Supporting information

Copper catalyzed β-Difluoroacetylation of Dihydropyrans and Glycals by Means of Direct C-H Functionalization.

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Section A: General information

General

All reactions were carried out using oven dried glassware and magnetic stirring under an atmosphere of argon unless otherwise stated. Flash chromatography was performed with silica gel (0.040-0.060 nm). Analytical thin layer chromatography was performed on silica gel aluminium plates with F-254 indicator and visualized by UV light (254 nm) and/or chemical staining with $KMnO_4$ solution. ^1H NMR spectra were recorded on a Bruker DXP 300, ^{13}C NMR spectra at 75 MHz and ^{19}F NMR spectra at 282 MHz. Chemical shifts (δ) are quoted in parts per million (ppm) relative to residual solvent ($CHCl_3$: δ = 7.27 ppm for ^1H, δ = 77.0 ppm for ^{13}C or relative to external $CFCl_3$: δ = 0 ppm). The following abbreviations have been used: δ (chemical shift), *J* (coupling constant), s (singlet), brs (broad singlet), d (doublet), dd (doublet of doublets), ddd (doublet of doublet of doublets), t (triplet), q (quartet), dq (doublet of quartets), m (multiplet). High-resolution mass spectra (HRMS) were recorded on Waters LCT Premier, IR spectra were recorded on a PerkinElmer Spectrum 100. Optical rotations were measured in $CHCl_3$ on a Perkin-Elmer 341 polarimeter with a 1 cm cell (*c* are given in g/100 mL). Melting points are uncorrected.

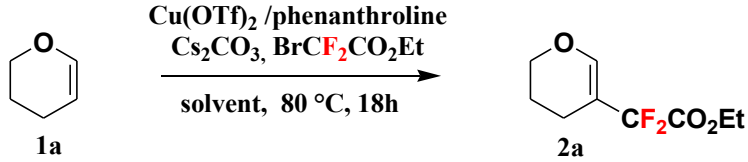
Material

All anhydrous solvents were dried by standard techniques and freshly distilled before use: dichloromethane were distilled from calcium hydride and tetrahydrofuran over Na/benzophenone. Dry DMF (sure sealed bottle) was purchased from Acros and NMP from VWR. Cs_2CO_3 was purchased from Acros, K_2CO_3 from Carlo Erba, $Cu(OTf)_2$, $Cu(CH_3CN)_4PF_6$, CuI from Aldrich, 2-hydroxymethyl-3,4-dihydro-2*H*-pyran from Alfa Aesar, 3,4,6-tri-*O*-acetyl-D-glucal, 3,4,6-tri-*O*-acetyl-D-galactal, 3,4-di-*O*-acetyl-6-deoxy-L-glucal and 3,4-di-*O*-acetyl-L-arabinal from Carbosynth and were used as received. Dihydropyran and ethyl bromodifluoroacetate were distilled prior to use. 3,4,6-tri-*O*-benzyl-D-glucal, 3,4,6-tri-*O*-methyl-D-glucal, 3,4,6-tri-*O*-pivaloyl-D-glucal,[1] 3,4,6-tri-*O*-(p-methoxybenzyl)-D-glucal,[2] 3,4,6-tri-*O*-benzyl-D-galactal,[3] 3,4,6-tri-*O*-methyl-D-galactal,[4] 3,4-di-*O*-benzyl-L-arabinal,[5] were prepared according to the known procedures.

[1] C. Bucher, R. Gilmour, *Angew. Chem. Int. Ed*. **2010**, *49*, 8724-8728.
[2] A. Fürstner, K. Radkowski, J. Grabowski, C. Wirtz, R. Mynott, *J. Org. Chem*. **2000**, *65*, 8758-8762.
[3] F. Leonelli, M. Capuzzi, V. Calcagno, P. Passacantilli, G. Piancatelli, *Eur. J. Org. Chem*. **2005**, 2671-2676.
[4] Bucher, C.; Gilmour, R. *Angew. Chem. Int. Ed.* **2010**, *49*, 8724-8728.
[5] A.G. Tolstikov, N.V. Khakhalina, L.V. Spirikhin, *Synthesis* **1998**, 221-222.

Section B: Optimization studies

Table 1. Solvent screening using **1a.**[a]

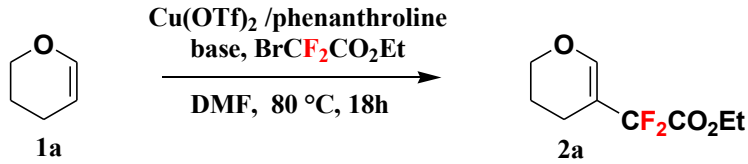


1a 2a

Entry	Solvent	Yield %[b], (%)[c]
1	toluene	NR
2	THF	38
3	1,4-dioxane	25
4	MeCN	44
5	DMF	42 (47)
6	DMA	50 (43)
7	DMI	47 (34)
8	NMP	70 (65)
9	water	NR

[a] Reaction conditions: **1a** (0.36 mmol), $BrCF_2CO_2Et$ (1.44 mmol), $Cu(OTf)_2$ (0.036 mmol), phenanthroline (0.043 mmol), Cs_2CO_3 (0.72 mmol), solvent (1.8 mL). [b] Determined by ^{19}F NMR using α,α,α-trifluorotoluene as an internal standard. [c] Isolated yield.

Table 2. Base screening using **1a.**[a]

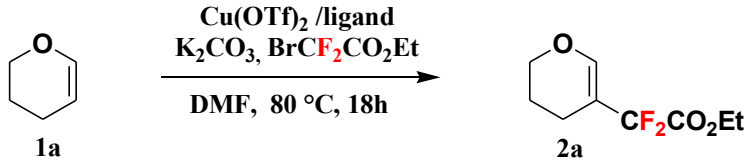


1a 2a

Entry	Base	Yield %[b], (%)[c]
1	Cs_2CO_3	42 (47)
2	K_2CO_3	74(73)
3	Na_2CO_3	12
4	K_3PO_4	4
5	2,6-lutidine	20
6	2,6-$^tBu_2$-pyridine	NR
7	Et_3N	21

[a] Reaction conditions: **1a** (0.36 mmol), $BrCF_2CO_2Et$ (1.44 mmol), $Cu(OTf)_2$ (0.036 mmol), phenanthroline (0.043 mmol), base (0.72 mmol), DMF (1.8 mL). [b] Determined by ^{19}F NMR using α,α,α-trifluorotoluene as an internal standard. [c] Isolated yield.

Table 3. Ligand screening using **1a.**[a]



1a 2a

Entry	Ligand	Yield %[b], (%)[c]
1	Phenanthroline	74 (73)
2	Bathophenanthroline	77 (62)
3	Neocuproine	61
4	Bathocuproine	61
5	2,2'-bipyridine	33
6	Terpyridine	13
7	BINAP	28

[a] Reaction conditions: **1a** (0.36 mmol), $BrCF_2CO_2Et$ (1.44 mmol), $Cu(OTf)_2$ (0.036 mmol), ligand (0.043 mmol), K_2CO_3 (0.72 mmol), DMF (1.8 mL). [b] Determined by ^{19}F NMR using α,α,α-trifluorotoluene as an internal standard. [c] Isolated yield.

Section C: Experimental procedures

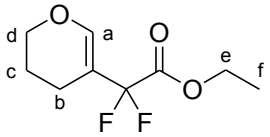
General Procedure for copper cross-coupling reaction of dihydropyran derivatives (A)

Under an air atmosphere, $Cu(OTf)_2$ (13 mg, 0.036 mmol), phenanthroline (8 mg, 0.043 mmol) and K_2CO_3 (100 mg, 0.72 mmol) were dissolved in DMF (1.8 mL). Then enol ether (0.36 mmol) and ethyl bromodifluoroacetate (0.19 mL, 1.44 mmol) were added and the tube was sealed. The resulting mixture was heated at 80 °C for 18h. The solution was cooled and extracted with Et_2O (3 x 10 mL). The organic layer was washed with water (2 x 10 mL), brine (2 x 10 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (SiO_2, pentane/Et_2O).

General Procedure for copper cross-coupling reaction of glycal derivatives (B)

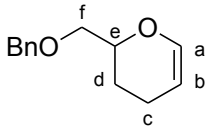
Under an air atmosphere, $Cu(CH_3CN)_4PF_6$ (9 mg, 0.024 mmol), phenanthroline (5 mg, 0.029 mmol) and K_2CO_3 (66 mg, 0.48 mmol) were dissolved in DMF (1.2 mL). Then glycal derivative (0.24 mmol) and ethyl bromodifluoroacetate (0.25 mL, 1.92 mmol) were added and the tube was sealed. The resulting mixture was heated at 110 °C for 24h. The solution was cooled and extracted with Et_2O (3 x 8 mL). The organic layer was washed with water (2 x 8 mL), brine (2 x 8 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (SiO_2, pentane/Et_2O).

A crude NMR yield could be determined using $PhCF_3$ as an internal standard.



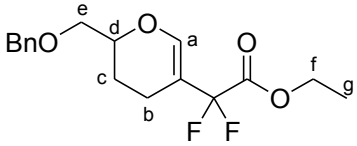
3,4-dihydro-5-(ethyl difluoro acetate)-2H-pyran 2a. Prepared following the procedure **A** from dihydropyran **1a**. Compound **2a** was obtained as a colorless oil in 73% yield (54 mg) after flash chromatography (SiO_2, pentane/Et_2O 19: 1, R_f = 0.34) (*caution: the product is highly volatile*).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.84 (brs, 1H, H_a), 4.33 (q, 2H, H_e, J_{HH} = 7.1 Hz), 4.00 (dd, 2H, H_d, J_{HH} = 5.3, 5.1 Hz), 2.14 (dt, 2H, H_b, J_{HH} = 6.3, 1.1 Hz), 1.93-1.85 (m, 2H, H_c), 1.35 (t, 3H, H_f, J_{HH} = 7.1 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.0 (t, J_{CF} = 35.8 Hz), 146.3 (t, J_{CF} = 11.0 Hz), 114.3 (t, J_{CF} = 248.1 Hz), 105.9 (t, J_{CF} = 24.8 Hz), 66.0, 62.8, 21.0, 17.8 (t, J_{CF} = 2.8 Hz), 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -105.3 (s, 2F). **IR** (neat, cm^{-1}) 2941, 1760, 1662, 1256, 1009. **HRMS** (AP+): calcd for $[M+H]^+$ $C_9H_{13}F_2O_3$: 207.0833 found: 207.0827 (-2.9 ppm).



2-(benzyloxymethyl)-3,4-dihydro-2H-pyran 1b. To a solution of 2-hydroxymethyl-3,4-dihydro-2*H*-pyran (1 g, 8.76 mmol) and TBAI (325 mg, 0.88 mmol) in DMF (70 mL) was added NaH (279 mg, 11.4 mmol, 98%) at room temperature over 15min. Then BnBr (1.4 mL, 11.4 mmol) was added dropwise at 0 °C and the mixture was allowed to warm up to room temperature. After 7h, the reaction mixture was quenched with sat. aq. NH_4Cl (30 mL) and extracted with Et_2O (3 x 30 mL). The combined organic layers were washed with water (2 x 20 mL), brine (2 x 20 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (cyclohexane/EtOAc 19: 1, R_f = 0.33) to afford **1b** as a colorless oil in 84% yield (1.5 g).

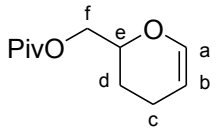
^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.37-7.28 (m, 5H, Bn), 6.41 (d, 1H, H_a, J = 6.2 Hz), 4.72-4.67 (m, 1H, H_b), 4.63 (d, 1H, Bn, J = 12.3 Hz), 4.58 (d, 1H, Bn, J = 12.3 Hz), 4.08-4.00 (m, 1H, H_e), 3.57 (dq, 2H, H_f, J = 10.1, 6.2 Hz), 2.18-2.04 (m, 1H, H_c), 2.03-1.93 (m, 1H, $H_{c'}$), 1.89-1.83 (m, 1H, H_d), 1.77-1.63 (m, 1H, $H_{d'}$). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 143.2, 137.8, 127.9 (2C), 127.23 (2C), 127.17, 99.9, 73.6, 72.9, 72.0, 24.2, 18.9. **IR** (neat, cm^{-1}) 3058, 2857, 1649, 1240, 1070, 731. **HRMS** (EI): calcd for [M] $C_{13}H_{16}O_2$: 204.1150 found: 204.1143 (-3.4 ppm). Spectral data in accordance with literature: A. Boshi, C. Chiappe, A. De Rubertis, M.-F. Ruasse, *J. Org. Chem*. **2000**, *65*, 8470-8477.



2-(benzyloxymethyl)-3,4-dihydro-5-(ethyl difluoro acetate)-2H-pyran 2b. Prepared following the procedure **A** from 2-(benzyloxymethyl)-3,4-dihydro-2*H*-pyran **1b**. Reaction was carried out on a 0.24 mmol scale using $Cu(CH_3CN)_4PF_6$ (9 mg, 0.024 mmol) as a catalyst.

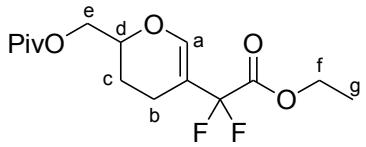
Compound **2b** was obtained as a colorless oil in 72% yield (56 mg) after flash chromatography (SiO_2, pentane/Et_2O 19: 1, R_f = 0.37).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.40-7.28 (m, 5H, Bn), 6.88 (brs, 1H, H_a), 4.64-4.55 (m, 2H, Bn), 4.33 (q, 2H, H_f, J_{HH} = 7.2 Hz), 4.10-4.03 (m, 1H, H_d), 3.62 (dd, 1H, H_e, J_{HH} = 10.2, 5.7 Hz), 3.56 (dd, 1H, $H_{e'}$, J_{HH} = 10.2, 4.5 Hz), 2.21-2.16 (m, 2H, H_b), 2.00-1.92 (m, 1H, H_c), 1.80-1.66 (m, 1H, $H_{c'}$), 1.35 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.0 (t, J_{CF} = 35.8 Hz), 146.0 (t, J_{CF} = 11.0 Hz), 137.8, 128.4, 127.8 (2C), 127.7 (2C), 114.2 (dd, J_{CF} = 248.7, 248.7 Hz), 105.8 (t, J_{CF} = 25.3 Hz), 74.9, 73.5, 71.6, 62.8, 23.0, 17.7 (t, J_{CF} = 2.8 Hz), 14.0. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -104.5 (d, J_{FF} = 253.4 Hz), -105.9 (d, J_{FF} = 253.4 Hz). **IR** (neat, cm^{-1}) 2859, 1760, 1662, 1271, 1198, 1089. **HRMS** (AP+): calcd for $[M+H]^+$ $C_{17}H_{21}F_2O_4$: 327.1408 found: 327.1401 (-2.1 ppm).



2-(pivaloyloxymethyl)-3,4-dihydro-2H-pyran 1c. To a solution of 2-hydroxymethyl-3,4-dihydro-2*H*-pyran (1.5 g, 13 mmol) and DMAP (3.2 g, 26 mmol) in THF (60 mL), PivCl (3.2 mL, 26 mmol) was added at 0 °C. The suspension was allowed to warm up to room temperature. After 12h, the reaction mixture was diluted with water (35 mL) and DCM (35 mL). The aqueous phase was extracted with DCM (2 x 35 mL). The combined organic phases were washed with brine (40 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (cyclohexane/EtOAc 19: 1, R_f = 0.39) to afford **1c** as a colorless oil in 89% yield (2.3 g).

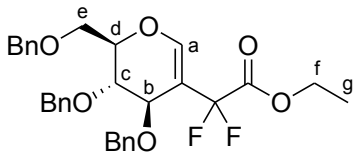
^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.38 (dt, 1H, H_a, J_{HH} = 6.2, 1.9 Hz), 4.73-4.68 (m, 1H, H_b), 4.18-4.17 (d, 2H, H_f, J_{HH} = 5.1 Hz), 4.07-4.00 (m, 1H, H_e), 2.18-1.94 (m, 2H, H_c), 1.90-1.83 (m, 1H, H_d), 1.76-1.63 (m, 1H, $H_{d'}$), 1.23 (s, 9H, Piv). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 177.9, 143.0, 99.9, 72.3, 65.4, 38.4, 26.7 (3C), 23.8, 18.7. **IR** (neat, cm^{-1}) 2971, 2935, 1810, 1737, 1156, 1035, 999. **HRMS** (AP+): calcd for $[M+H]^+$ $C_{11}H_{19}O_3$: 199.1334 found: 199.1338 (+2.0 ppm).



2-(pivaloyloxymethyl)-3,4-dihydro-5-(ethyl difluoro acetate)-2H-pyran 2c. Prepared following the procedure **A** from 2-(pivaloyloxymethyl)-3,4-dihydro-2*H*-pyran **1c**. Reaction was carried out on a 0.24 mmol scale using $Cu(CH_3CN)_4PF_6$ (9 mg, 0.024 mmol) as a catalyst. Compound **2c** was obtained as a colorless oil in 60% yield (46 mg) after flash chromatography (SiO_2, pentane/Et_2O 9: 1, R_f = 0.34).

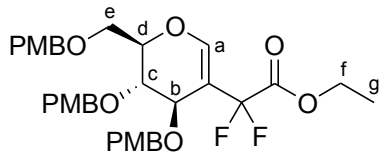
^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.86 (brs, 1H, H_a), 4.33 (q, 2H, H_f, J_{HH} = 7.2 Hz), 4.22 (dd, 1H, H_e, J_{HH} = 11.7, 4.7 Hz), 4.17 (dd, 1H, $H_{e'}$, J_{HH} = 11.7, 5.3 Hz), 4.12-4.04 (m, 1H, H_d), 2.23-2.19 (m, 2H, H_b), 2.00-1.92 (m, 1H, H_c), 1.77-1.67 (m, 1H, $H_{c'}$), 1.36 (t, 3H, H_g, J_{HH} = 7.2 Hz), 1.22 (s, 9H, Piv). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 178.2, 163.9 (t, J_{CF} = 35.8 Hz), 145.8 (dd, J_{CF} = 11.0, 11.0 Hz), 114.1 (dd, J_{CF} = 248.7, 248.7 Hz), 105.9 (t, J_{CF} = 24.8 Hz), 73.5, 65.1, 62.9, 38.8, 27.1 (3C), 22.8, 17.6 (t, J_{CF} = 2.8 Hz), 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -103.9 (d, J_{FF} = 253.4 Hz), -105.6 (d, J_{FF} = 253.4 Hz). **IR** (neat, cm^{-1}) 2971, 1755, 1737, 1659,

1283, 1156, 1096. **HRMS** (AP+): calcd for $[M+H]^+$ $C_{15}H_{23}F_2O_5$: 321.1514 found: 321.1520 (+1.9 ppm).



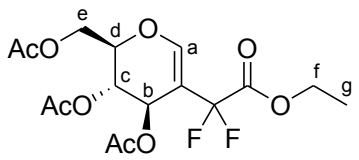
1,5-anhydro-3,4,6-tri-O-benzyl-2-deoxy-2-(ethyl difluoro acetate)-D-arabino-hex-1-enitol 2d. Prepared following the procedure **B** from 3,4,6-tri-*O*-benzyl-D-glucal **1d**. Compound **2d** was obtained as a colorless oil in 62% yield (80 mg) after flash chromatography (SiO_2, pentane/Et_2O 4: 1, R_f = 0.30).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.37-7.19 (m, 15H, Bn), 6.97 (d, 1H, H_a, J_{HF} = 2.6 Hz), 4.61-4.60 (m, 2H, Bn), 4.50-4.49 (m, 4H, Bn), 4.45-4.40 (m, 1H, H_d), 4.14-4.01 (m, 3H, $H_{b,f}$), 3.89-3.86 (m, 1H, H_c), 3.78 (dd, 1H, H_e, J_{HH} = 10.6, 6.4 Hz), 3.66 (dd, 1H, $H_{e'}$, J_{HH} = 10.6, 4.5 Hz), 1.15 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 163.9 (dd, J_{CF} = 37.9, 33.6 Hz), 146.6 (dd, J_{CF} = 12.7, 9.4 Hz), 137.6, 137.5, 137.3, 128.5 (2C), 128.4 (2C), 128.2 (2C), 128.0, 127.8 (2C), 127.73 (2C), 127.69 (2C), 127.63 (2C), 113.4 (t, J_{CF} = 250.3 Hz), 105.7 (dd, J_{CF} = 26.4, 22.0 Hz), 76.3, 73.3, 72.5, 72.2, 71.9, 70.0 (d, J_{CF} = 3.9 Hz), 67.6, 62.6, 13.7. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -103.2 (d, J_{FF} = 256.5 Hz), -109.4 (d, J_{FF} = 256.5 Hz). **IR** (neat, cm^{-1}) 2928, 2869, 1762, 1291, 1202, 1088, 1068. **HRMS** (ESI+): calcd for $[M+Na]^+$ $C_{31}H_{32}F_2O_6Na$: 561.2065 found: 561.2063 (-0.4 ppm). $[\alpha]_D^{20}$ = -9.2° (c = 0.25, $CHCl_3$).



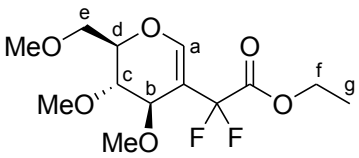
1,5-anhydro-3,4,6-tri-O-(p-methoxybenzyl)-2-deoxy-2-(ethyl difluoro acetate)-D-arabino-hex-1-enitol 2e. Prepared following the procedure **B** from 3,4,6-tri-*O*-(p-methoxybenzyl)-D-glucal **1e** except that the reaction mixture was heated at 110 °C for 30h instead of 24h. Compound **2e** was obtained as a colorless oil in 50% (76 mg) yield after flash chromatography (SiO_2, pentane/Et_2O 1: 1, R_f = 0.62).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.25-7.14 (m, 6H, PMB), 6.95 (d, 1H, H_a, J_{HF} = 2.6 Hz), 6.89-6.81 (m, 6H, PMB), 4.60-4.34 (m, 8H, PMB, $H_{c,d}$), 4.16-4.01 (m, 3H, $H_{b,f}$), 3.81 (s, 3H, PMB), 3.81 (s, 3H, PMB), 3.80 (s, 3H, PMB), 3.73 (dd, 1H, H_e, J_{HH} = 10.6, 6.6 Hz), 3.60 (dd, 1H, $H_{e'}$, J_{HH} = 10.6, 4.3 Hz), 1.16 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.0 (dd, J_{CF} = 38.0, 34.1 Hz), 159.4 (2C), 159.2 (2C), 159.1 (2C), 146.6 (dd, J_{CF} = 12.7, 9.4 Hz), 129.8, 129.7, 129.5, 129.44, 129.40, 129.37, 113.8 (2C), 113.7 (2C), 113.5 (2C), 113.4 (t, J_{CF} = 250.3 Hz), 105.8 (dd, J_{CF} = 26.4, 22.0 Hz), 76.5, 73.0, 72.2, 71.9, 71.7, 69.9 (d, J_{CF} = 3.9 Hz), 67.4, 62.6, 55.2 (3C), 13.8. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -103.2 (d, J_{FF} = 255.5 Hz), -109.5 (d, J_{FF} = 255.5 Hz). **IR** (neat, cm^{-1}) 2936, 1763, 1611, 1513, 1301, 1246, 1075, 1030. **HRMS** (ESI+): calcd for $[M+NH_4]^+$ $C_{34}H_{42}F_2NO_9$: 646.2828 found: 646.2839 (+1.7 ppm). $[\alpha]_D^{20}$ = -25.5° (c = 0.20, $CHCl_3$).



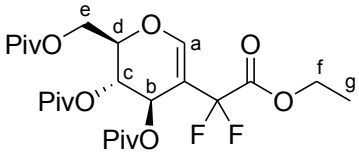
1,5-anhydro-3,4,6-tri-O-acetyl-2-deoxy-2-(ethyl difluoro acetate)-D-arabino-hex-1-enitol 2f. Prepared following the procedure **B** from 3,4,6-tri-*O*-acetyl-D-glucal **1f**. Compound **2f** was obtained as a colorless oil in 65% yield (62 mg) after flash chromatography (SiO_2, pentane/Et_2O 3: 2, R_f = 0.22).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.08 (brs, 1H, H_a), 5.61 (d, 1H, H_b, J_{HH} = 4.3 Hz), 5.16 (t, 1H, H_c, J_{HH} = 4.3 Hz), 4.47-4.18 (m, 5H, $H_{d,e,f}$), 2.10 (s, 3H, Ac), 2.09 (s, 3H, Ac), 2.03 (s, 3H, Ac), 1.36 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 170.3, 169.4, 169.3, 163.3 (dd, J_{CF} = 35.8, 35.8 Hz), 148.7 (t, J_{CF} = 10.5 Hz), 112.6 (dd, J_{CF} = 250.9, 250.9 Hz), 104.0 (t, J_{CF} = 24.8 Hz), 74.1, 66.1, 63.1, 62.8 (dd, J_{CF} = 3.3, 2.2 Hz), 60.8, 20.7, 20.6, 20.5, 13.7. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -104.3 (d, J_{FF} = 262.6 Hz), -105.4 (d, J_{FF} = 262.6 Hz). **IR** (neat, cm^{-1}) 2990, 1743, 1661, 1369, 1216, 1198, 1021. **HRMS** (ESI+): calcd for $[M+Na]^+$ $C_{16}H_{20}F_2O_9Na$: 417.0980 found: 417.0973 (-1.7 ppm). $[\alpha]_D^{20}$ = +31.2° (c = 0.25, $CHCl_3$).



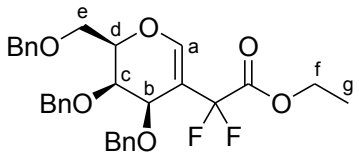
1,5-anhydro-3,4,6-tri-O-methyl-2-deoxy-2-(ethyl difluoro acetate)-D-arabino-hex-1-enitol 2g. Prepared following the procedure **B** from 3,4,6-tri-*O*-methyl-D-glucal **1g**. Compound **2g** was obtained as a colorless oil in 51% yield (38 mg) after flash chromatography (SiO_2, pentane/Et_2O 4: 1, R_f = 0.28).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.89 (d, 1H, H_a, J_{HF} = 3.0 Hz), 4.38-4.21 (m, 3H, $H_{c,f}$), 3.82 (d, 1H, H_b, J_{HH} = 4.2 Hz), 3.70-3.52 (m, 3H, $H_{d,e}$), 3.49 (s, 3H, Me), 3.40 (s, 3H, Me), 3.39 (s, 3H, Me), 1.33 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.0 (dd, J_{CF} = 38.0, 33.6 Hz), 146.3 dd, J_{CF} = 12.7, 8.8 Hz), 113.2 (t, J_{CF} = 250.3 Hz), 106.1 (dd, J_{CF} = 26.4, 21.5 Hz), 76.0, 74.4, 72.4 (dd, J_{CF} = 3.9 Hz), 69.9, 62.7, 59.1, 58.3, 58.1, 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -102.9 (d, J_{FF} = 256.5 Hz), -110.4 (d, J_{FF} = 256.5 Hz). **IR** (neat, cm^{-1}) 2935, 1765, 1667, 1456, 1371, 1294, 1203, 1081, 1198. **HRMS** (ESI+): calcd for $[M+NH_4]^+$ $C_{13}H_{24}F_2NO_6$: 328.1572 found: 328.1558 (-4.2 ppm). $[\alpha]_D^{20}$ = +77.6° (c = 0.25, $CHCl_3$).



