

Supporting information

1,1'-Dibenzyl-bis-(triazolyl)diphosphine dioxide: a new efficient organocatalyst for silicon tetrachloride-mediated enantioselective Abramov-type phosphonylation of aldehydes with trialkyl phosphites

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I. General informations

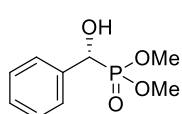
All reactions were run under an atmosphere of nitrogen using standard Schlenk techniques otherwise stated. Liquid aldehydes were distilled under reduced pressure before use. Reaction vessels were flame-dried under vacuum and cooled under a stream of nitrogen. Solvents were carefully dried by conventional methods or were purified with an MBRAUN Solvent Purification System and degassed prior to use. Reactions were monitored by thin layer chromatography (TLC) on silica gel pre-coated plastic sheets (0.2 mm, Machery-Nagel). Visualization of the developed chromatogram was performed by UV light and revealed using either potassium permanganate or phosphomolybdic acid solutions. Flash column chromatography (FC) was performed on Merck silica gel (60, particle size 0.040-0.063 mm). ¹H, ¹³C, ¹⁹F and ³¹P NMR spectra were recorded with a Bruker Avance 400 MHz spectrometer. Chemical shifts are reported in delta (δ) units, part per million (ppm) downfield from tetramethylsilane (TMS) relative to the residual deuterated solvent peaks. Coupling constants are reported in Hertz (Hz). The following abbreviations are used: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad signal. Enantiomeric ratios were determined by HPLC analysis measured on a Shimadzu[®] LC 20 AHPLC with a UV/visible detector at 195nm using a chiral stationary phase column specified in the individual experiment, by comparing the samples with the appropriate racemic mixtures. Optical rotations were measured on a polarimeter at 589 nm (sodium lamp) with a Bellingham + Stanley[®] ADP 440 Polarimeter. High resolution mass spectroscopic (HRMS) analysis were measured on a Xevo G2 Q TOF spectrometer using the electrospray method by the Laboratoire de Mesures Physiques of the University of Montpellier

II. Typical procedure for phosphonylation of aldehydes

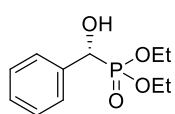
Aldehyde (0.5 mmol), iPr₂NEt (1.5 mmol), nBu₄NI (0.5 mmol) and (S)-1,1'-dibenzyl-bis-(triazolyl)diphosphine dioxide (5 mol %, 0.025 mmol) were mixed in anhydrous Et₂O (2.0 mL) at -78 °C

in a flame dried Schlenk tube under nitrogen atmosphere. To this solution was added the desired phosphite (0.60 mmol) and then silicon tetrachloride (1M dichloromethane solution, 0.75 mL, 0.75 mmol) was introduced over 10min using a syringe. The reaction progress was monitored by TLC (ethyl acetate). Upon completion, deionized water (2 mL), saturated aqueous NaHCO₃ (5 mL), and ethyl acetate (5 mL) were carefully added to the reaction mixture. After being stirred for approximately 1 h, the reaction mixture was filtered through a short Celite pad. The two phases were then separated and the aqueous phase was extracted with ethyl acetate (3 × 5 mL). The combined organic layers were washed with brine, dried over anhydrous MgSO₄, filtered, and evaporated under reduced pressure. The residue was purified by flash chromatography (silica gel, hexane /ethyl acetate : 50/50 to 0/100) to give the corresponding α -hydroxyphosphonates. The enantiomeric ratios were determined by HPLC using IC or AS-H Chiralpak columns.

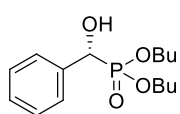
III. Description of phosphonylation products 2a–p



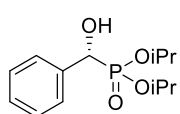
Dimethyl (*R*)-(hydroxy(phenyl)methyl)phosphonate (4b) (known product)¹: Yield = 87%; [α]²⁴_D = +30.4 (c 1.05, CHCl₃) [Lit.¹ [α]²⁷_D = +21.5 (c 0.80, CHCl₃) for 28% ee (*R*)]. HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, λ = 195 nm, t_R = 41.77 min (*S*, minor), t_R = 45.19 min (*R*, major); e.r. = 84.6:15.4. ¹H NMR (400.13 MHz, CDCl₃) δ 7.50–7.48 (m, 2H), 7.40–7.31 (m, 3H), 5.06 (d, J = 10.9 Hz, 1H), 3.71 (d, J = 10.5 Hz, 3H), 3.67 (d, J = 10.4 Hz, 3H). ¹³C NMR (100.61 MHz, CDCl₃) δ 136.48 (d, J = 2.1 Hz), 128.54 (d, J = 2.5 Hz, two carbons), 128.39 (d, J = 3.2 Hz), 127.17 (d, J = 5.9 Hz, two carbons), 70.78 (d, J = 159.4 Hz), 54.07 (d, J = 7.0 Hz), 53.78 (d, J = 7.4 Hz). ³¹P (CDCl₃, 161.97 MHz) δ (ppm) = 23.47 (s).



