diluted with EtOAc, washed with water, dried over anhydrous Na_2SO_4 and the solvent removed. The residue was submitted to flash column chromatography (SiO_2, EtOAc:Hexane mixtures) to give the corresponding cyclic products.

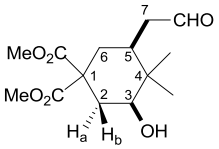
2.2. Cyclic compounds

Compound **2**



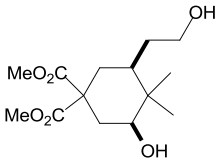
2

Compound **4**



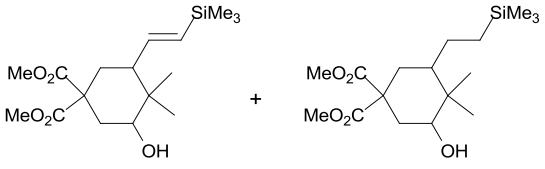
4

Compound **5**



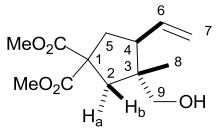
5

Compounds **7** *and* **8**



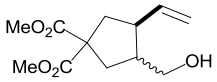
7 **8**

Compound **10**



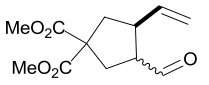
10

Compound **12**



12

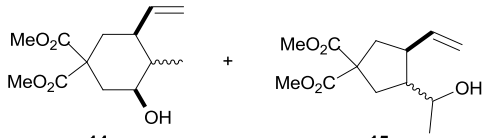
Compound **12** was oxidized to simplify the ^{1}H-NMR spectrum and confirm the ratio of diastereomers obtained.



S40

Dess-Martin Periodinane (79 mg, 0.19 mmol) was added to a solution of **12** (30 mg, 0.12 mmol) in CH_2Cl_2 (4 mL). The mixture was stirred at room temperature and monitored by TLC until starting material dissappeared (3 h). Then the mixture was diluted with CH_2Cl_2, washed with saturated aqueous solution of $Na_2S_2O_3$ and $NaHCO_3$ in 1:1 proportion and dried over anhydrous Na_2SO_4. The residue was purified by chromatography through a short pad of silica (EtOAc:Hexane, 15:85) to give a 7/3 mixture of *cis/trans* diastereoisomers of **S40** (18 mg, 63%) as a colorless oil. Its spectroscopic data were identical to the reported data of a *trans*/*cis* mixture in 13:1 dr.[19] Mayor diastereomer *cis*-**S40**: ^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 9.68 (d, *J* = 1.3 Hz, 1H), 5.78 (ddd, *J* = 17.4, 10.3, 7.8 Hz, 1H), 5.17 (d, *J* = 17.4 Hz, 1H), 5.11 (d, *J* = 11.5 Hz, 1H), 3.75 (s, 3H), 3.74 (s, 3H), 3.09 (td, *J* = 15.0, 8.0 Hz, 1H), 2.70 - 2.57 (m, 2H), 2.55 - 2.41 (m, 2H), 2.19 (dd, *J* = 13.7, 9.3 Hz, 1H).

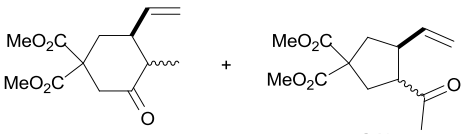
Compounds **14** *and* **15**



14 **15**

The mixture of compounds **14** and **15** was oxidized to simplify the ^{1}H-NMR spectrum and confirm both compounds and dr obtained.

[19] M. Li, S. Datta, D. M. Barber and D. J. Dixon, *Org. Lett.*, 2012, **14**, 6350-6353.



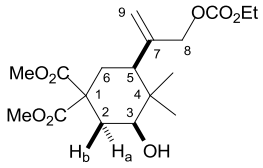
S41 **S42**

Dess-Martin Periodinane (99 mg, 0.23 mmol) was added to a solution of cycles **14**/**15** (40 mg, 0.16 mmol) in CH_2Cl_2 (4 mL). The mixture was stirred at room temperature and monitored by TLC until starting material dissappeared (3 h). Then the mixture was diluted with CH_2Cl_2, washed with saturated aqueous solution of $Na_2S_2O_3$ and $NaHCO_3$ in 1:1 proportion and dried over anhydrous Na_2SO_4. The residue was purified by chromatography through a short pad of silica (EtOAc:Hexane, 15:85) to give compounds **S41** (2:1 dr) and **S42** (2:1 dr) in a 1/1 mixture (23 mg, 58%) as a colorless oil.

^{1}H-NMR (500 MHz, $CDCl_3$) δ(ppm): 5.76 – 5.56 (m, 1H), 5.13 – 4.99 (m, 2H), 3.73 (s, 3H), 3.72 (s, 3H), 3.23 (q, *J* = 8.3 Hz, 1H, **S42**), 3.08 - 3.01 (m, 1H, **S42**), 3.02 (dd, *J* = 14.4, 2.7 Hz, 1H, **S41**), 2.85 - 2.73 (m, 2H, **S41**), 2.58 - 2.54 (m, 1H), 2.47 - 2.40 (m, 1H), 2.36 (dd, *J* = 14.0, 7 Hz, 1H, **S42**), 2.28 (dd, *J* = 13.9, 7.2 Hz, 1H, **S42**), 2.17 - 2.12 (m, 1H, **S41**), 2.13 (s, 3H, **S42**, *minor diastereomer*), 2.08 (s, 3H, **S42**, *mayor diastereomer*), 1.03 (d, *J* = 7.4 Hz, 3H, **S41**, *minor diastereomer*), 1.01 (d, *J* = 5.8 Hz, 3H, **S41**, *mayor diastereomer*). (Only characteristic signals for minor diastereoisomers are listed)

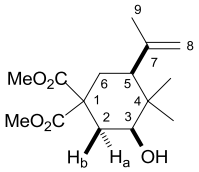
^{13}C-NMR (125 MHz, $CDCl_3$) δ(ppm): 208.4 (C), 207.1 (C), 173.0 (C), 172.5 (C), 172.1 (C), 171.9 (C), 171.1 (C), 170.9 (C), 170.8 (C), 170.8 (C), 139.8 (CH), 139.2 (CH), 137.6 (CH), 137.2 (CH), 116.7 (CH_2), 116.6 (CH_2), 116.4 (CH_2), 116.2 (CH_2), 59.1 (C), 58.8 (C), 57.3 (CH), 56.4 (C), 55.5 (C), 53.2 (CH_3), 53.2 (CH_3), 53.2 (CH_3), 53.1 (CH_3), 53.1 (CH_3), 53.0 (CH_3), 52.9 (CH_3), 48.5 (CH), 47.5 (CH), 47.1 (CH), 45.9 (CH), 45.9 (CH), 45.1 (CH_2), 41.8 (CH_2), 40.6 (CH), 40.5 (CH_2), 39.5 (CH_2), 36.8 (CH_2), 36.6 (CH_2), 34.9 (CH_2), 31.1 (CH_3), 30.3 (CH_2), 30.1 (CH_3), 12.2 (CH_3), 12.0 (CH_3).

Compound **17**



17

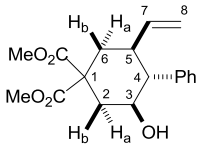
Compound **S43**



S43

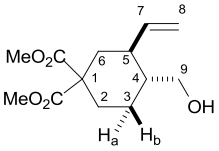
Colorless oil; 12% yield.
^{1}H-NMR (500 MHz, $CDCl_3$) δ(ppm): 4.92 (s, 1H), 4.68 (s, 1H), 3.76 (s, 3H), 3.71 (s, 3H), 3.40 (dd, *J* = 12.0, 3.9 Hz, 1H), 2.47 – 2.32 (m, 1H), 2.11 (dt, *J* = 13.7, 2.2 Hz 1H), 1.99 (t, *J* = 13.6 Hz, 1H), 1.94 – 1.85 (m, 1H), 1.84 (t, *J* = 12.5 Hz, 1H), 1.76 (s, 3H), 0.95 (s, 3H), 0.86 (s, 3H). NOE-diff. experiment: proton irradiated, (NOEs observed): H-2a, (H-2b, H-3), H-3, (H-2a, H-5).
^{13}C-NMR (125 MHz, $CDCl_3$) δ(ppm): 171.9 (C), 171.5 (C), 145.1 (C), 114.0 (CH), 75.0 (CH), 55.1 (C), 52.9 (CH_3), 52.8 (CH_3), 49.1 (CH), 38.9 (C), 34.7 (CH_2), 32.0 (CH_2), 26.0 (CH_3), 24.3 (CH_3), 13.1 (CH_3).
HRMS (TOF MS ES+) *m/z* calcd. for $C_{15}H_{24}O_5Na$ $[M+Na]^+$: 307.1515; found: 307.1520.

Compound **19**



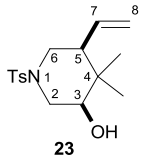
19

Compound **21**



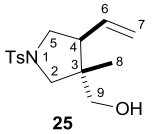
21

Compound **23**



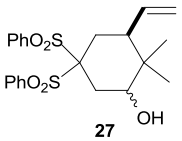
23

Compound **25**



25

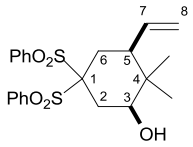
Compound **27**



27

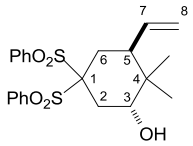
Compound **27** was obtained as a mixture of *cis/trans* diastereoisomers.

cis-**27a**:



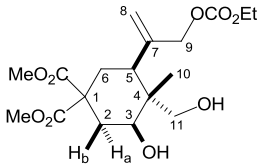
27a

trans-**27b**:



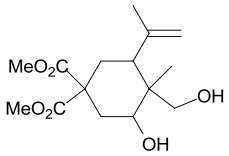
27b

Compound **29**



29

Compound **S44**



S44

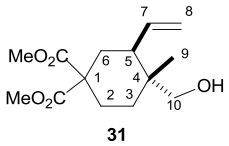
Colorless oil; 15% yield.

^{1}H-NMR (300 MHz, $CDCl_3$) δ(ppm): 4.90 (s, 1H), 4.73 (s, 1H), 3.85 – 3.75 (m, 1H), 3.76 (s, 3H), 3.72 (s, 3H), 3.64 (d, *J* = 10.6 Hz, 1H), 3.48 (d, *J* = 10.6 Hz, 1H), 2.38 (dd, *J* = 13.9, 4.1 Hz, 1H), 2.14 – 2.00 (m, 3H), 1.87 (t, *J* = 13.0 Hz, 1H), 1.74 (s, 3H), 1.70 – 1.59 (bs, 1H), 0.97 (s, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$) δ(ppm): 171.84 (C), 171.44 (C), 144.64 (C), 114.40 (CH_2), 72.68 (CH), 70.66 (CH_2), 54.76 (C), 52.99 (CH_3), 52.86 (CH_3), 44.35 (C), 42.23 (CH), 34.21 (CH_2), 31.43 (CH_2), 23.51 (CH_3), 9.58 (CH_3).

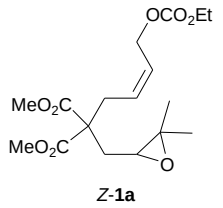
HRMS (TOF MS ES+) *m/z* calcd. for $C_{15}H_{24}O_6Na$ $[M+Na]^+$: 323.1465, found: 323.1467.

Compound **31**

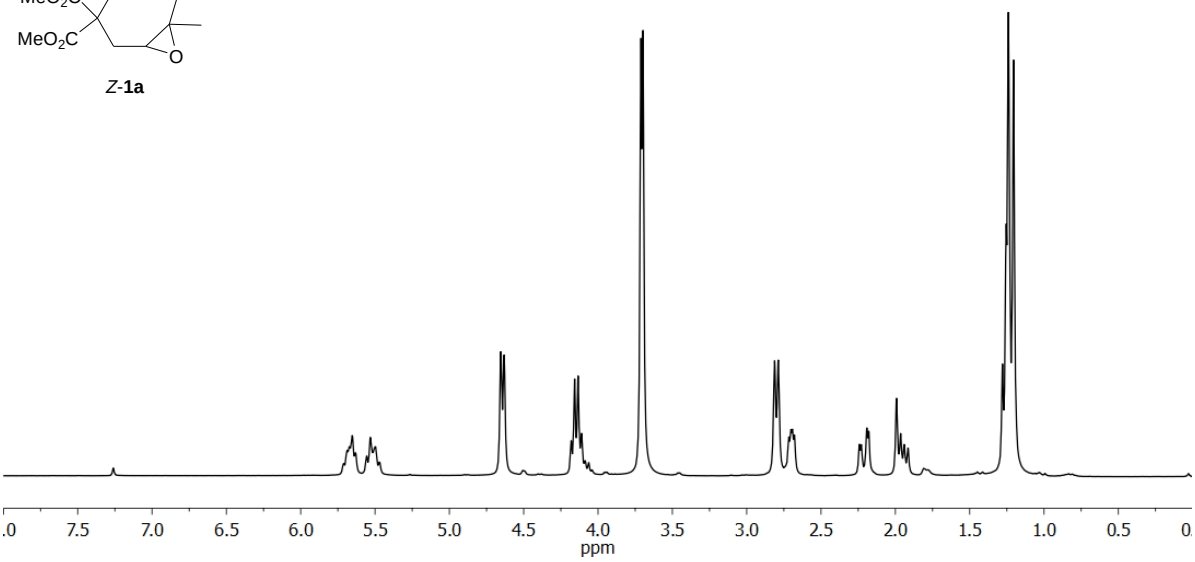


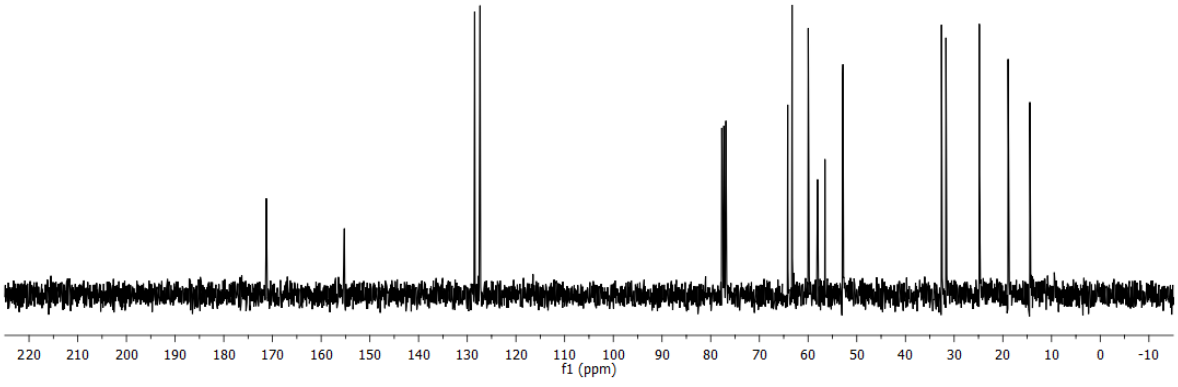
31

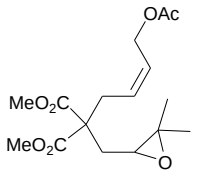
3. Copies of ^{1}H-NMR and ^{13}C-NMR of polyfunctionalized substrates