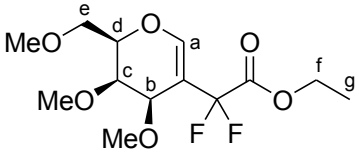
1,5-anhydro-3,4,6-tri-O-pivaloyl-2-deoxy-2-(ethyl difluoro acetate)-D-arabino-hex-1-enitol 2h. Prepared following the procedure **B** from 3,4,6-tri-*O*-pivaloyl-D-glucal **1h**. Compound **2h** was obtained as a colorless oil in 67% yield (84 mg) after flash chromatography (SiO_2, pentane/Et_2O 9: 1, R_f = 0.21).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.08 (brs, 1H, H_a), 5.53 (d, 1H, H_b, J_{HH} = 3.4 Hz), 5.10 (t, 1H, H_c, J_{HH} = 3.4 Hz), 4.41-4.52 (m, 2H, H_e), 4.32 (q, 2H, H_f, J_{HH} = 7.2 Hz), 4.11 (q, 1H, H_d, J_{HH} = 7.6 Hz), 1.35 (t, 3H, H_g, J_{HH} = 7.2 Hz), 1.21 (s, 9H, Piv), 1.19 (s, 9H, H_g, Piv), 1.17 (s, 9H, Piv). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 177.7, 176.5, 176.2, 163.0 (t, J_{CF} = 35.8 Hz), 148.6 (dd, J_{CF} = 11.0, 9.9 Hz), 112.8 (t, J_{CF} = 251.4 Hz), 103.6 (dd, J_{CF} = 25.9, 24.2 Hz), 73.9, 65.6, 62.9, 61.8 (t, J_{CF} = 2.2 Hz), 60.8, 38.59, 38.57, 38.56, 26.9 (3C), 26.69 (3C), 26.67 (3C), 13.7. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -100.7 (d, J_{FF} = 265.7 Hz), -105.0 (d, J_{FF} = 265.7 Hz). **IR** (neat, cm^{-1}) 2975, 1734, 1661, 1481, 1277, 1122. **HRMS** (ESI+): calcd for $[M+NH_4]^+$ $C_{25}H_{42}F_2NO_9$: 538.2828 found: 538.2831 (+0.6 ppm). $[\alpha]_D^{20}$ = +4.0° (c = 0.25, $CHCl_3$).



1,5-anhydro-3,4,6-tri-O-benzyl-2-deoxy-2-(ethyl difluoro acetate)-D-lyxo-hex-1-enitol 2i. Prepared following the procedure **B** from 3,4,6-tri-*O*-benzyl-D-galactal **1i**. Compound **2i** was obtained as a colorless oil in 49% yield (63 mg) after flash chromatography (SiO_2, pentane/Et_2O 9: 1, R_f = 0.29).

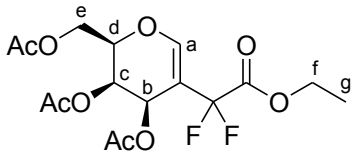
^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.37-7.28 (m, 15H, Bn), 6.89 (d, 1H, H_a, J_{HF} = 2.8 Hz), 4.79-4.39 (m, 7H, H_d, Bn), 4.33-4.32 (m, 1H, H_b), 4.04 (q, 2H, H_f, J_{HH} = 7.2 Hz), 4.00-3.97 (m, 1H, H_c), 3.73 (dd, 1H, H_e, J_{HH} = 10.6, 6.6 Hz), 3.60 (dd, 1H, $H_{e'}$, J_{HH} = 10.6, 4.5 Hz), 1.09 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 163.8 (dd, J_{CF} = 38.5, 33.0 Hz), 146.2 (dd, J_{CF} = 13.2, 9.4 Hz), 137.9, 137.8, 137.7, 128.48 (2C), 128.45 (2C), 128.2 (2C), 128.0 (2C), 127.94, 127.92 (2C), 127.8, 127.73 (2C), 127.67, 113.3 (dd, J_{CF} = 249.8, 248.1 Hz), 106.7 (dd, J_{CF} = 26.4, 20.4 Hz), 76.1, 73.9, 73.5, 72.9, 72.1, 69.5, 67.8, 62.6, 13.7. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -101.9 (d, J_{FF} = 257.5 Hz), -109.8 (d, J_{FF} = 257.5 Hz). **IR** (neat, cm^{-1}) 2923, 2863, 1761, 1296, 1211, 1096. **HRMS** (ES+): calcd for $[M+NH_4]^+$ $C_{31}H_{36}F_2NO_6$: 556.2511 found: 556.2527 (+2.87 ppm) . $[\alpha]_D^{20}$ = -11.5° (c = 0.4, $CHCl_3$).



1,5-anhydro-3,4,6-tri-O-methyl-2-deoxy-2-(ethyl difluoro acetate)-D-lyxo-hex-1-enitol 2j. Prepared following the procedure **B** from 3,4,6-tri-*O*-methyl-D-galactal **1j**. Compound **2j** was obtained as a colorless oil in 50% yield (37 mg) after flash chromatography (SiO_2, pentane/Et_2O 7: 3, R_f = 0.31).

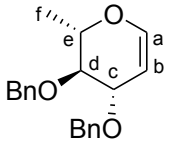
^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.84 (d, 1H, H_a, J_{HF} = 2.8 Hz), 4.40-4.24 (m, 3H, $H_{c,f}$), 4.06-4.05 (m, 1H, H_b), 3.77-3.62 (m, 3H, $H_{d,e}$), 3.56 (s, 3H, Me), 3.43 (s, 3H, Me), 3.41 (s, 3H, Me), 1.34 (t, 3H, H_g, J_{HH} = 7.0 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 163.8 (dd, J_{CF} = 38.5, 33.6 Hz), 146.0 (dd, J_{CF} = 12.7, 9.4 Hz), 113.2 (dd, J_{CF} = 250.3, 248.1 Hz), 106.7 (dd, J_{CF} = 26.4, 20.9 Hz), 75.8, 73.9, 71.2 (d, J_{CF} = 3.9 Hz), 69.9, 62.6, 59.4, 59.3, 59.2, 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -102.2 (d, J_{FF} = 258.5 Hz), -109.4 (d, J_{FF} = 258.5 Hz). **IR** (neat, cm^{-1}) 2942, 2841,

1767, 1665, 1275, 1199, 1095. **HRMS** (ES+): calcd for $[M+NH_4]^+$ $C_{13}H_{24}F_2NO_6$: 328.1572 found: 328.1570 (-0.6 ppm). $[\alpha]_D^{20}$ = 27.5° (c = 0.6, $CHCl_3$).



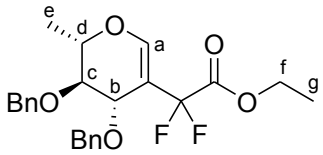
1,5-anhydro-3,4,6-tri-O-acetyl-2-deoxy-2-(ethyl difluoro acetate)-D-lyxo-hex-1-enitol 2k. Prepared following the procedure **B** from 3,4,6-tri-*O*-acetyl-D-galactal **1k**. Compound **2k** was obtained as a colorless oil in 40% yield (38 mg) after flash chromatography (SiO_2, pentane/Et_2O 3: 2, R_f = 0.26).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.02 (d, 1H, H_a, J_{HF} = 1.1 Hz), 5.80 (d, 1H, H_b, J_{HH} = 4.1 Hz), 5.44 (dd, 1H, H_c, J_{HH} = 4.1, 2.6 Hz), 4.44-4.22 (m, 5H, $H_{d,e,f}$), 2.10 (s, 6H, Ac), 2.00 (s, 3H, Ac), 1.35 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 170.5, 169.7, 169.5, 163.3 (dd, J_{CF} = 35.8, 35.8 Hz), 148.1 (dd, J_{CF} = 10.4, 10.4 Hz), 112.4 (t, J_{CF} = 250.9 Hz), 104.2 (dd, J_{CF} = 25.3, 23.7 Hz), 73.3, 63.1, 63.0, 61.9, 61.3, 20.7, 20.5, 20.3, 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -104.2 (d, J_{FF} = 265.7 Hz), -105.3 (d, J_{FF} = 265.7 Hz). **IR** (neat, cm^{-1}) 2996, 1743, 1671, 1374, 1204, 1090, 1029. **HRMS** (ES+): calcd for $[M+NH_4]^+$ $C_{16}H_{24}F_2NO_9$: 412.1419 found: 412.1418 (-0.2 ppm). $[\alpha]_D^{20}$ = -13.2° (c = 0.25, $CHCl_3$).



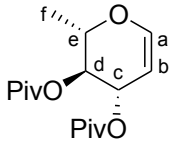
3,4-di-O-benzyl-6-deoxy-L-glucal 1l. To a solution of 3,4-di-*O*-acetyl-6-deoxy-L-glucal (1.5 g, 7 mmol) in MeOH (40 mL) was added K_2CO_3 (39 mg, 0.28 mmol). After 12h at room temperature, the solvent was removed under vacuum. The viscous residue was dissolved in $CHCl_3$ and concentrated under vacuum. This procedure was repeated two times. DMF (25 mL) and TBAI (259 mg, 0.7 mmol) were added to the crude yellow solid and the solution was cooled to 0 °C. NaH (784 mg, 19.6 mmol, 60% in oil) was added portionwise over 30min. Then BnBr (2.33 mL, 19.6 mmol) was added dropwise at 0 °C and the mixture was allowed to warm up to room temperature. After 12h, the reaction mixture was quenched with sat. aq. NH_4Cl (30 mL) and extracted with Et_2O (3 x 30 mL). The combined organic layers were washed with water (2 x 30 mL), brine (2 x 20 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (cyclohexane/EtOAc 19: 1, R_f = 0.40) to afford **1l** as a colorless oil in 78% yield (1.7 g).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.39-7.29 (m, 10H, Bn), 6.38 (dd, 1H, H_a, J = 6.2, 1.3 Hz), 4.92-4.87 (m, 2H, H_b, Bn), 4.74-4.57 (m, 3H, Bn), 4.24 (ddd, 1H, H_c, J = 6.4, 2.1, 1.3 Hz), 3.98 (dq, 1H, H_e, J = 8.9, 6.4 Hz), 3.51 (dd, 1H, H_d, J = 8.9, 6.4 Hz), 1.40 (d, 3H, H_f, J = 6.4 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 144.8, 138.4, 138.2, 128.4 (4C), 128.0 (2C), 127.7 (2C), 127.6 (2C), 100.1, 79.5, 76.4, 74.1, 73.9, 70.5, 17.5. **IR** (neat, cm^{-1}) 3035, 2870, 1644, 1453, 1237, 1098, 1057. **HRMS** (AP+): calcd for $[M+Na]^+$ $C_{20}H_{22}O_3Na$: 333.1467 found: 333.1466 (-0.3 ppm). $[\alpha]_D^{20}$ = +37.2° (c = 0.25, $CHCl_3$).



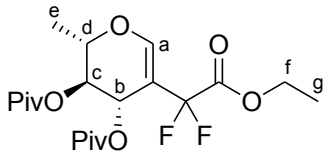
1,5-anhydro-2,6-dideoxy-3,4-di-O-benzyl-2-(ethyl difluoro acetate)-L-arabino-hex-1-enitol 2l. Prepared following the procedure **B** from 3,4-di-*O*-benzyl-6-deoxy-L-glucal **1l** using CuI (5 mg, 0.024 mmol) as a catalyst. Compound **2l** was obtained as a colorless oil in 51% yield (53 mg) after flash chromatography (SiO_2, pentane/Et_2O 19: 1, R_f = 0.27).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.39-7.29 (m, 10H, Bn), 6.93 (d, 1H, H_a, J_{HF} = 2.6 Hz), 4.68-4.56 (m, 4H, Bn), 4.41-4.30 (m, 1H, H_d), 4.17-4.16 (m, 1H, H_b), 4.14-3.97 (m, 2H, H_f), 3.59 (t, 1H, H_c, J_{HH} = 4.3 Hz), 1.39 (d, 3H, H_e, J_{HH} = 6.8 Hz), 1.15 (t, 3H, H_g, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 163.7 (dd, J_{CF} = 38.5, 34.1 Hz), 146.0 (dd, J_{CF} = 12.7, 8.8 Hz), 137.4, 137.0, 128.1 (2C), 127.8 (2C), 127.6, 127.4 (2C), 127.3 (2C), 127.2, 113.2 (t, J_{CF} = 249.8 Hz), 105.1 (dd, J_{CF} = 26.4, 21.5 Hz), 76.0, 73.3, 72.2, 72.1, 70.5 (d, J_{CF} = 3.9 Hz), 62.2, 15.9, 13.3. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -103.1 (d, J_{FF} = 256.5 Hz), -109.6 (d, J_{FF} = 256.5 Hz). **IR** (neat, cm^{-1}) 2986, 2870, 1762, 1661, 1455, 1212, 1202, 1066. **HRMS** (AP+): calcd for $[M+NH_4]^+$ $C_{24}H_{30}F_2NO_5$: 450.2092 found: 450.2096 (+0.9 ppm). $[\alpha]_D^{20}$ = +51.2° (c = 0.25, $CHCl_3$).



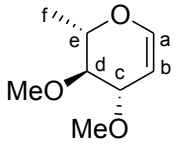
3,4-di-O-pivaloyl-6-deoxy-L-glucal 1m. To a solution of 3,4-di-*O*-acetyl-6-deoxy-L-glucal (1.5 g, 7 mmol) in MeOH (40 mL) was added K_2CO_3 (39 mg, 0.28 mmol). After 12h at room temperature, the solvent was removed under vacuum. The viscous residue was dissolved in $CHCl_3$ and concentrated under vacuum. This procedure was repeated two times. The crude yellow solid was dissolved in THF (50 mL) and cooled to 0 °C. DMAP (3.4 g, 28 mmol) and PivCl (3.4 mL, 28 mmol) were added. The suspension was allowed to warm up to room temperature. After 12h, the reaction mixture was diluted with water (40 mL) and DCM (40 mL). The aqueous phase was extracted with DCM (2 x 40 mL). The combined organic phases were washed with brine (40 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (cyclohexane/EtOAc 19: 1, R_f = 0.37) to afford **1m** as a white solid in 57% yield (1.2 g).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.43 (dd, 1H, H_a, J = 6.0, 1.1 Hz), 5.36 (ddd, 1H, H_c, J = 6.6, 2.8, 1.1 Hz), 5.09 (dd, 1H, H_d, J = 8.7, 6.6 Hz), 4.75 (dd, 1H, H_b, J = 6.0, 2.8 Hz), 4.11 (dq, 1H, H_e, J = 8.7, 6.6 Hz), 1.30 (d, 3H, H_f, J = 6.6 Hz), 1.20 (s, 9H, Piv), 1.18 (s, 9H, Piv). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 178.0, 177.1, 145.8, 99.2, 72.7, 71.3, 68.4, 38.74, 38.69, 27.0 (6C), 16.6. **IR** (neat, cm^{-1}) 2970, 1739, 1717, 1649, 1481, 1237, 1134, 1042. **HRMS** (ES+): calcd for for $[M+NH_4]^+$ $C_{16}H_{30}NO_5$: 316.2124 found: 316.2119 (-1.6 ppm). $[\alpha]_D^{20}$ = +63.6° (c = 0.25, $CHCl_3$). Mp: 58-59°C.



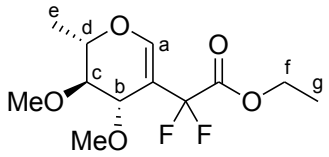
1,5-anhydro-2,6-dideoxy-3,4-di-O-pivaloyl-2-(ethyl difluoro acetate)-L-arabino-hex-1-enitol 2m. Prepared following the procedure **B** from 3,4-di-*O*-pivaloyl-6-deoxy-L-glucal **1m** except that the reaction mixture was heated at 110 °C for 30h instead of 24h. Compound **2m** was obtained as a colorless oil in 50% yield (50 mg) after flash chromatography (SiO_2, pentane/Et_2O 9: 1, R_f = 0.34).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.06 (brs, 1H, H_a), 5.55 (d, 1H, H_b, J_{HH} = 3.9 Hz), 4.94 (t, 1H, H_c, J_{HH} = 3.9 Hz), 4.38-4.33 (m, 1H, H_d), 4.31 (q, 2H, H_f, J_{HH} = 7.2 Hz), 1.38 (d, 3H, H_e, J_{HH} = 6.4 Hz), 1.35 (t, 3H, H_g, J_{HH} = 7.2 Hz), 1.18 (s, 18H, Piv). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 176.9, 176.8, 163.3 (t, J_{CF} = 35.8 Hz), 149.1 (dd, J_{CF} = 11.0, 9.4 Hz), 113.2 (t, J_{CF} = 250.9 Hz), 103.1 (dd, J_{CF} = 25.9, 24.2 Hz), 72.6, 69.7, 63.1, 62.7 (t, J_{CF} = 2.2 Hz), 38.77, 38.75, 26.91 (3C), 26.87 (3C), 15.9, 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -100.2 (d, J_{FF} = 263.6 Hz), -104.6 (d, J_{FF} = 263.6 Hz). **IR** (neat, cm^{-1}) 2978, 2880, 1773, 1737, 1277, 1132. **HRMS** (ES+): calcd for $[M+NH_4]^+$ $C_{20}H_{34}F_2NO_7$: 438.2303 found: 438.2299 (-0.9 ppm). $[\alpha]_D^{20}$ = +24.4° (c = 0.80, $CHCl_3$).



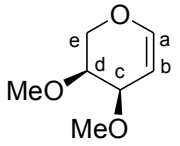
3,4-di-O-methyl-6-deoxy-L-glucal 1n. To a solution of 3,4-di-*O*-acetyl-6-deoxy-L-glucal (1.5 g, 7.0 mmol) in MeOH (40 mL) was added K_2CO_3 (39 mg, 0.28 mmol). After 12h at room temperature, the solvent was removed under vacuum. The viscous residue was dissolved in $CHCl_3$ and concentrated under vacuum. This procedure was repeated two times. DMF (30 mL) was added to the crude yellow solid and the solution was cooled to 0 °C. NaH (616 mg, 15.4 mmol, 60% in oil) was added portionwise over 30min. Then, MeI (0.96 mL, 15.4 mmol) was added dropwise at 0 °C and the mixture was allowed to warm up to room temperature. After 12h, the reaction mixture was quenched with MeOH (10 mL), stirred for 15min and extracted with EtOAc (3 x 30 mL). The combined organic layers were washed with water (2 x 30 mL), brine (2 x 30 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (cyclohexane/EtOAc 19: 1, R_f = 0.33) to afford **1n** as a colorless oil in 23% yield (255 mg).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.35 (dd, 1H, H_a, J = 6.2, 1.1 Hz), 4.82 (dd, 1H, H_b, J = 6.2, 2.5 Hz), 3.94-3.85 (m, 2H, $H_{c,e}$), 3.57 (s, 3H, Me), 3.41 (s, 3H, Me), 3.14 (dd, 1H, H_d, J = 8.7, 6.4 Hz), 1.37 (d, 3H, H_f, J = 6.4 Hz).**^{13}C NMR ($CDCl_3$, 75 MHz)** δ 144.5, 99.5, 81.0, 77.3, 73.4, 59.4, 55.5, 17.0. **IR** (neat, cm^{-1}) 2934, 1646, 1236, 1104, 1088, 1054. **Elemental analysis**: calcd for $C_8H_{14}O_3$: C, 60.74; H, 8.92. found: C, 60.56; H, 8.80. **MS** (IE): calcd for $[M]^+$ $C_8H_{14}O_3$: 158 found: 158. $[\alpha]_D^{20}$ = +36.8° (c = 0.25, $CHCl_3$).



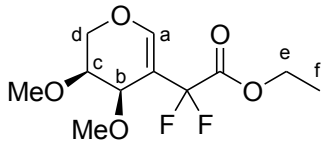
1,5-anhydro-2,6-dideoxy-3,4-di-O-methyl-2-(ethyl difluoro acetate)-L-arabino-hex-1-enitol 2n. Prepared following the procedure **B** from 3,4-di-*O*-methyl-6-deoxy-L-glucal **1n**. Compound **2n** was obtained as a colorless oil in 60% yield (40 mg) after flash chromatography (SiO_2, pentane/Et_2O 9: 1, R_f = 0.31).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.85 (d, 1H, H_a, J_{HF} = 2.8 Hz), 4.36-4.16 (m, 3H, $H_{d,f}$), 3.84 (d, 1H, H_b, J_{HH} = 4.3 Hz), 3.51 (s, 3H, Me), 3.41 (s, 3H, Me), 3.28 (t, 1H, H_c, J_{HH} = 4.3 Hz), 1.37 (d, 3H, H_e, J_{HH} = 6.8 Hz), 1.33 (t, 3H, H_g, J_{HH} = 7.0 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.6 (dd, J_{CF} = 38.5, 33.6 Hz), 146.6 (dd, J_{CF} = 12.7, 9.4 Hz), 114.0 (t, J_{CF} = 249.8 Hz), 106.5 (dd, J_{CF} = 26.4, 20.9 Hz), 79.9, 74.0, 73.8 (d, J_{CF} = 3.9 Hz), 63.0, 59.1, 58.7, 16.6, 14.3. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -102.9 (d, J_{FF} = 256.5 Hz), -110.3 (d, J_{FF} = 256.5 Hz). **IR** (neat, cm^{-1}) 2989, 2939, 1764, 1667, 1287, 1195, 1083. **HRMS** (ES+): calcd for $[M+NH_4]^+$ $C_{12}H_{22}F_2NO_5$: 298.1463 found: 298.1466 (+1.0 ppm). $[\alpha]_D^{20}$ = -55.0° (c = 0.30, $CHCl_3$).



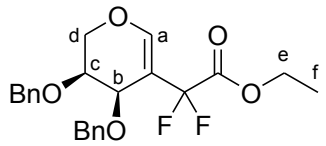
3,4-di-O-methyl-L-arabinal 1o. To a solution of 3,4-di-*O*-acetyl-L-arabinal (1.5 g, 7.5 mmol) in MeOH (35 mL) was added K_2CO_3 (41 mg, 0.30 mmol). After 12h at room temperature, the solvent was removed under vacuum. The viscous residue was dissolved in $CHCl_3$ and concentrated under vacuum. This procedure was repeated two times. DMF (35 mL) was added to the crude yellow solid and the solution was cooled to 0 °C. NaH (656 mg, 16.4 mmol, 60% in oil) was added portionwise over 30min. Then, MeI (1.0 mL, 16.4 mmol) was added dropwise at 0 °C and the mixture was allowed to warm up to room temperature. After 12h, the reaction mixture was quenched with MeOH (10 mL), stirred for 15min and extracted with EtOAc (3 x 30 mL). The combined organic layers were washed with water (2 x 30 mL), brine (2 x 30 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the residue was purified by flash chromatography (cyclohexane/EtOAc 9: 1, R_f = 0.22) to afford **1o** as a colorless oil in 23% yield (251 mg).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.37 (d, 1H, H_a, J = 6.0 Hz), 4.88 (dd, 1H, H_b, J = 6.0, 3.8 Hz), 3.96-3.88 (m, 2H, H_e), 3.85 (t, 1H, H_c, J = 3.8 Hz), 3.54 (ddd, 1H, H_d, J = 9.4, 4.5, 3.8 Hz), 3.43 (s, 3H, Me), 3.40 (s, 3H, Me). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 146.5, 98.2, 75.2, 68.9, 62.7, 57.0, 56.2. **IR** (neat, cm^{-1}) 2932, 2888, 1639, 1235, 1121, 1070. **Elemental analysis**: calcd for $C_7H_{12}O_3$: C, 58.32; H, 8.39. found: C, 58.50; H, 8.53. **MS** (IE): calcd for $[M]^+$ $C_7H_{12}O_3$: 144 found: 144. $[\alpha]_D^{20}$ = -245.2° (c = 0.25, $CHCl_3$).



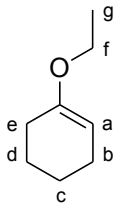
1,5-anhydro-2,3-di-O-methyl-4-deoxy-4-(ethyl difluoro acetate)-D-erythro-pent-4-enitol 2o. Prepared following the procedure **B** from 3,4-di-*O*-methyl-L-arabinal **1o** using CuI (5 mg, 0.024 mmol) as a catalyst. Compound **2o** was obtained as a colorless oil in 39% yield (25 mg) after flash chromatography (SiO_2, pentane/Et_2O 4: 1, R_f = 0.37).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.89 (d, 1H, H_a, J_{HF} = 2.6 Hz), 4.38-4.27 (m, 2H, H_e), 4.10-3.92 (m, 3H, $H_{b,d}$), 3.55 (ddd, 1H, H_c, J_{HH} = 11.1, 4.2, 3.2 Hz), 3.50 (s, 3H, Me), 3.49 (s, 3H, Me), 1.35 (t, 3H, H_f, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.1 (dd, J_{CF} = 37.4, 34.1 Hz), 148.5 (dd, J_{CF} = 12.1, 9.4 Hz), 113.1 (dd, J_{CF} = 250.9, 249.8 Hz), 106.4 (dd, J_{CF} = 27.0, 23.1 Hz), 76.1, 68.2 (d, J_{CF} = 3.3 Hz), 62.9, 62.5, 59.9, 57.7, 13.9. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -101.3 (d, J_{FF} = 251.4 Hz), -108.2 (d, J_{FF} = 251.4 Hz). **IR** (neat, cm^{-1}) 2933, 1765, 1660, 1295, 1209, 1079. **HRMS** (ES+): calcd for $[M+NH_4]^+$ $C_{11}H_{20}F_2NO_5$: 284.1310 found: 284.1314 (+1.4 ppm). $[\alpha]_D^{20}$ = -80.1° (c = 0.45, $CHCl_3$).



1,5-anhydro-2,3-di-O-benzyl-4-deoxy-4-(ethyl difluoro acetate)-D-erythro-pent-4-enitol 2p. Prepared following the procedure **B** from 3,4-di-*O*-benzyl-L-arabinal **1p** using CuI (5 mg, 0.024 mmol) as a catalyst. Compound **2p** was obtained as a colorless oil in 42% yield (42 mg) after flash chromatography (SiO_2, pentane/Et_2O 19: 1, R_f = 0.18).

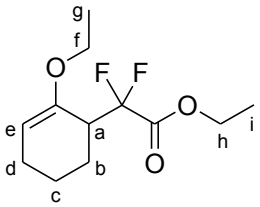
^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.40-7.28 (m, 10H, Bn), 6.90 (d, 1H, H_a, J_{HF} = 2.8 Hz), 4.98-4.59 (m, 4H, Bn), 4.32 (d, 1H, H_b, J_{HH} = 2.3 Hz), 4.18-4.06 (m, 4H, $H_{d,e}$), 3.81 (ddd, 1H, H_c, J_{HH} = 10.6, 4.9, 2.3 Hz), 1.21 (t, 3H, H_f, J_{HH} = 7.2 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.0 (dd, J_{CF} = 38.0, 34.1 Hz), 148.6 (dd, J_{CF} = 12.1, 8.8 Hz), 138.4, 137.6, 128.6 (2C), 128.1 (2C), 128.0 (2C), 127.47 (2C), 127.45 (2C), 113.1 (dd, J_{CF} = 250.9, 248.7 Hz), 106.4 (dd, J_{CF} = 26.4, 22.6 Hz), 74.1, 74.0, 71.7 (2C), 67.2 (d, J_{CF} = 3.9 Hz), 62.8, 13.8. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -101.0 (d, J_{FF} = 251.4 Hz), -108.1 (d, J_{FF} = 251.4 Hz). **IR** (neat, cm^{-1}) 2923, 1767, 1659, 1296, 1199, 1084. **HRMS** (ES+) : calcd for $[M+NH_4]^+$ $C_{23}H_{28}F_2NO_5$: 436.1936 found: 436.1939 (+0.7 ppm). $[\alpha]_D^{20}$ = -124.2° (c = 0.45, $CHCl_3$).