Diethyl (*R*)-(hydroxy(phenyl)methyl)phosphonate (4a) (known product)¹: Yield = 91%; [α]²⁴_D = 22.0 (c 1.09, CHCl₃) [Lit.¹ [α]²⁷_D = +14.8 (c 1.01, CHCl₃) for 41% ee (*R*)]. HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, λ = 195 nm, t_R = 26.96 min (*R*, major), t_R = 32.14 min (*S*, minor); e.r. = 84.5:15.5. ¹H NMR (400.13 MHz, CDCl₃) δ 7.50–7.48 (m, 2H), 7.38–7.29 (m, 3H), 5.02 (dd, J = 10.8, J = 2.7 Hz, 1H), 4.10–3.92 (m, 4H), 3.63–3.50 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.21 (t, J = 7.1 Hz, 3H); ¹³C NMR (100.61 MHz, CDCl₃) δ 136.85 (d, J = 1.9 Hz), 128.28 (d, J = 2.5 Hz, two carbons), 128.08 (d, J = 3.2 Hz), 127.22 (d, J = 5.8 Hz, two carbons), 70.86 (d, J = 159.2 Hz), 63.44 (d, J = 7.0 Hz), 63.09 (d, J = 7.3 Hz), 16.46 (d, J = 5.6 Hz), 16.43 (d, J = 5.5 Hz); ³¹P (CDCl₃, 161.97 MHz) δ (ppm) = 21.35 (s).



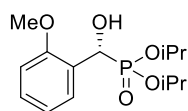
Dibutyl (*R*)-(hydroxy(phenyl)methyl)phosphonate (4c) (known product)¹: Yield = 79%; [α]²⁴_D = +11.5 (c 1.04, CHCl₃) [Lit.¹ [α]²⁷_D = +8.8 (c 1.05, CHCl₃) for 33% ee (*R*)]. HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, λ = 195 nm, t_R = 16.49 min (*R*, major), t_R = 19.11 min (*S*, minor); e.r. = 78.5:11.5. ¹H NMR (400.13 MHz, CDCl₃) δ 7.49–7.46 (m, 2H), 7.37–7.28 (m, 3H), 5.02 (dd, J = 10.8, J = 4.9 Hz, 1H), 4.02–3.86 (m, 4H), 3.65–3.61 (m, 1H), 1.63–1.49 (m, 4H), 1.39–1.24 (m, 4H), 0.89 (t, J = 7.4 Hz, 4H), 0.86 (t, J = 7.4 Hz, 1H). ¹³C NMR (100.61 MHz, CDCl₃) δ 137.04 (d, J = 1.8 Hz), 128.14 (d, J = 2.5 Hz, two carbons), 127.91 (d, J = 3.1 Hz), 127.19 (d, J = 5.8 Hz, two carbons), 70.78 (d, J = 159.7 Hz), 67.06 (d, J = 7.3 Hz), 66.65 (d, J = 7.6 Hz), 32.53 (d, J = 5.7 Hz), 32.52 (d, J = 5.6 Hz), 18.62 (d, J = 4.6 Hz, two carbons), 13.59 (d, J = 1.4 Hz, two carbons). ³¹P (CDCl₃, 161.97 MHz) δ (ppm) = 21.27 (s).