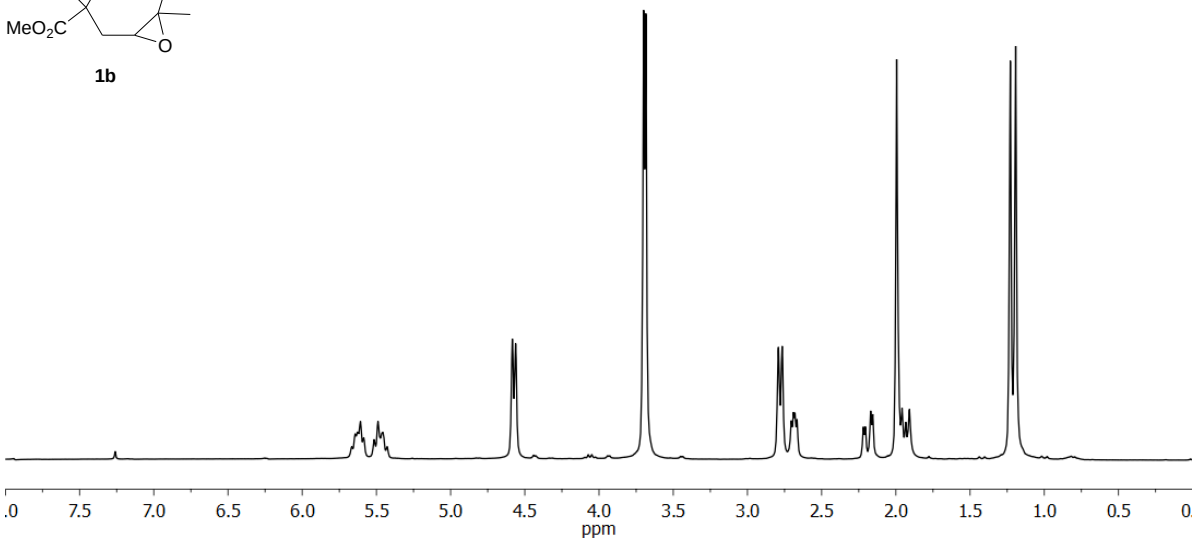
Z-**1a**

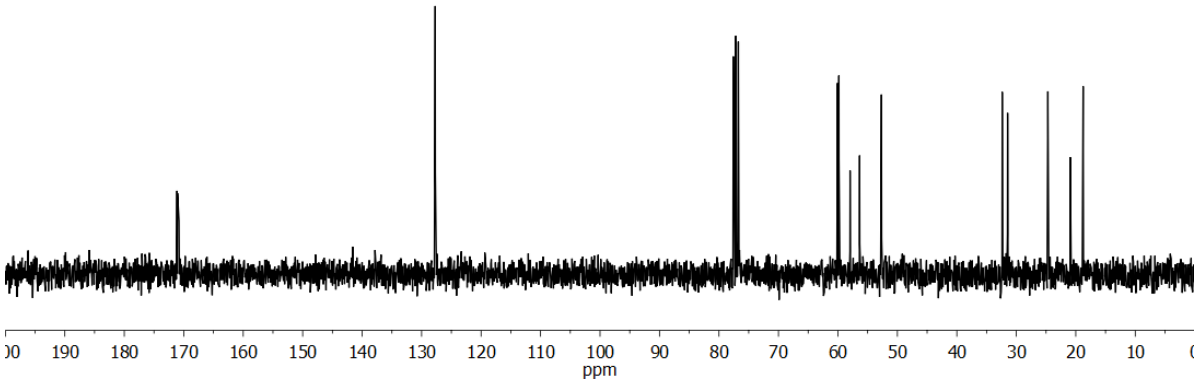


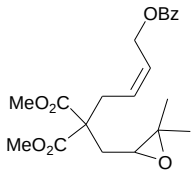



OAc
MeO2C
MeO2C
O

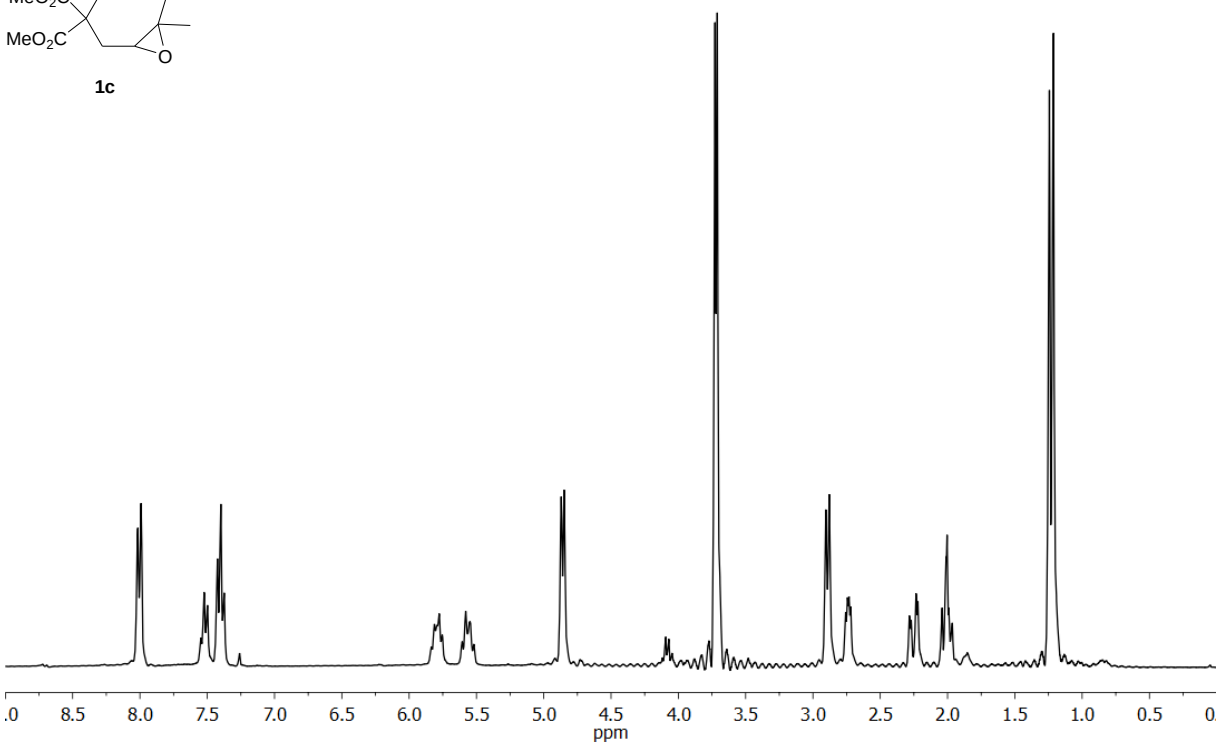
1b

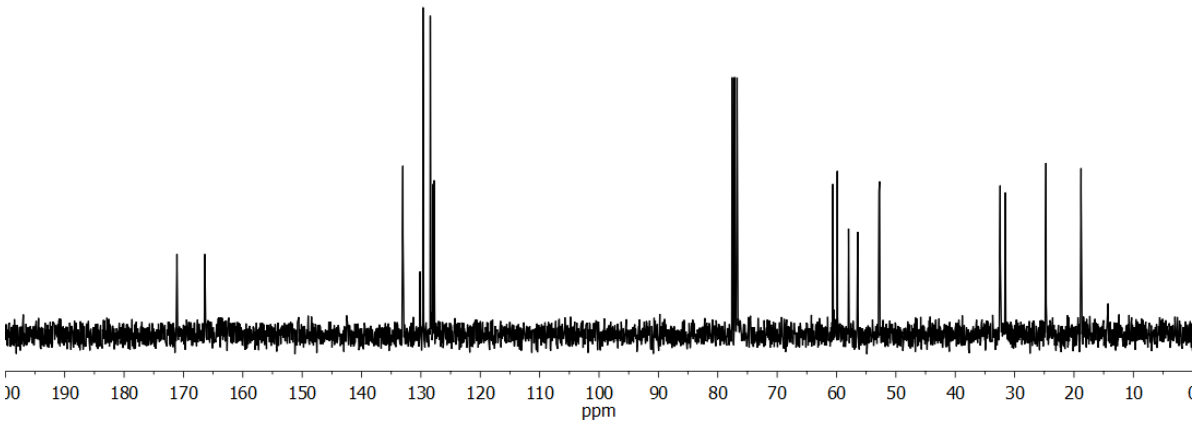

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

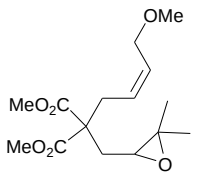

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OBz
MeO2C
MeO2C
O

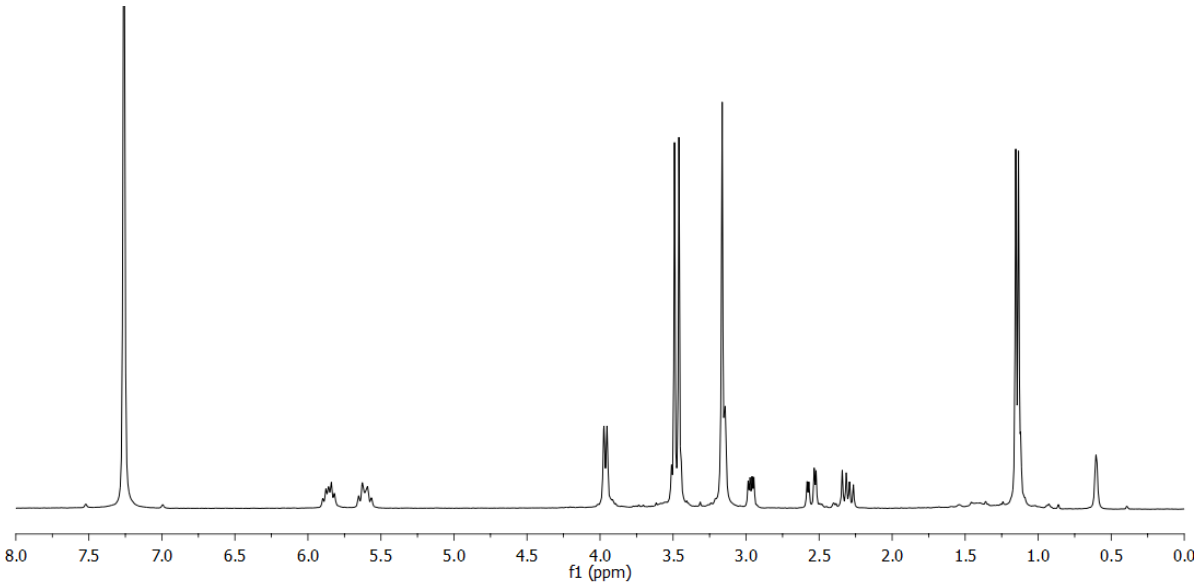
1c

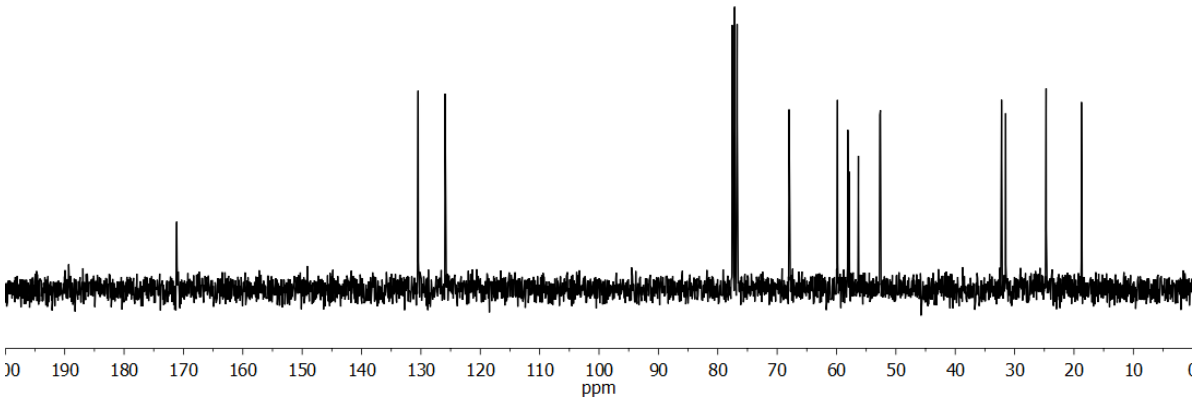

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

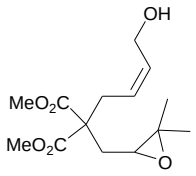

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OMe
MeO2C
MeO2C
O

1d

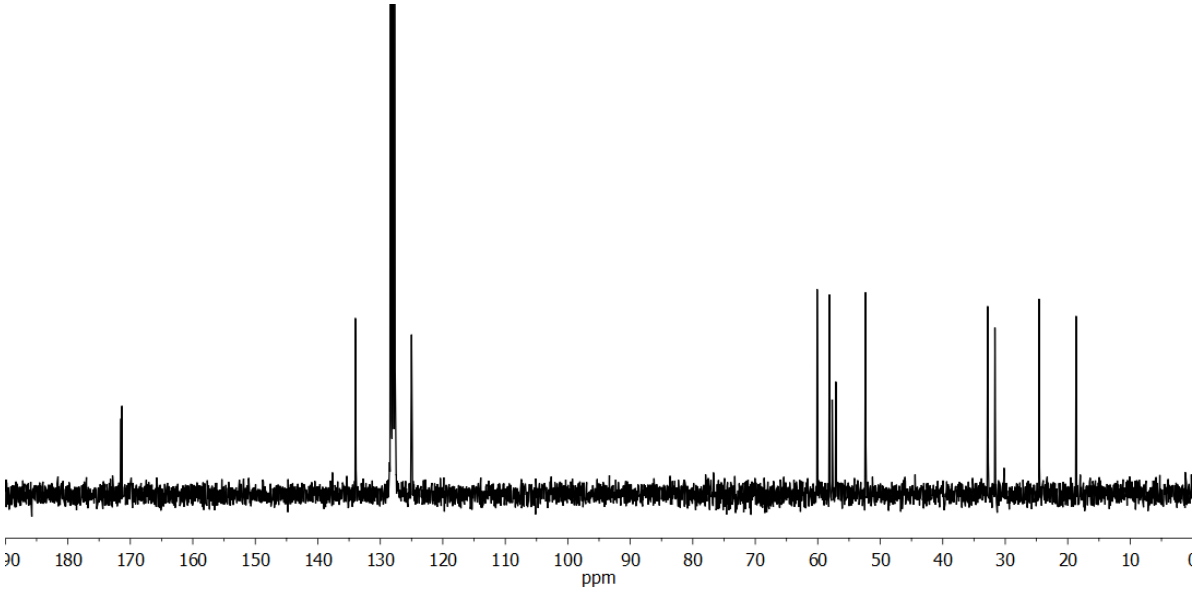

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

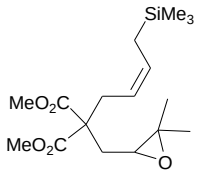

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OH
MeO2C
MeO2C
O

3

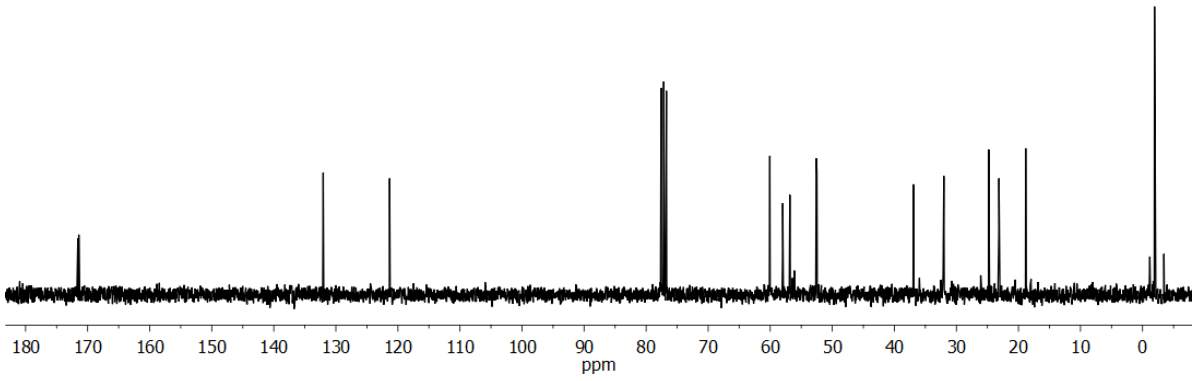
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

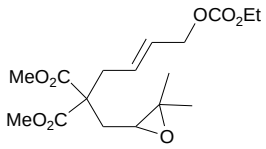

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


SiMe3
MeO2C
MeO2C
O

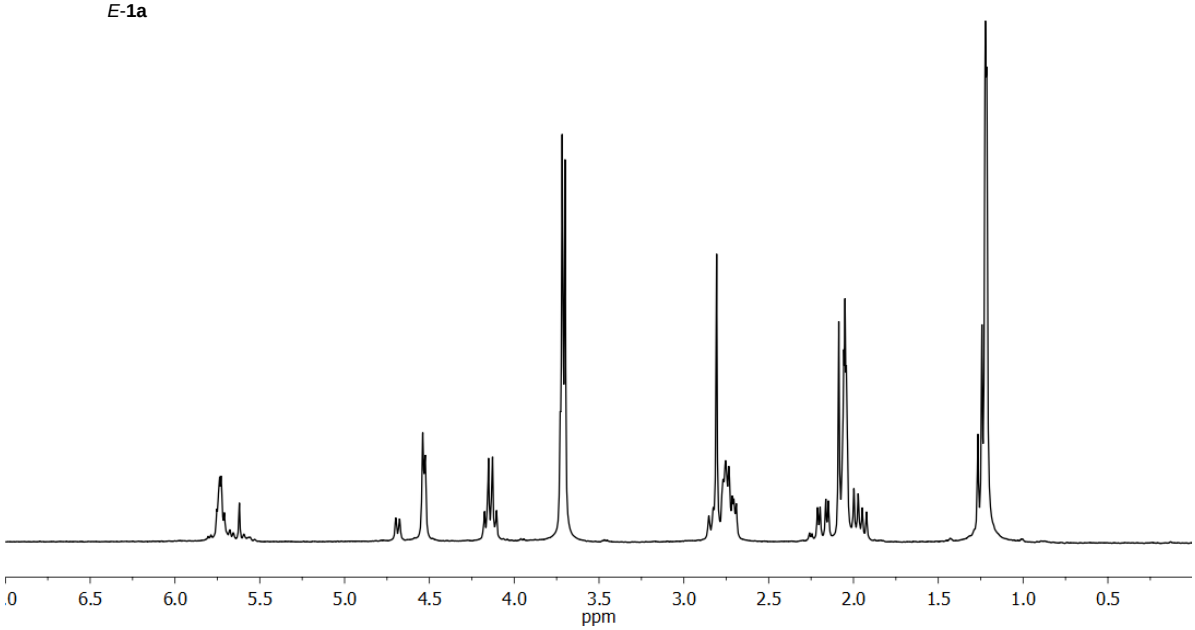
6

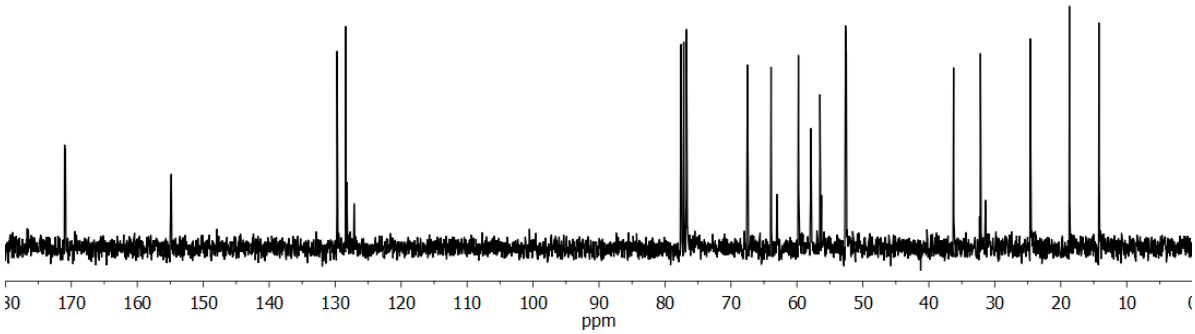
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm

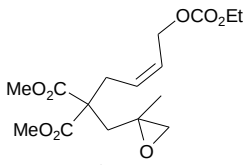

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


OCO2Et
MeO2C
MeO2C
O

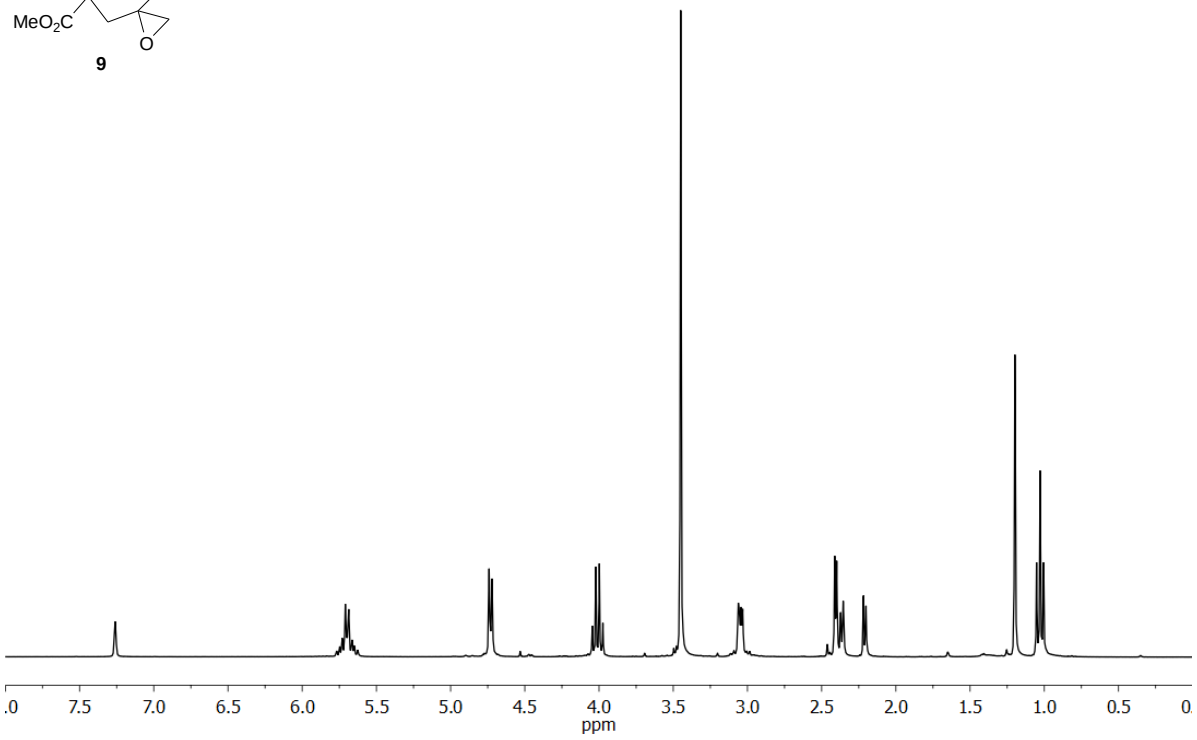
E-**1a**

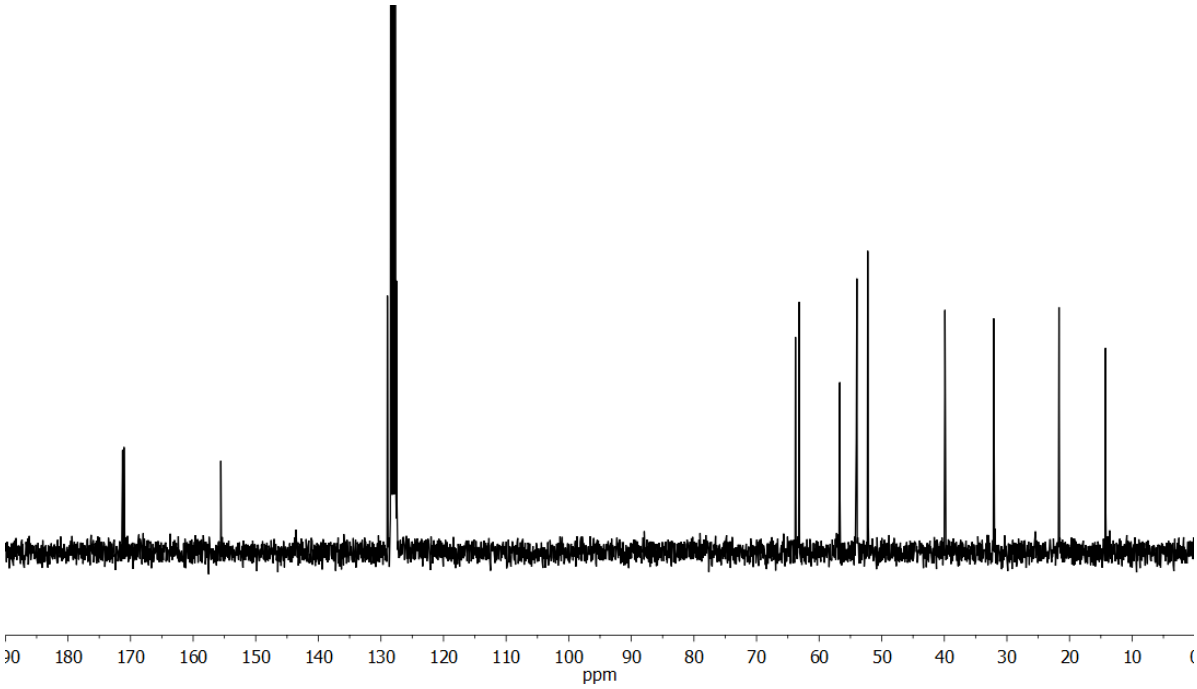

6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm


170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OCO2Et
MeO2C
MeO2C
O

9


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
ppm


180
170
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140
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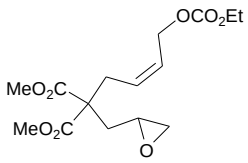
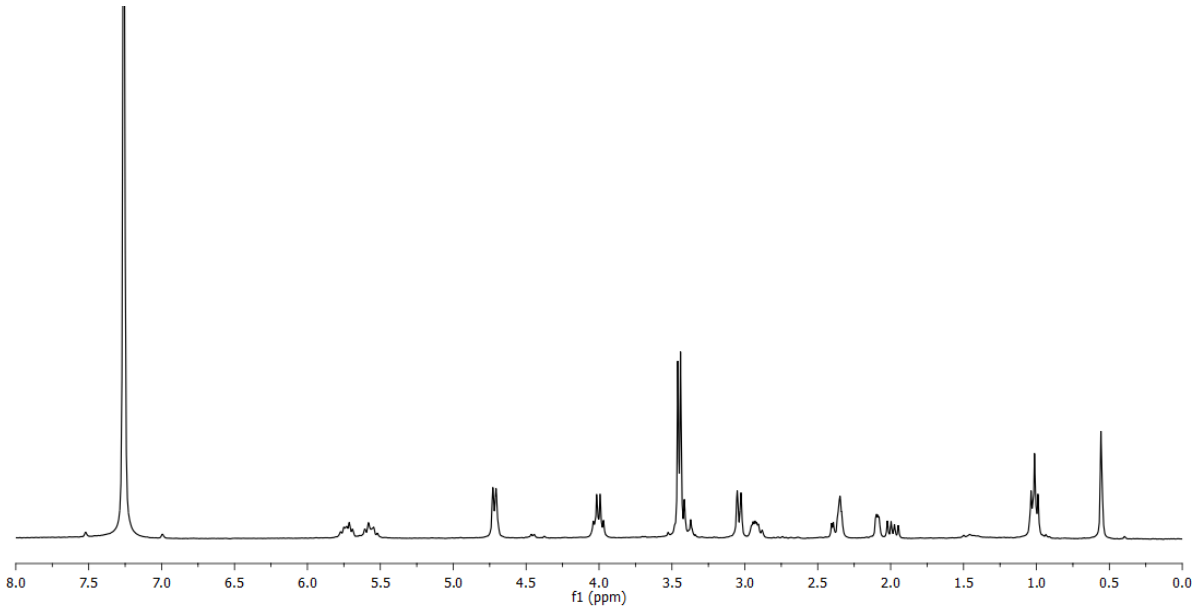
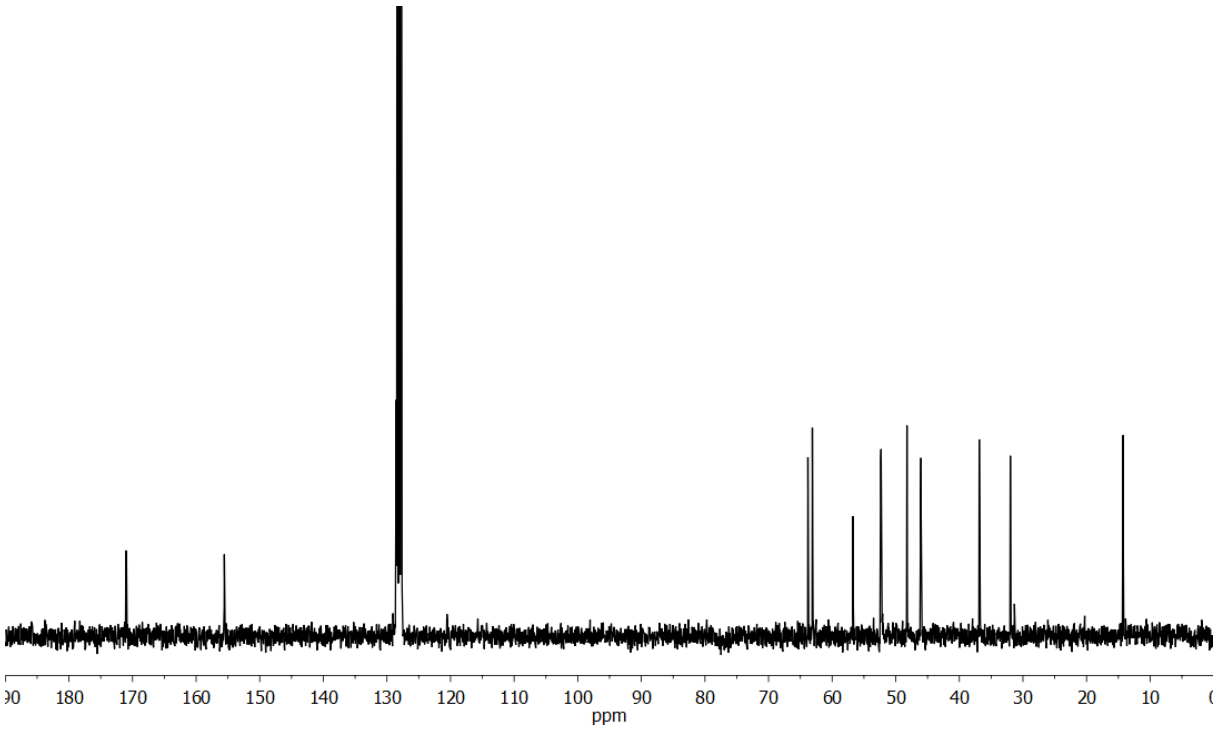
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OCO2Et
MeO2C
MeO2C
O

11


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
f1 (ppm)


180
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140
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120
110
100
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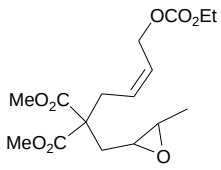
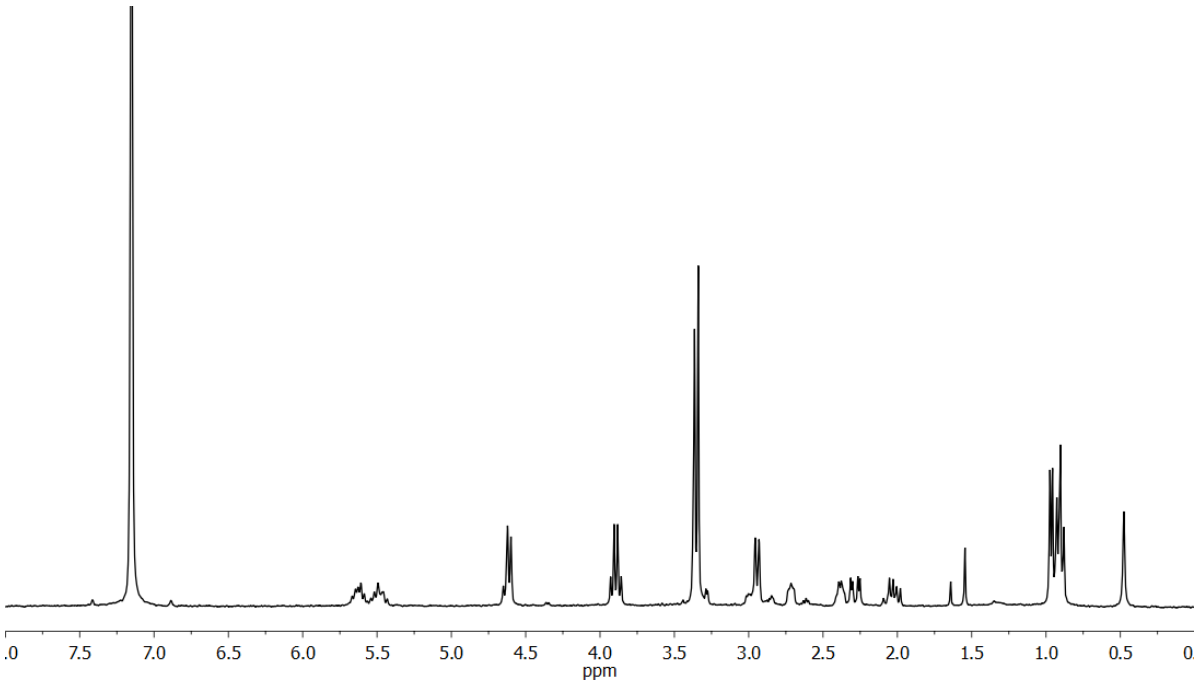
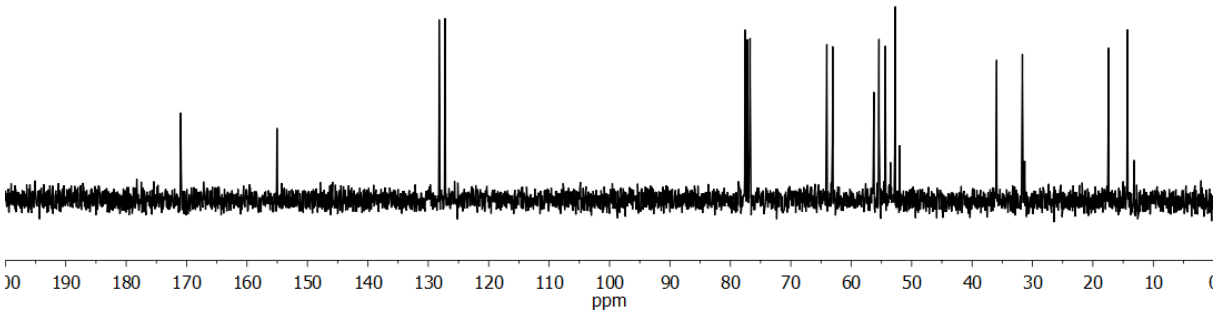
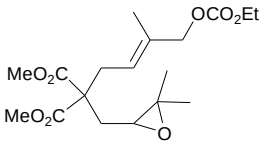
80
70
60
50
40
30
20
10
ppm


OCO2Et
MeO2C
MeO2C
O

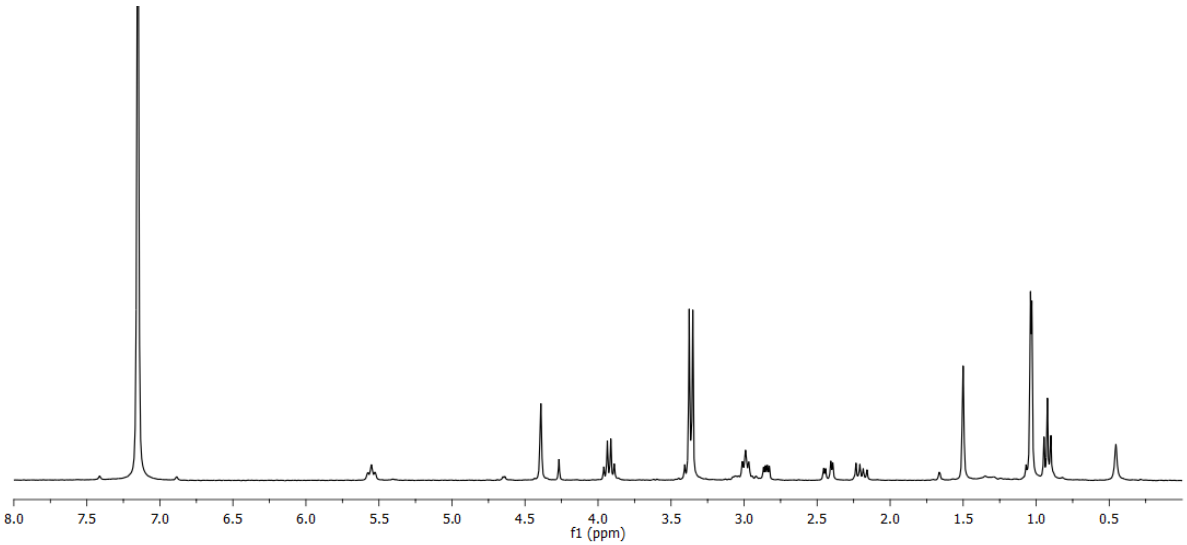
13

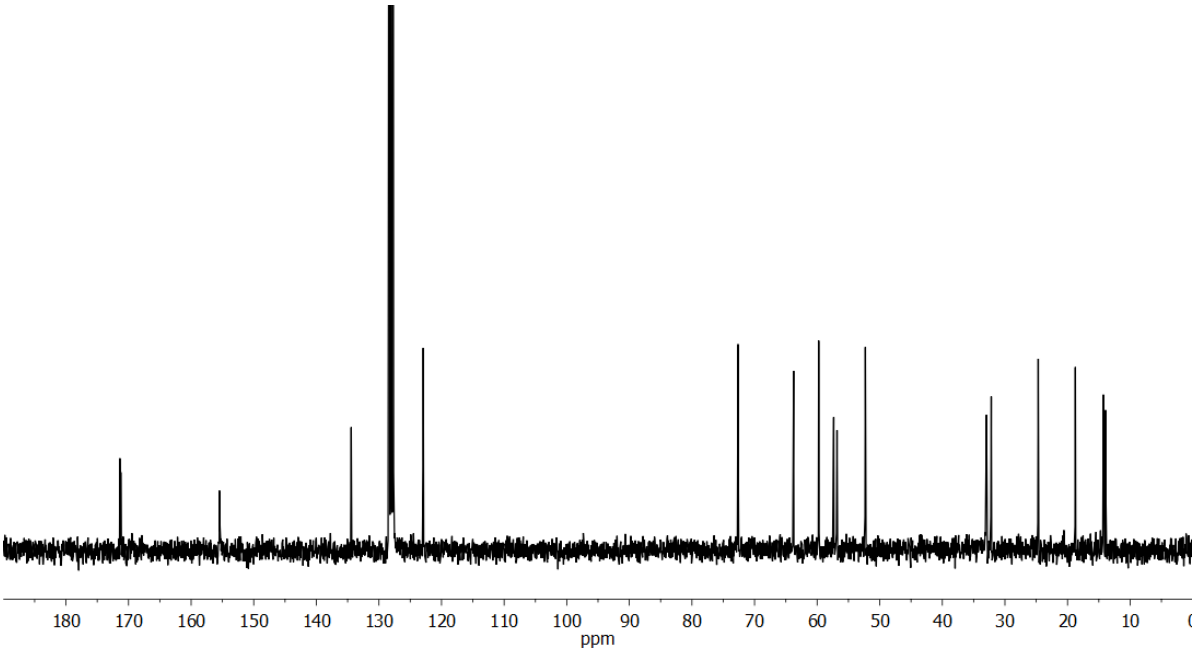

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm


190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OCO2Et
MeO2C
MeO2C
O

16


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
f1 (ppm)


180
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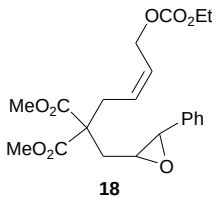
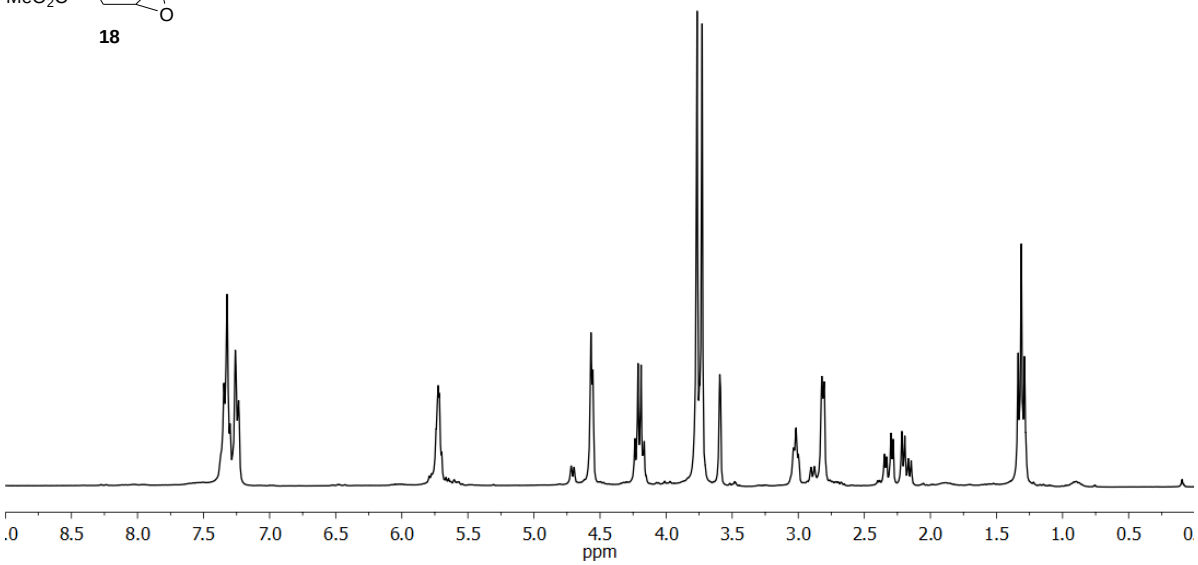
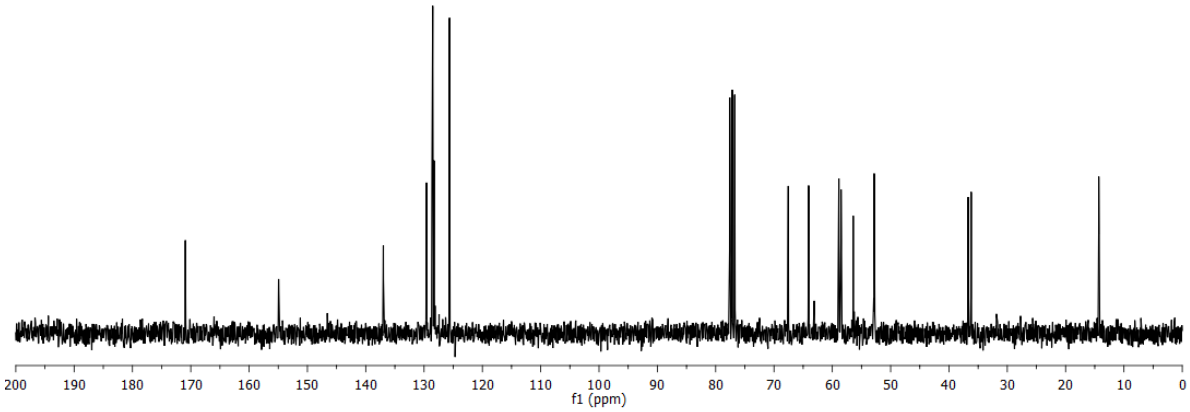
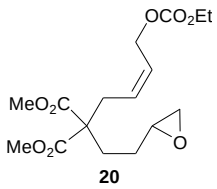
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


OCO2Et
MeO2C
MeO2C
Ph
O

18

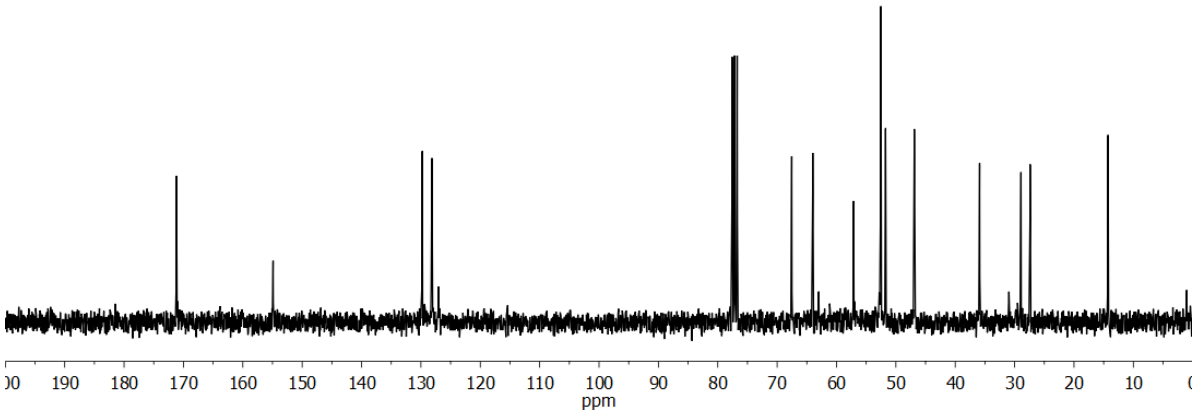

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

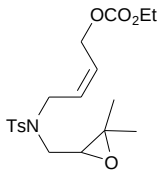

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


OCO2Et
MeO2C
MeO2C
O

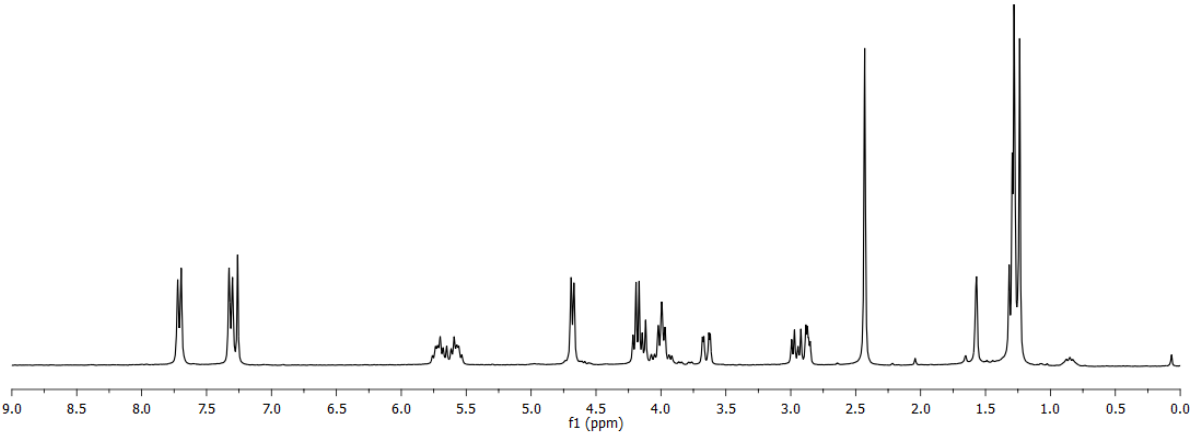
20

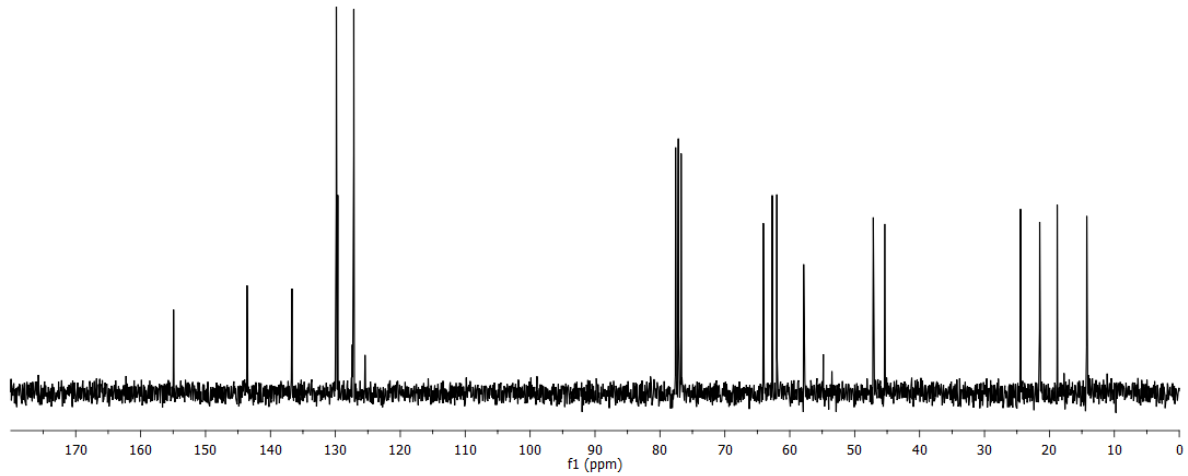
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