1-ethoxycylohex-1-ene 4. At -20 °C, TMSOTf (11.5 mL, 63.8 mmol) was added dropwise to a solution of cyclohexanone diethyl acetal (10.0 g, 58.1 mmol) and *N*,*N*-diisopropylethylamine (12.1 mL, 69.7 mmol) in DCM (100 mL). The reaction mixture was allowed to warm to room temperature and stirred for 3 days. Aqueous sodium hydroxide

solution (1 N, 11.6 mmol) was added and the reaction mixture was stirred vigorously for 5 minutes. The organic layer was separated, diluted with pentane (200 mL) and cooled overnight. The precipitate was removed by filtration. The solvent was removed under vacuum and the residue was distilled (110 °C, 12 mmHg) to afford **4** as a colorless oil in 44% yield (3.2 g).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 4.60 (t, 1H, H_a, J = 3.2 Hz), 3.69 (q, 2H, H_f, J = 7.0 Hz), 2.08-2.02 (m, 4H, $H_{b,e}$), 1.72-1.62 (m, 2H, $H_{c\ or\ d}$), 1.58-1.50 (m, 2H, $H_{c\ or\ d}$), 1.29 (t, 3H, H_g, J = 7.0 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 154.4, 93.3, 61.3, 27.8, 23.4, 22.8, 22.7, 15.5. **IR** (neat, cm^{-1}) 2935, 2864, 1721, 1658, 1450, 1381, 1185, 1112, 1049. **HRMS** (EI): calcd for [M] $C_8H_{14}O$: 126.1045 found: 126.1048 (+2.4 ppm).



1-ethoxy-6-(ethyl difluoro acetate)-cylohex-1-ene 5. Prepared following the procedure **B** from enol ether **4** except that the reaction mixture was heated at 80 °C for 4h. Compound **5** was obtained as a colorless oil in 34% yield (20 mg) after flash chromatography (SiO_2, pentane/Et_2O 49: 1, R_f = 0.35).

^{1}H NMR ($CDCl_3$, 300 MHz) δ 4.83-4.80 (m, 1H, H_e), 4.29 (q, 2H, H_h, J_{HH} = 7.2 Hz), 3.71-3.56 (m, 2H, H_f), 3.28-3.11 (m, 1H, H_a), 2.18-2.04 (m, 2H, H_d), 1.94-1.74 (m, 3H, $H_{b,c}$), 1.56-1.44 (m, 1H, $H_{c'}$), 1.36 (t, 3H, H_i, J_{HH} = 7.2 Hz), 1.19 (t, 3H, H_g, J_{HH} = 7.0 Hz). **^{13}C NMR ($CDCl_3$, 75 MHz)** δ 164.0 (dd, J_{CF} = 34.1, 30.8 Hz), 148.7 (d, J_{CF} = 9.9 Hz), 115.4 (dd, J_{CF} = 258.0, 245.9 Hz), 97.7, 61.75, 61.68, 41.3 (dd, J_{CF} = 24.8, 22.6 Hz), 22.7, 21.1 (dd, J_{CF} = 6.1, 1.7 Hz), 20.1, 13.6, 13.5. **^{19}F NMR ($CDCl_3$, $CFCl_3$, 282 MHz)** δ -108.3 (d, J_{FF} = 253.4 Hz), -119.9 (d, J_{FF} = 253.4 Hz). **IR** (neat, cm^{-1}) 2983, 2926, 1773, 1760, 1667, 1285, 1209, 1037. **HRMS** (ESI+): calcd for [M] $C_{12}H_{18}F_2O_3$: 248.1224 found: 248.1226 (+0.8 ppm).

Elucidation of the difluoromethylene moiety's position in the glycal skeleton

The structure of 1,5-anhydro-3,4,6-tri-*O*-(p-methoxybenzyl)-2-deoxy-2-(ethyl difluoro acetate)-D-*arabino*-hex-1-enitol **2e** was established by NMR studies. Assignment of resonances for protons and carbons given in the list of spectral data were deduced from 1D NMR (^{1}H, ^{13}C and ^{13}C-JMOD) and 2D NMR (COSY, HMQC and HMBC) spectra. Subsequent long range C-H correlation by HMBC experiment was helpful in establishing the position of the difluoromethylene moiety in the glycal skeleton. Indeed, significant long range coupling between H_a with C_b and C_d of glycal skeleton had confirmed the formation of the *b*-adduct: the C2-CF_2CO_2Et glycal derivative.

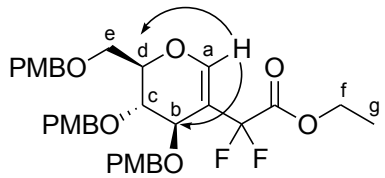
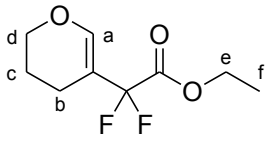
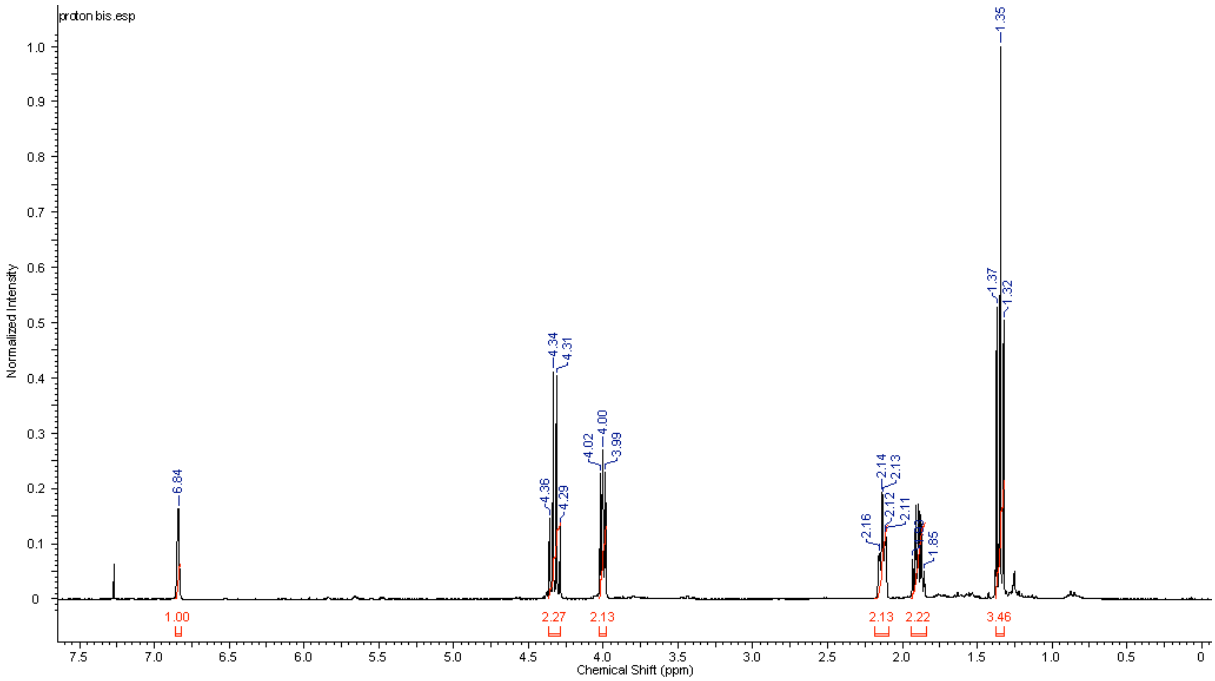


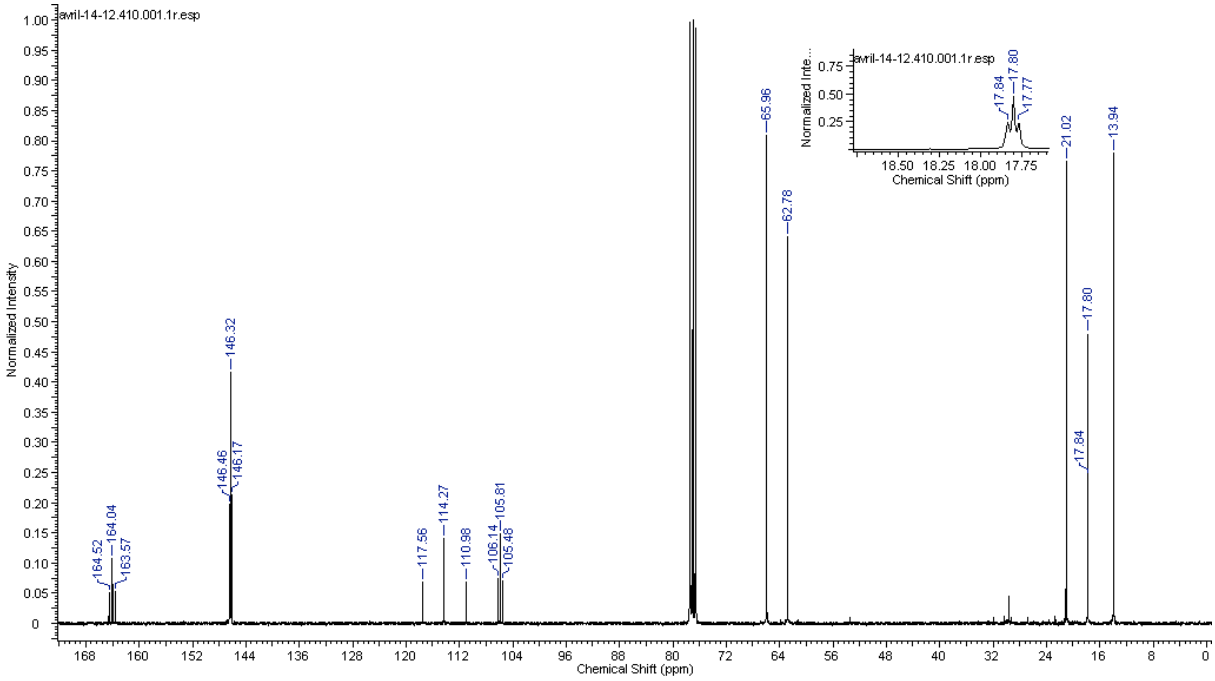
Figure 1. Elucidation of the difluoromethylene moity's position in the glycal skeleton by NMR spectroscopy

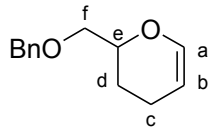
Section D: Copies of ^{1}H, ^{19}F and ^{13}C NMR spectra



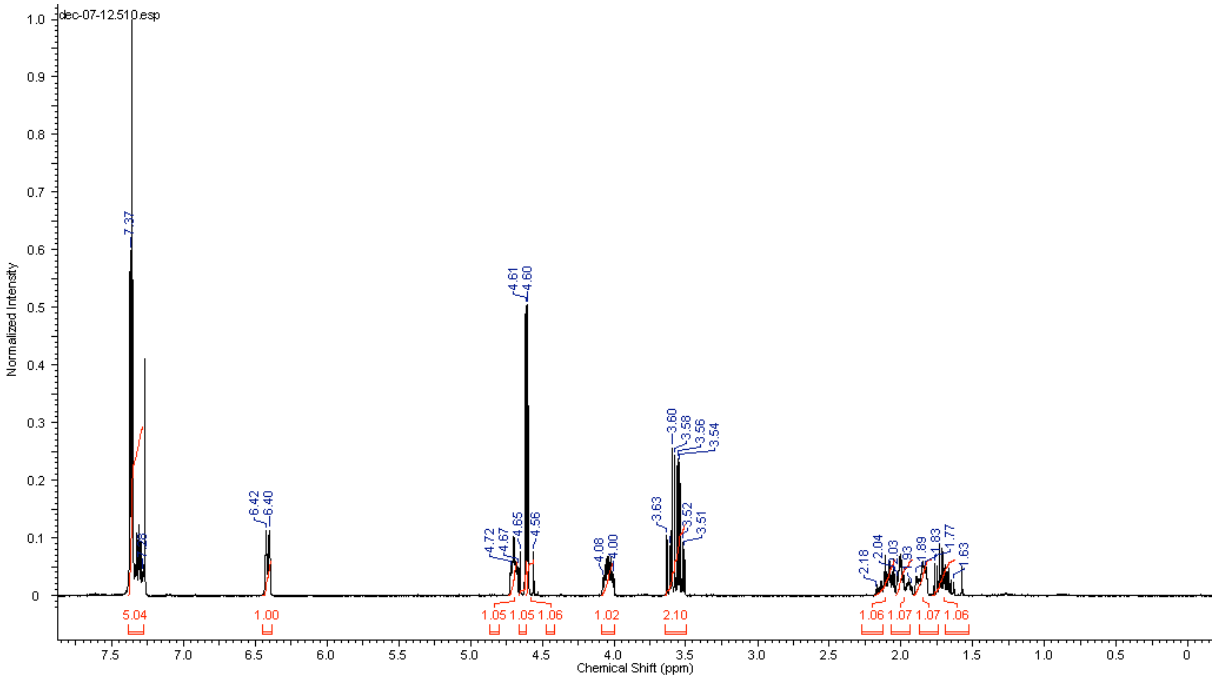
2a






f
e
O
BnO
a
b
d
c

1b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6.40
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4.65
4.61
4.60
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4.00
3.63
3.60
3.58
3.56
3.54
3.52
3.51
2.18
2.04
2.03
1.93
1.89
1.83
1.77
1.63
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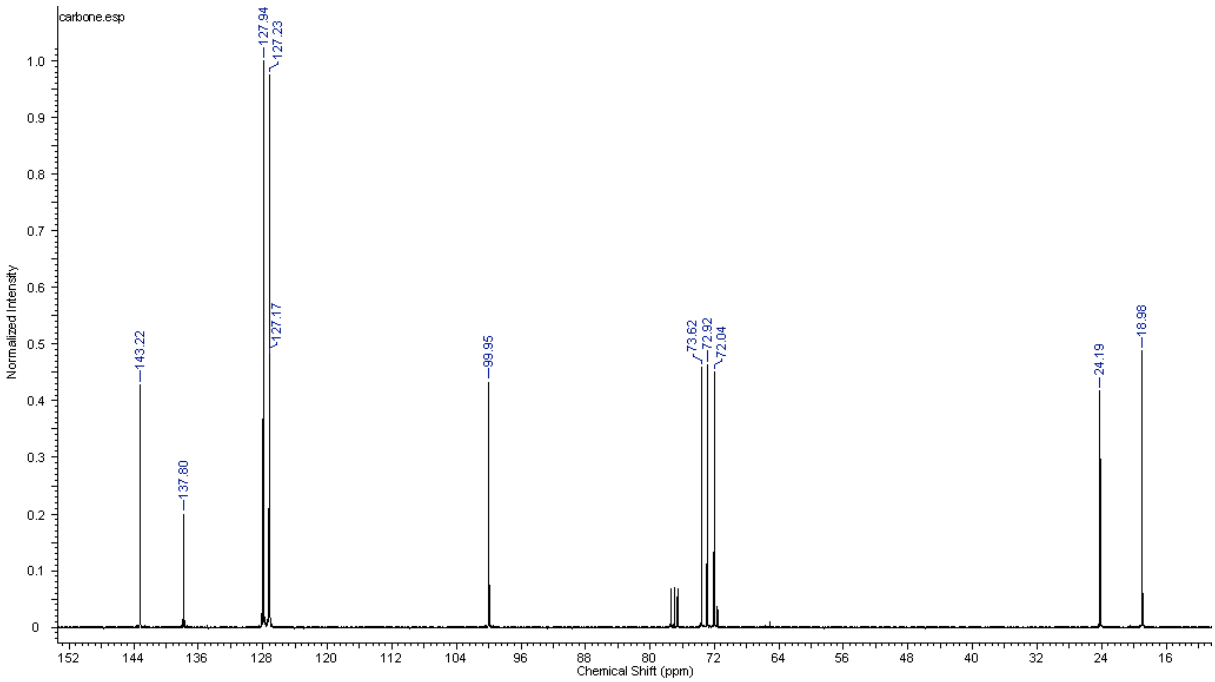
1.06
1.07
1.07
1.06
Chemical Shift (ppm)


carbone.esp
Normalized Intensity
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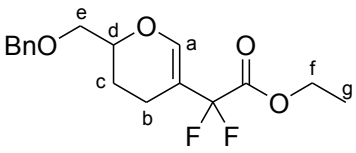
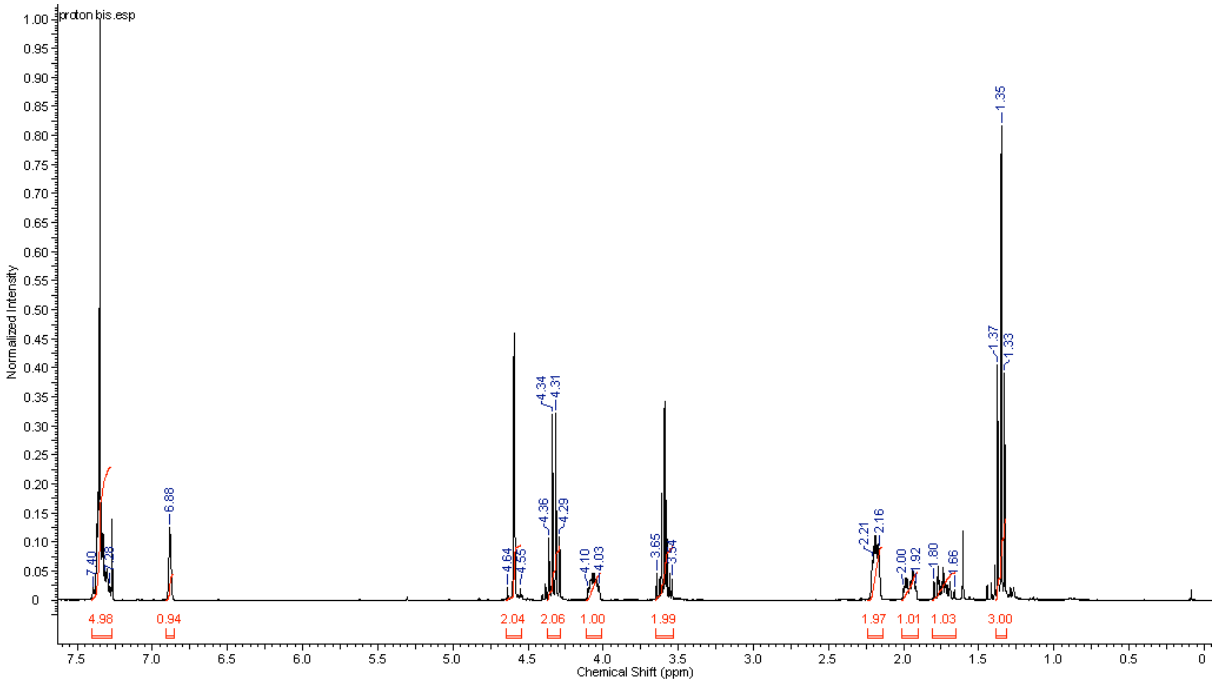
137.80
99.95
73.62
72.92
72.04
24.19
18.98
Chemical Shift (ppm)


BnO
O
O
O
F
F
a
b
c
d
e
f
g

2b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Normalized Intensity
Chemical Shift (ppm)
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4.36
4.34
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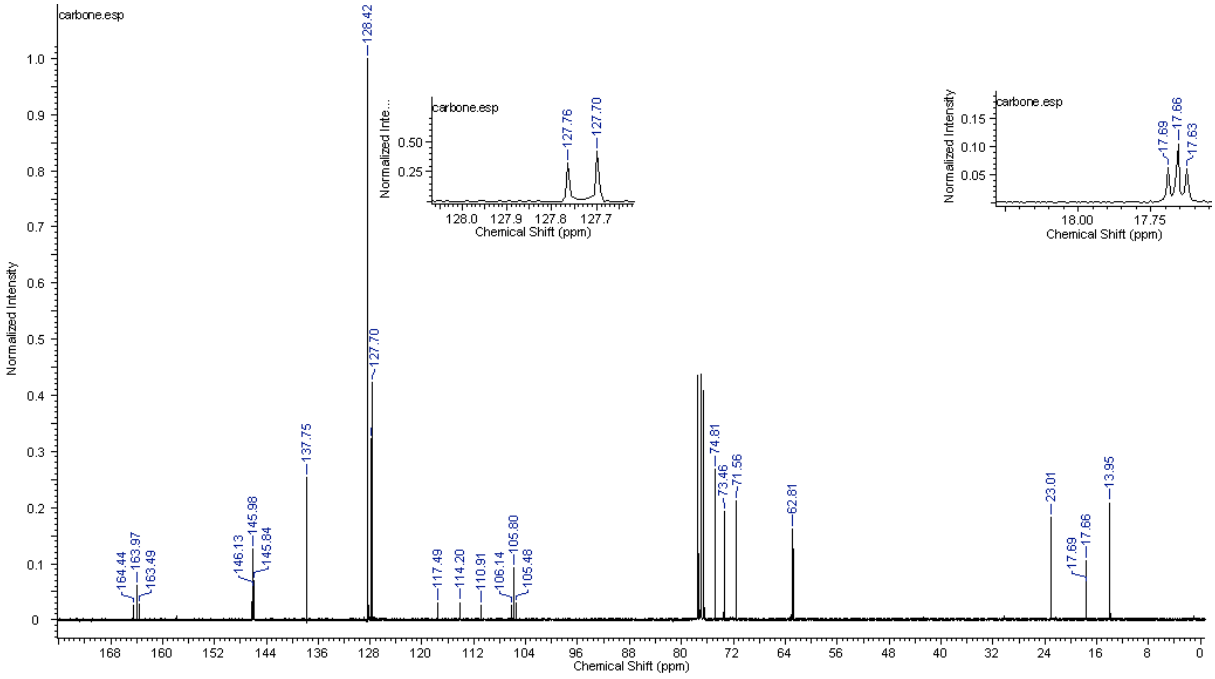
4.03
3.65
3.54
2.21
2.16
2.00
1.92
1.80
1.66
1.37
1.35
1.33
4.98
0.94
2.04
2.06
1.00
1.99
1.97
1.01
1.03
3.00


carbone.esp
Normalized Intensity
Chemical Shift (ppm)
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127.70
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163.97
163.49
146.13
145.98
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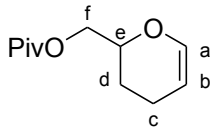
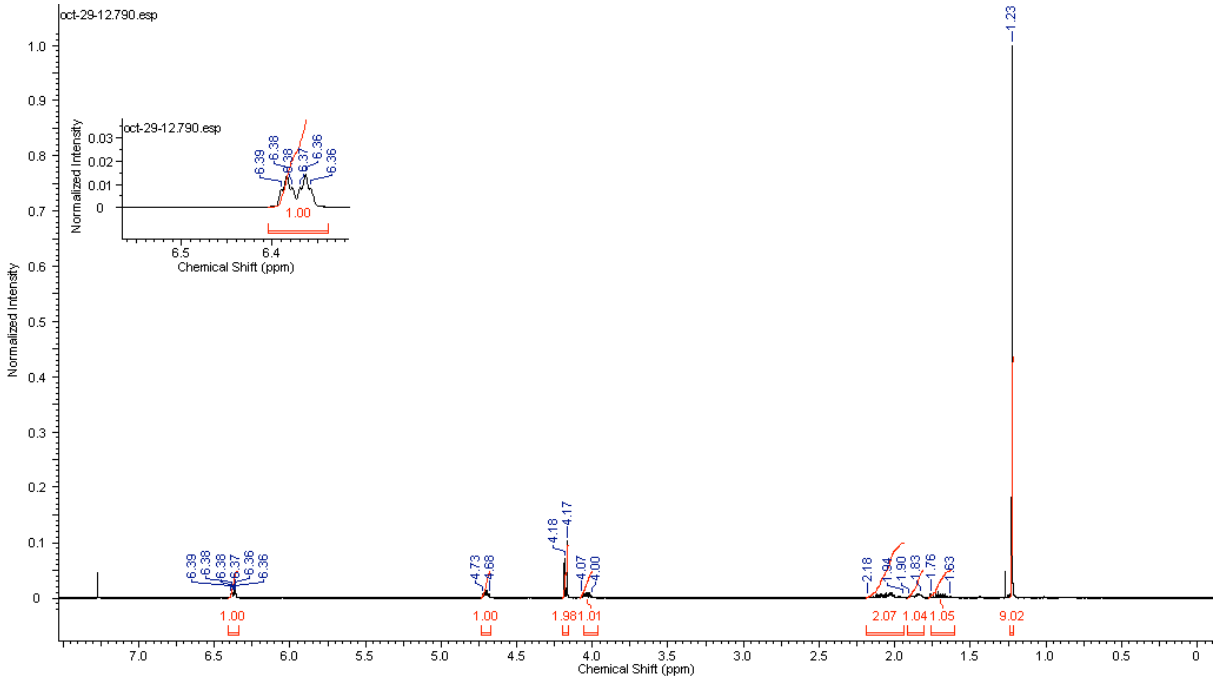
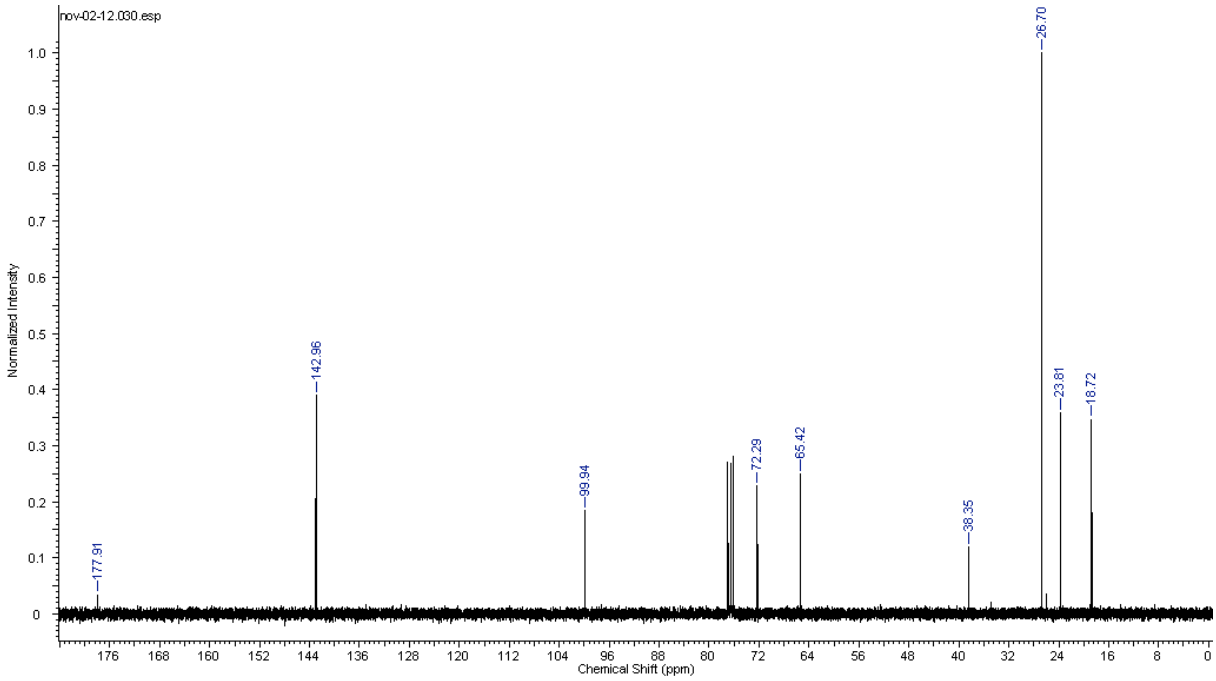
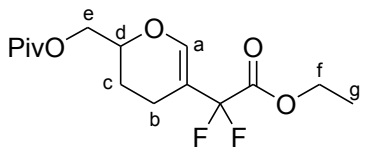
114.20
110.91
106.14
105.80
105.48
74.81
73.46
71.56
62.81
23.01
17.69
17.66
13.95
carbone.esp
Normalized Inte...
127.76
127.70
carbone.esp
Normalized Intensity
17.69
17.66
17.63