Diisopropyl (*R*)-(hydroxy(phenyl)methyl)phosphonate (4d) (known product)¹: Yield = 92%; [α]²⁴_D = +22.2 (c 1.08, CHCl₃) [Lit.¹ [α]²⁷_D = +12.2 (c 1.01, CHCl₃) for 40% ee (*R*)]. HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, λ = 195 nm,

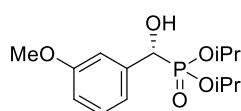
¹ K. Nakanishi, S. Kotani, M. Sugiura, M. Nakajima, *Tetrahedron*, **2008**, *64*, 6415

$t_R = 12.33$ min (*R*, major), $t_R = 17.07$ min (*S*, minor); e.r. = 88.4:11.6. ^1H NMR (400.13 MHz, CDCl_3) δ 7.50–7.48 (m, 2H), 7.37–7.27 (m, 3H), 4.96 (d, $J = 10.9$ Hz, 1H), 4.66–4.57 (m, 2H), 1.28 (d, $J = 6.2$, 3H), 1.27 (d, $J = 6.2$, 3H), 1.24 (d, $J = 6.2$ Hz, 3H), 1.13 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 137.06 (d, $J = 1.9$ Hz), 128.12 (d, $J = 2.5$ Hz, two carbons), 127.89 (d, $J = 3.1$ Hz), 127.39 (d, $J = 5.8$ Hz, two carbons), 71.16 (d, $J = 160.4$ Hz), 72.03 (d, $J = 7.3$ Hz), 71.67 (d, $J = 7.6$ Hz), 24.26 (d, $J = 3.1$ Hz), 24.13 (d, $J = 3.6$ Hz), 23.96 (d, $J = 5.0$ Hz), 23.63 (d, $J = 5.5$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.74 (s).



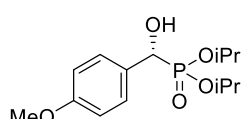
Diisopropyl (*R*)-(hydroxy(2-methoxyphenyl)methyl)phosphonate (4e): Yield = 79%;

$[\alpha]^{24}_D = +18.0$ (c 1.11, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_R = 25.55$ min (*R*, major), $t_R = 48.97$ min (*S*, minor); e.r. = 72:28. ^1H NMR (400.13 MHz, CDCl_3) δ 7.53 (dt, $J = 7.6$, 1.9 Hz, 1H), 7.28–7.23 (m, 1H), 6.97 (t, $J = 7.5$ Hz, 1H), 6.86 (d, $J = 8.3$ Hz, 1H), 5.34 (d, $J = 12.4$ Hz, 1H), 4.77–4.66 (m, 1H), 4.59–4.48 (m, 1H), 3.85 (brs, 1H), 3.83 (s, 3H), 1.30 (d, $J = 6.6$ Hz, 3H), 1.29 (d, $J = 6.5$ Hz, 3H), 1.23 (d, $J = 6.2$ Hz, 3H), 1.02 (t, $J = 5.8$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 156.67 (d, $J = 6.6$ Hz), 128.87, 128.86 (d, $J = 7.0$ Hz), 125.80, 120.55 (d, $J = 2.7$ Hz), 110.29 (d, $J = 2.0$ Hz), 71.58 (d, $J = 7.4$ Hz), 71.17 (d, $J = 7.4$ Hz), 65.08 (d, $J = 163.5$ Hz), 55.35 (s), 24.23 (d, $J = 2.9$ Hz), 24.06 (d, $J = 3.4$ Hz), 23.83 (d, $J = 5.2$ Hz), 23.33 (d, $J = 5.7$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 20.71 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{14}\text{H}_{24}\text{O}_5\text{P}$: 303.1361, found 303.1357.



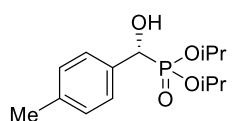
Diisopropyl (*R*)-(hydroxy(3-methoxyphenyl)methyl)phosphonate (4f): Yield =

93%; $[\alpha]^{24}_D = +10.8$ (c 1.11, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_R = 34.82$ min (*S*, minor). $t_R = 41.01$ min (*R*, major); e.r. = 88.5:11.5. ^1H NMR (400.13 MHz, CDCl_3) δ 7.23 (t, $J = 7.9$ Hz, 1H), 7.08–7.04 (m, 2H), 6.82 (d, $J = 8.2$ Hz, 1H), 4.93 (d, $J = 11.0$ Hz, 1H), 4.69–4.56 (m, 2H), 4.11 (brs, 1H), 3.79 (s, 3H), 1.26 (d, $J = 6.2$ Hz, 9H), 1.15 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 159.34 (d, $J = 2.5$ Hz), 138.77 (d, $J = 1.3$ Hz), 128.83 (d, $J = 2.4$ Hz), 119.80 (d, $J = 6.0$ Hz), 113.72 (d, $J = 3.1$ Hz), 112.46 (d, $J = 5.6$ Hz), 71.92 (d, $J = 7.4$ Hz), 71.53 (d, $J = 7.6$ Hz), 70.89 (d, $J = 161.3$ Hz), 55.12, 24.10 (d, $J = 14.6$ Hz), 24.16 (d, $J = 3.0$ Hz), 24.07 (d, $J = 15.2$ Hz), 24.01 (d, $J = 3.6$ Hz), 23.86 (d, $J = 5.0$ Hz), 23.54 (d, $J = 5.5$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.79 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{14}\text{H}_{24}\text{O}_5\text{P}$: 303.1361, found 303.1360.