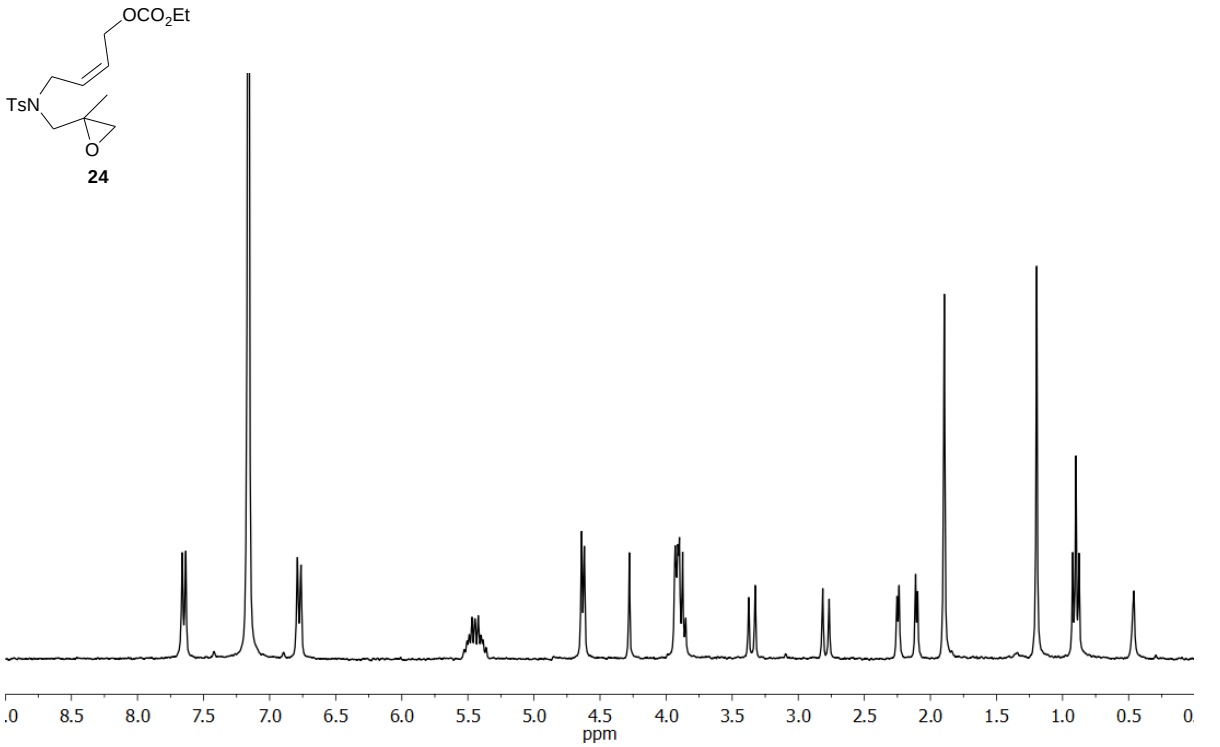

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

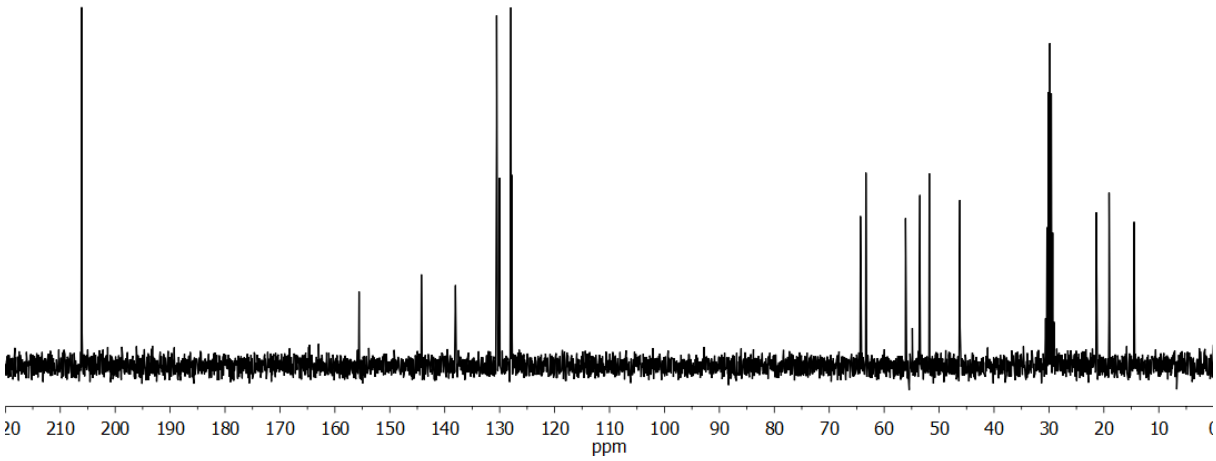

OCO2Et
TsN
O

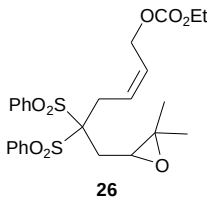
22


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
f1 (ppm)

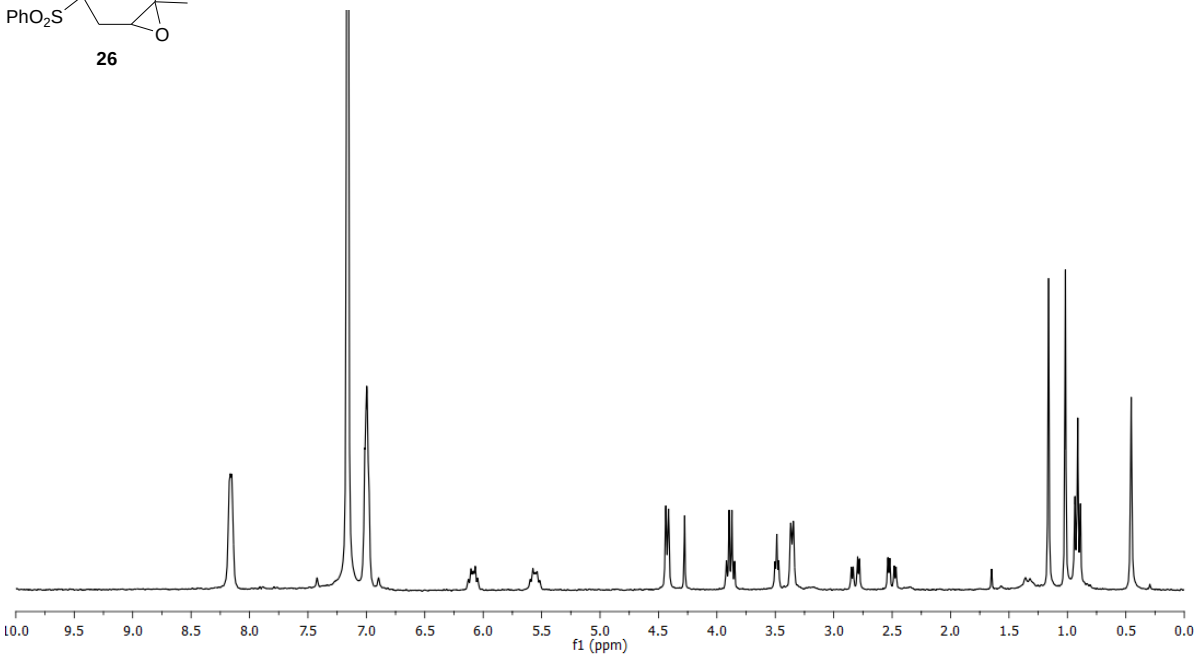

170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

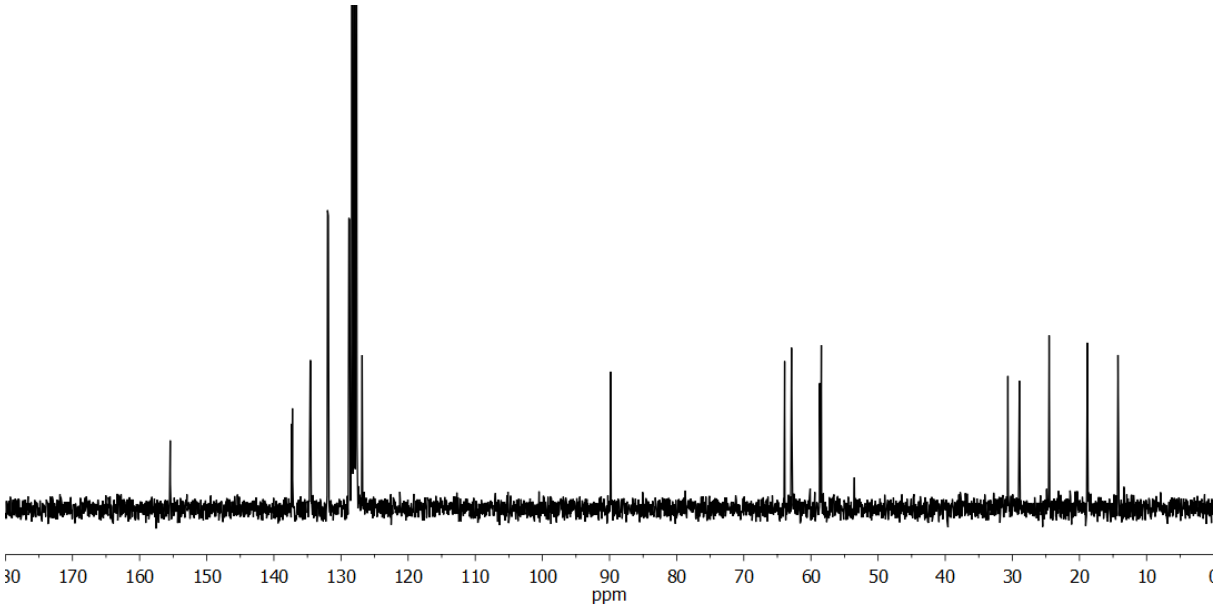

OCO2Et
TsN
O
24
.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0
ppm

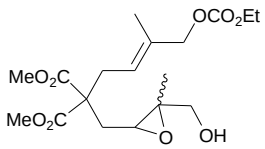

20 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm


OCO2Et
PhO2S
PhO2S
O

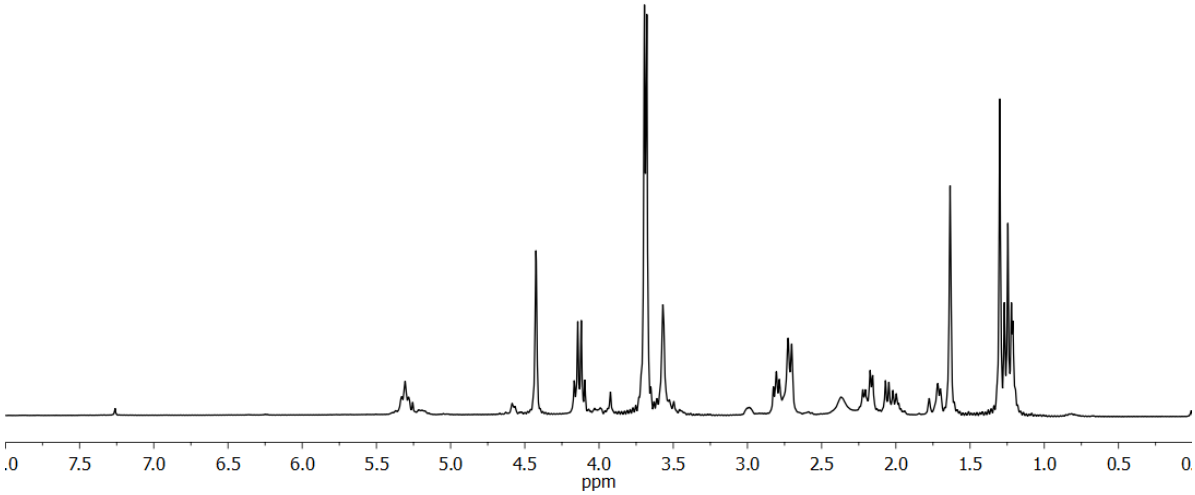
26

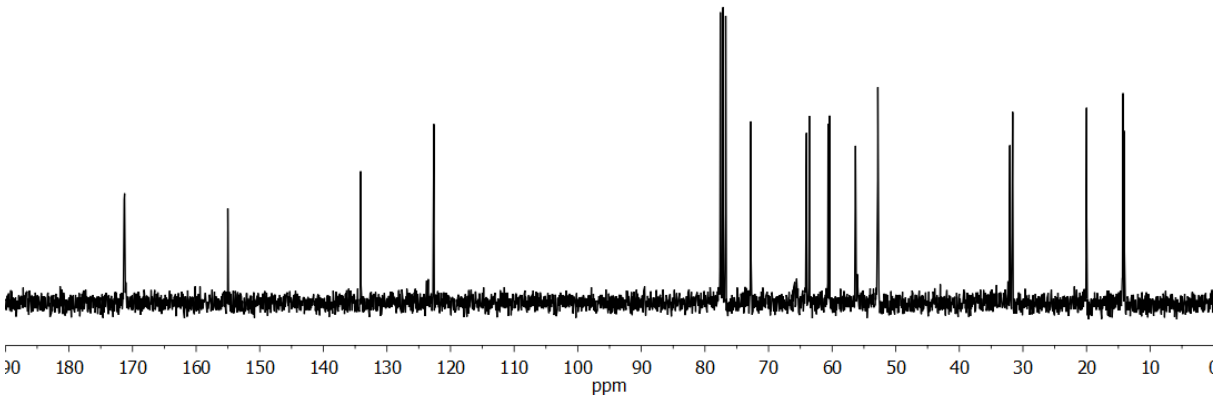

10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

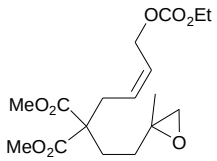

30 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm


OCO2Et
MeO2C
MeO2C
O
OH

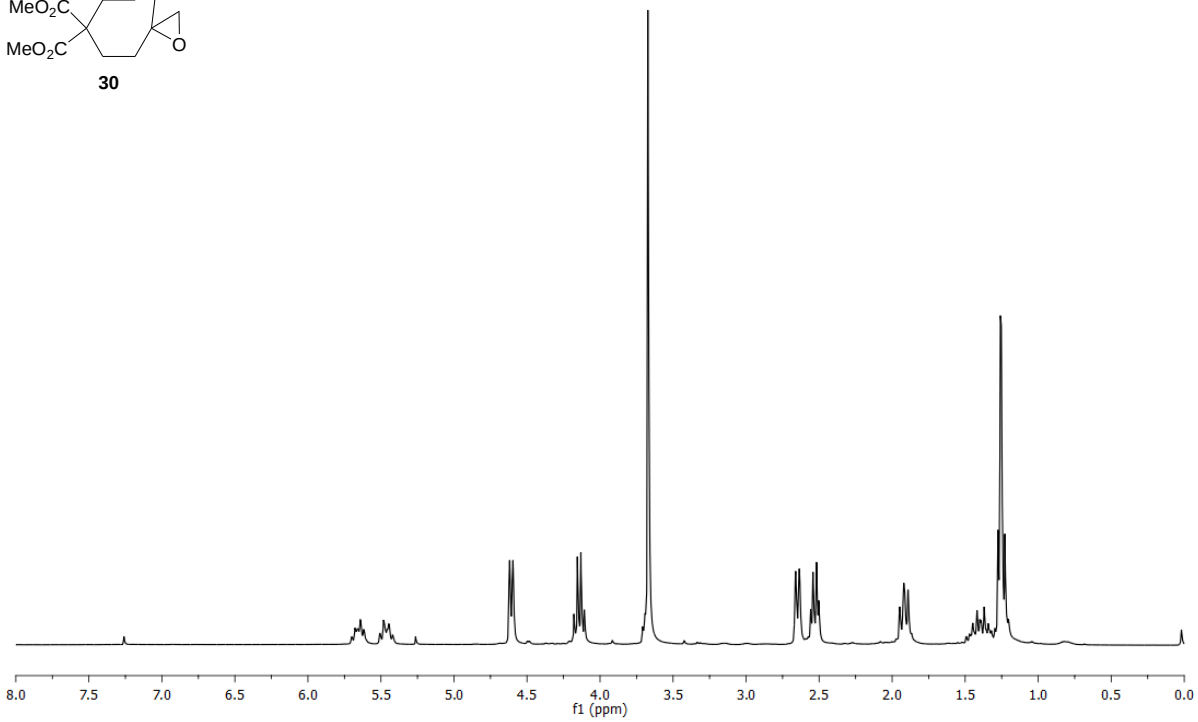
28

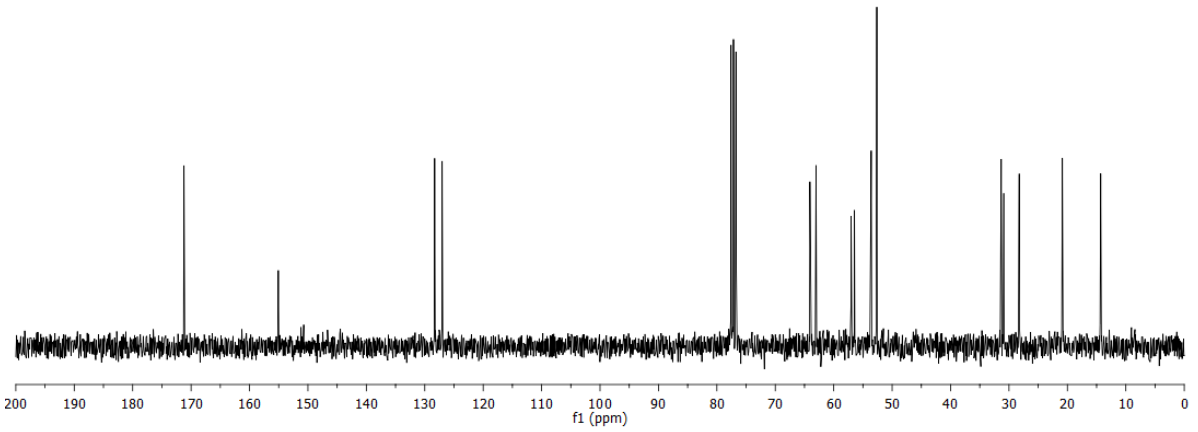

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm


180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

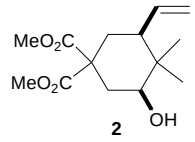

OCO2Et
MeO2C
MeO2C
O

30

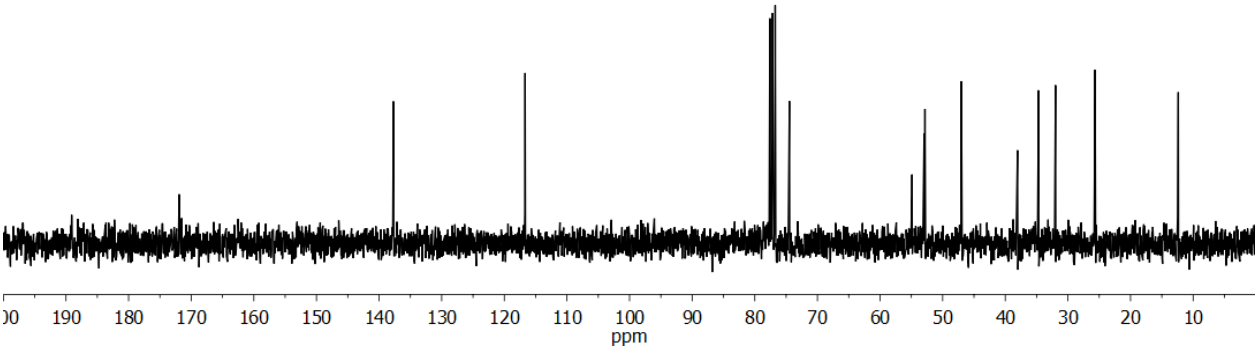

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

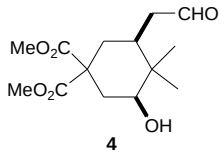

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4. Copies of ^{1}H-NMR and ^{13}C-NMR of cyclization products