f
e
O
PivO
a
b
d
c

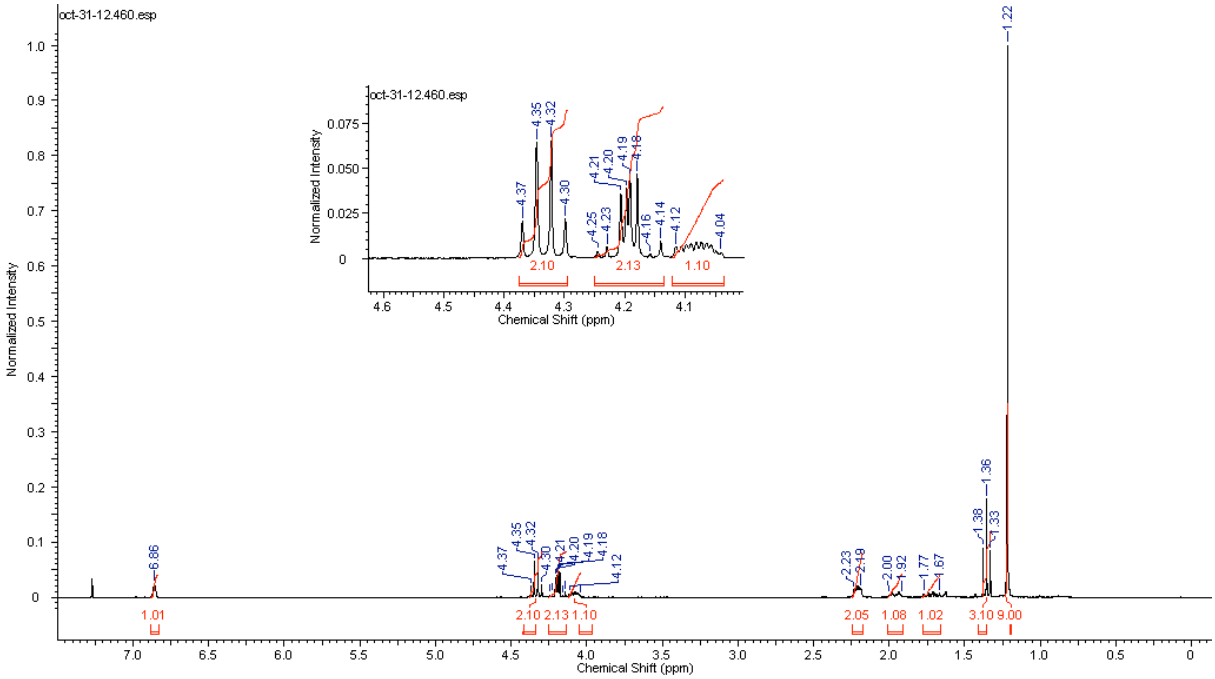
1c

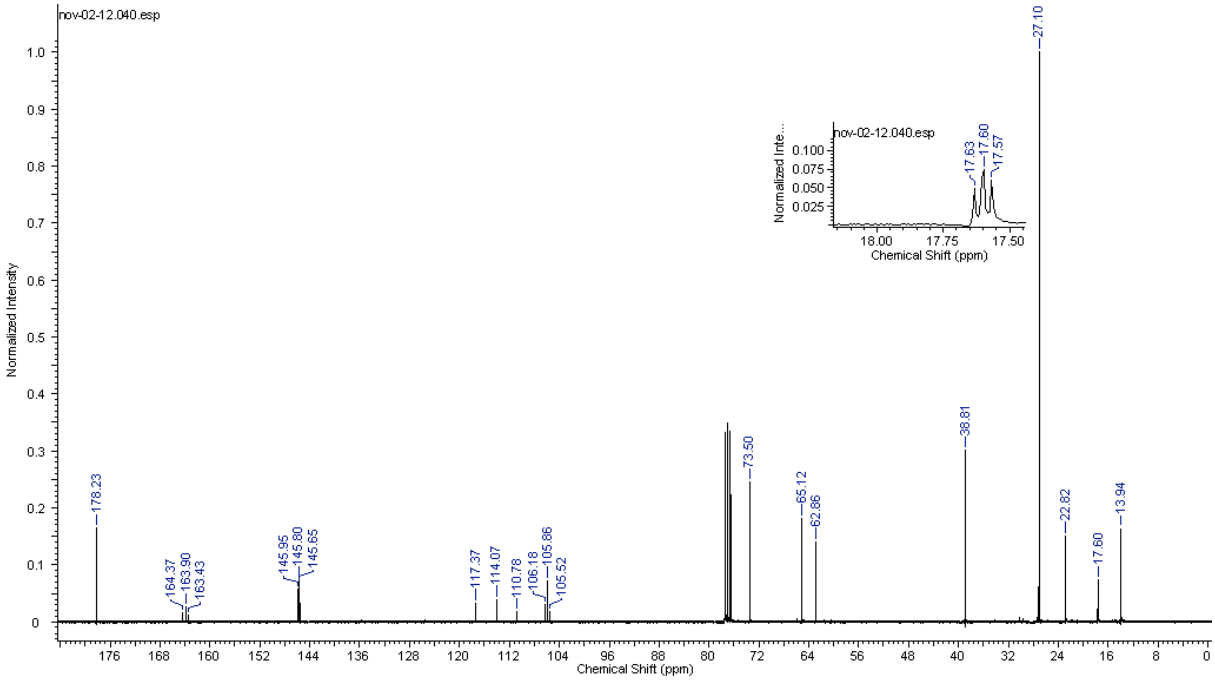

oct-29-12.790.esp
Normalized Intensity
Chemical Shift (ppm)
1.23
6.39
6.38
6.38
6.37
6.36
6.36
4.73
4.68
4.18
4.17
4.07
4.00
2.18
1.94
1.90
1.83
1.76
1.63
1.00
1.00
1.98
1.01
2.07
1.04
1.05
9.02

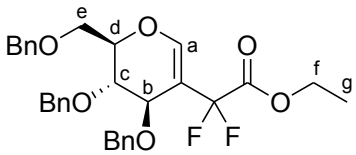

nov-02-12.030.esp
Normalized Intensity
Chemical Shift (ppm)
177.91
142.96
99.94
72.29
65.42
38.35
26.70
23.81
18.72


PivO
O
O
O
F
F
a
b
c
d
e
f
g

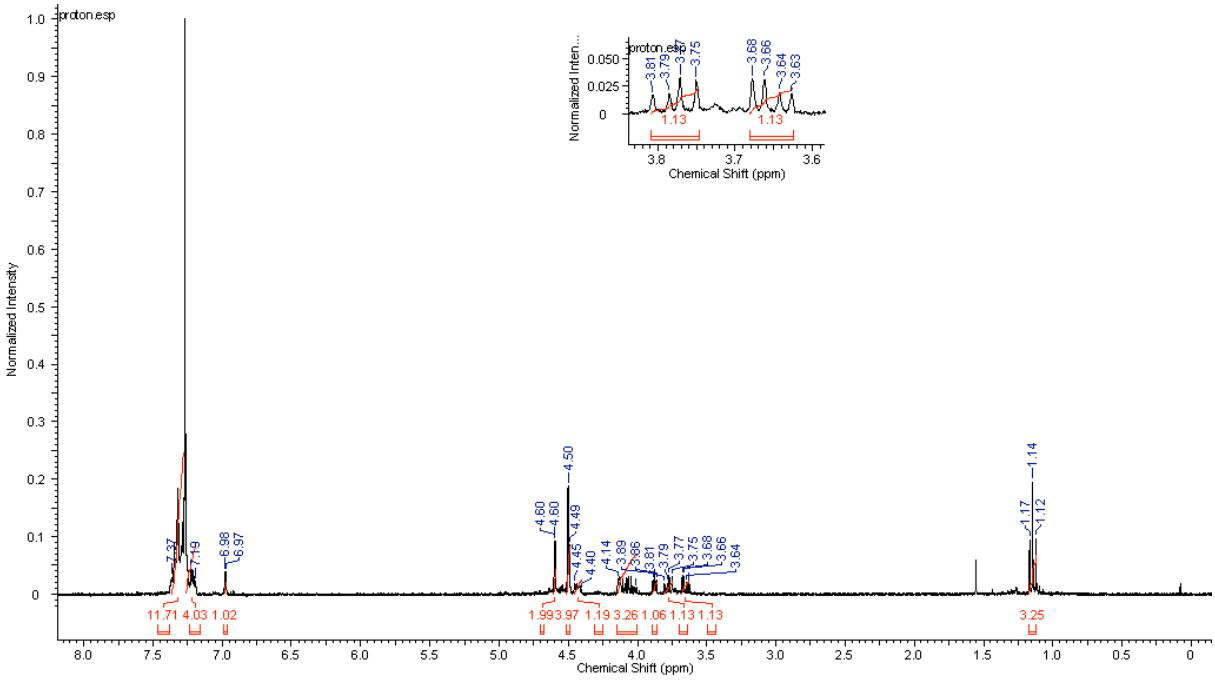
2c

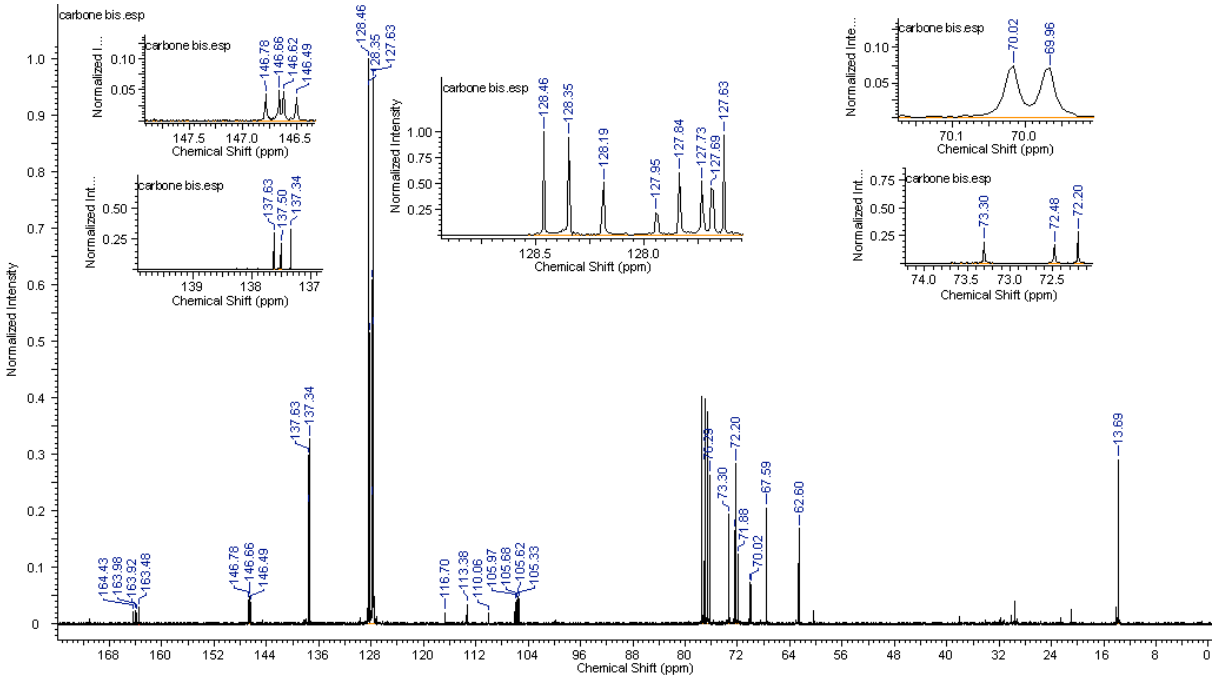

oct-31-12.460.esp
Normalized Intensity
Chemical Shift (ppm)
1.22
6.86
4.37
4.35
4.32
4.30
4.21
4.20
4.19
4.18
4.12
2.23
2.19
2.00
1.92
1.77
1.67
1.38
1.36
1.33
1.01
2.10
2.13
1.10
2.05
1.08
1.02
3.10
9.00

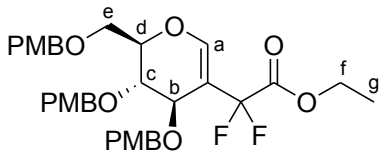

nov-02-12.040.esp
Normalized Intensity
Chemical Shift (ppm)
27.10
178.23
164.37
163.90
163.43
145.95
145.80
145.65
117.37
114.07
110.78
106.18
105.86
105.52
73.50
65.12
62.86
38.81
22.82
17.60
13.94


e
d
O
a
O
BnO
c
b
f
g
BnO
O
BnO
F
F

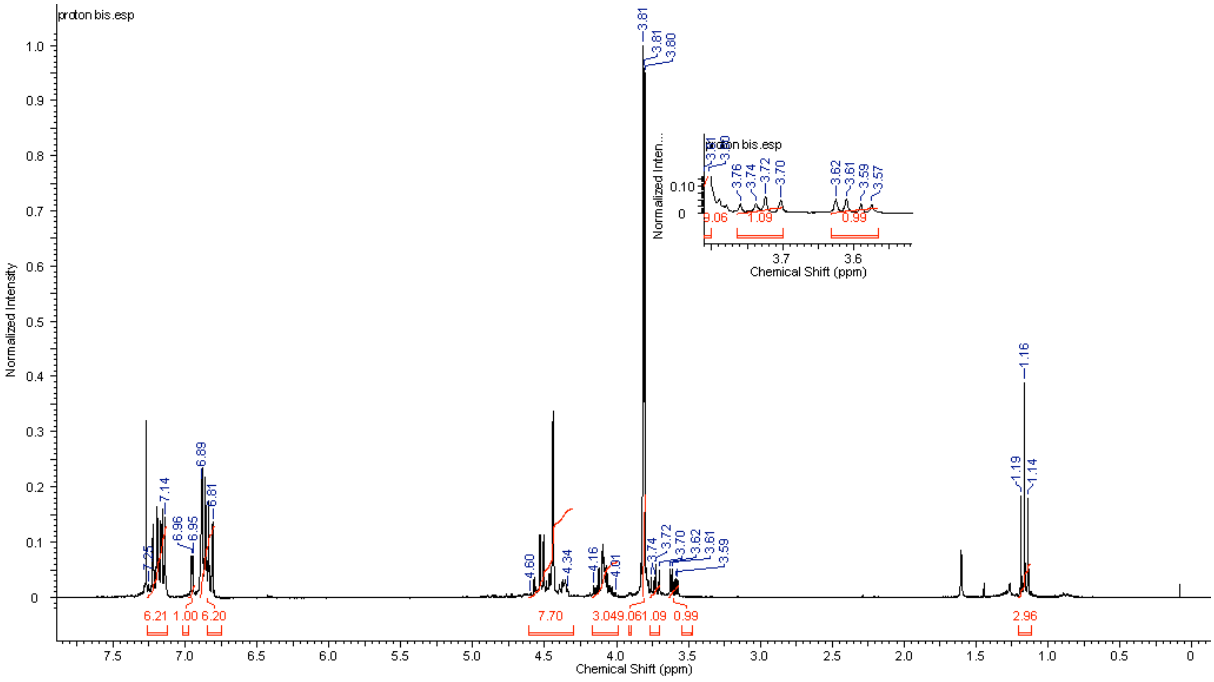
2d

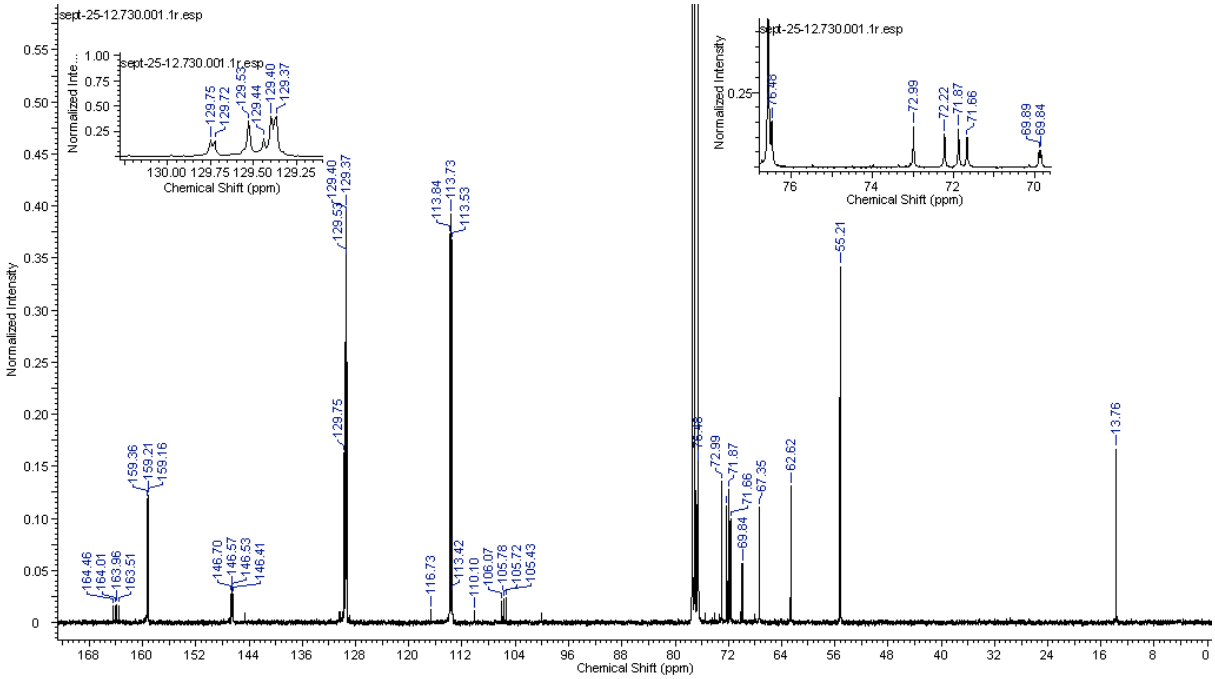

proton.esp
Normalized Intensity
Chemical Shift (ppm)
11.71
4.03
1.02
1.99
3.97
1.19
3.26
1.06
1.13
1.13
3.25

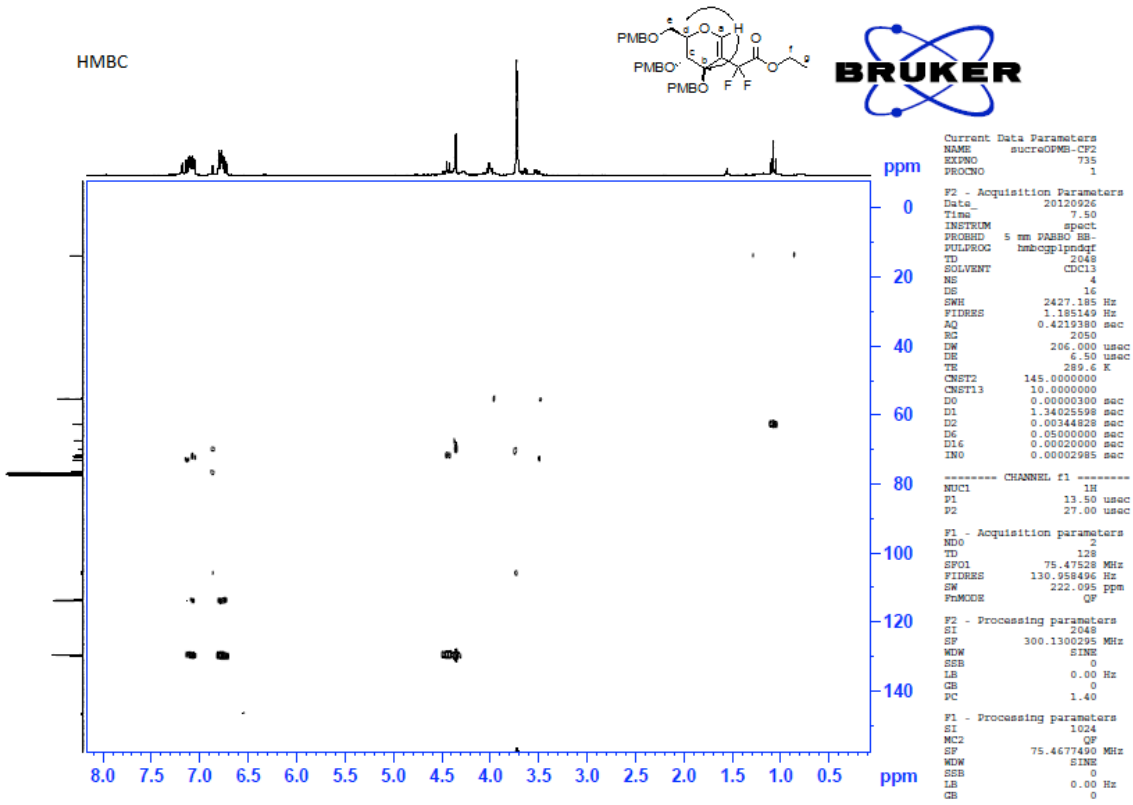

carbone bis.esp
Normalized Intensity
Chemical Shift (ppm)

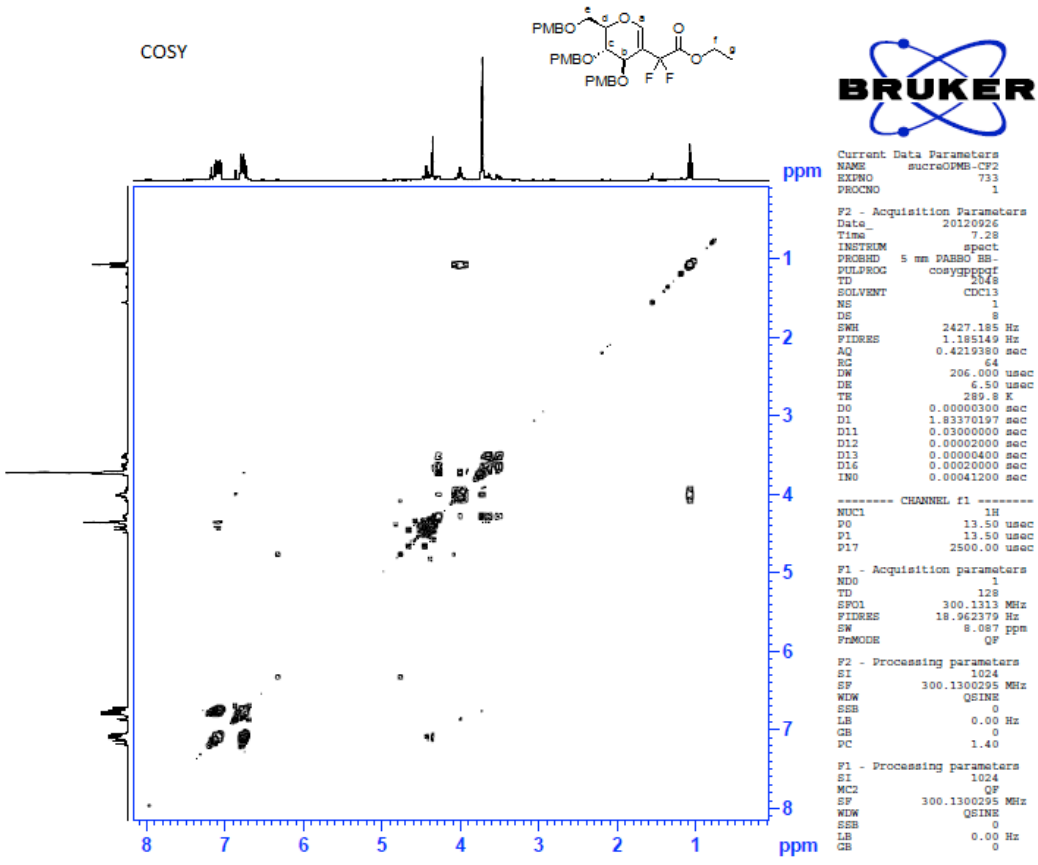

PMBO
PMBO
PMBO
O
O
O
F
F
a
b
c
d
e
f
g

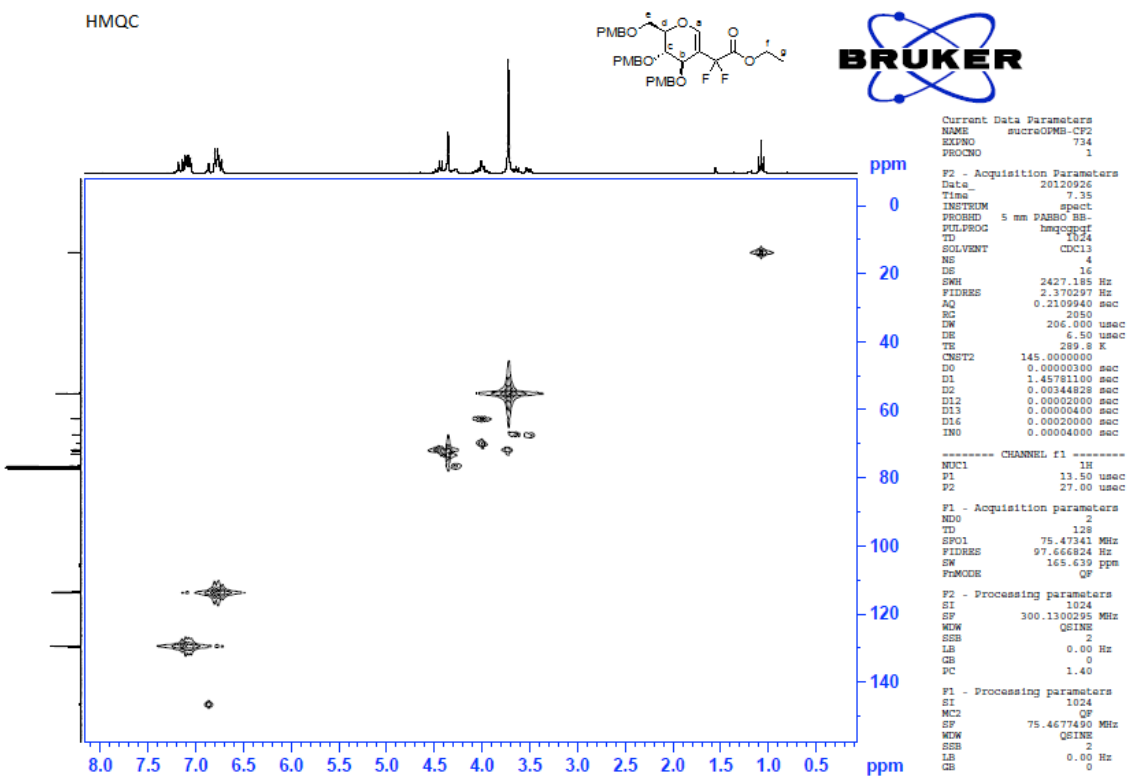
2e

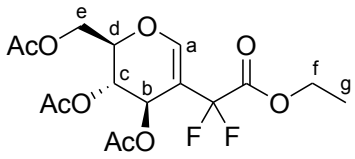

proton bis.esp
Normalized Intensity
Chemical Shift (ppm)
3.81
3.80
7.14
6.96
6.95
6.89
6.81
4.60
4.34
4.16
4.01
3.74
3.72
3.70
3.62
3.61
3.59
1.16
1.19
1.14
6.21
1.00
6.20
7.70
3.04
9.06
1.09
0.99
2.96


sept-25-12.730.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
129.75
129.72
129.53
129.44
129.40
129.37
159.36
159.21
159.16
164.46
164.01
163.96
163.51
146.70
146.57
146.53
146.41
116.73
113.84
113.73
113.53
113.42
110.10
106.07
105.78
105.72
105.43
76.48
72.99
72.22
71.87
71.66
69.89
69.84
67.35
62.62
55.21
13.76