Diisopropyl (*R*)-(hydroxy(4-methoxyphenyl)methyl)phosphonate (4j) (known

product)²: Yield = 95%; $[\alpha]^{24}_D = +15.5$ (c 1.03, CHCl_3) [lit.² $[\alpha]^{22}_D = -7.5$ (c 0.80, CHCl_3) for 35% ee (*S*)]. HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_R = 19.14$ min (*R*, major), $t_R = 28.03$ min (*S*, minor); e.r. = 85.5:14.5. ^1H NMR (400.13 MHz, CDCl_3) δ 7.41 (dd, $J = 8.7$, 2.1 Hz, 2H), 6.89 (d, $J = 8.6$ Hz, 2H), 4.88 (dd, $J = 9.9$, 4.7 Hz, 1H), 4.68–4.56 (m, 2H), 3.81 (s, 3H), 2.79 (dd, $J = 10.2$, 4.8 Hz, 1H), 1.30–1.25 (m, 9H), 1.13 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 159.36 (d, $J = 2.8$ Hz), 129.18 (d, $J = 1.7$ Hz), 128.73 (d, $J = 6.1$ Hz), 113.55 (d, $J = 2.1$ Hz), 71.86 (d, $J = 7.3$ Hz), 71.52 (d, $J = 7.6$ Hz), 70.64 (d, $J = 162.7$ Hz), 55.28 (s), 24.25 (d, $J = 3.0$ Hz), 24.12 (d, $J = 3.5$ Hz), 23.97 (d, $J = 5.0$ Hz), 23.66 (d, $J = 5.4$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 20.00 (s).

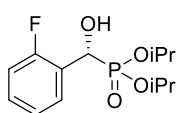


Diisopropyl (*R*)-(hydroxy(4-methylphenyl)methyl)phosphonate (4h) (known

product)²: Yield = 94%; $[\alpha]^{24}_D = +23.0$ (c 1.04, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_R = 14.40$ min (*R*, major), $t_R = 23.31$ min (*S*, minor); e.r. = 86.5:13.5. ^1H NMR (400.13 MHz, CDCl_3) δ 7.37 (dd,

² K. V. Zaitsev, M. V. Bermeshev, A. A. Samsonov, J. F. Oprunenko, A. V. Churakov, J. A. L. Howard, S. S. Karlov, G. S. Zaitseva, *New J. Chem.*, **2008**, 32, 1415.

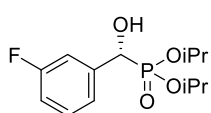
$J = 8.1, 2.1$ Hz, 2H), 7.16 (d, $J = 8.1$ Hz, 2H), 4.91 (dd, $J = 10.5, 4.8$ Hz, 1H), 4.69–4.55 (m, 2H), 2.84 (dd, $J = 10.1, 4.4$ Hz, 1H), 2.34 (d, $J = 1.7$ Hz, 3H), 1.29–1.27 (m, 9H), 1.25 (d, $J = 6.2$ Hz, 3H), 1.13 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 137.44 (d, $J = 3.2$ Hz), 134.08 (d, $J = 1.8$ Hz), 128.76 (d, $J = 2.4$ Hz), 127.32 (d, $J = 6.0$ Hz), 71.88 (d, $J = 7.3$ Hz), 71.52 (d, $J = 7.6$ Hz), 70.93 (d, $J = 161.4$ Hz), 24.24 (d, $J = 3.1$ Hz), 24.11 (d, $J = 3.6$ Hz), 23.94 (d, $J = 5.0$ Hz), 23.62 (d, $J = 5.5$ Hz), 21.23 (d, $J = 0.9$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.98 (s).