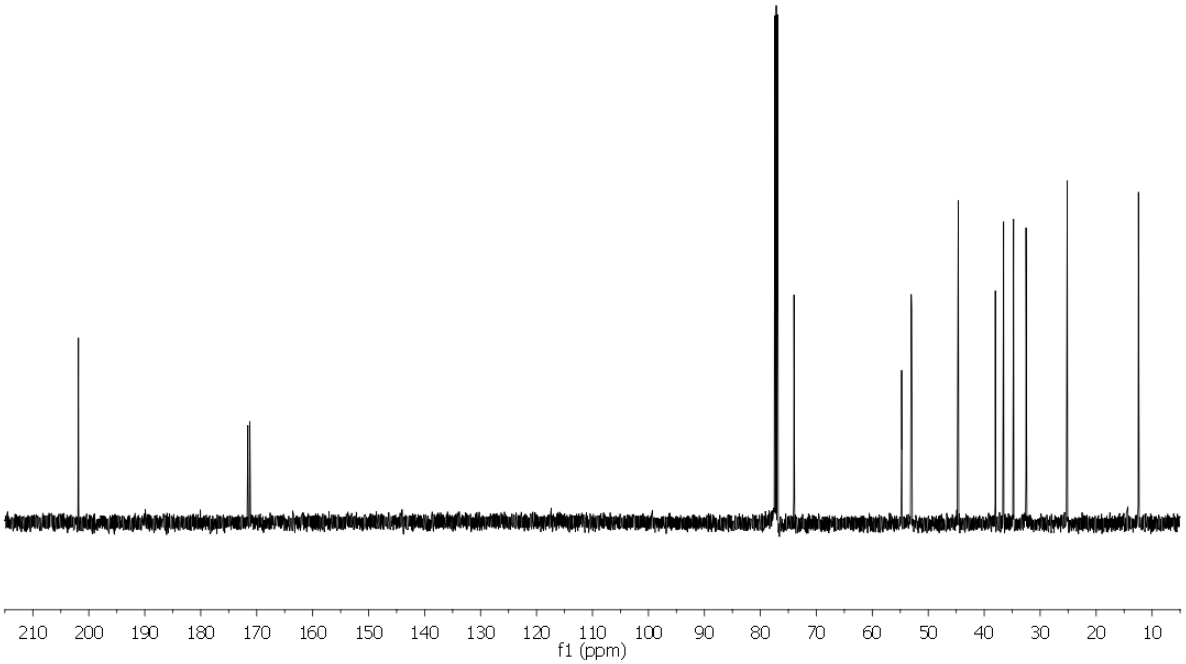
2

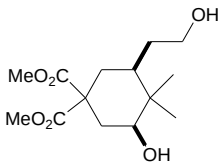



CHO
MeO2C
MeO2C
OH

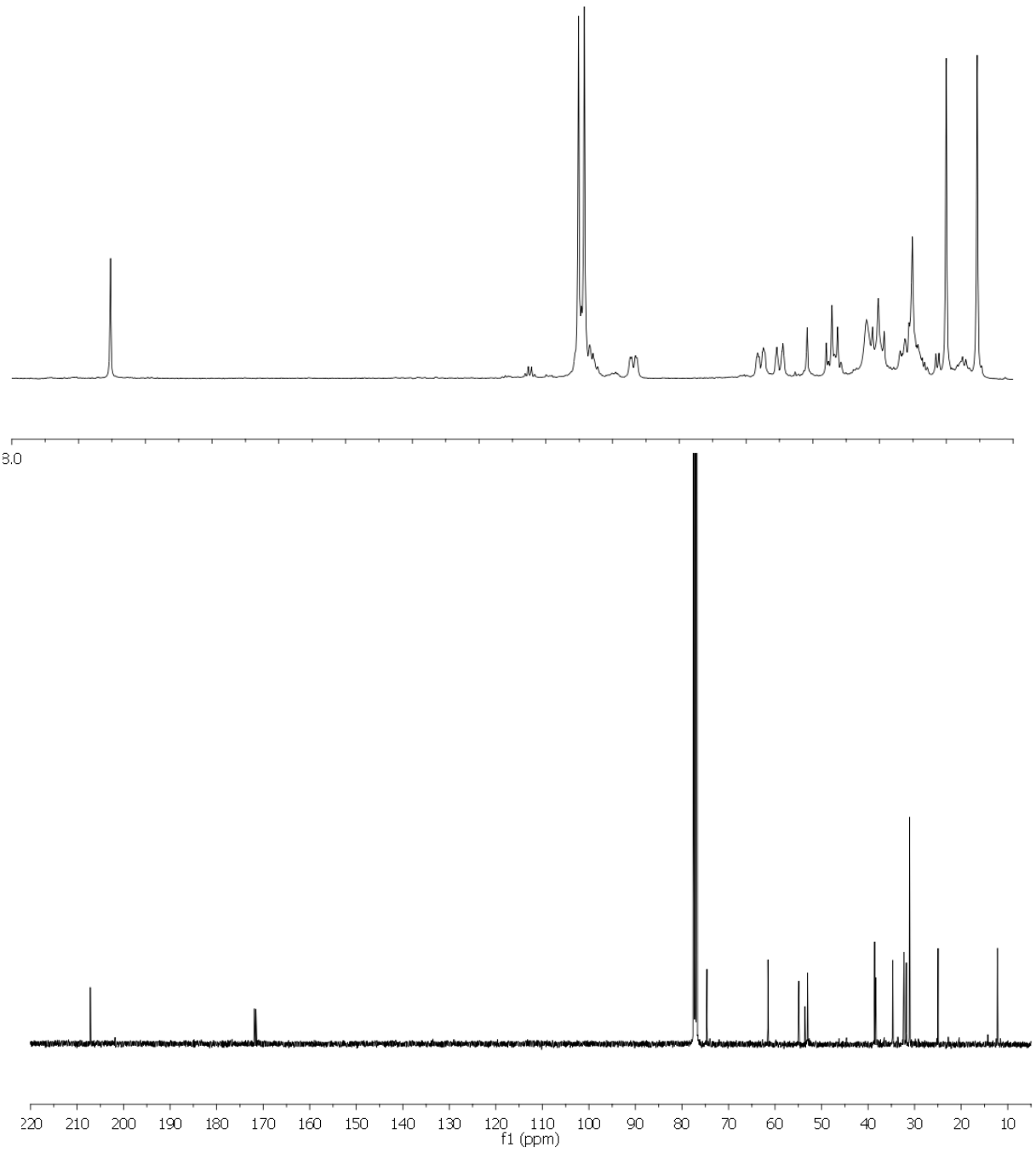
4

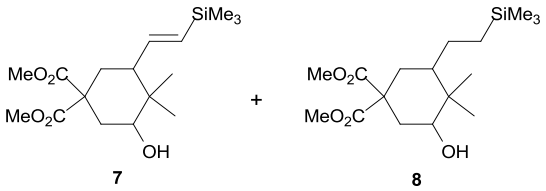
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 0.5


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

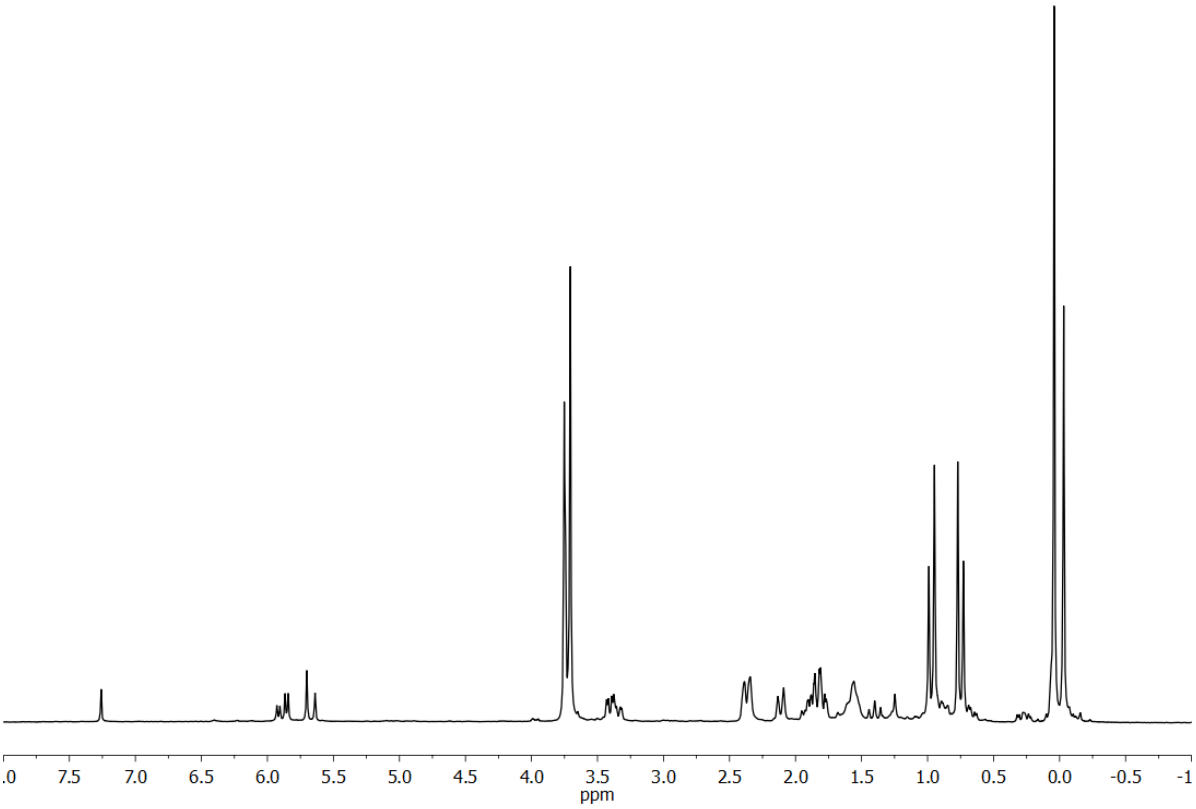

OH
MeO2C
MeO2C
OH

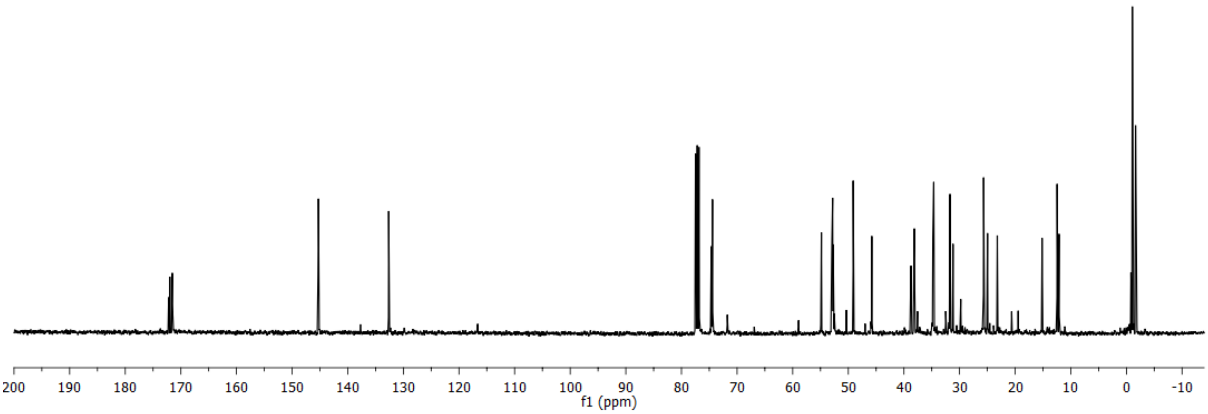
5

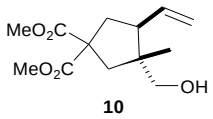

3.0
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


SiMe3
MeO2C
MeO2C
OH
+
SiMe3
MeO2C
MeO2C
OH

7 **8**

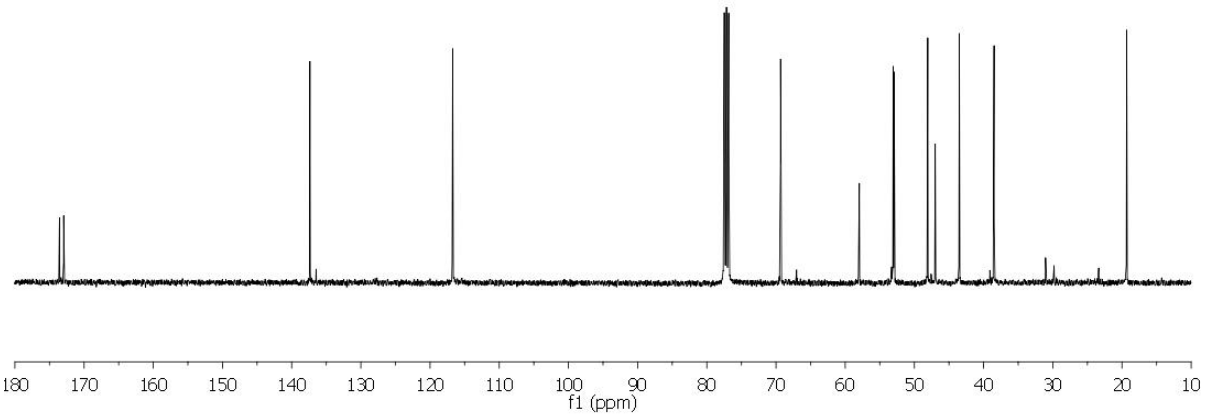

.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
ppm

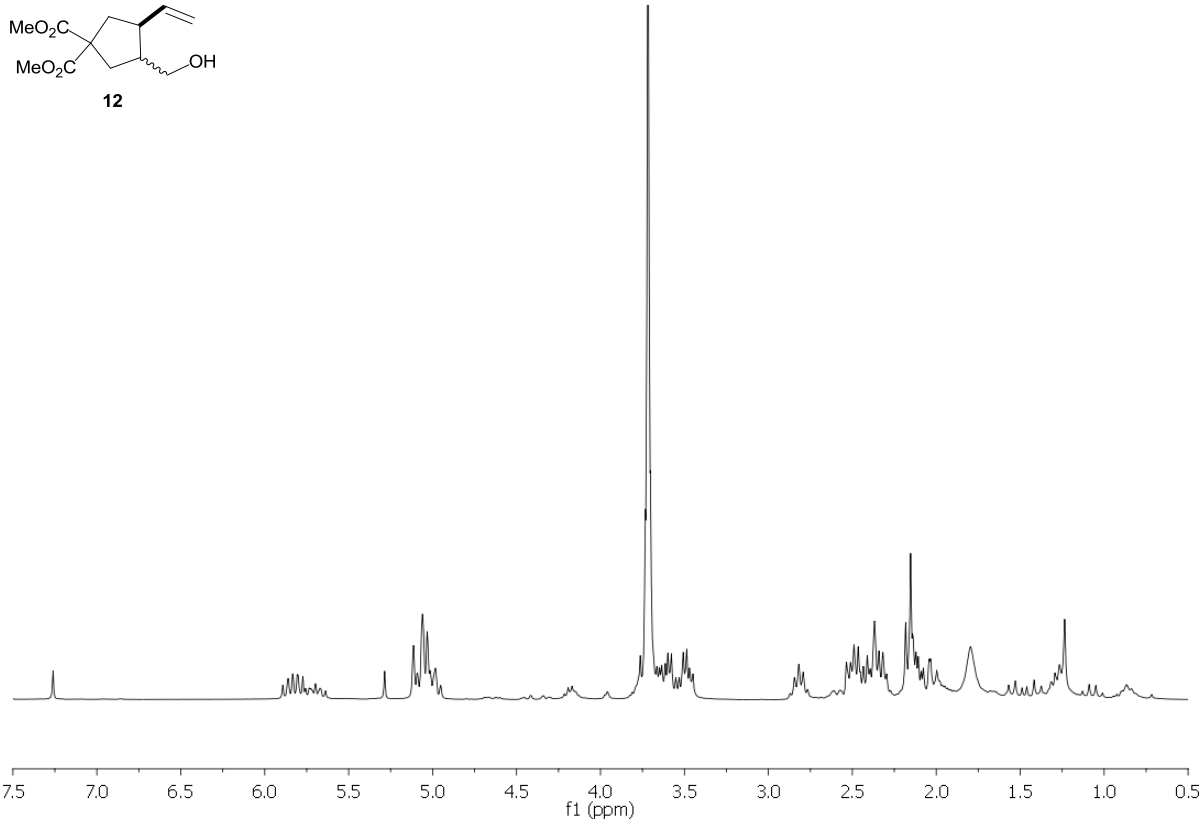

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

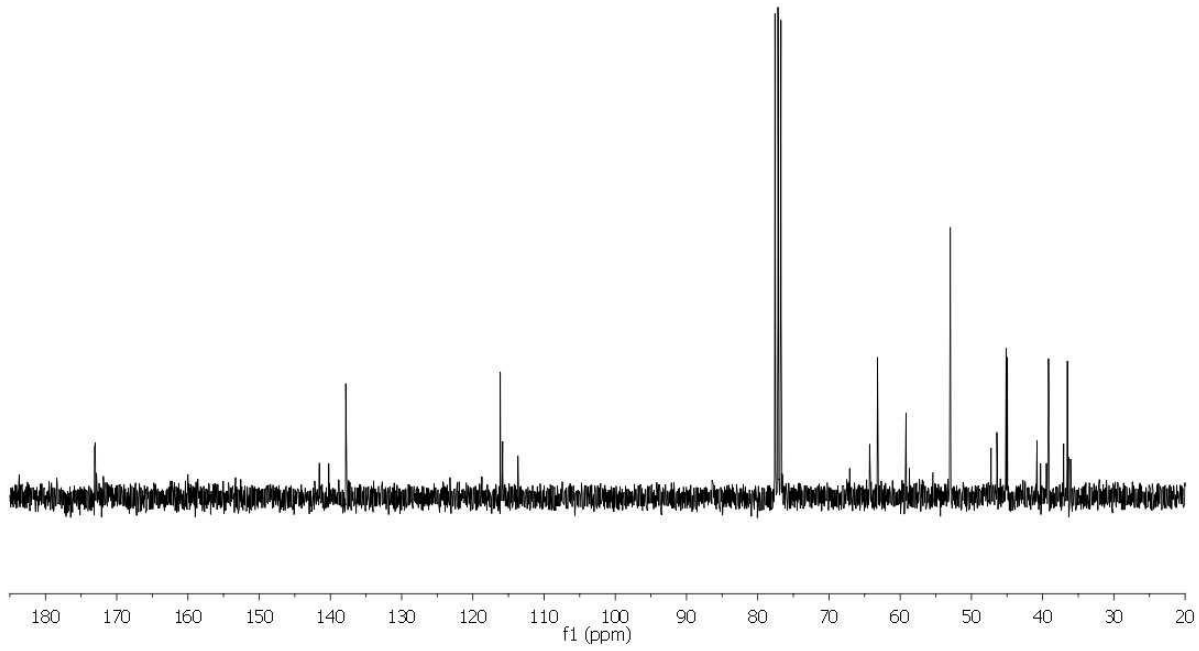

MeO2C
MeO2C
OH

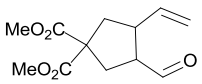
10

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
f1 (ppm)