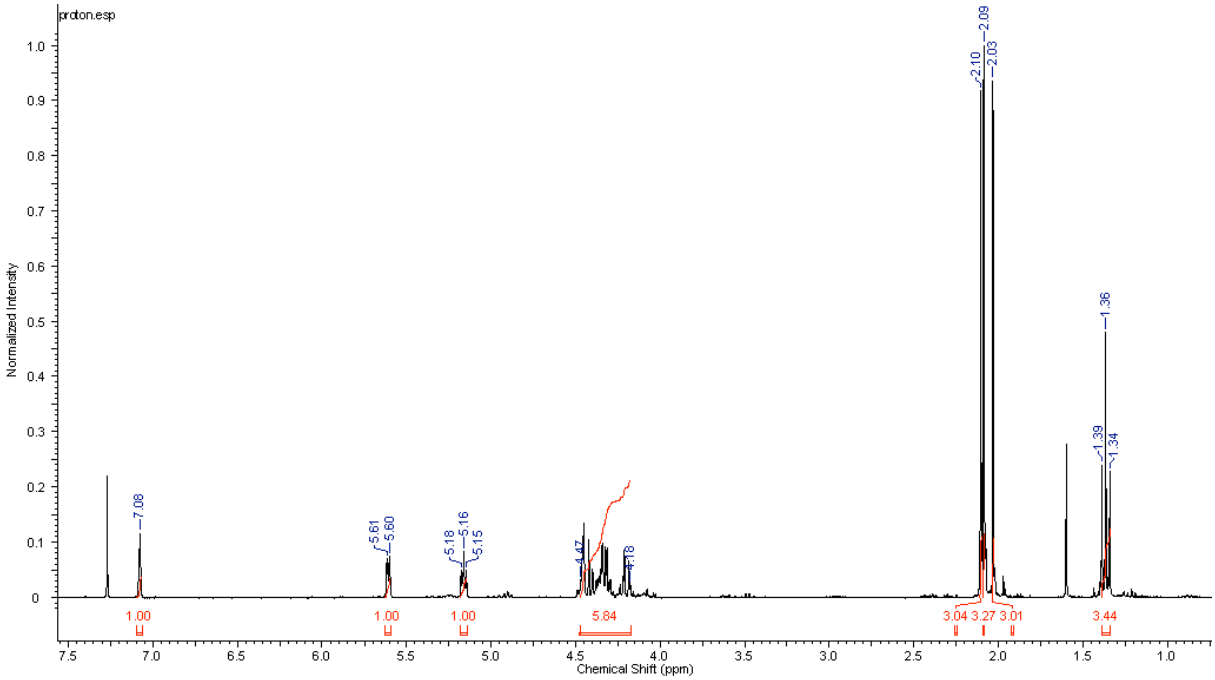

HMBC
PMBO
PMBO
PMBO
F F
BRUKER
ppm
0
20
40
60
80
100
120
140
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm
Current Data Parameters
NAME sucraOPMB-CF2
EXPNO 735
PROCNO 1
F2 - Acquisition Parameters
Date_ 20120926
Time 7.50
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG hmbcgplpndqf
TD 2048
SOLVENT CDC13
NS 4
DS 16
SWH 2427.185 Hz
FIDRES 1.185149 Hz
AQ 0.4219380 sec
RG 2050
DW 206.000 usec
DE 6.50 usec
TE 289.6 K
CNST2 145.0000000
CNST13 10.0000000
D0 0.00000300 sec
D1 1.34025598 sec
D2 0.00344828 sec
D6 0.05000000 sec
D16 0.00020000 sec
IN0 0.00002985 sec
======== CHANNEL f1 ========
NUC1 1H
P1 13.50 usec
P2 27.00 usec
F1 - Acquisition parameters
ND0 2
TD 128
SFO1 75.47528 MHz
FIDRES 130.958496 Hz
SW 222.095 ppm
FnMODE QF
F2 - Processing parameters
SI 2048
SF 300.1300295 MHz
WDW SINE
SSB 0
LB 0.00 Hz
GB 0
PC 1.40
F1 - Processing parameters
SI 1024
MC2 QF
SF 75.4677490 MHz
WDW SINE
SSB 0
LB 0.00 Hz
GB 0

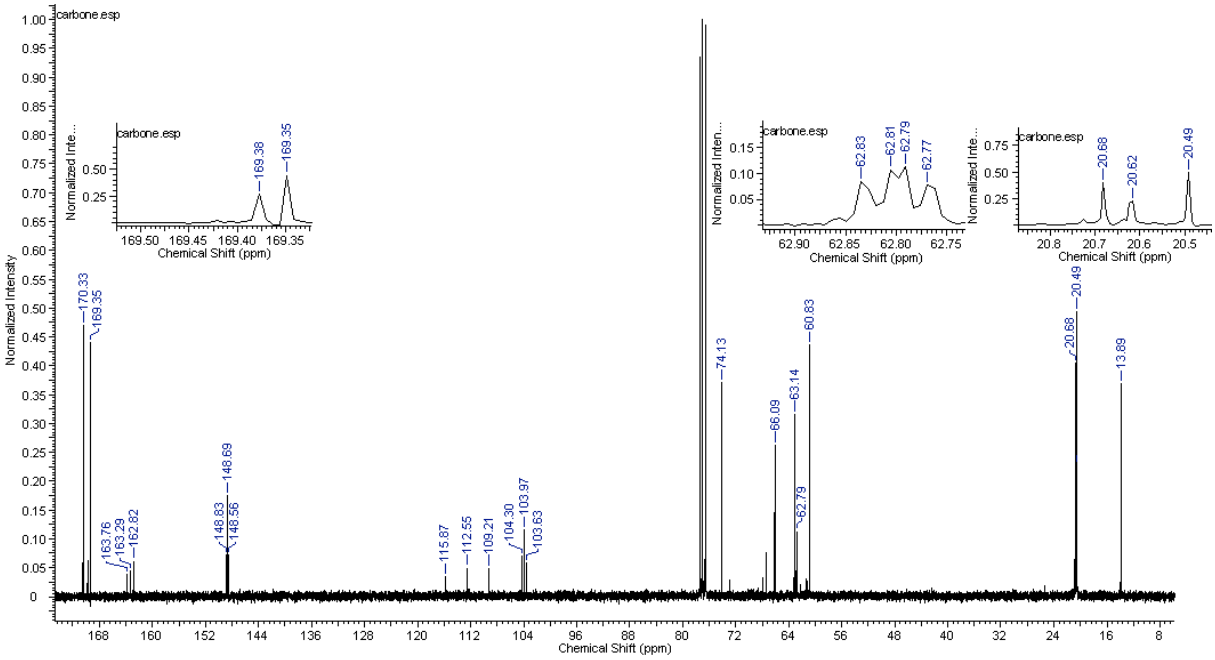

COSY
PMBO
PMBO
PMBO
F F
BRUKER
ppm
1
2
3
4
5
6
7
8
8 7 6 5 4 3 2 1
ppm
Current Data Parameters
NAME sucraOPMB-CF2
EXPNO 733
PROCNO 1
F2 - Acquisition Parameters
Date_ 20120926
Time 7.28
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG cosygpppqf
TD 2048
SOLVENT CDC13
NS 1
DS 8
SWH 2427.185 Hz
FIDRES 1.185149 Hz
AQ 0.4219380 sec
RG 64
DW 206.000 usec
DE 6.50 usec
TE 289.8 K
D0 0.00000300 sec
D1 1.83370197 sec
D11 0.03000000 sec
D12 0.00002000 sec
D13 0.00000400 sec
D16 0.00020000 sec
IN0 0.00041200 sec
======== CHANNEL f1 ========
NUC1 1H
P0 13.50 usec
P1 13.50 usec
P17 2500.00 usec
F1 - Acquisition parameters
ND0 1
TD 128
SFO1 300.1313 MHz
FIDRES 18.962379 Hz
SW 8.087 ppm
FnMODE QF
F2 - Processing parameters
SI 1024
SF 300.1300295 MHz
WDW QSINE
SSB 0
LB 0.00 Hz
GB 0
PC 1.40
F1 - Processing parameters
SI 1024
MC2 QF
SF 300.1300295 MHz
WDW QSINE
SSB 0
LB 0.00 Hz
GB 0

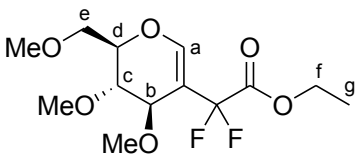

HMQC
PMBO
PMBO
PMBO
F F
BRUKER
ppm
0
20
40
60
80
100
120
140
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
ppm
Current Data Parameters
NAME sucroOPMB-CF2
EXPNO 734
PROCNO 1
F2 - Acquisition Parameters
Date_ 20120926
Time 7.35
INSTRUM spect
PROBHD 5 mm PABBO BB-
PULPROG hmqcgpqf
TD 1024
SOLVENT CDCl3
NS 4
DS 16
SWH 2427.185 Hz
FIDRES 2.370297 Hz
AQ 0.2109940 sec
RG 2050
DW 206.000 usec
DE 6.50 usec
TE 289.8 K
CNST2 145.0000000
D0 0.00000300 sec
D1 1.45781100 sec
D2 0.00344828 sec
D12 0.00002000 sec
D13 0.00000400 sec
D16 0.00020000 sec
IN0 0.00004000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 13.50 usec
P2 27.00 usec
F1 - Acquisition parameters
ND0 2
TD 128
SFO1 75.47341 MHz
FIDRES 97.666824 Hz
SW 165.639 ppm
FnMODE QF
F2 - Processing parameters
SI 1024
SF 300.1300295 MHz
WDW QSINE
SSB 2
LB 0.00 Hz
GB 0
PC 1.40
F1 - Processing parameters
SI 1024
MC2 QF
SF 75.4677490 MHz
WDW QSINE
SSB 2
LB 0.00 Hz
GB 0


e
d
O
a
O
AcO
c
b
f
g
AcO
O
AcO
F
F

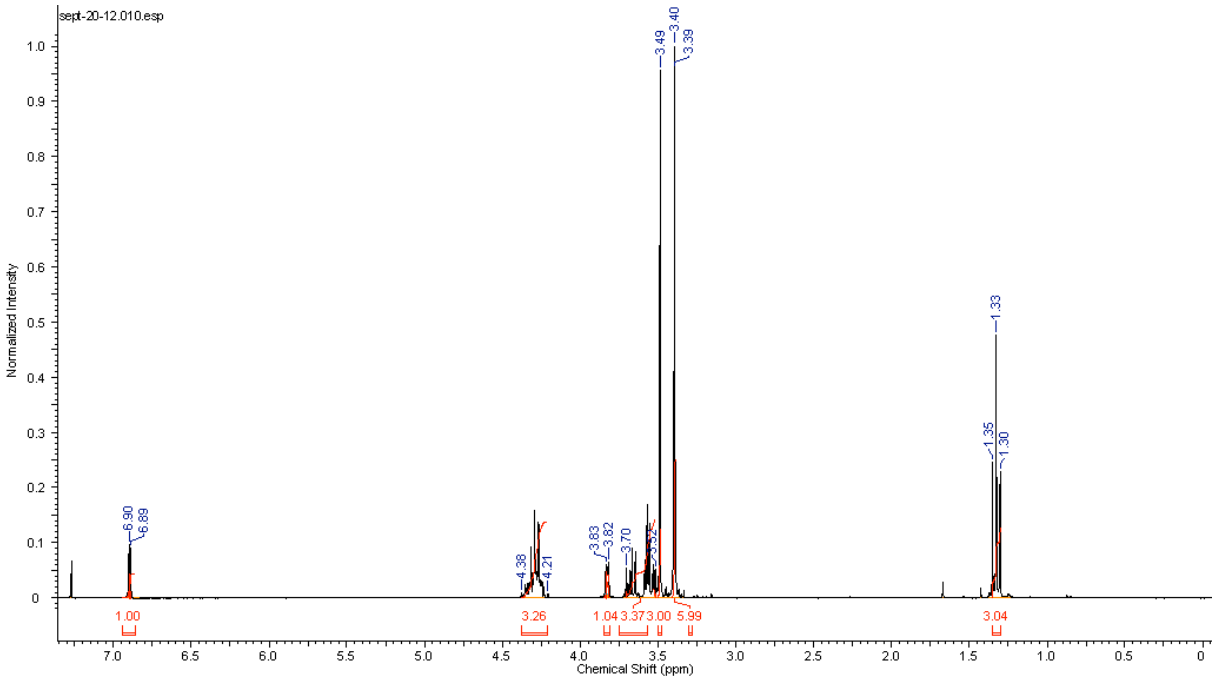
2f

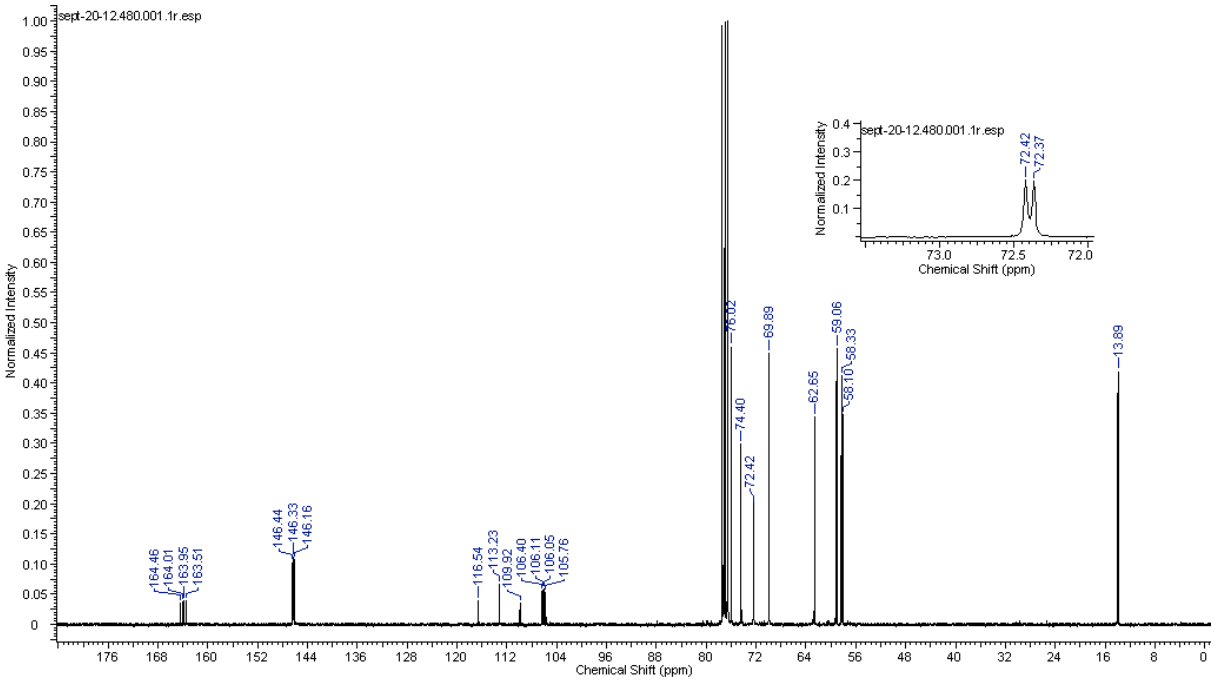

proton.esp
Normalized Intensity
Chemical Shift (ppm)
7.08
5.61
5.60
5.18
5.16
5.15
4.47
4.18
2.10
2.09
2.03
1.39
1.36
1.34
1.00
1.00
1.00
5.84
3.04
3.27
3.01
3.44

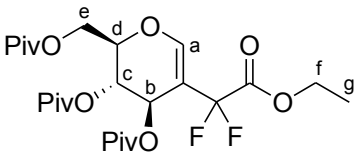

carbone.esp
Normalized Intensity
Chemical Shift (ppm)
170.33
169.35
163.76
163.29
162.82
148.83
148.69
148.56
115.87
112.55
109.21
104.30
103.97
103.63
74.13
66.09
63.14
62.79
60.83
20.68
20.49
13.89
carbone.esp
169.38
169.35
carbone.esp
62.83
62.81
62.79
62.77
carbone.esp
20.68
20.62
20.49


e
d
O
a
O
MeO
c
b
f
g
MeO
O
MeO
F
F

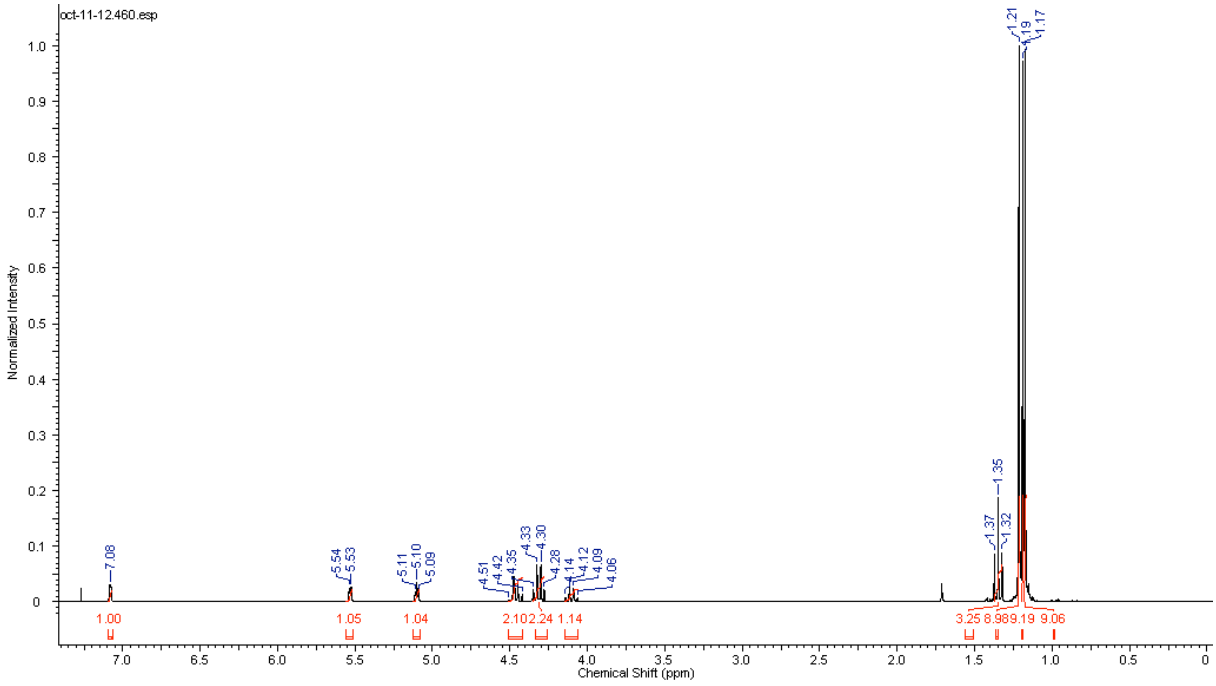
2g

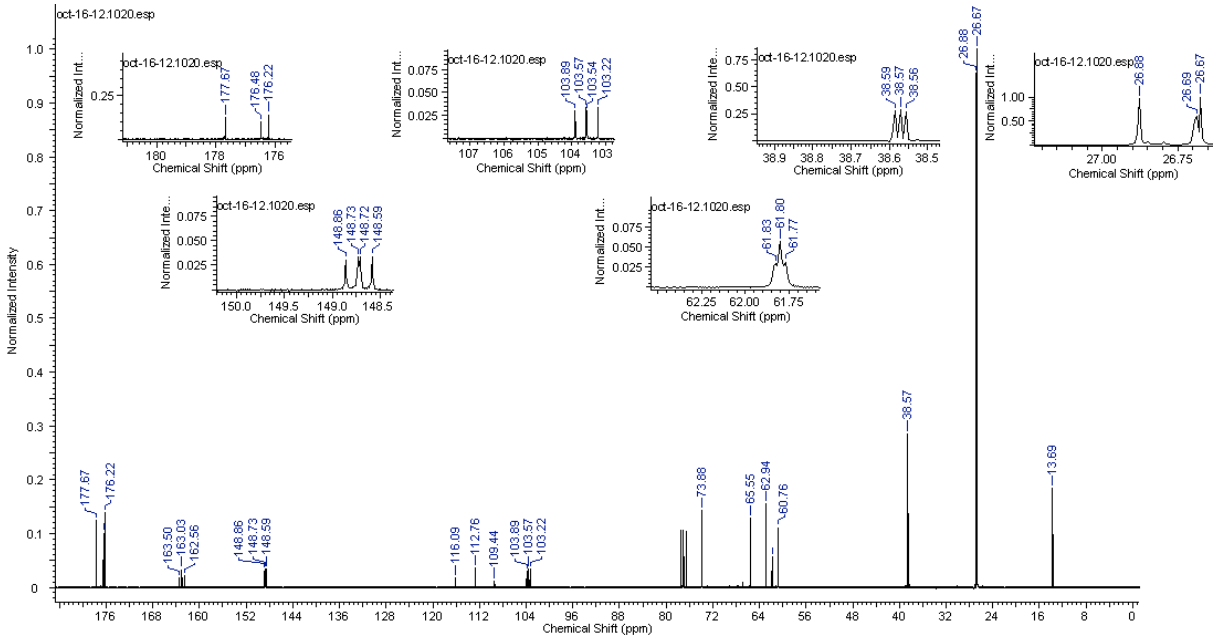

sept-20-12.010.esp
Normalized Intensity
Chemical Shift (ppm)
3.49
3.40
3.39
1.33
1.35
1.30
6.90
6.89
4.38
4.21
3.83
3.82
3.70
1.00
3.26
1.04
3.37
3.00
5.99
3.04

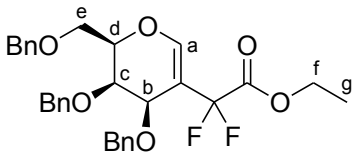

sept-20-12.480.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
76.02
74.40
72.42
69.89
62.65
59.06
58.33
58.10
13.89
146.44
146.33
146.16
164.46
164.01
163.95
163.51
116.54
113.23
109.92
106.40
106.11
106.05
105.76
sept-20-12.480.001.1r.esp
72.42
72.37


e
d
O
a
O
PivO
c
b
f
g
PivO
O
PivO
F
F

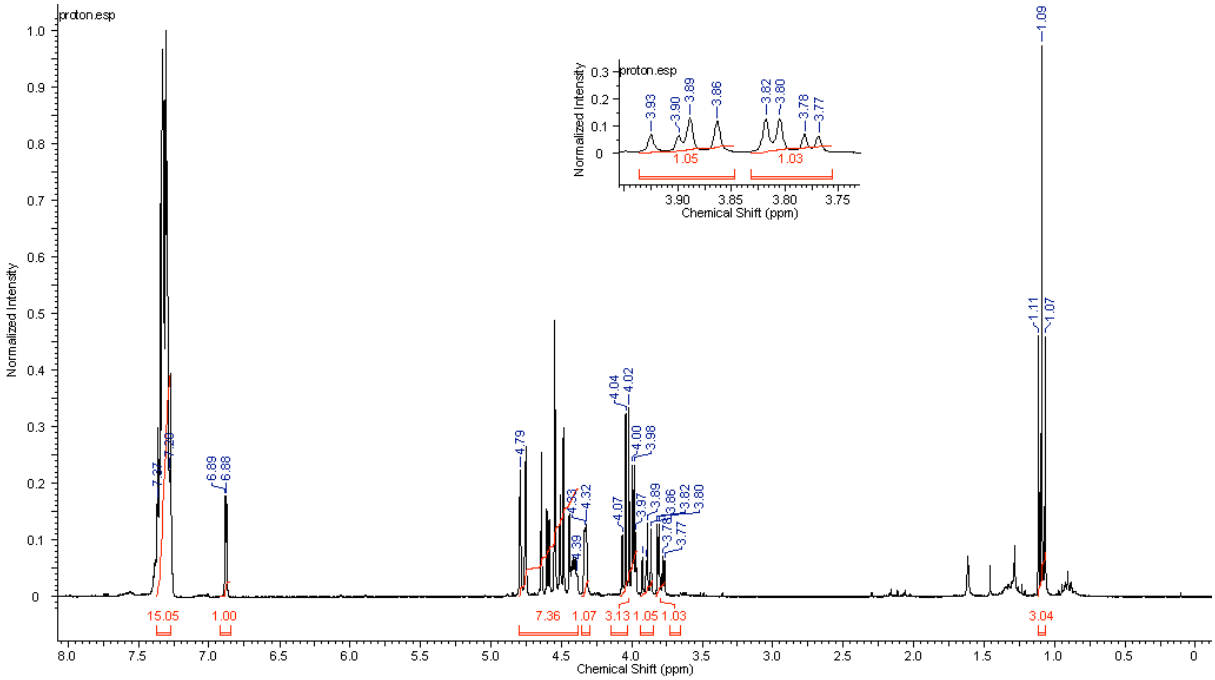
2h

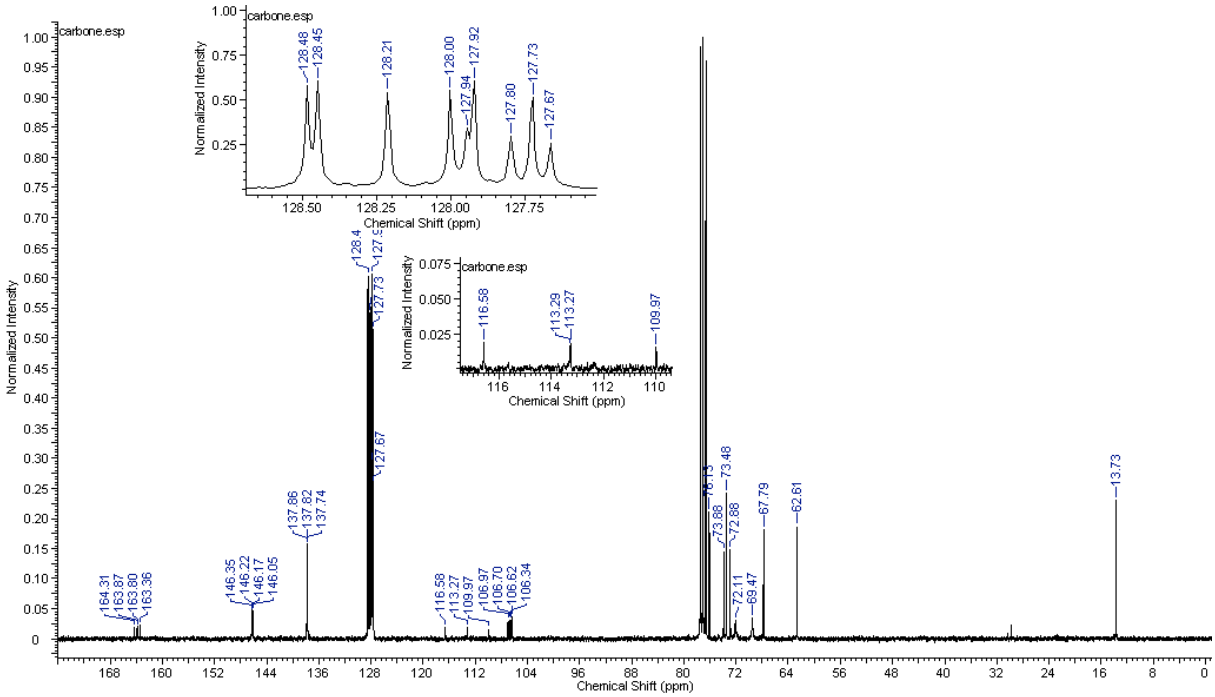

oct-11-12.460.esp
Normalized Intensity
Chemical Shift (ppm)
7.08
5.54
5.53
5.11
5.10
5.09
4.51
4.42
4.35
4.33
4.30
4.28
4.14
4.12
4.09
4.06
1.37
1.35
1.32
1.21
1.19
1.17
1.00
1.05
1.04
2.10
2.24
1.14
3.25
8.98
9.19
9.06