Diisopropyl (R)-(hydroxy(2-fluorophenyl)methyl)phosphonate (4i): Yield = 81%;

$[\alpha]^{24}_{\text{D}} = +14.0$ (c 1.14 CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 9.11$ min (*R*, major), $t_{\text{R}} = 12.15$ min (*S*, minor); e.r. = 66.5:33.5. ^1H NMR (400.13 MHz, CDCl_3) δ 7.71–7.67 (m, 1H), 7.29–7.24 (m, 1H), 7.18–

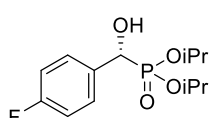
7.14 (m, 1H), 7.04–6.99 (m, 1H), 5.32 (d, $J = 11.6$ Hz, 1H), 4.76–4.58 (m, 3H), 1.33 (d, $J = 6.2$ Hz, 3H), 1.28–1.24 (m, 6H), 1.14 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 159.91 (dd, $J = 247.0, 6.9$ Hz), 129.46 (dd, $J = 8.2, 3.1$ Hz), 129.26 (dd, $J_{\text{CF}} = J_{\text{CP}} = 3.7$ Hz), 125.02 (d, $J = 13.7$ Hz), 124.17 (dd, $J_{\text{CF}} = J_{\text{CP}} = 3.1$ Hz), 114.96 (dd, $J = 22.1, 2.2$ Hz), 72.35 (d, $J = 7.5$ Hz), 71.93 (d, $J = 7.6$ Hz), 64.12 (dd, $J = 165.1, 3.2$ Hz), 24.29 (d, $J = 3.1$ Hz), 24.10 (d, $J = 3.6$ Hz), 23.92 (d, $J = 5.0$ Hz), 23.55 (d, $J = 5.6$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.22 (d, $J = 6.6$ Hz). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{13}\text{H}_{21}\text{O}_4\text{FP}$: 291.1161, found 291.1152.



Diisopropyl (R)-(hydroxy(3-fluorophenyl)methyl)phosphonate (4j): Yield = 93%;

$[\alpha]^{24}_{\text{D}} = +19.3$ (c 1.24, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 7.60$ min (*S*, minor), $t_{\text{R}} = 8.37$ min (*R*, major); e.r. = 81:19. ^1H NMR (400.13 MHz, CDCl_3) δ 7.32–7.23 (m, 3H), 7.00–6.95 (m, 1H), 4.96

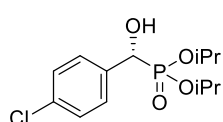
(d, $J = 8.6$ Hz, 1H), 4.70–4.61 (m, 2H), 4.22 (brs, 1H), 1.28–1.26 (m, 9H), 1.18 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 162.79 (dd, $J = 245.3, 2.9$ Hz), 139.72 (d, $J = 7.4$ Hz), 129.55 (dd, $J = 8.1, 2.5$ Hz), 122.95 (dd, $J = 5.7, 2.9$ Hz), 114.73 (dd, $J = 21.2, 3.1$ Hz), 114.29 (dd, $J = 22.8, 5.4$ Hz), 72.37 (d, $J = 7.4$ Hz), 72.00 (d, $J = 7.7$ Hz), 70.61 (dd, $J = 160.3, 1.8$ Hz), 24.26 (d, $J = 3.2$ Hz), 24.11 (d, $J = 3.7$ Hz), 23.99 (d, $J = 5.0$ Hz), 23.71 (d, $J = 5.4$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.07 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{13}\text{H}_{21}\text{O}_4\text{FP}$: 291.1161, found 291.1152.



Diisopropyl (R)-(hydroxy(4-fluorophenyl)methyl)phosphonate (4k): Yield = 95%;

$[\alpha]^{24}_{\text{D}} = +25.6$ (c 1.09, CHCl_3) [lit 2 $[\alpha]^{22}_{\text{D}} = -80.0$ (c 0.80, CHCl_3) for 40% ee (*S*)]. HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 8.54$ min (*R*, major), $t_{\text{R}} = 9.65$ min (*S*, minor); e.r. = 89:11. ^1H NMR (400.13 MHz,

CDCl_3) δ 7.48–7.44 (m, 2H), 7.02 (t, $J = 8.5$ Hz, 2H), 4.93 (dd, $J = 10.4, 5.2$ Hz, 1H), 4.69–4.57 (m, 2H), 4.38 (dd, $J = 7.7, 5.4$ Hz, 1H), 1.27–1.24 (m, 9H), 1.16 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 162.47 (dd, $J = 245.8, 3.4$ Hz), 133.09 (dd, $J = 3.0, 1.8$ Hz), 129.09 (dd, $J = 8.1, 5.9$ Hz, two carbons), 114.91 (dd, $J = 21.5, 2.4$ Hz, two carbons), 72.11 (d, $J = 7.4$ Hz), 71.70 (d, $J = 7.7$ Hz), 70.35 (d, $J = 162.5$ Hz), 24.19 (d, $J = 3.2$ Hz), 24.04 (d, $J = 3.7$ Hz), 23.96 (d, $J = 4.9$ Hz), 23.65 (d, $J = 5.4$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.50 (d, $J = 4.9$ Hz). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{13}\text{H}_{21}\text{O}_4\text{FP}$: 291.1161, found 291.1150.