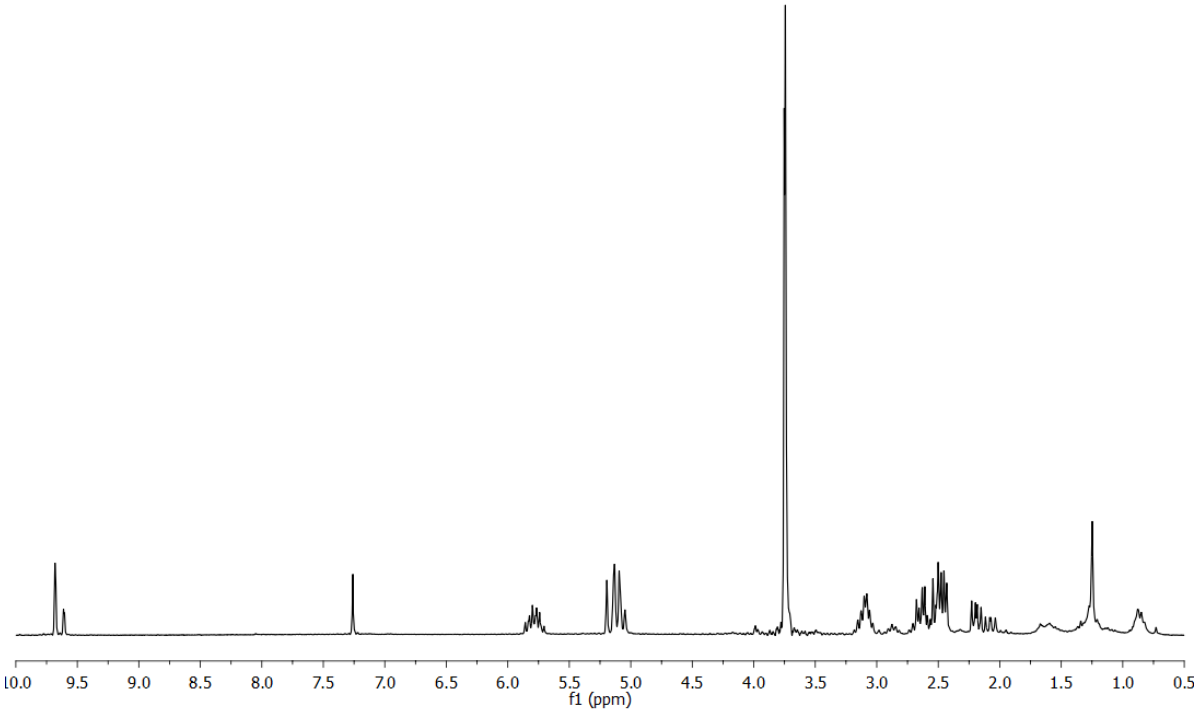

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

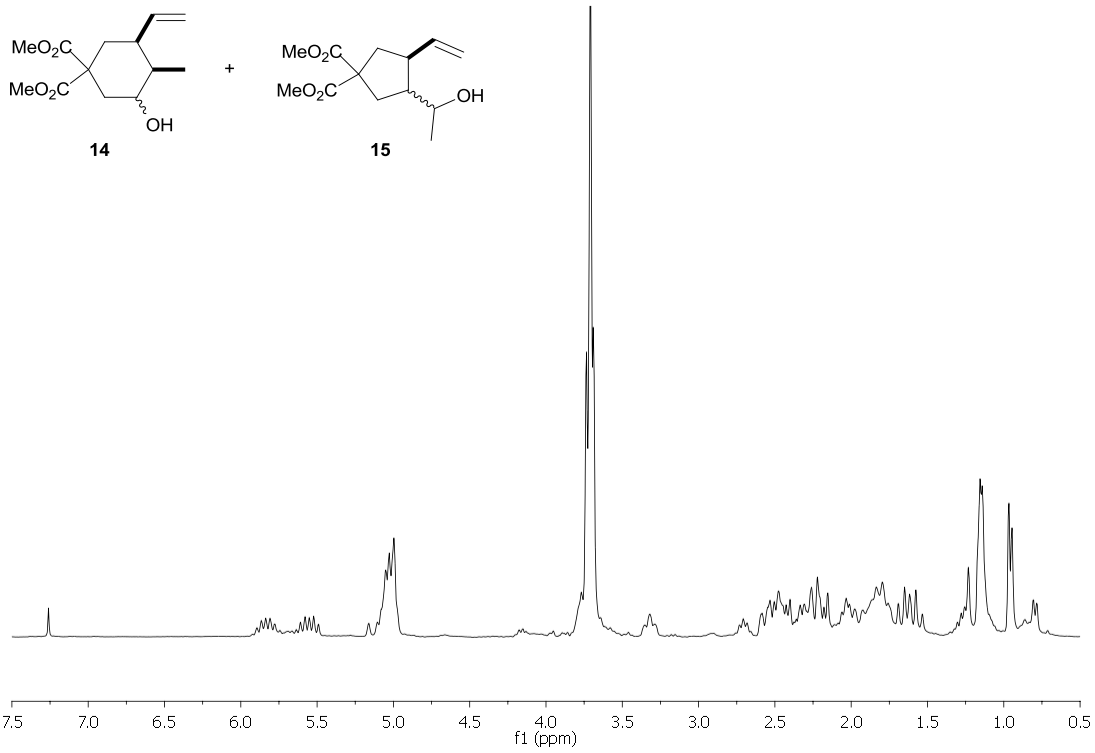

MeO2C
MeO2C
OH
12
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

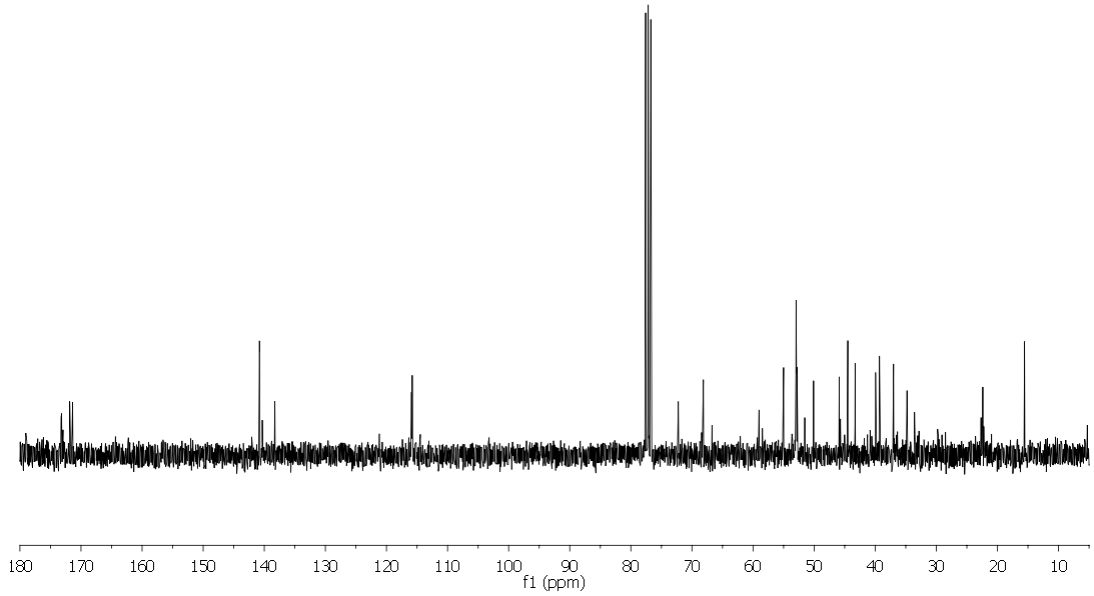

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)

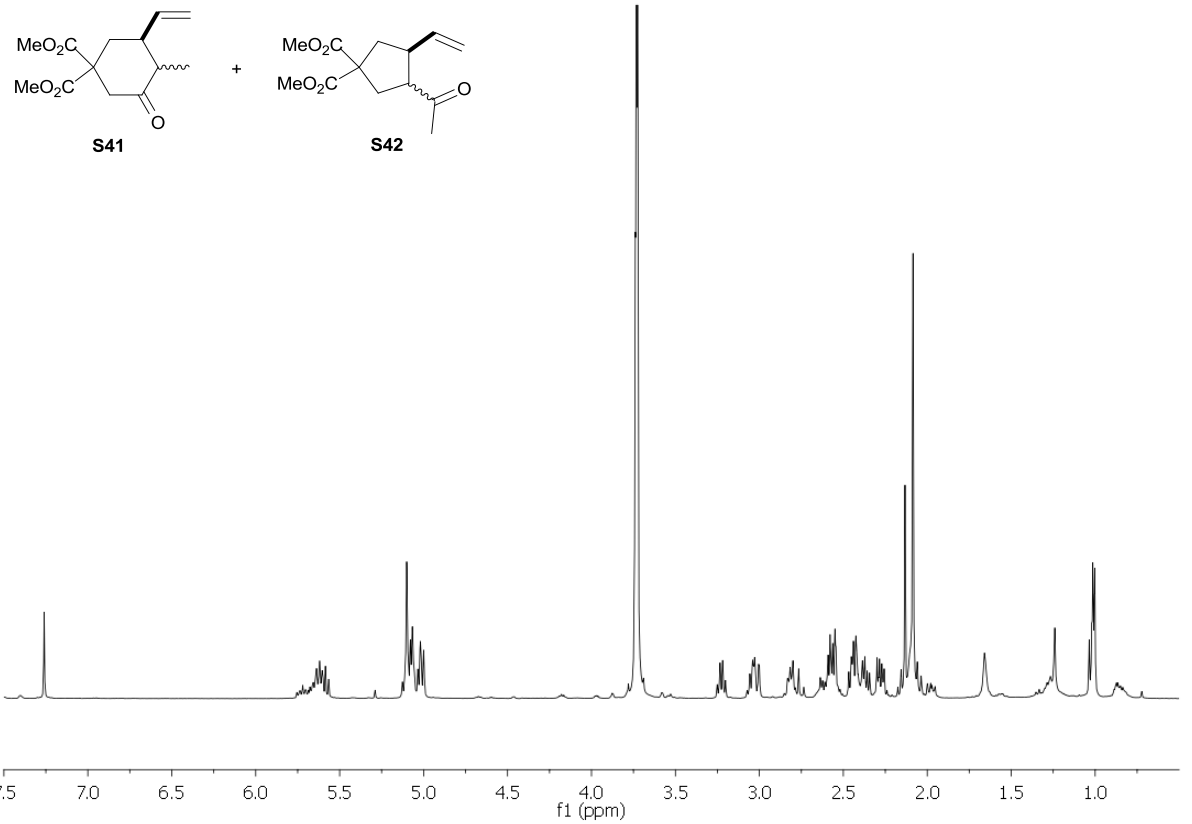

MeO2C
MeO2C
O

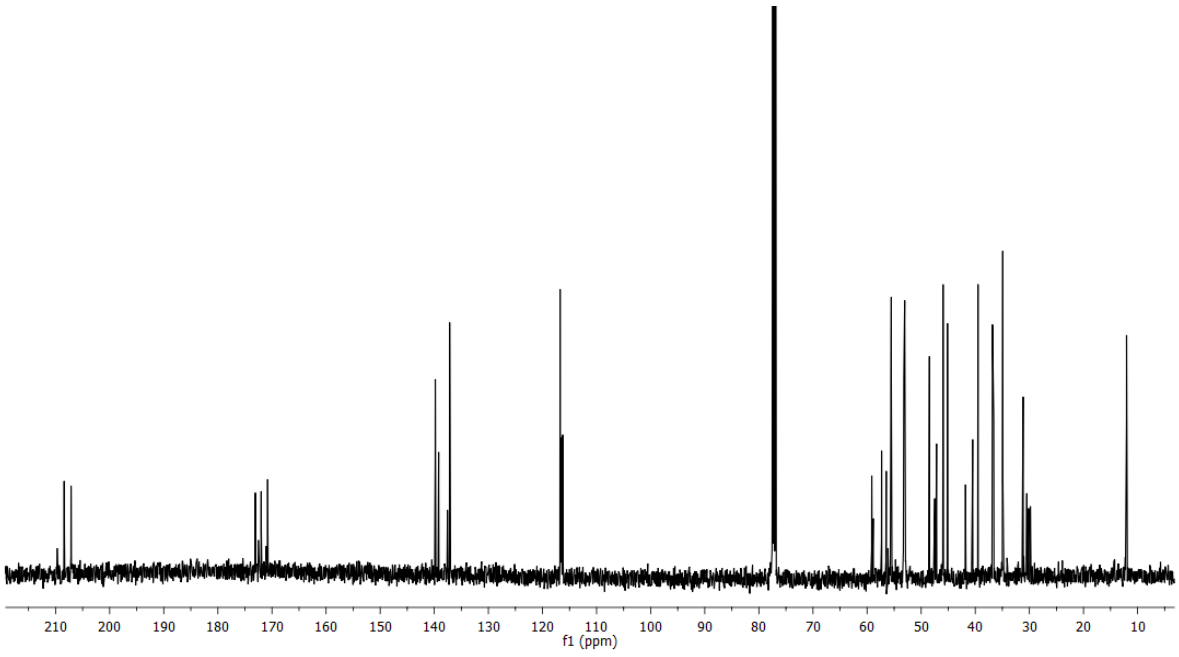
S40

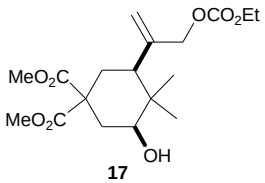

10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)


MeO2C
MeO2C
OH
14
+
MeO2C
MeO2C
OH
15
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
f1 (ppm)

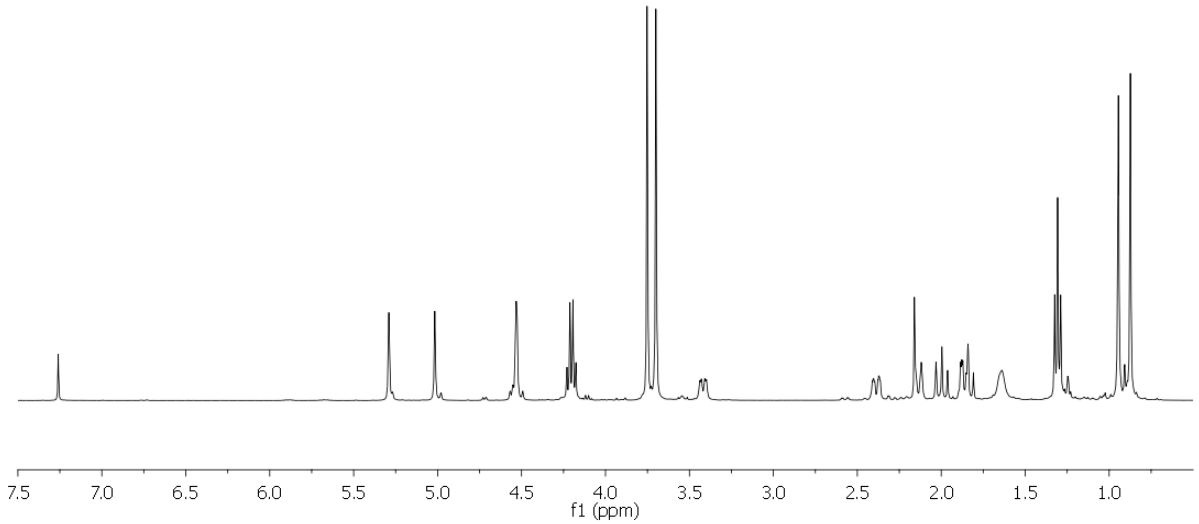

180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

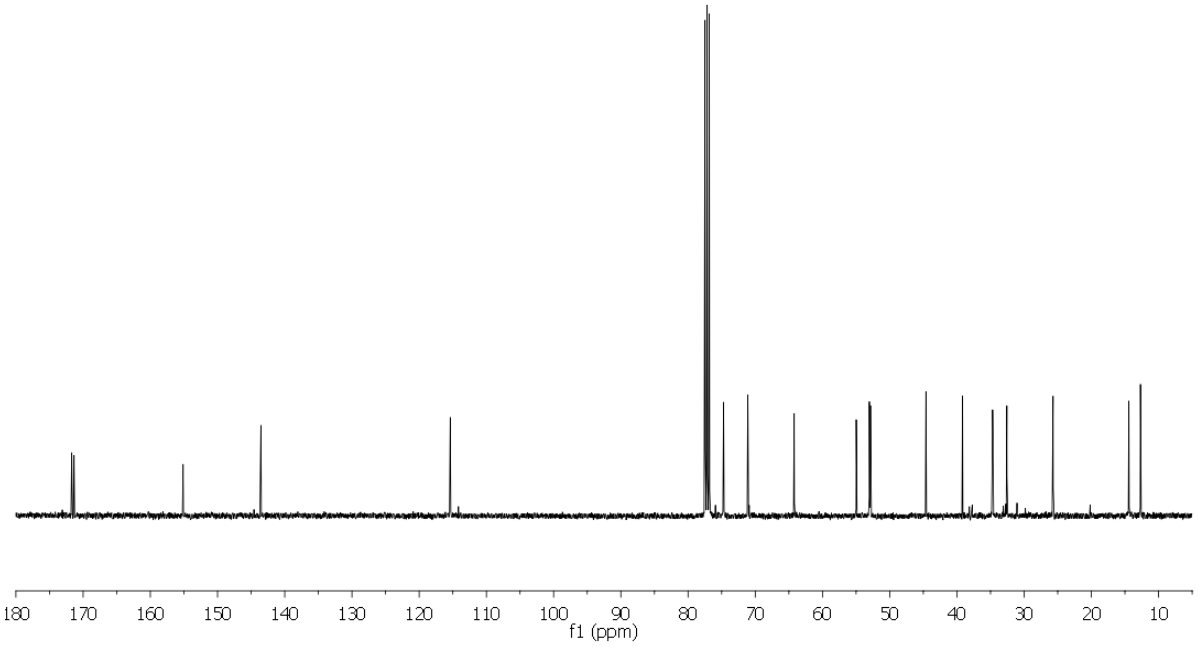

MeO2C
MeO2C
O
S41
+
MeO2C
MeO2C
O
S42
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