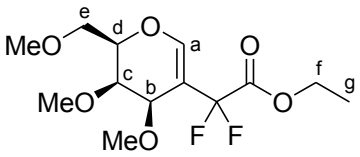

oct-16-12.1020.esp
Normalized Intensity
Chemical Shift (ppm)
177.67
176.48
176.22
103.89
103.57
103.54
103.22
38.59
38.57
38.56
26.88
26.67
26.69
148.86
148.73
148.72
148.59
61.83
61.80
61.77
177.67
176.22
163.50
163.03
162.56
148.86
148.73
148.59
116.09
112.76
109.44
103.89
103.57
103.22
73.88
65.55
62.94
60.76
38.57
26.88
26.67
13.69


e
d
O
a
O
BnO
c
b
f
g
BnO
O
BnO
F
F

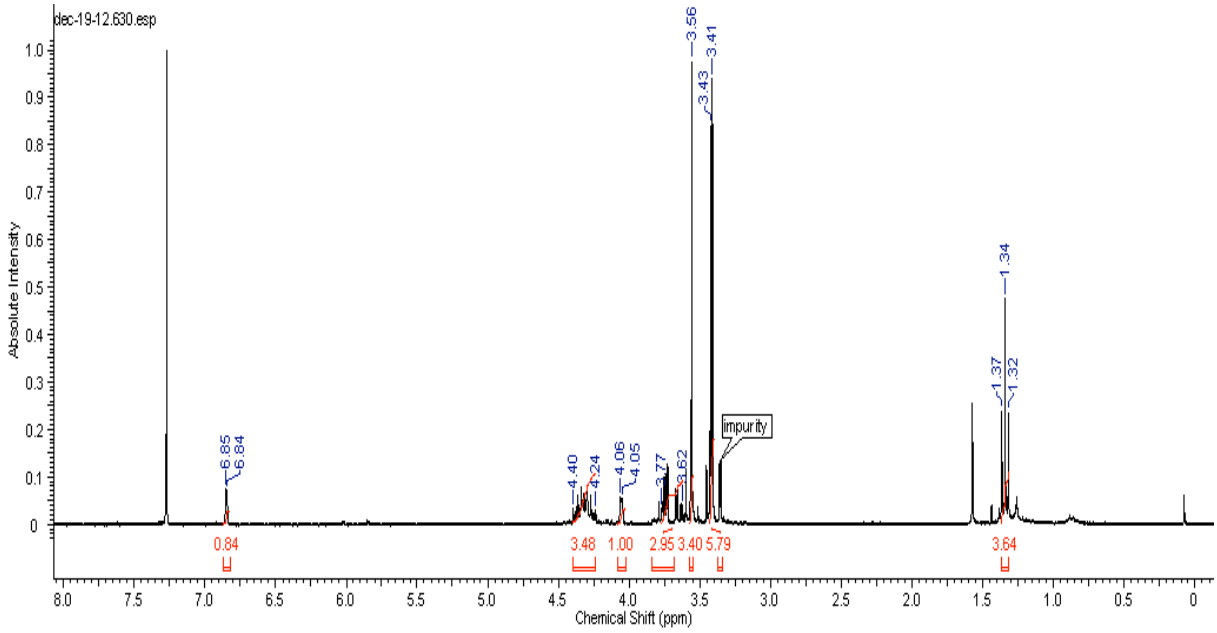
2i

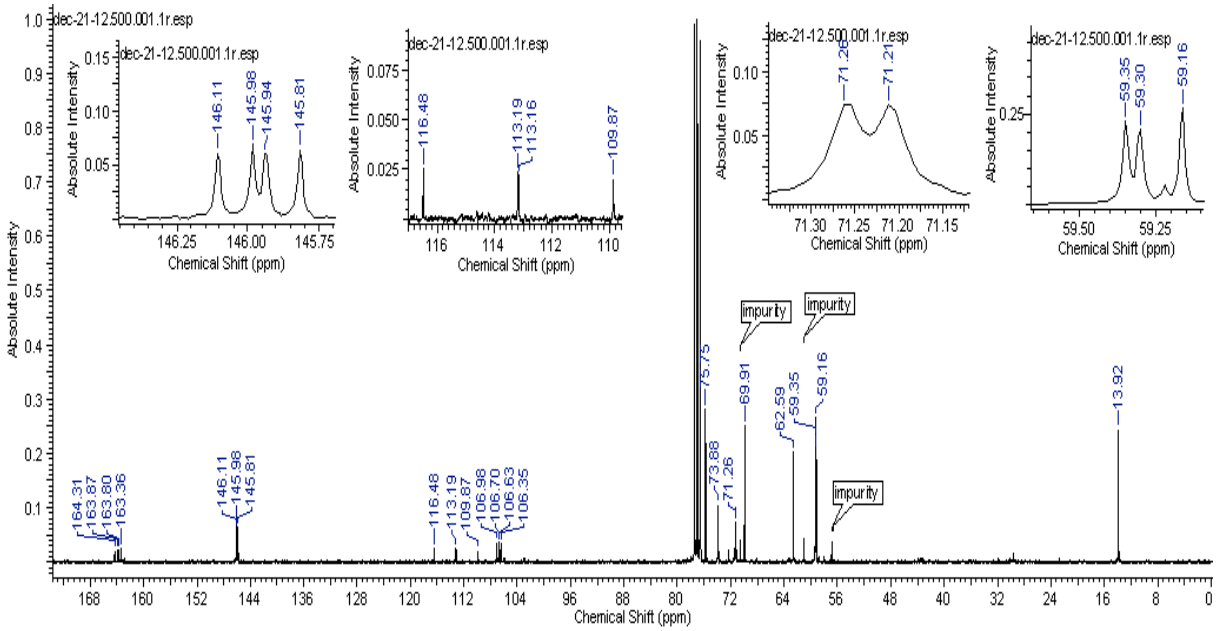

proton.esp
Normalized Intensity
Chemical Shift (ppm)
15.05
1.00
7.36
1.07
3.13
1.05
1.03
3.04

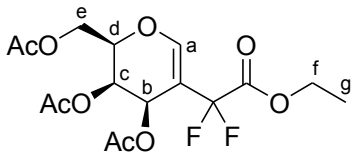

carbone.esp
Normalized Intensity
Chemical Shift (ppm)


e
d
O
a
O
MeO
c
b
f
g
MeO
O
MeO
F
F

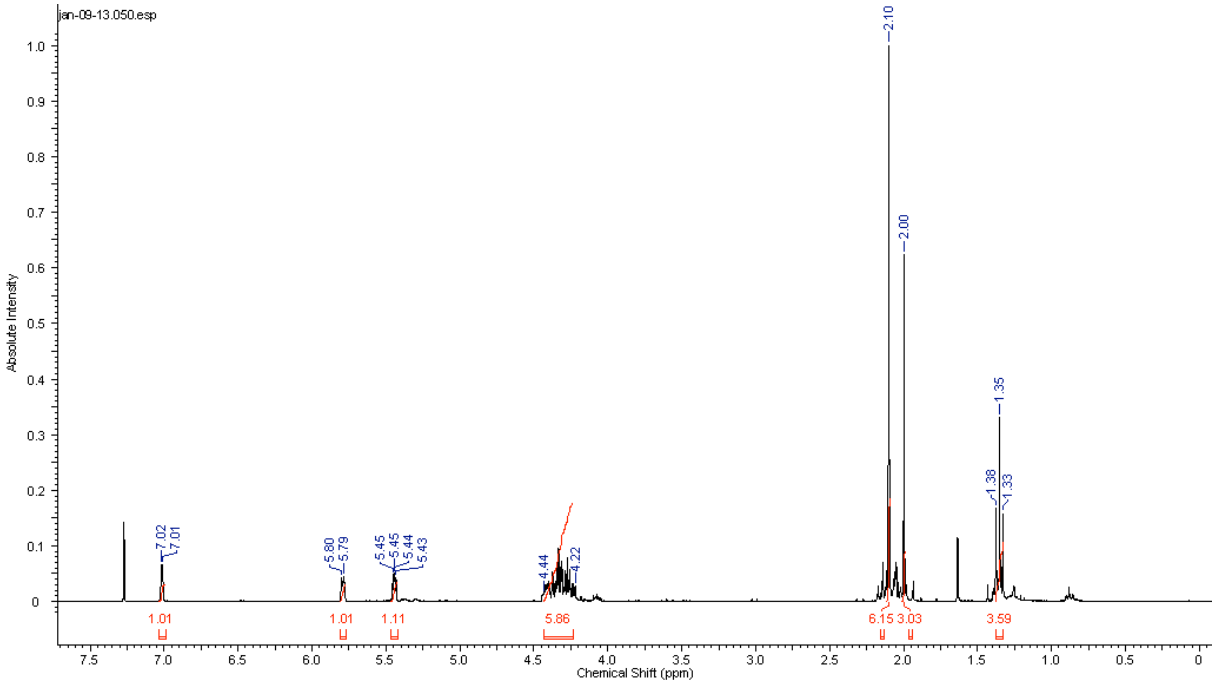
2j

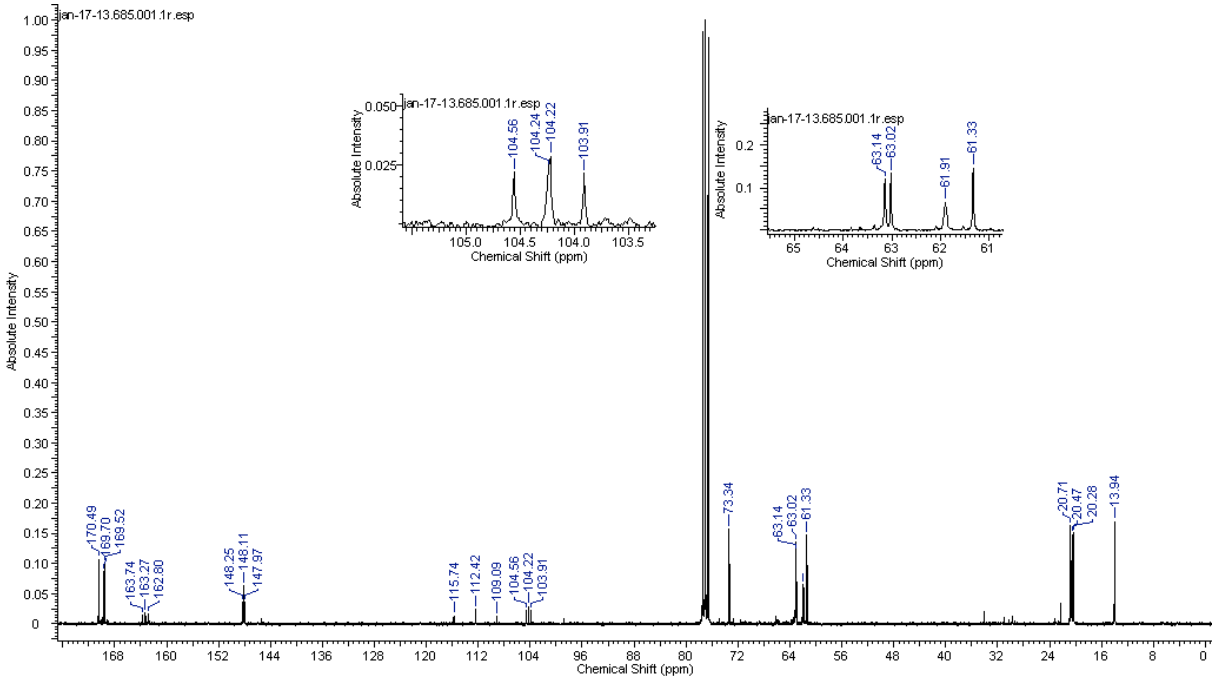

dec-19-12.630.esp
Absolute Intensity
Chemical Shift (ppm)
3.56
3.41
3.43
1.34
1.37
1.32
6.85
6.84
4.40
4.24
4.06
4.05
3.77
3.62
impurity
0.84
3.48
1.00
2.95
3.40
5.79
3.64

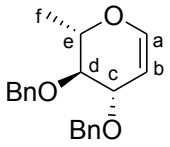

dec-21-12.500.001.1r.esp
Absolute Intensity
Chemical Shift (ppm)
146.11
145.98
145.94
145.81
116.48
113.19
113.16
109.87
71.26
71.21
59.35
59.30
59.16
impurity
impurity
impurity
75.75
69.91
62.59
59.35
59.16
73.88
71.26
13.92
164.31
163.87
163.80
163.36
146.11
145.98
145.81
116.48
113.19
109.87
106.98
106.70
106.63
106.35


e
d
O
a
AcO
O
c
b
f
g
AcO
O
AcO
F
F

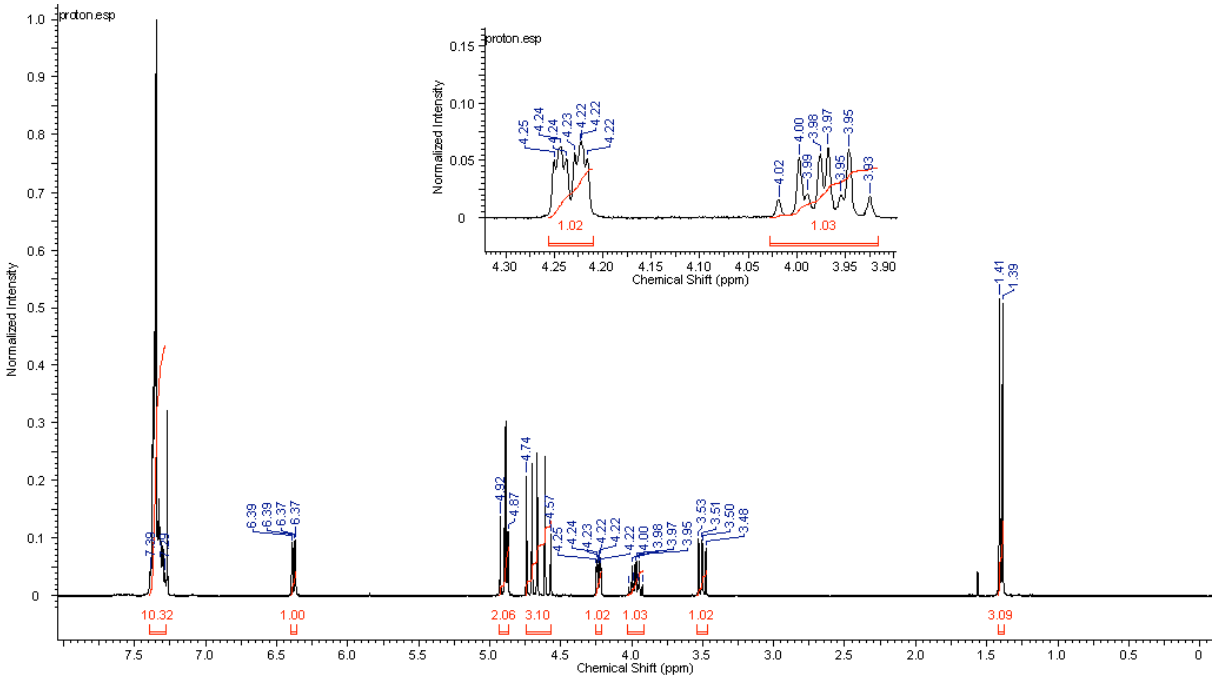
2k

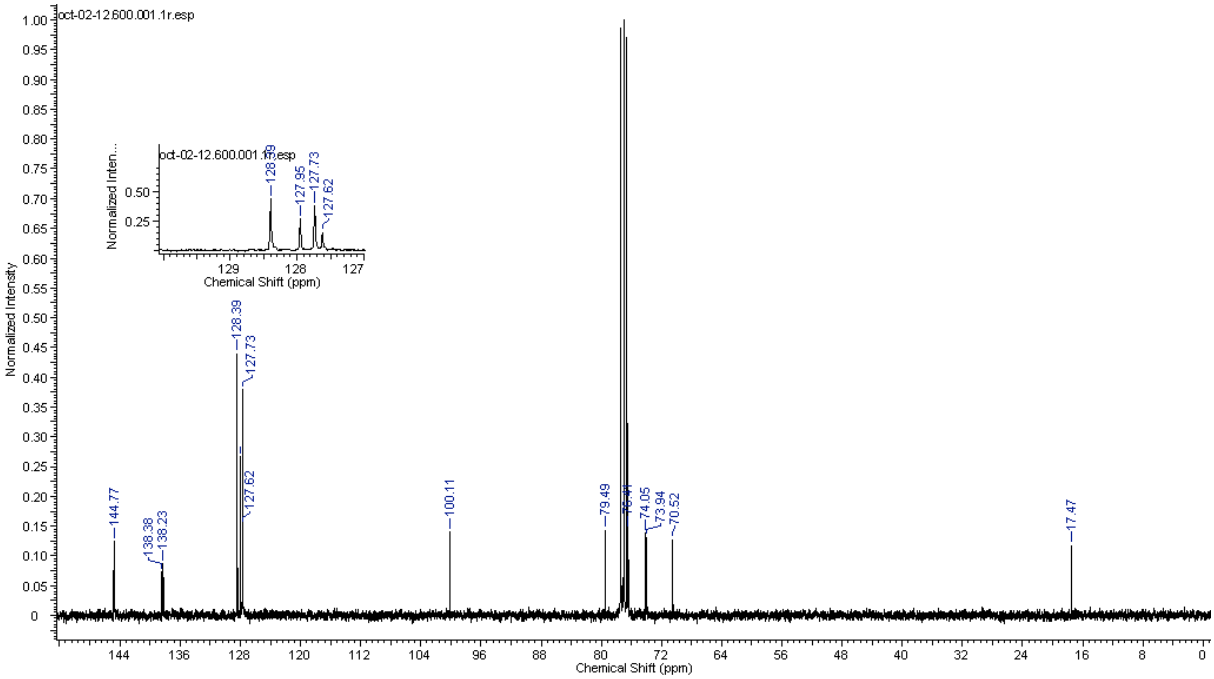

jan-09-13.050.esp
Absolute Intensity
Chemical Shift (ppm)
2.10
2.00
1.35
1.38
1.33
7.02
7.01
5.80
5.79
5.45
5.45
5.44
5.43
4.44
4.22
1.01
1.01
1.11
5.86
6.15
3.03
3.59

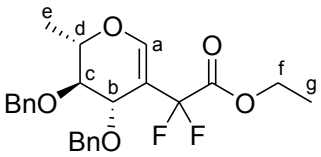

jan-17-13.685.001.1r.esp
Absolute Intensity
Chemical Shift (ppm)
170.49
169.70
169.52
163.74
163.27
162.80
148.25
148.11
147.97
115.74
112.42
109.09
104.56
104.22
103.91
73.34
63.14
63.02
61.33
20.71
20.47
20.28
13.94
jan-17-13.685.001.1r.esp
104.56
104.24
104.22
103.91
jan-17-13.685.001.1r.esp
63.14
63.02
61.91
61.33


f
O
e
a
d
c
b
BnO
BnO

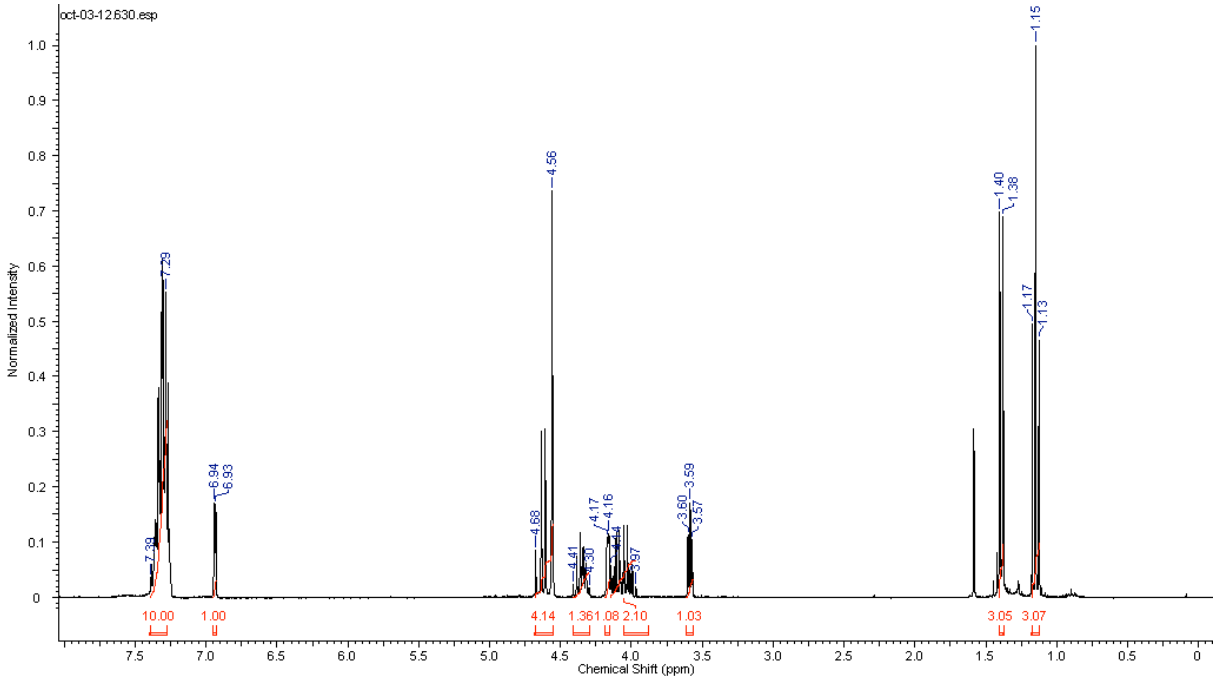
1l

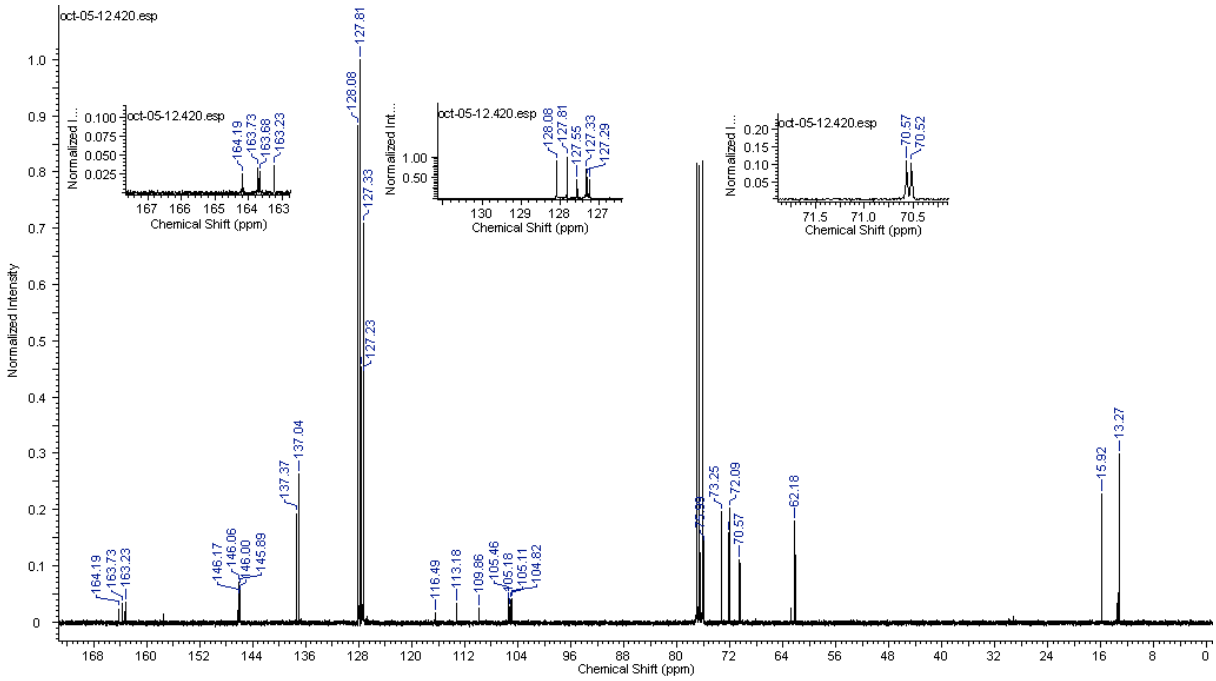

proton.esp
Normalized Intensity
Chemical Shift (ppm)
10.32
1.00
2.06
3.10
1.02
1.03
1.02
3.09
1.02
1.03