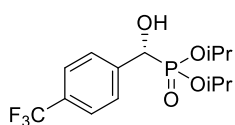


Diisopropyl (R)-(hydroxy(4-chlorophenyl)methyl)phosphonate (4l): Yield = 93%;

$[\alpha]^{24}_{\text{D}} = +20.8$ (c 1.15, CHCl_3). HPLC analysis: Chiralpak AS-H column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 6.66$ min (*R*, major), $t_{\text{R}} = 8.41$ min (*S*, minor); e.r. = 86:14. ^1H NMR (400.13 MHz, CDCl_3) δ 7.42 (dd, $J = 8.6, 2.1$ Hz, 2H), 7.32 (d, $J = 8.5$ Hz, 2H), 4.94 (d, $J = 10.7$ Hz, 1H), 4.70–4.57 (m, 1H), 3.77 (brs, 1H, OH), 1.28–1.25 (m, 9H), 1.18

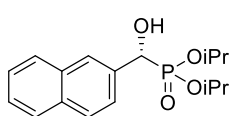
(d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 135.62 (d, $J = 2.3$ Hz), 133.72 (d, $J = 3.8$ Hz), 128.66 (d, $J = 5.7$ Hz, two carbon), 128.33 (d, $J = 2.6$ Hz, two carbon), 72.28 (d, $J = 7.4$ Hz), 71.93 (d, $J = 7.7$ Hz),

70.51 (d, $J = 160.8$ Hz), 24.26 (d, $J = 3.3$ Hz), 24.12 (d, $J = 3.7$ Hz), 24.03 (d, $J = 5.0$ Hz), 23.78 (d, $J = 5.4$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.11 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{13}\text{H}_{21}\text{O}_4\text{P}$: 307.0866, found 307.0865.



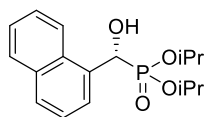
Diisopropyl (R)-(hydroxy(4-(trifluoromethyl)phenyl)methyl)phosphonate (4m):

Yield = 91%; $[\alpha]^{24}_{\text{D}} = +11.4$ (c 1.05, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 7.86$ min (*S*, minor), $t_{\text{R}} = 8.79$ min (*R*, major); e.r. = 72:28. ^1H NMR (400.13 MHz, CDCl_3) δ 7.61 (s, 4H), 5.04 (dd, $J = 11.5, 4.6$ Hz, 1H), 4.74–4.59 (m, 2H), 3.77 (m, 1H, OH), 1.29–1.25 (m, 9H), 1.20 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 141.43, 129.89 (qd, $J = 32.4, 3.4$ Hz), 127.55 (d, $J = 5.4$ Hz), 125.17–124.61 (m, two carbons), 124.29 (q, $J = 273.1$ Hz), 72.51 (d, $J = 7.4$ Hz), 72.05 (d, $J = 7.8$ Hz), 70.56 (d, $J = 160.6$ Hz), 24.20 (d, $J = 3.2$ Hz), 24.03 (d, $J = 3.6$ Hz), 24.01 (d, $J = 4.9$ Hz), 23.70 (d, $J = 5.4$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 18.71 (d, $J = 2.4$ Hz). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{14}\text{H}_{21}\text{O}_4\text{PF}_3$: 341.1130, found 341.1127.