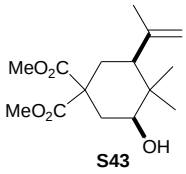

210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


OCO2Et
MeO2C
MeO2C
OH

17

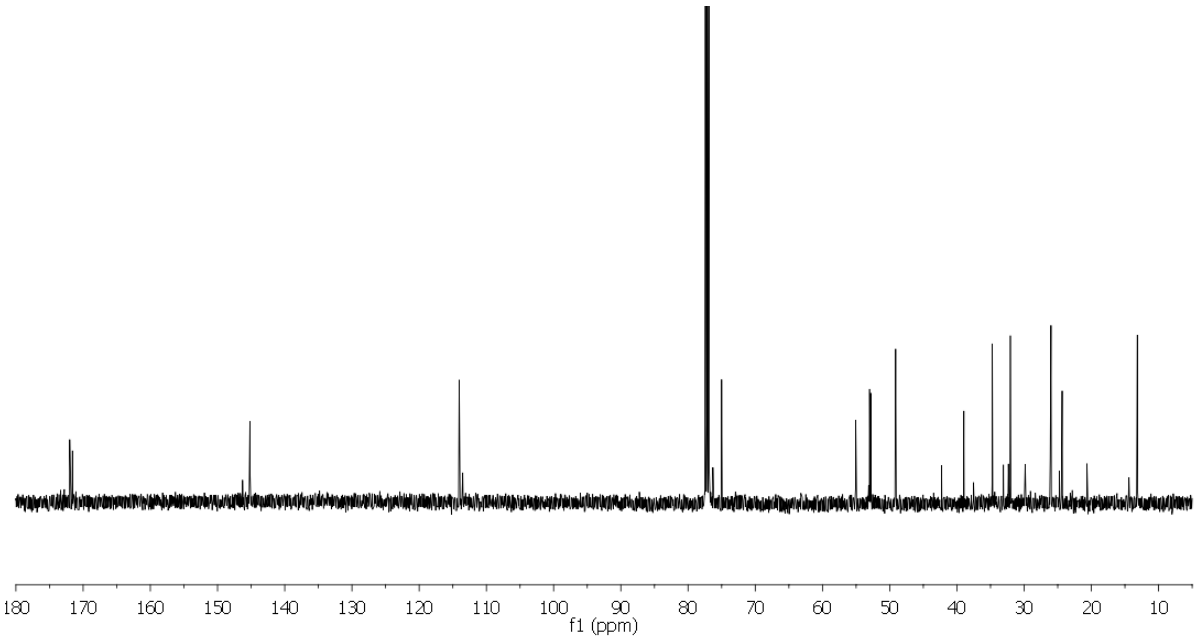

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

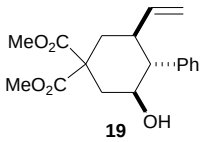

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


MeO2C
MeO2C
OH

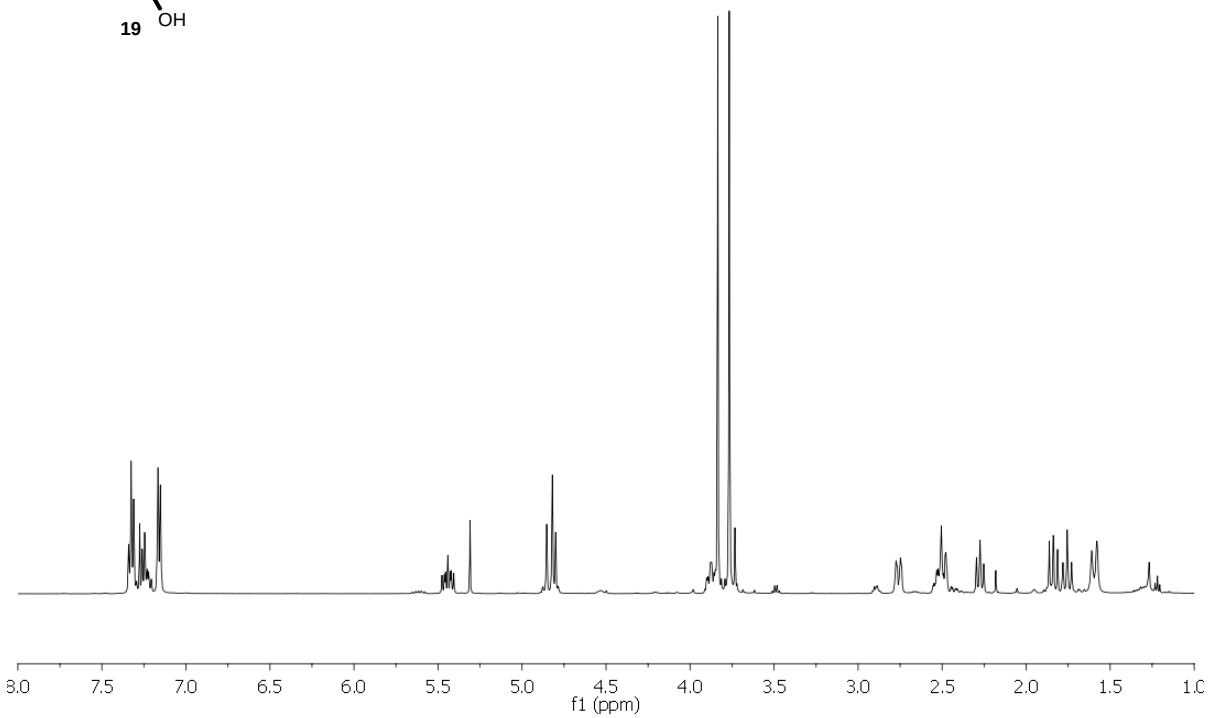
S43

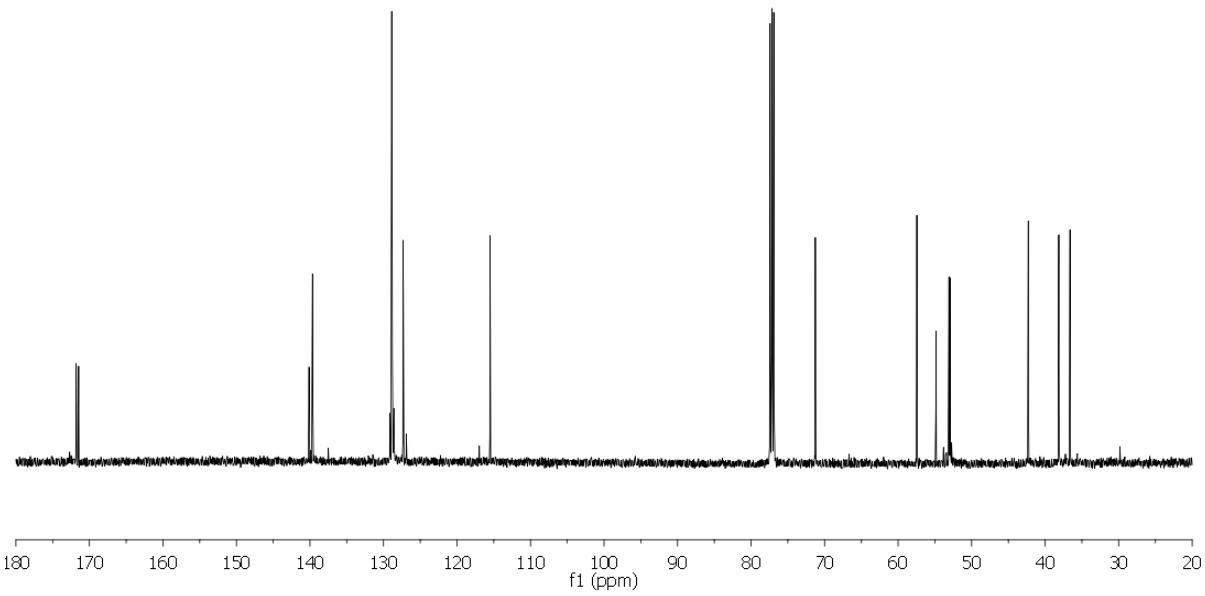
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

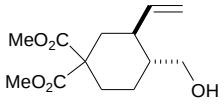

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


MeO2C
MeO2C
Ph
OH

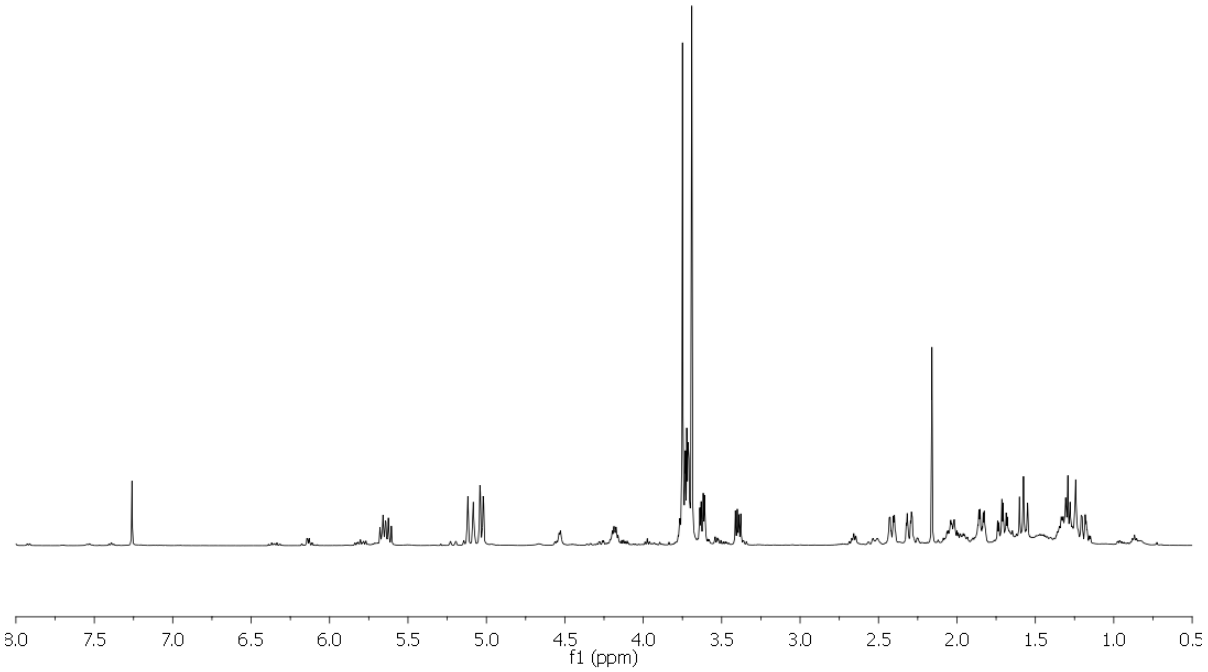
19

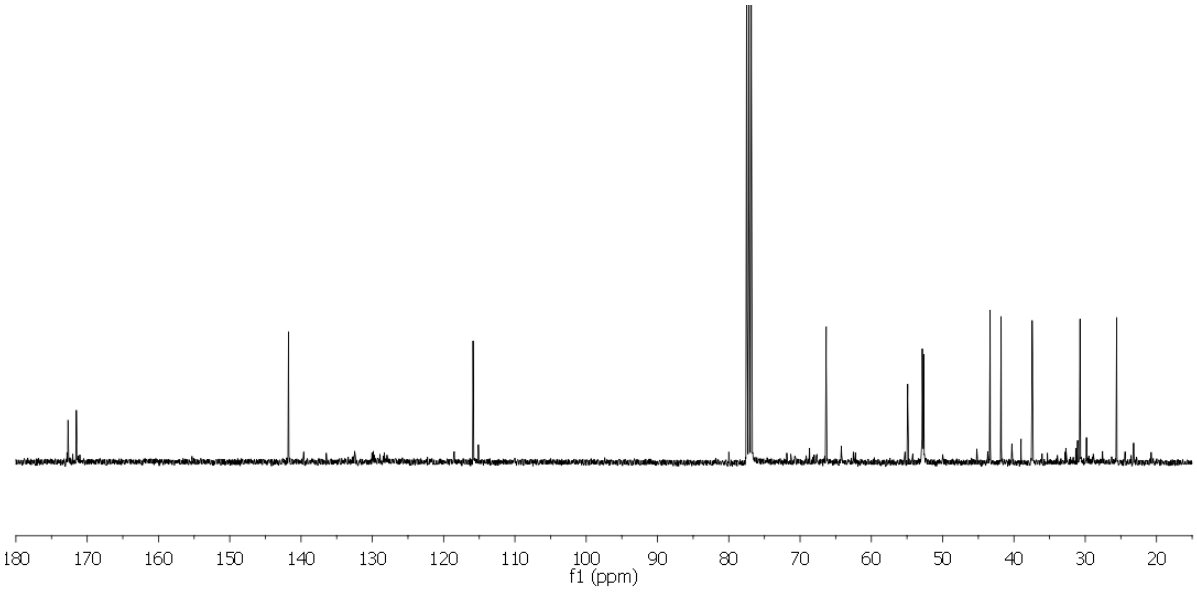

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

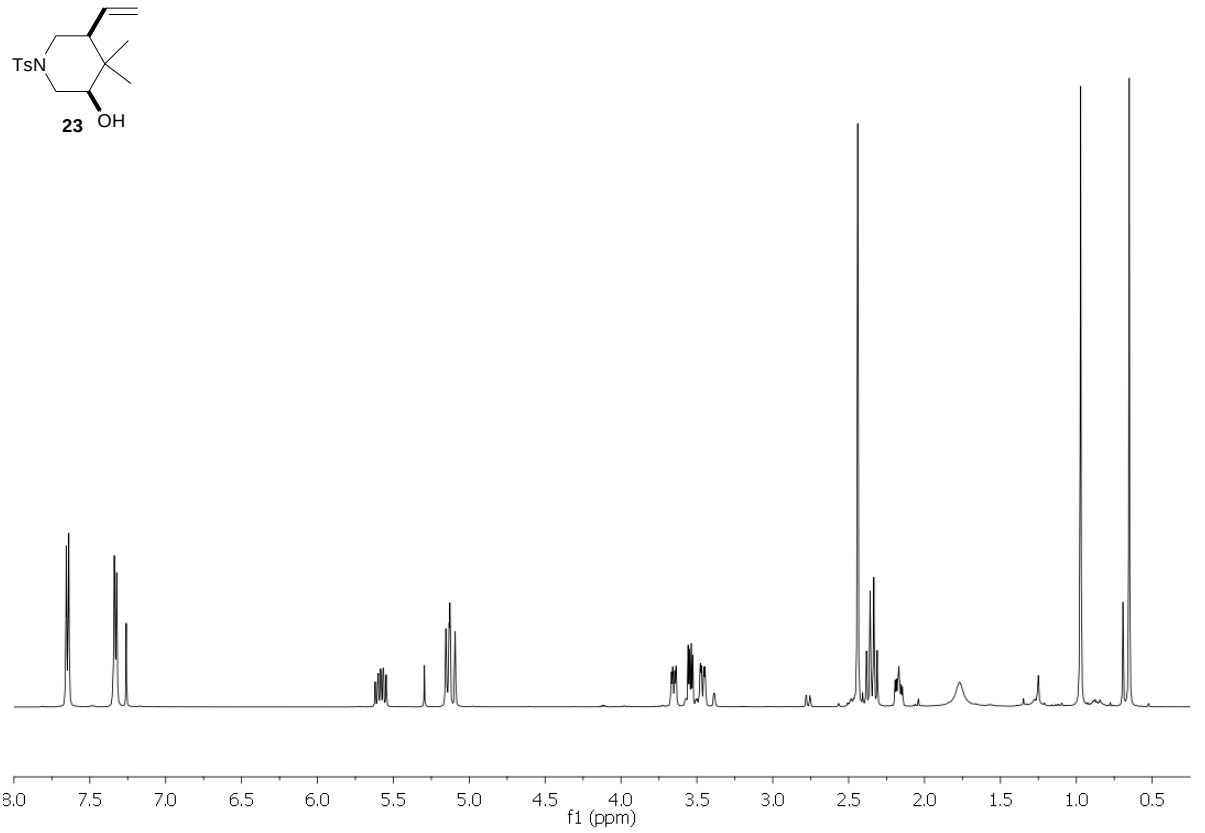

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)

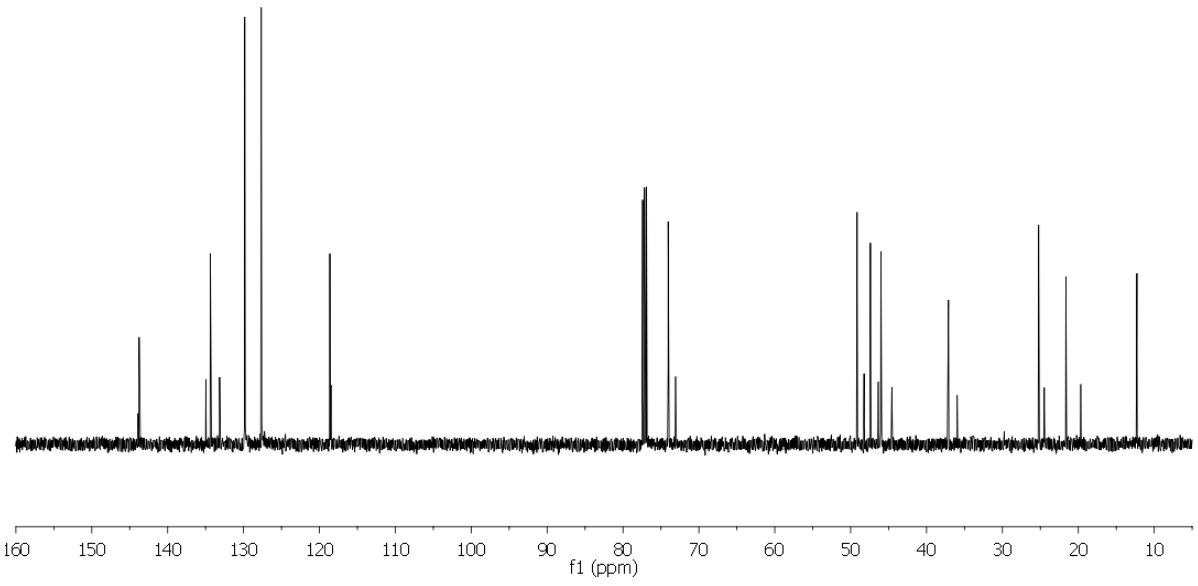

MeO2C
MeO2C
OH

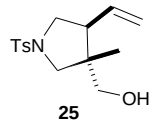
21


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
f1 (ppm)


180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)

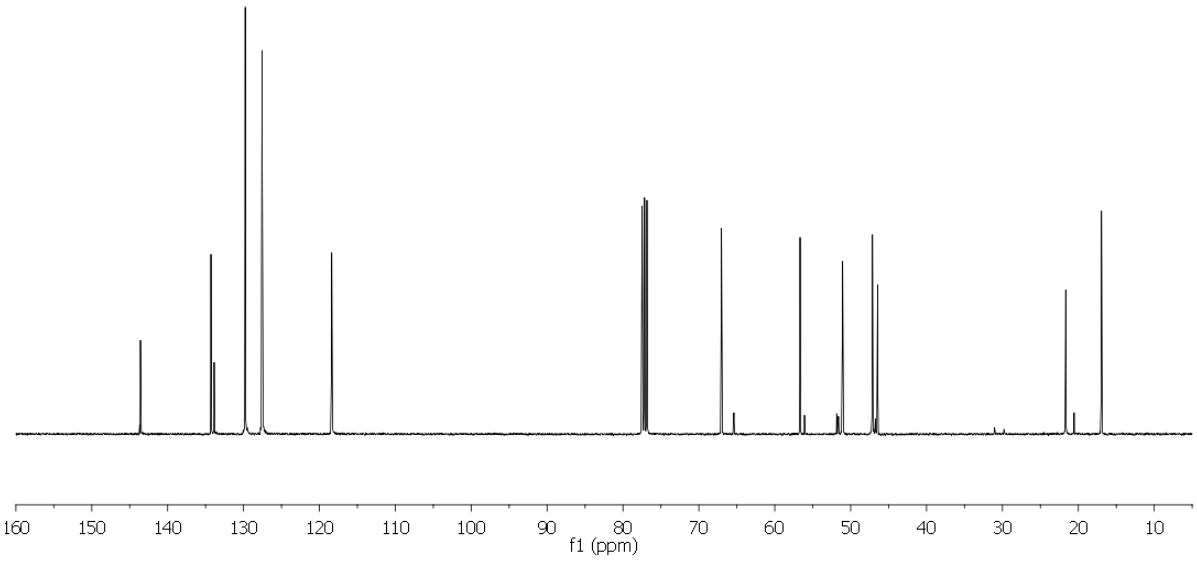

TsN
OH
23
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

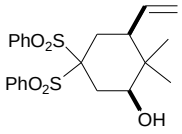

160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


TsN
OH

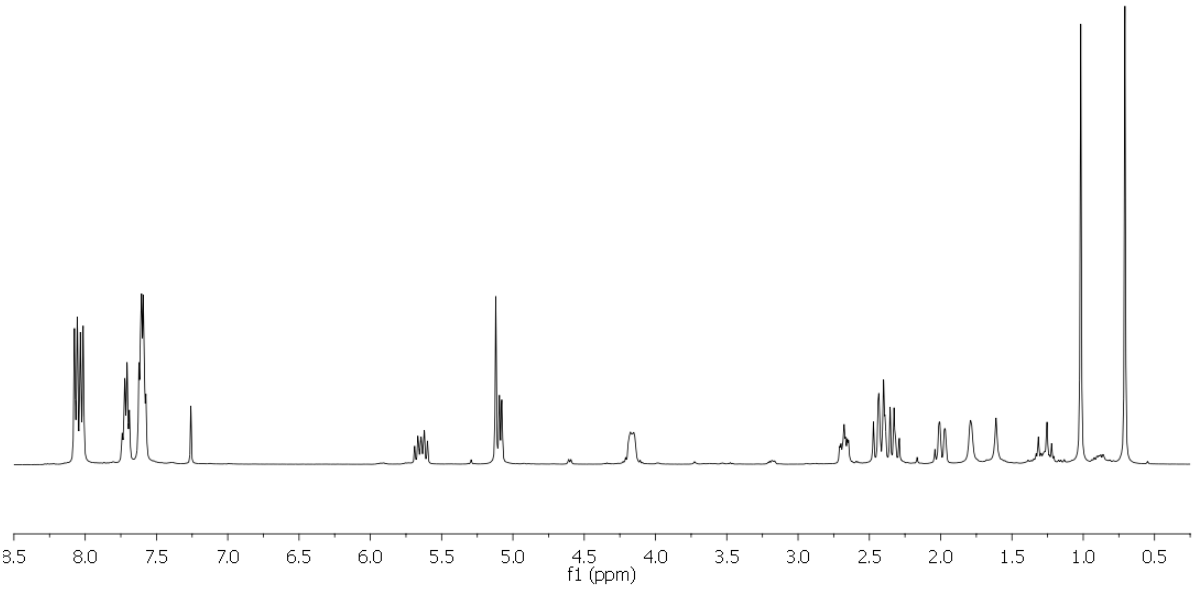
25

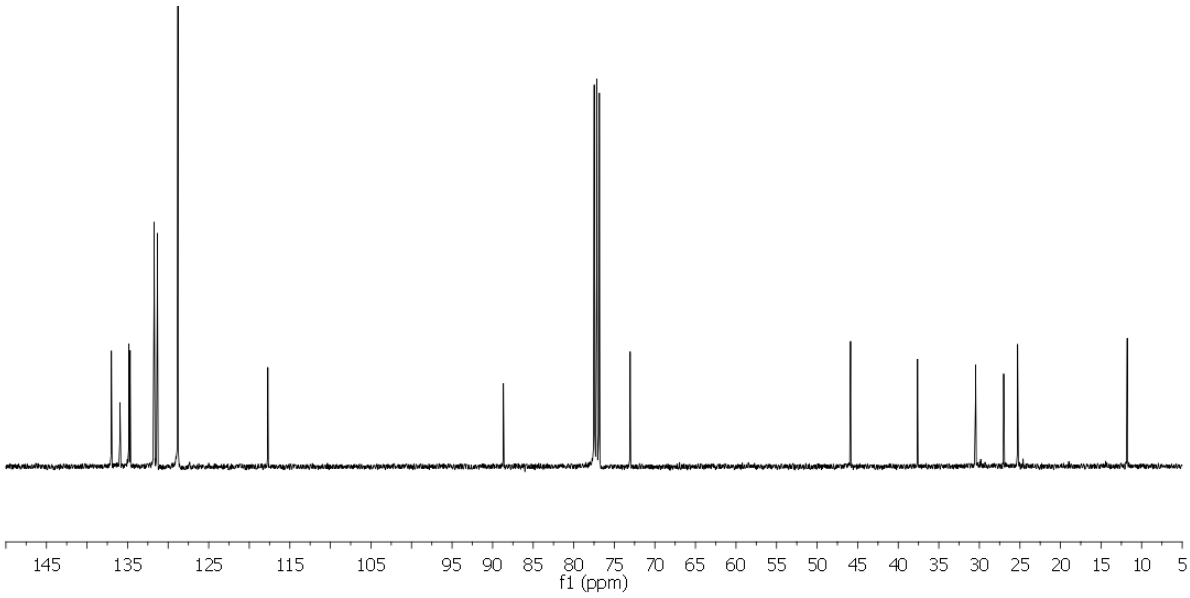
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