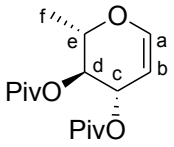

oct-02-12.600.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
144.77
138.38
138.23
128.39
127.73
127.62
100.11
79.49
74.05
73.94
70.52
17.47


e
d
O
a
O
c
b
f
g
BnO
O
BnO
F
F

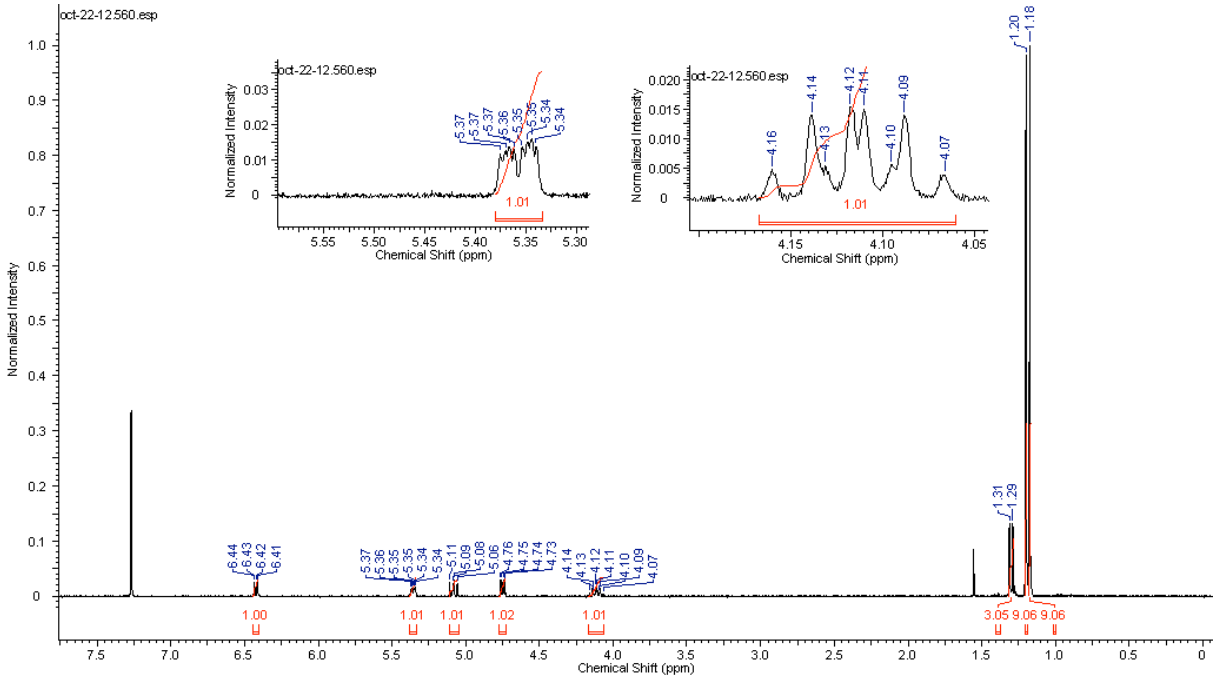
2l

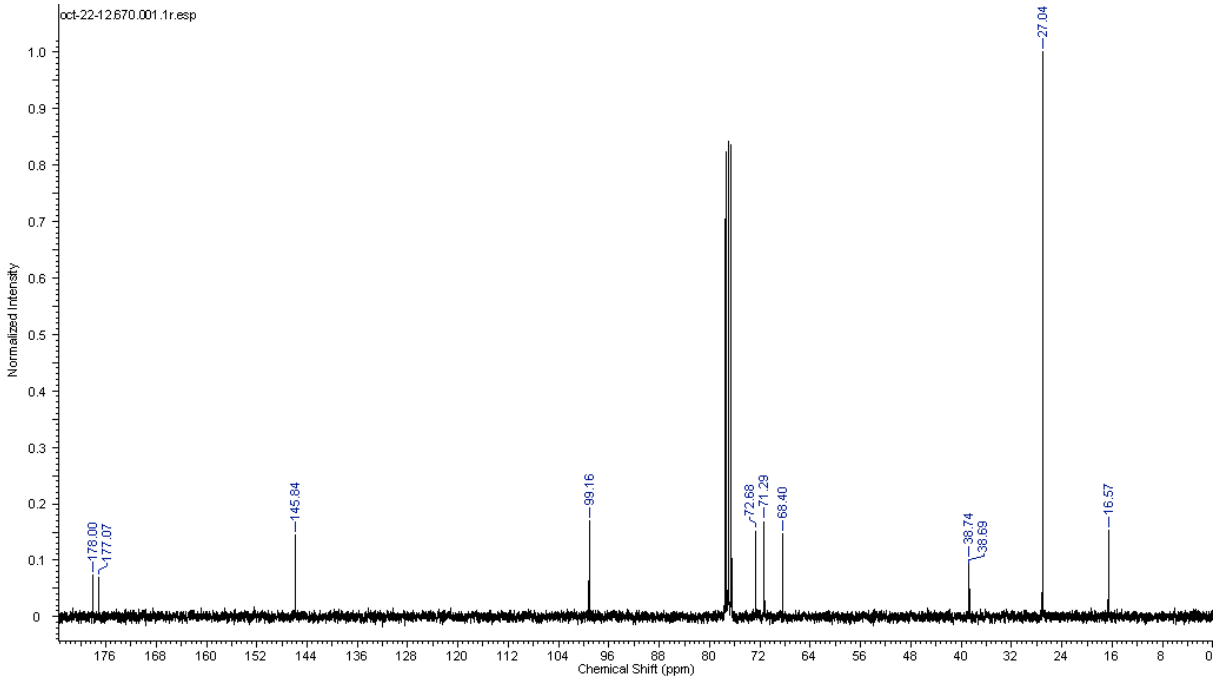

oct-03-12.630.esp
Normalized Intensity
Chemical Shift (ppm)
7.39
7.29
6.94
6.93
4.68
4.56
4.41
4.30
4.17
4.16
3.97
3.60
3.59
3.57
1.40
1.38
1.17
1.15
1.13
10.00
1.00
4.14
1.36
1.08
2.10
1.03
3.05
3.07

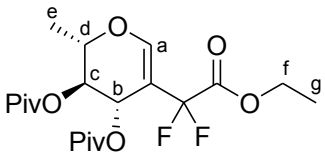

oct-05-12.420.esp
Normalized Intensity
Chemical Shift (ppm)
164.19
163.73
163.23
146.17
146.06
146.00
145.89
137.37
137.04
128.08
127.81
127.33
127.23
116.49
113.18
109.86
105.46
105.18
105.11
104.82
73.25
72.09
70.57
62.18
15.92
13.27


f
O
e
a
d
c
b
PivO
PivO

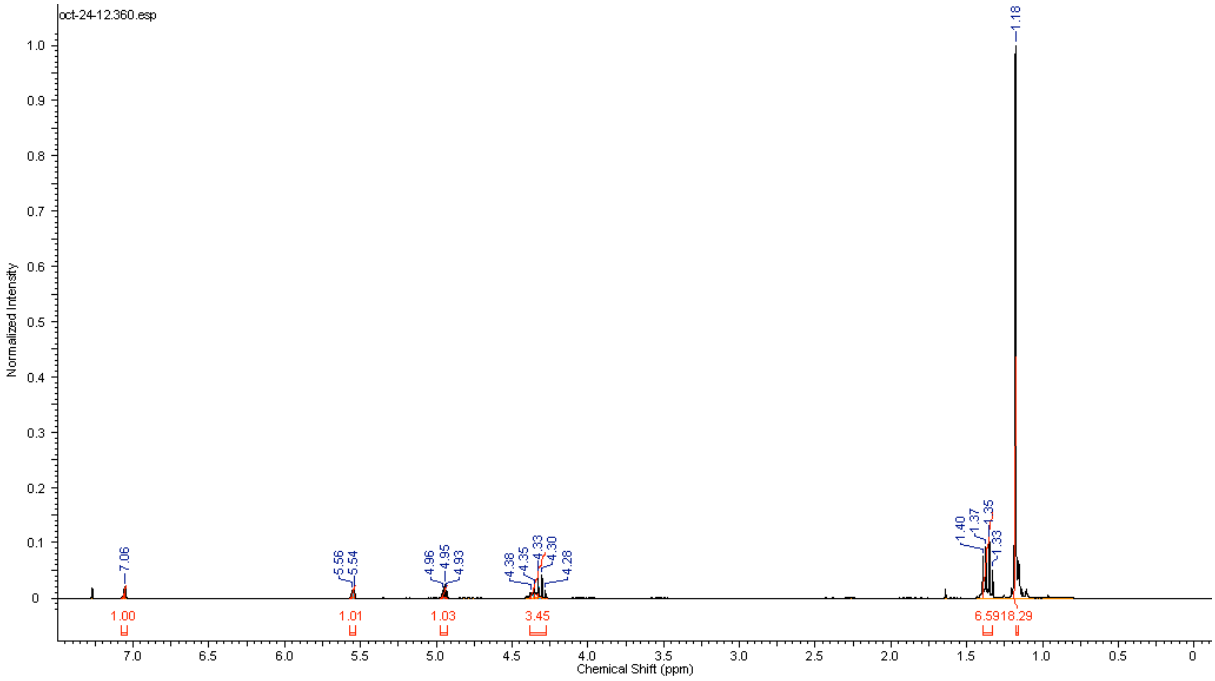
1m

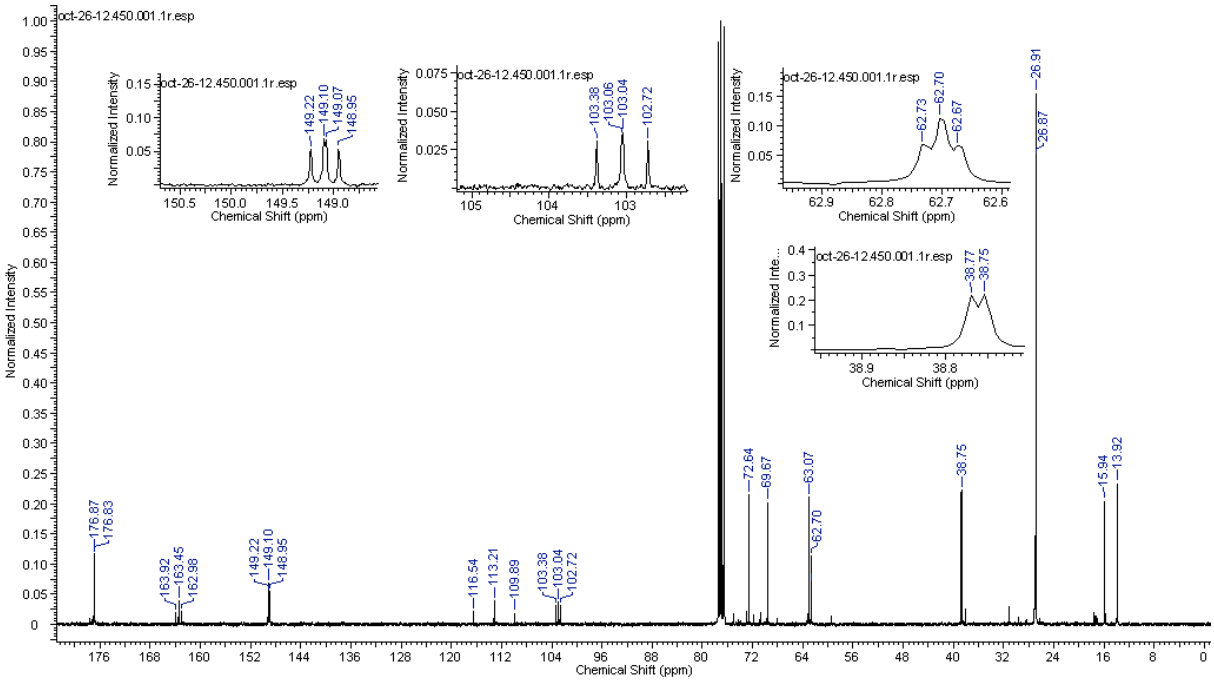

oct-22-12.560.esp
Normalized Intensity
Chemical Shift (ppm)
1.00
1.01
1.01
1.02
1.01
3.05
9.06
9.06

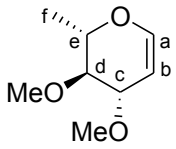

oct-22-12.670.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
178.00
177.07
145.84
99.16
72.68
71.29
68.40
38.74
38.69
27.04
16.57


e
d
O
a
O
c
b
f
g
PivO
O
PivO
F
F

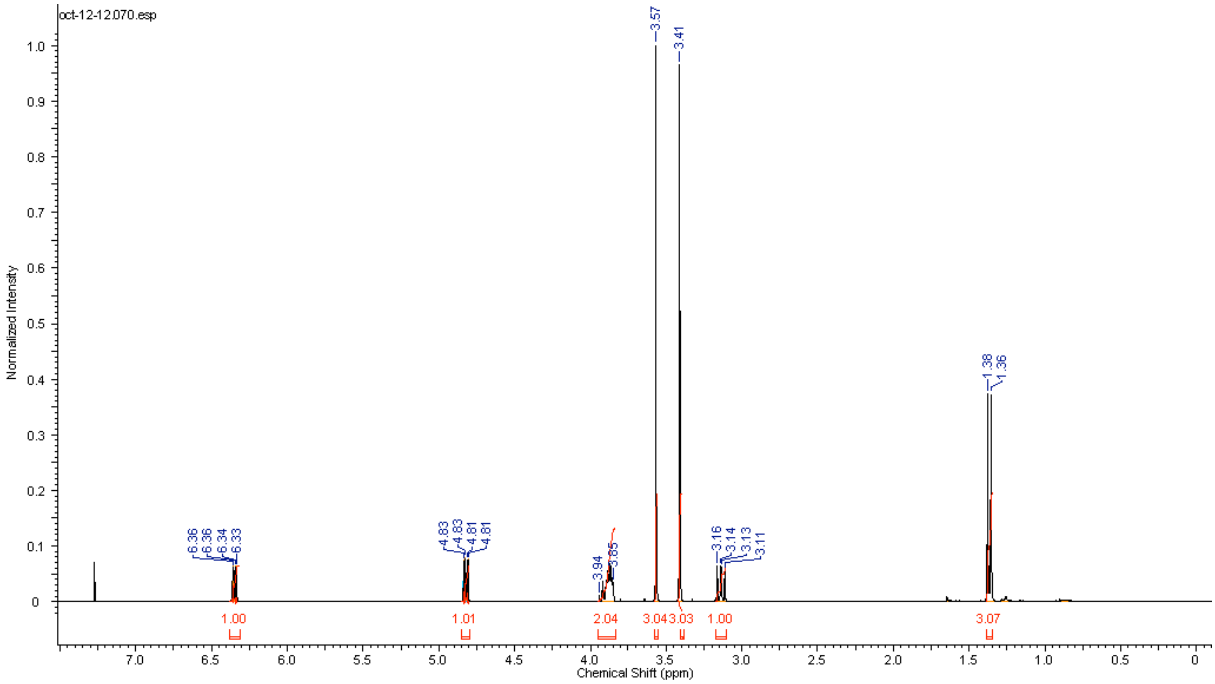
2m

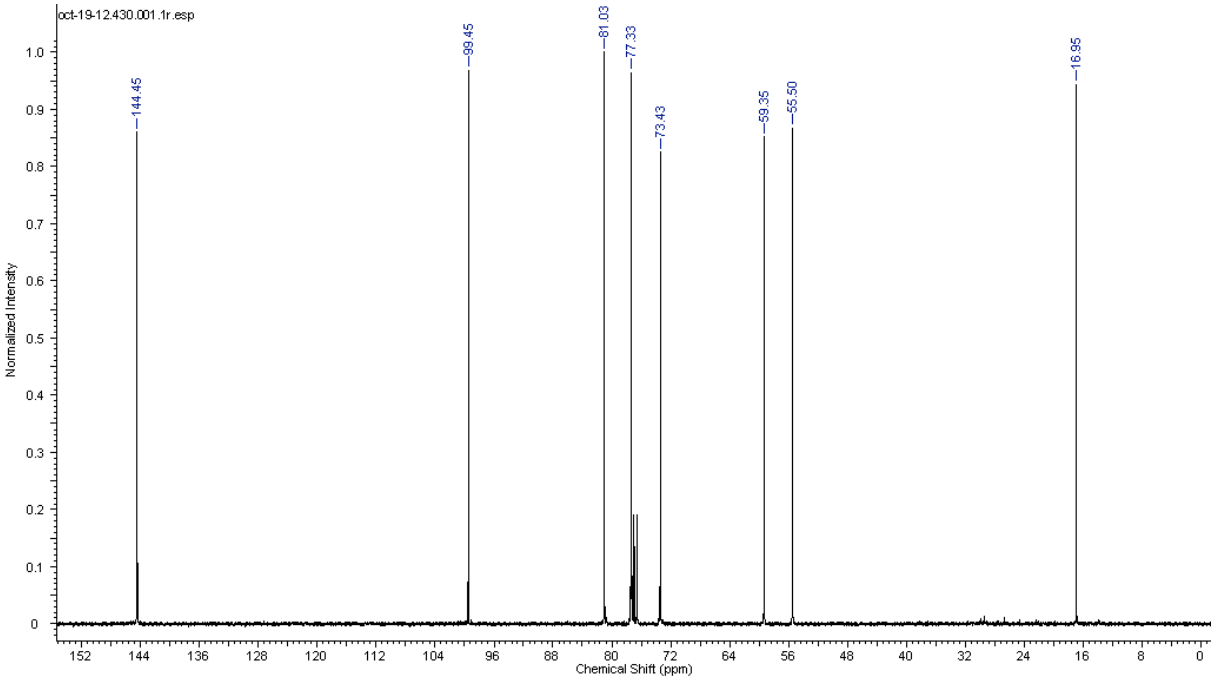

oct-24-12.360.esp
Normalized Intensity
Chemical Shift (ppm)
7.06
5.56
5.54
4.96
4.95
4.93
4.38
4.35
4.33
4.30
4.28
1.40
1.37
1.35
1.33
1.18
1.00
1.01
1.03
3.45
6.59
18.29

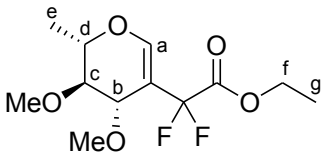

oct-26-12.450.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
149.22
149.10
149.07
148.95
103.38
103.06
103.04
102.72
62.73
62.70
62.67
38.77
38.75
26.91
26.87
176.87
176.83
163.92
163.45
162.98
149.22
149.10
148.95
116.54
113.21
109.89
103.38
103.04
102.72
72.64
69.67
63.07
62.70
38.75
15.94
13.92


f
O
e
a
d
c
b
MeO
MeO

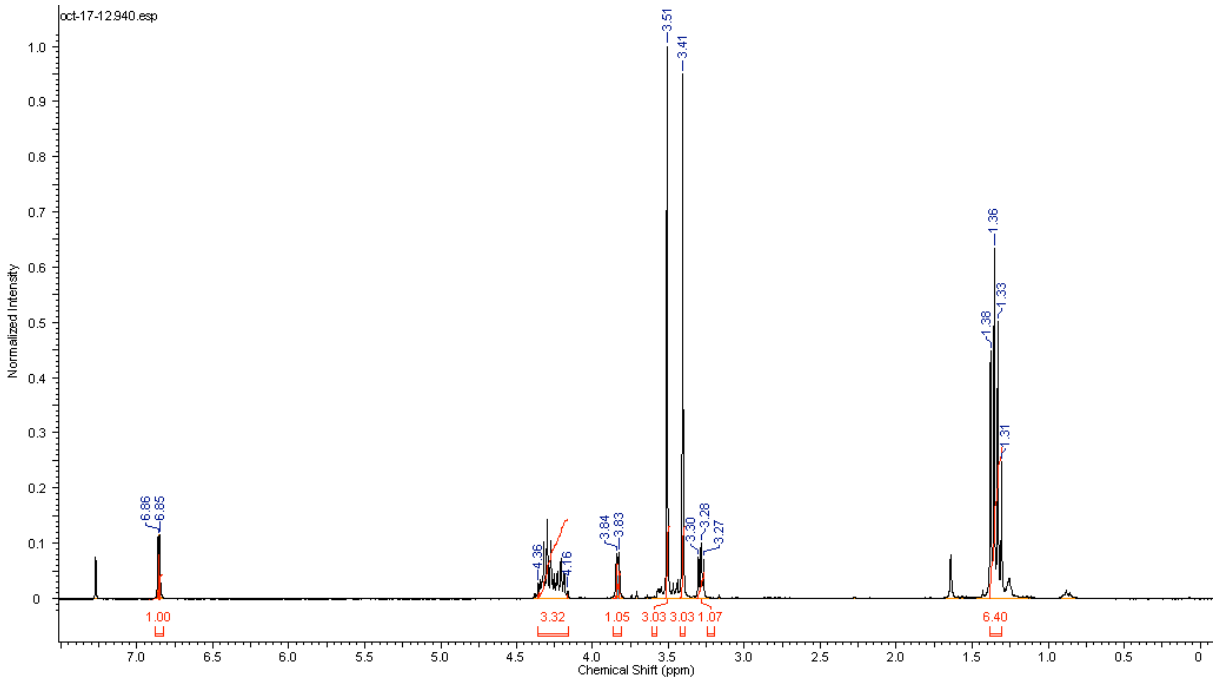
1n

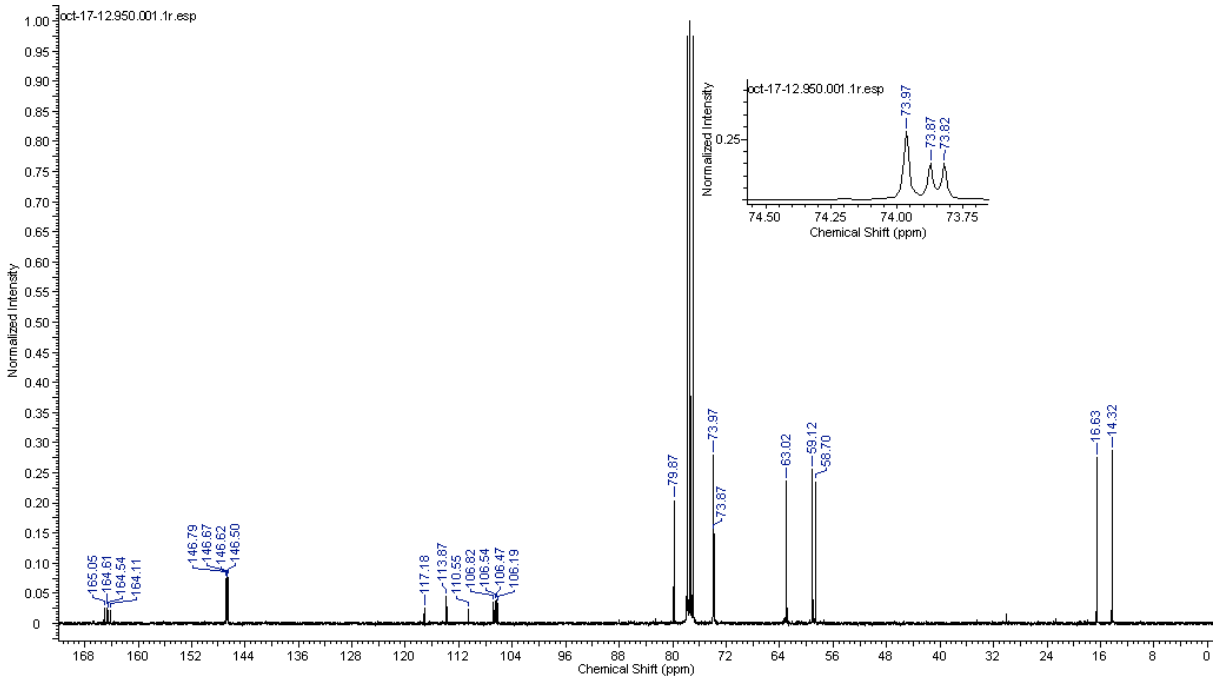

oct-12-12.070.esp
Normalized Intensity
Chemical Shift (ppm)
6.36
6.36
6.34
6.33
4.83
4.83
4.81
4.81
3.94
3.85
3.57
3.41
3.16
3.14
3.13
3.11
1.38
1.36
1.00
1.01
2.04
3.04
3.03
1.00
3.07

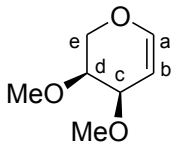

oct-19-12.430.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
144.45
99.45
81.03
77.33
73.43
59.35
55.50
16.95


e
d
O
a
O
c
b
f
g
MeO
O
MeO
F
F

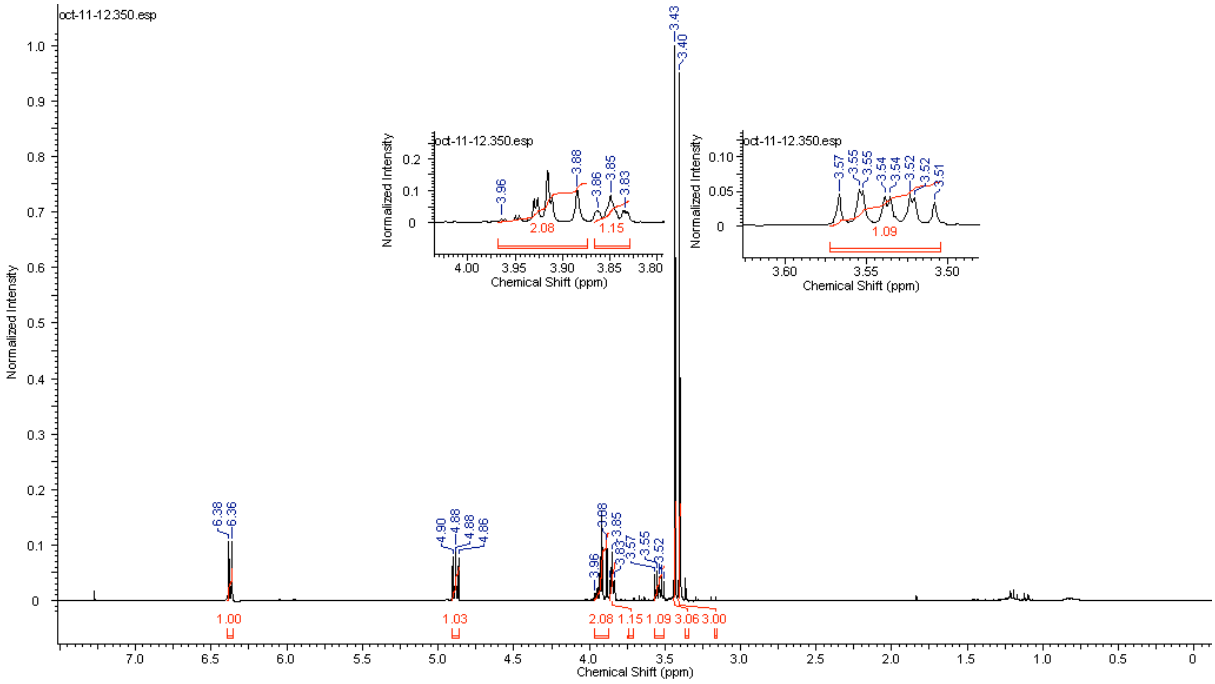
2n

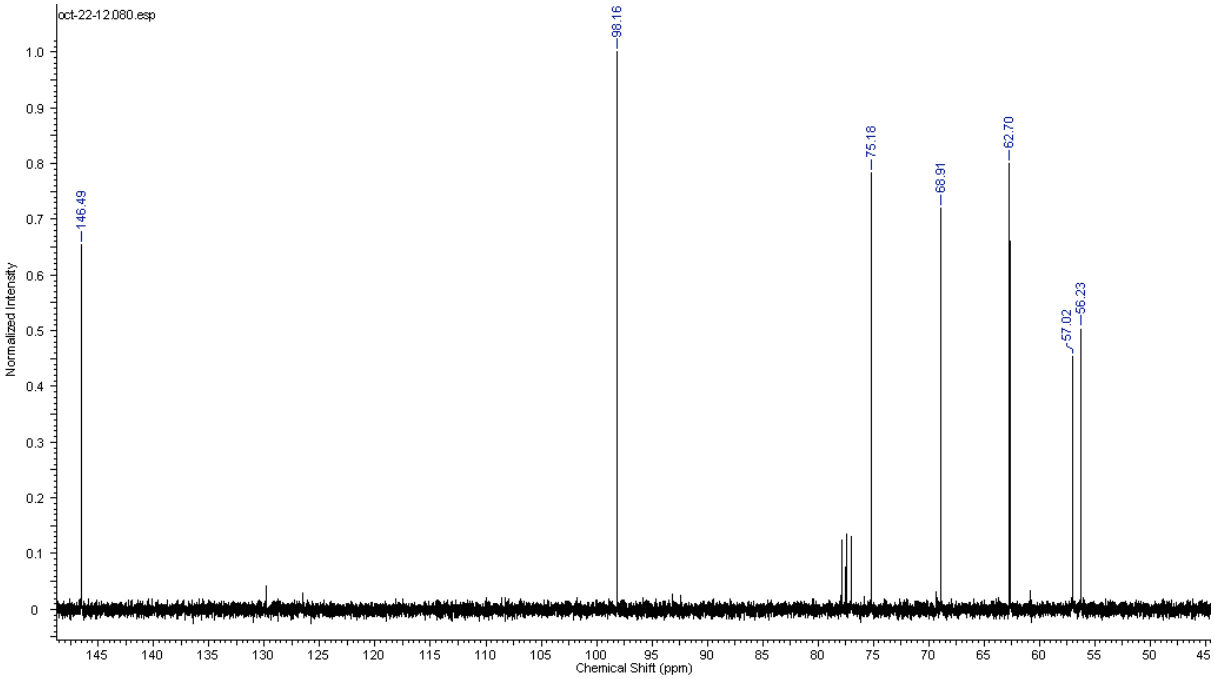

oct-17-12.940.esp
Normalized Intensity
Chemical Shift (ppm)
6.86
6.85
4.36
4.16
3.84
3.83
3.51
3.41
3.30
3.28
3.27
1.36
1.33
1.38
1.31
1.00
3.32
1.05
3.03
3.03
1.07
6.40