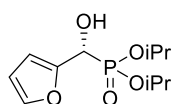
Diisopropyl (R)-(hydroxy(naphthalen-2-yl)methyl)phosphonate (4n):

Yield = 95%; $[\alpha]^{24}_{\text{D}} = +19.0$ (c = 1.05, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 13.76$ min (*R*, major), $t_{\text{R}} = 15.67$ min (*S*, minor); e.r. = 88.5:11.5. ^1H NMR (400.13 MHz, CDCl_3) δ 7.96 (brs, 1H), 7.84–7.82 (m, 2H), 7.61 (dt, $J = 8.6, 1.5$ Hz, 1H), 7.49–7.46 (m, 2H), 5.14 (d, $J = 10.7$ Hz, 1H), 4.70–4.57 (m, 2H), 3.51 (brs, 1H, OH), 1.28 (d, $J = 6.2$ Hz, 3H), 1.27 (d, $J = 6.2$ Hz, 3H), 1.24 (d, $J = 6.2$ Hz, 3H), 1.13 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 134.80 (d, $J = 2.2$ Hz), 133.15 (d, $J = 2.5$ Hz), 133.06 (d, $J = 2.2$ Hz), 128.11 (d, $J = 1.2$ Hz), 127.67 (d, $J = 1.3$ Hz), 127.57 (d, $J = 2.0$ Hz), 126.31 (d, $J = 7.6$ Hz), 125.99 (s), 125.92 (d, $J = 1.1$ Hz), 125.43 (d, $J = 4.3$ Hz), 72.05 (d, $J = 7.4$ Hz), 71.71 (d, $J = 7.7$ Hz), 71.17 (d, $J = 161.2$ Hz), 24.21 (d, $J = 3.1$ Hz), 24.08 (d, $J = 3.6$ Hz), 23.96 (d, $J = 5.0$ Hz), 23.67 (d, $J = 5.5$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 19.71 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{17}\text{H}_{24}\text{O}_4\text{P}$: 323.1412, found 323.1411.



Diisopropyl (R)-(hydroxy(naphthalen-1-yl)methyl)phosphonate (4o):