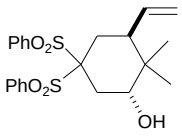

160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


PhO2S
PhO2S
OH

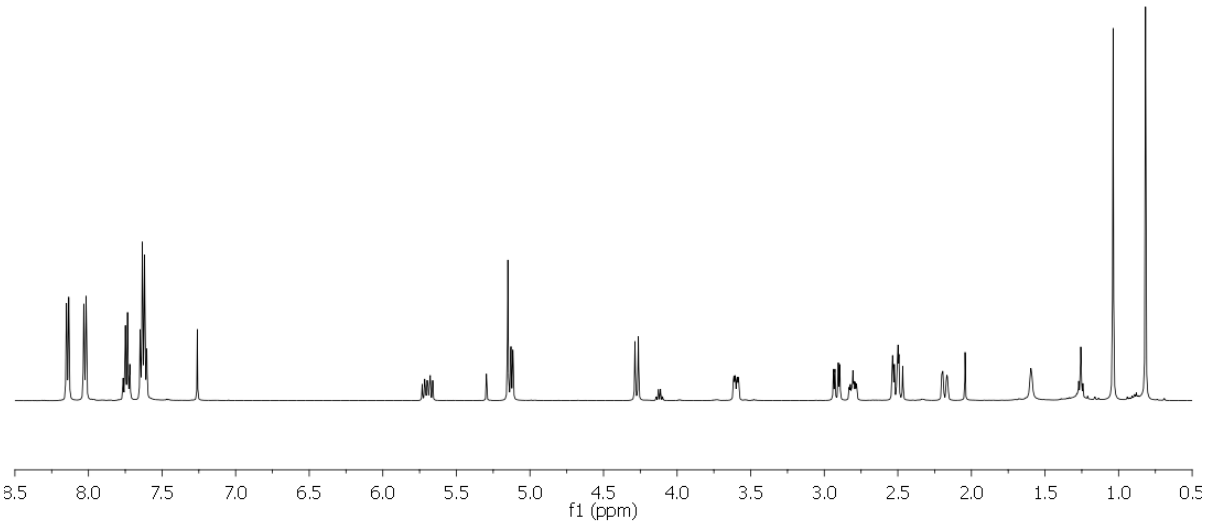
27a

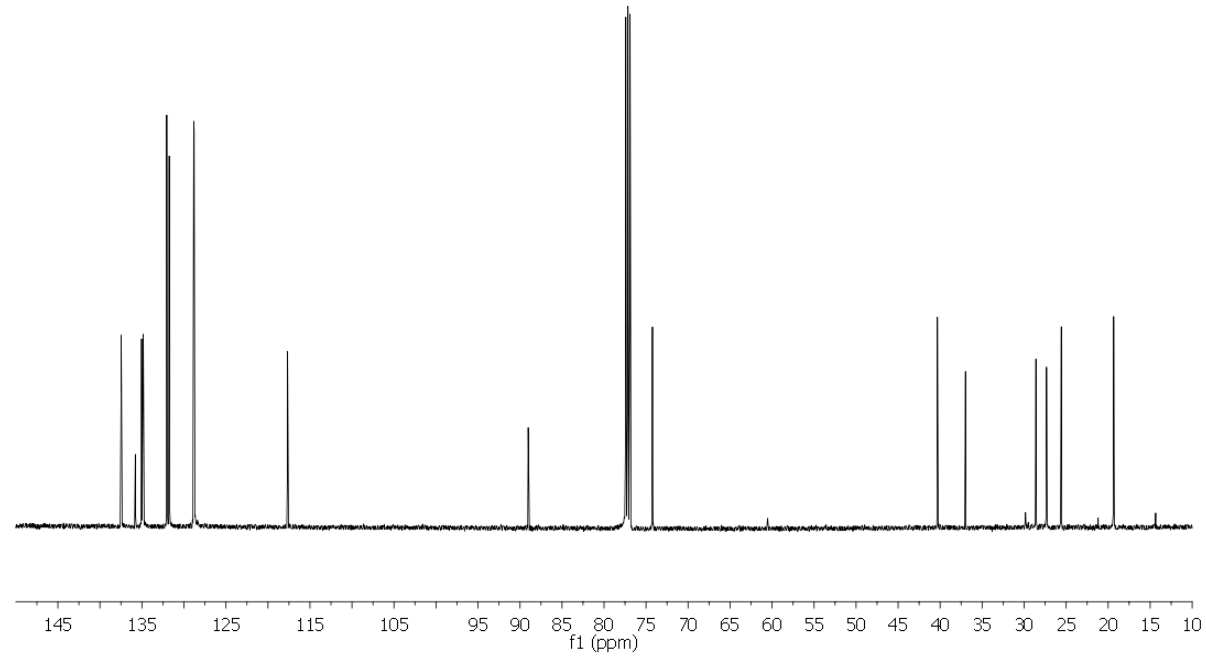

8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

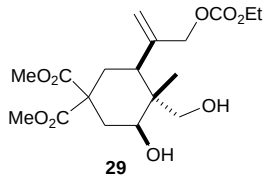

145 135 125 115 105 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
f1 (ppm)


PhO2S
PhO2S
OH

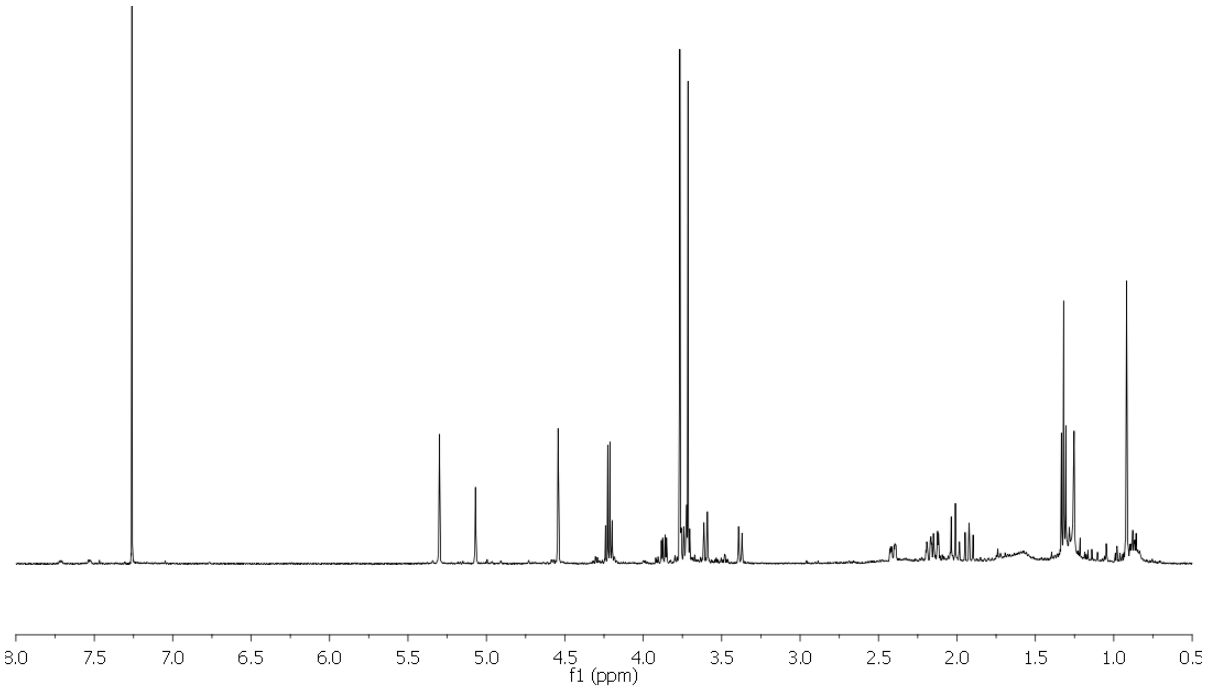
27b

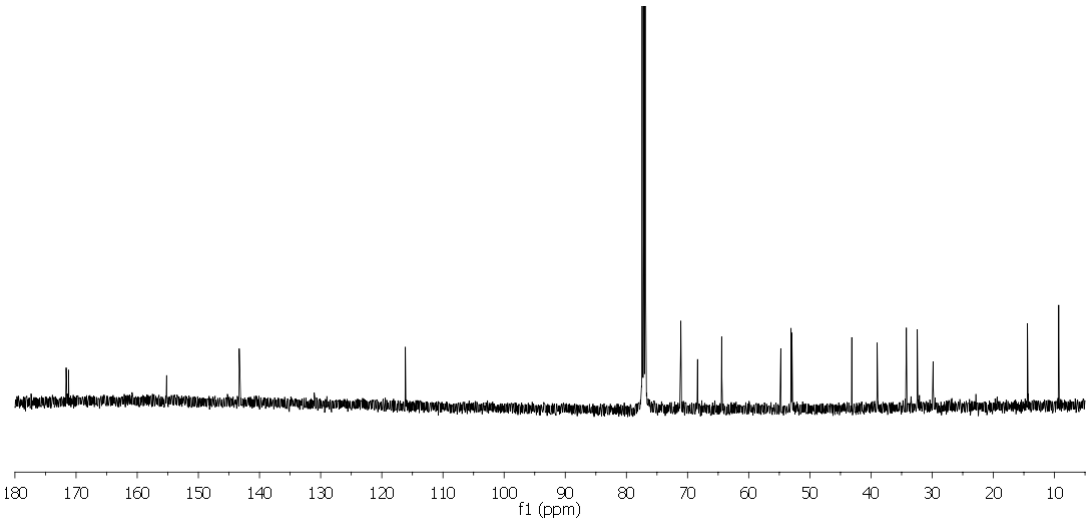

8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

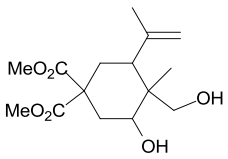

145 135 125 115 105 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10
f1 (ppm)


OCO2Et
MeO2C
MeO2C
OH
OH

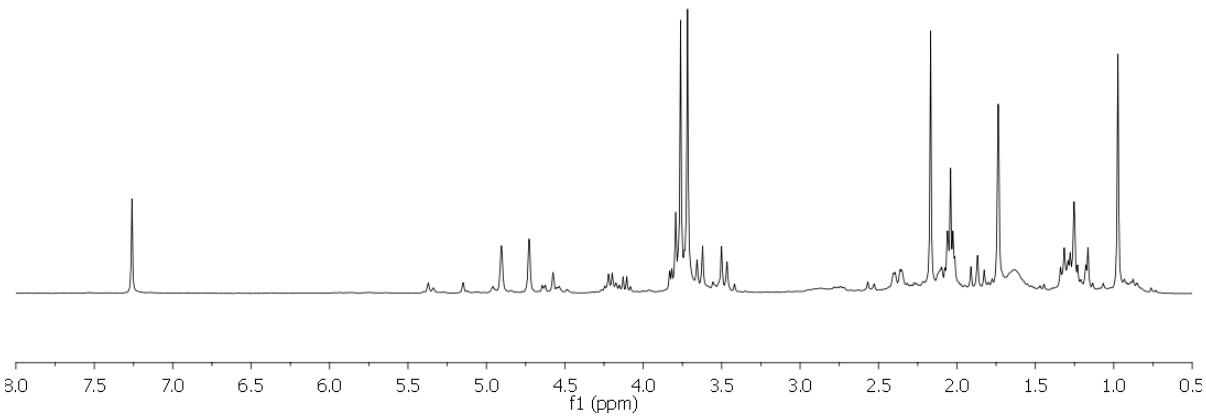
29

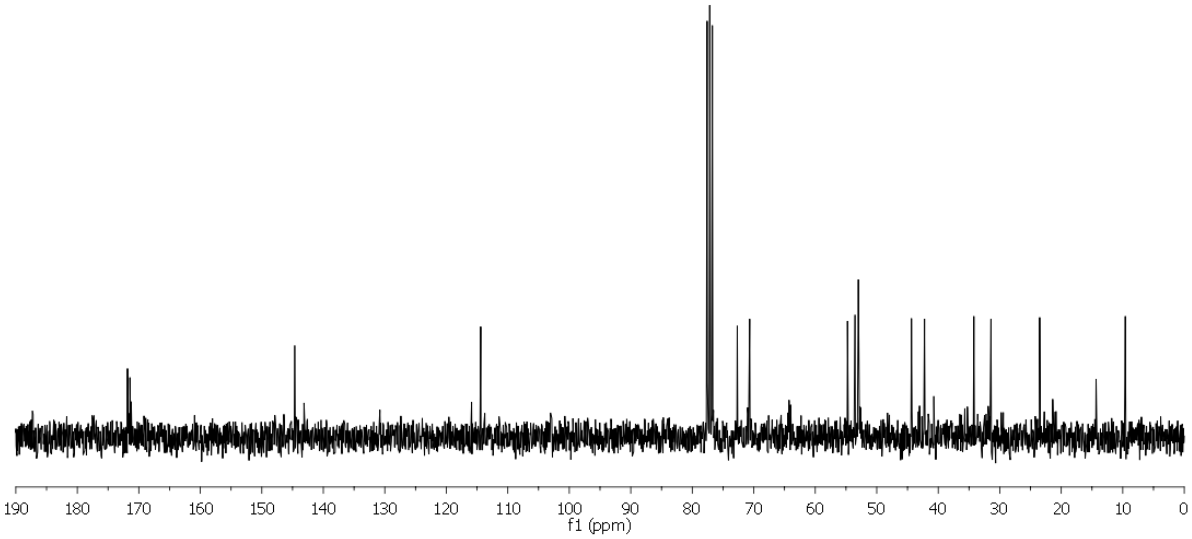

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

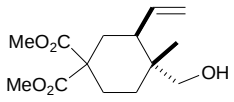

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


MeO2C
MeO2C
OH
OH

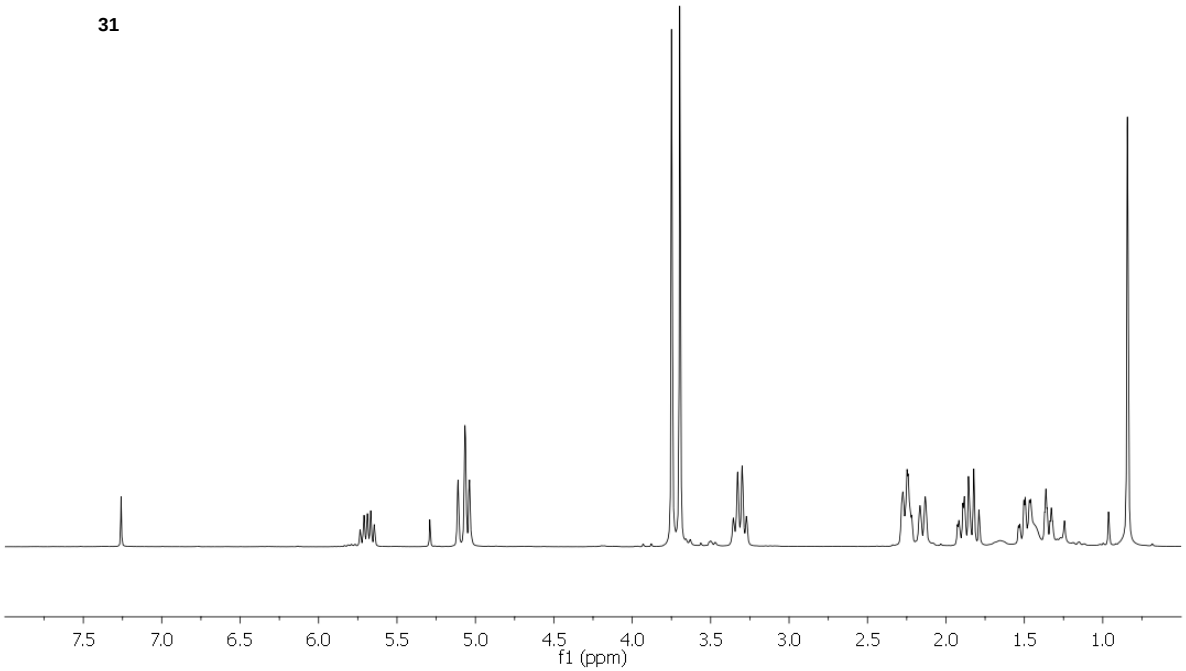
S44

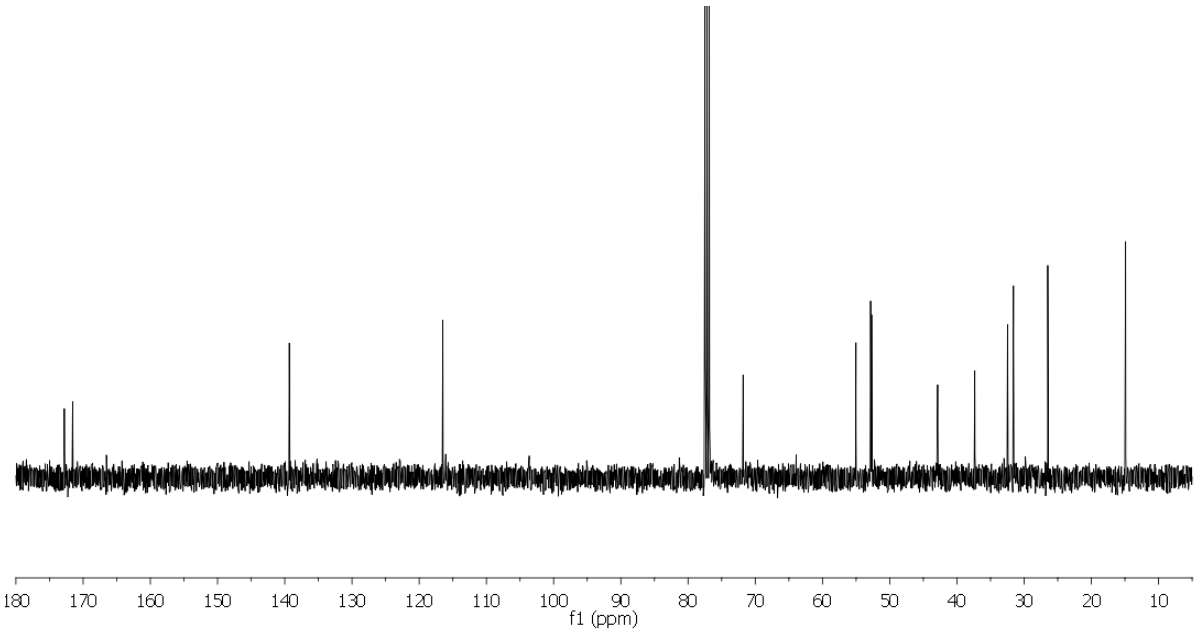

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)


190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


MeO2C
MeO2C
OH

31


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
f1 (ppm)


180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)