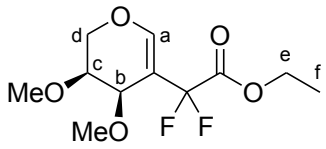

oct-17-12.950.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
165.05
164.61
164.54
164.11
146.79
146.67
146.62
146.50
117.18
113.87
110.55
106.82
106.54
106.47
106.19
79.87
73.97
73.87
63.02
59.12
58.70
16.63
14.32
oct-17-12.950.001.1r.esp
73.97
73.87
73.82


O
e
a
d
c
b
MeO
MeO

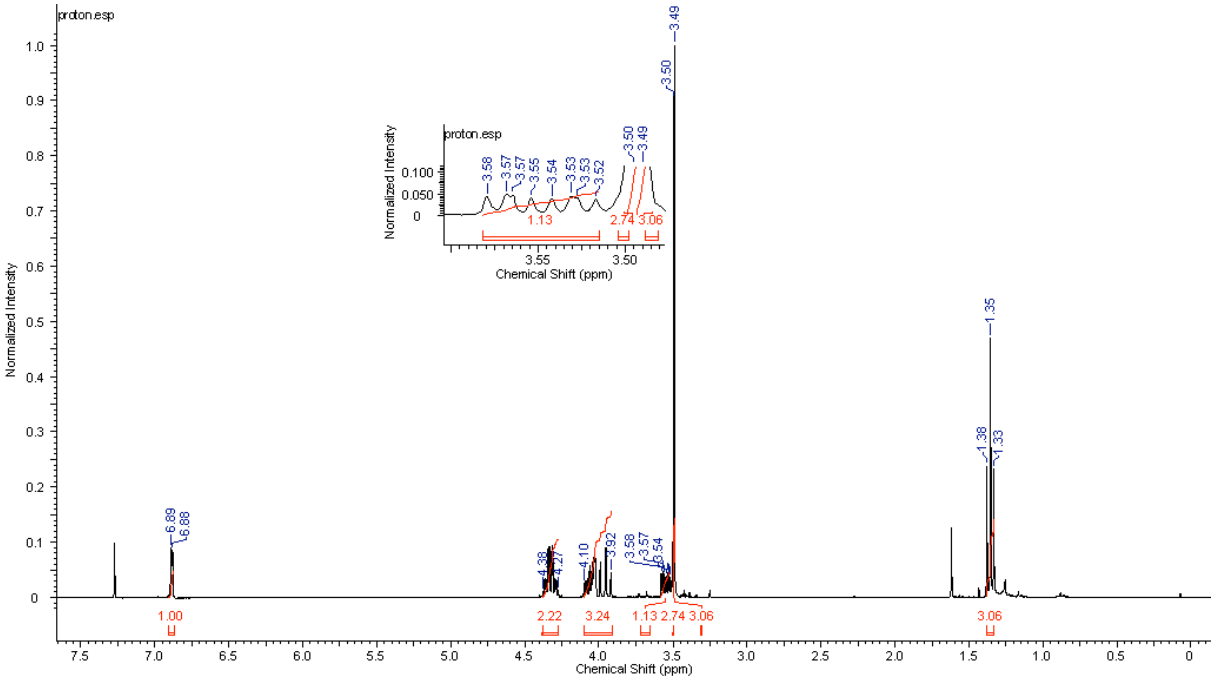
1o

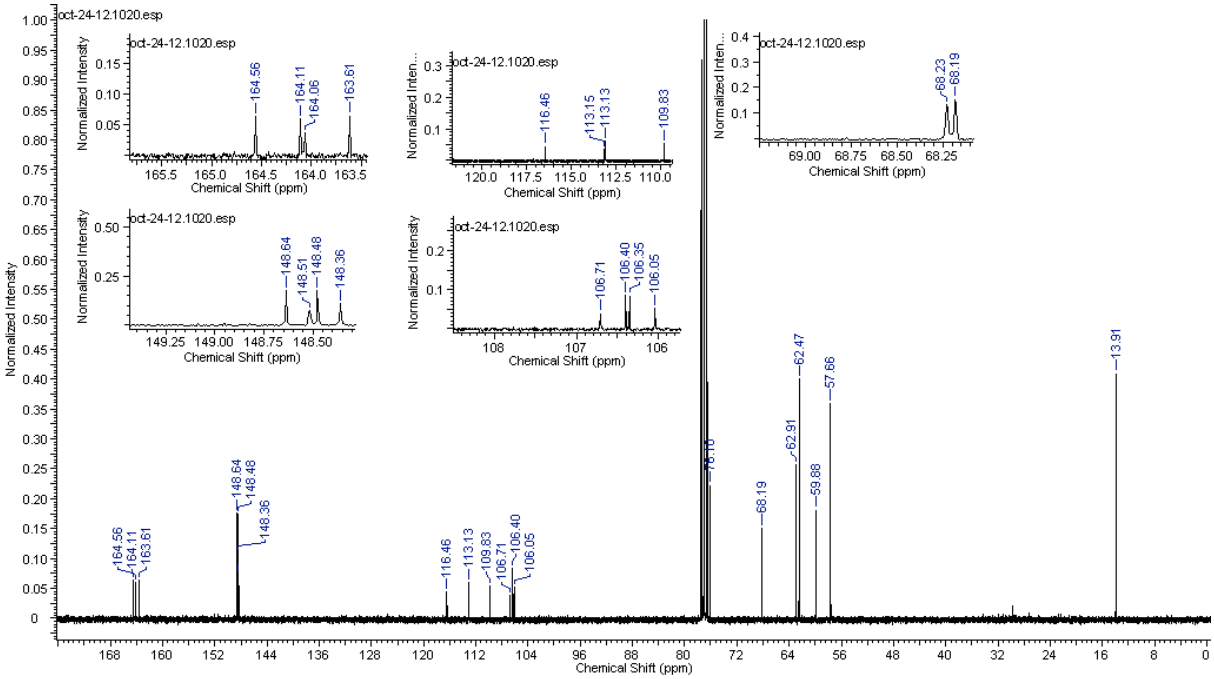

oct-11-12.350.esp
Normalized Intensity
Chemical Shift (ppm)
6.38
6.36
4.90
4.88
4.88
4.86
3.96
3.88
3.86
3.85
3.83
3.57
3.55
3.52
3.43
3.40
1.00
1.03
2.08
1.15
1.09
3.06
3.00

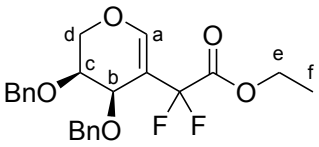

oct-22-12.080.esp
Normalized Intensity
Chemical Shift (ppm)
146.49
98.16
75.18
68.91
62.70
57.02
56.23


d
O
a
O
e
f
c
b
MeO
O
MeO
F
F

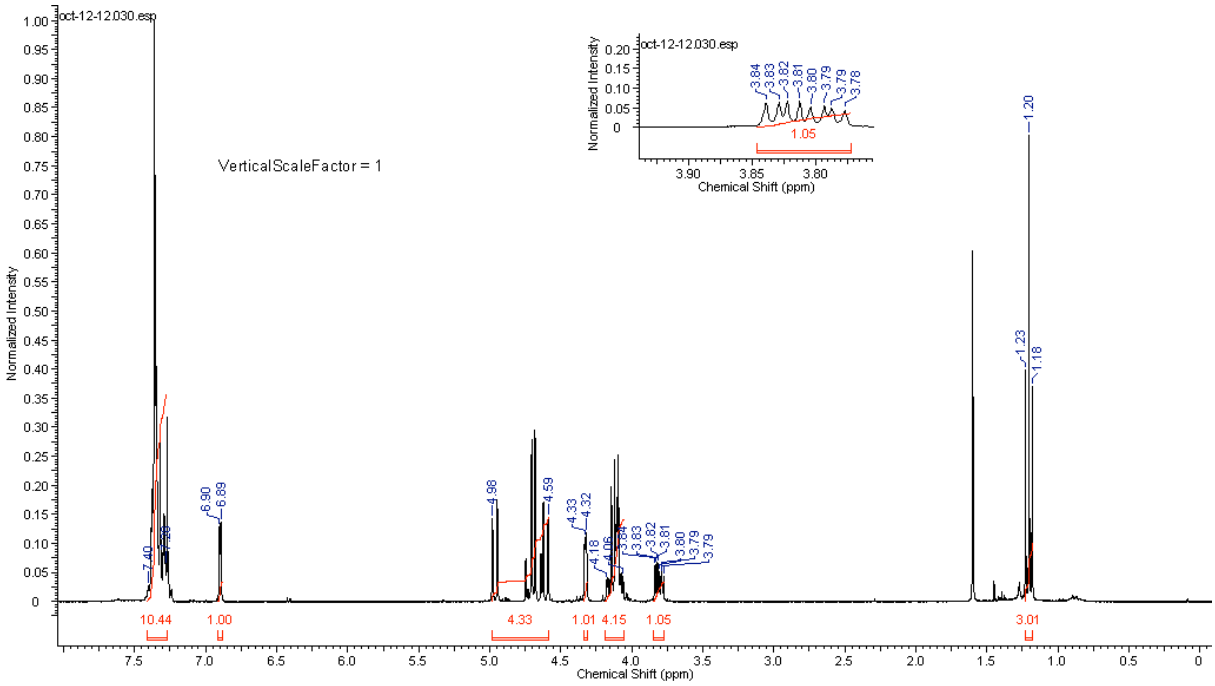
2o

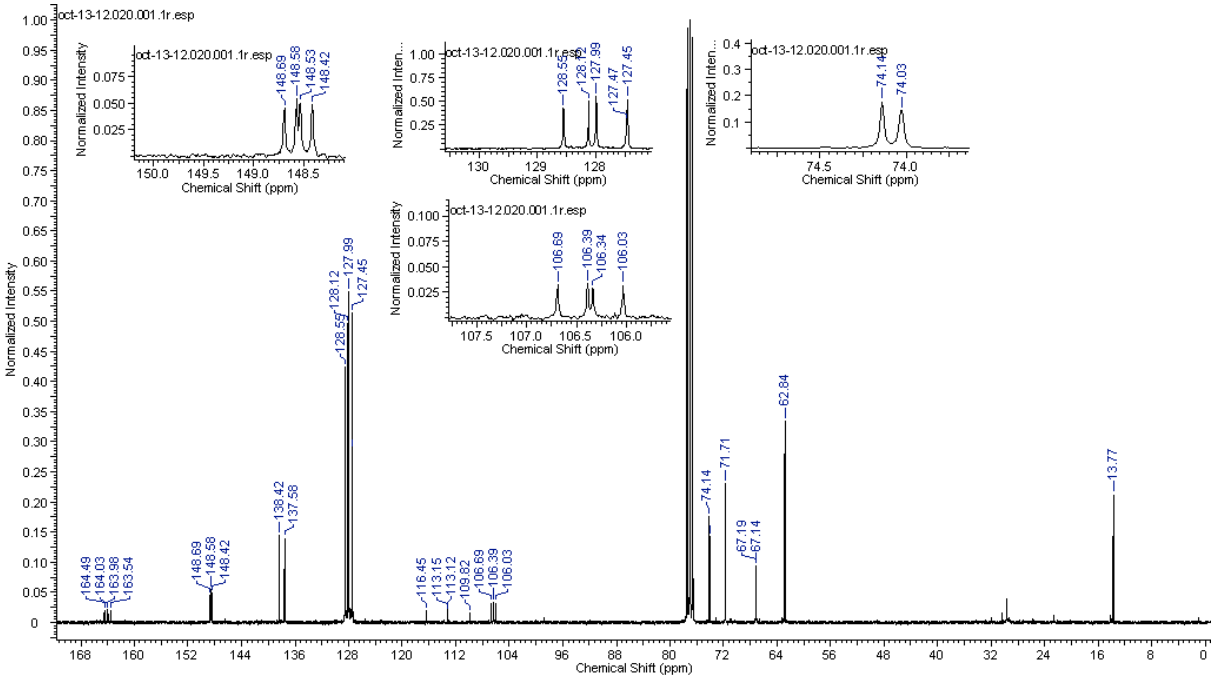

proton.esp
Normalized Intensity
Chemical Shift (ppm)
3.49
3.50
1.35
1.38
1.33
6.89
6.88
4.10
3.92
3.58
3.57
3.54
1.00
2.22
3.24
1.13
2.74
3.06
3.06

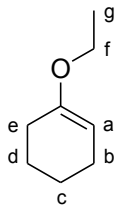

oct-24-12.1020.esp
Normalized Intensity
Chemical Shift (ppm)
164.56
164.11
164.06
163.61
116.46
113.15
113.13
109.83
68.23
68.19
148.64
148.51
148.48
148.36
106.71
106.40
106.35
106.05
78.10
68.19
62.91
62.47
59.88
57.66
13.91


d
O
a
O
e
f
c
b
BnO
O
BnO
F F

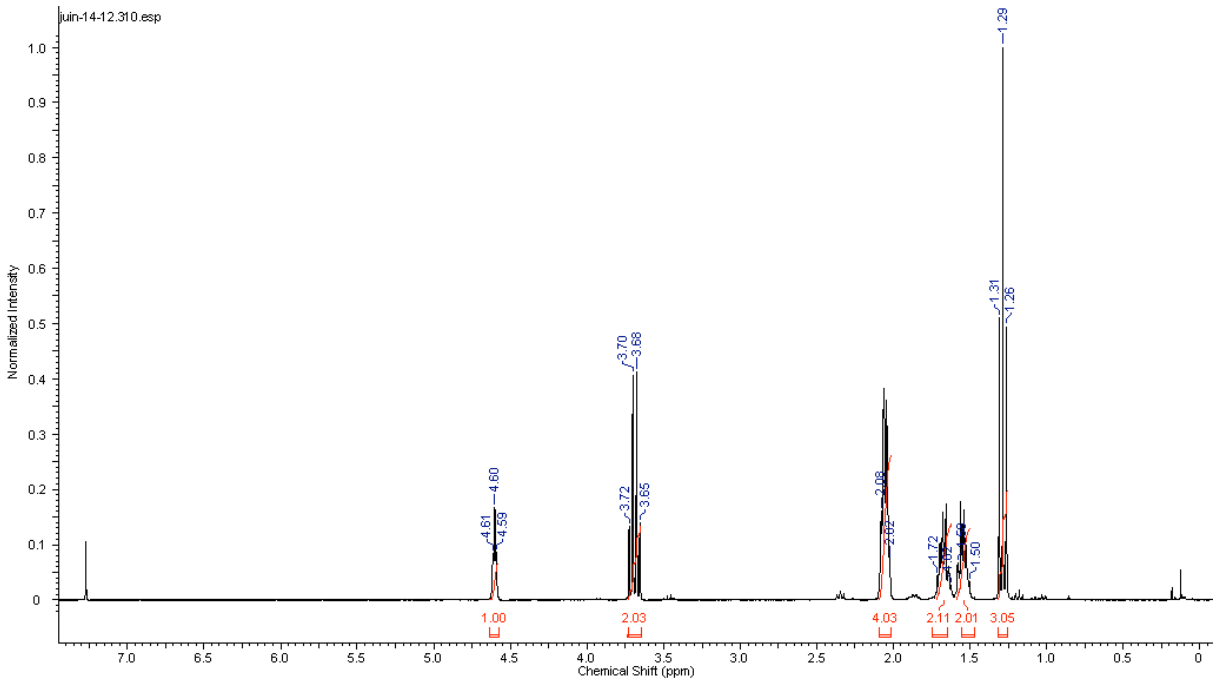
2p

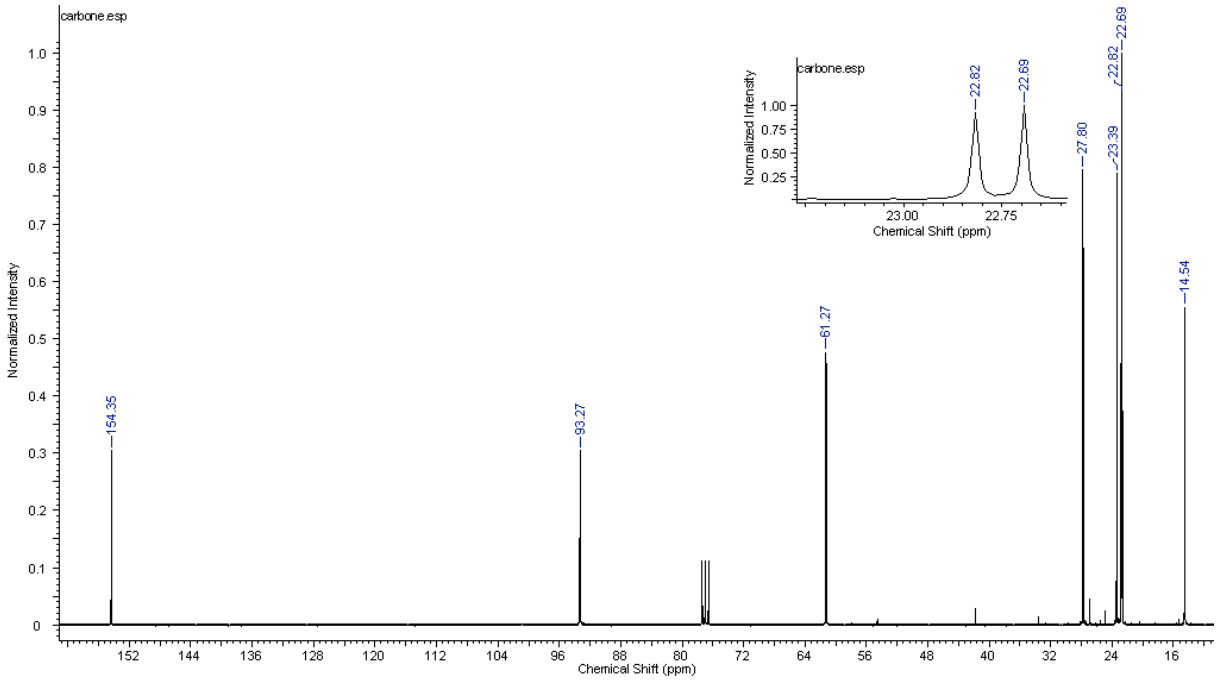

oct-12-12.030.esp
VerticalScaleFactor = 1
Normalized Intensity
Chemical Shift (ppm)
10.44
1.00
4.33
1.01
4.15
1.05
3.01

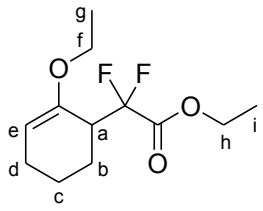

oct-13-12.020.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)


g
f
O
e
a
d
b
c

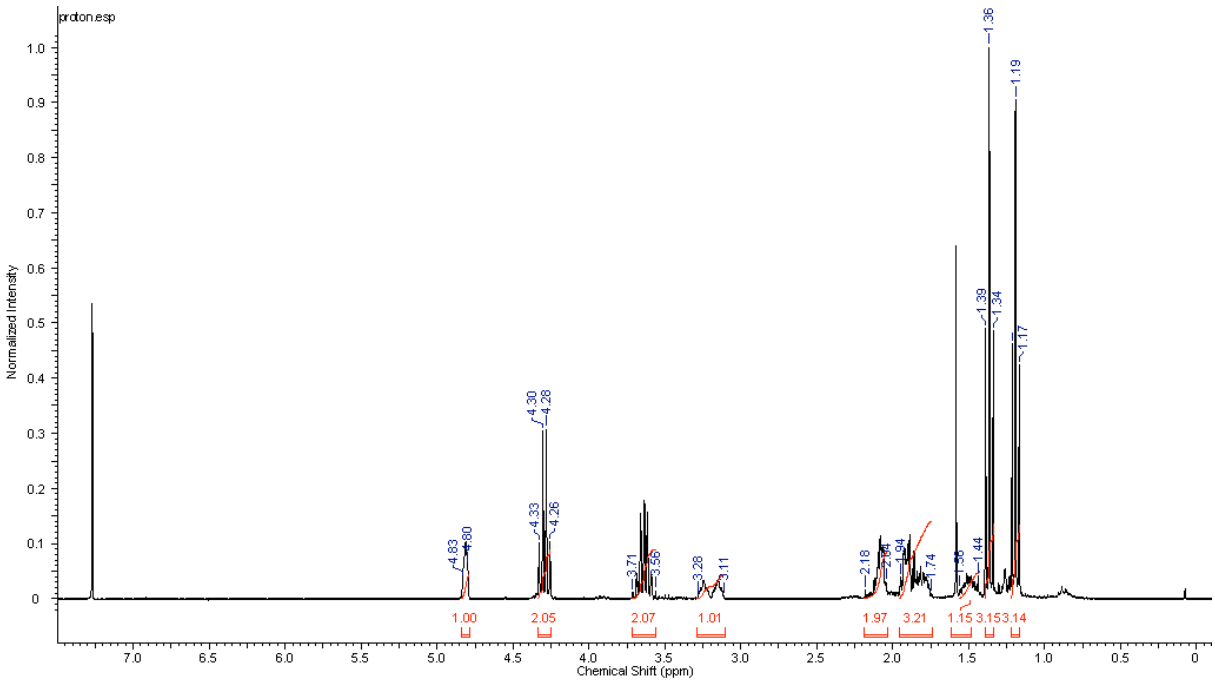
4

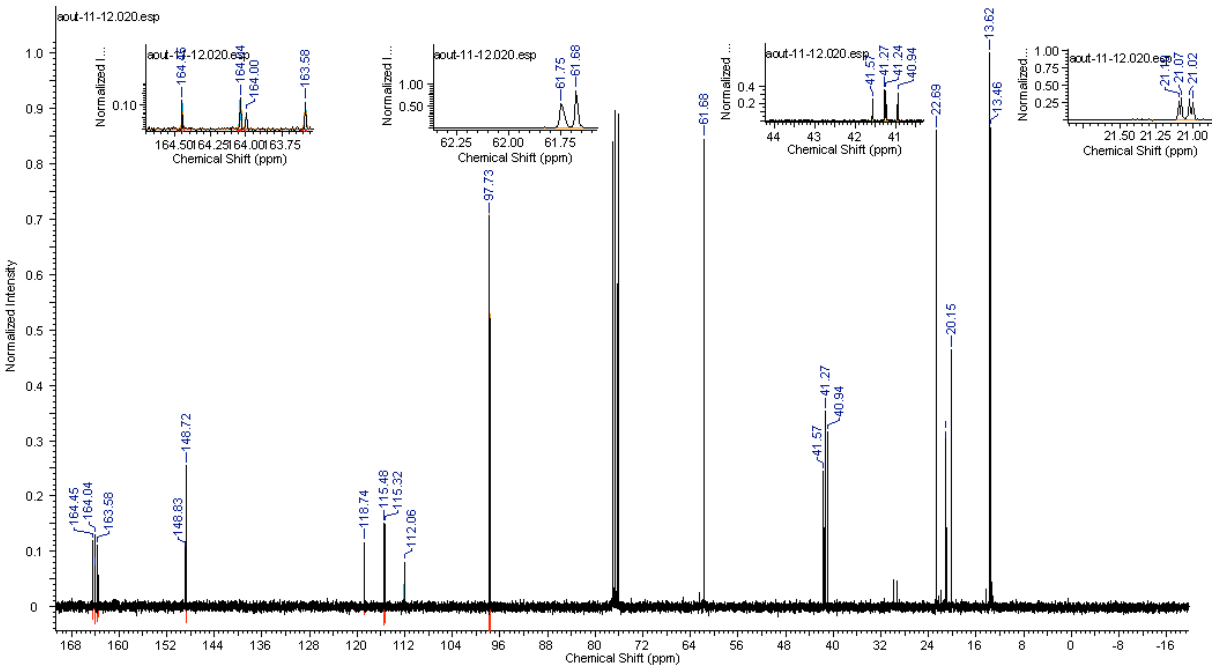

juin-14-12.310.esp
Normalized Intensity
Chemical Shift (ppm)
1.29
1.31
1.26
3.70
3.68
4.60
4.61
4.59
3.72
3.65
2.08
2.02
1.72
1.50
1.00
2.03
4.03
2.11
2.01
3.05


carbone.esp
Normalized Intensity
Chemical Shift (ppm)
154.35
93.27
61.27
27.80
23.39
22.82
22.69
14.54
carbone.esp
22.82
22.69
23.00
22.75


g
f
O
F
F
O
e
a
h
i
d
b
O
c

5


proton.esp
Normalized Intensity
Chemical Shift (ppm)
1.36
1.19
1.39
1.34
1.17
4.30
4.28
4.33
4.26
4.83
4.80
3.71
3.56
3.28
3.11
2.18
1.94
1.74
1.44
1.00
2.05
2.07
1.01
1.97
3.21
1.15
3.15
3.14


aout-11-12.020.esp
Normalized Intensity
Chemical Shift (ppm)
164.45
164.04
163.58
148.72
148.83
118.74
115.48
115.32
112.06
97.73
61.68
41.57
41.27
40.94
22.69
20.15
13.62
13.46