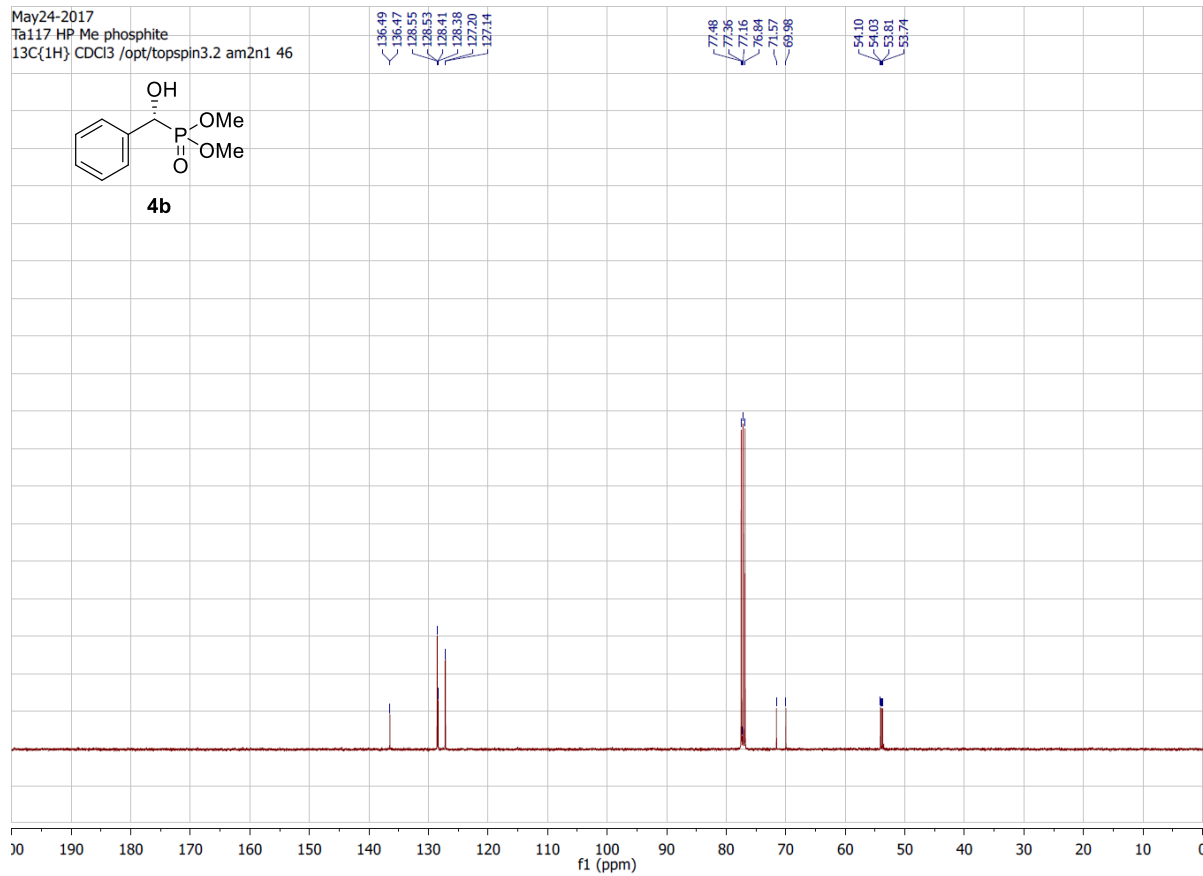
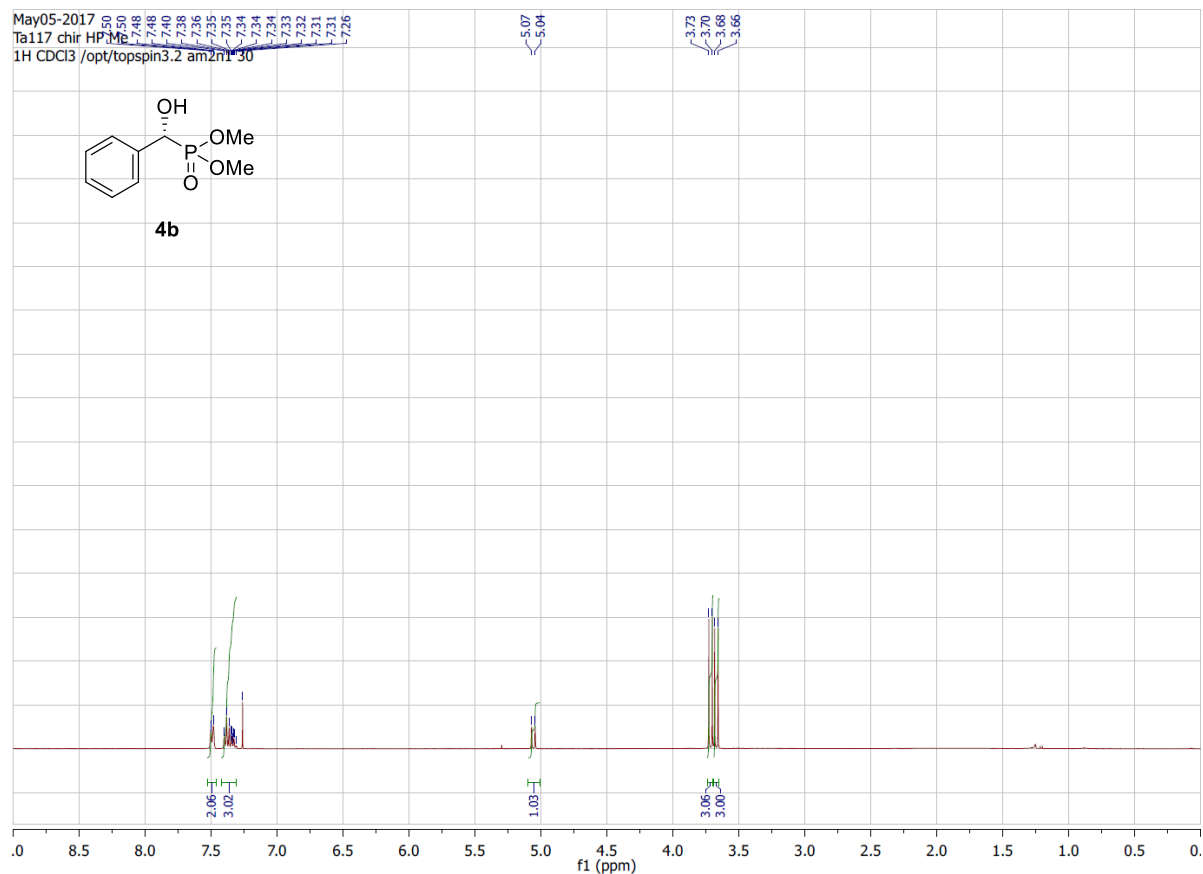
Yield = 78%; $[\alpha]^{24}_{\text{D}} = +37.3$ (c 1.07, CHCl_3). HPLC analysis: Chiralpak IC column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 18.78$ min (*S*, minor), $t_{\text{R}} = 20.78$ min (*R*, major); e.r. = 67.5:32.5. ^1H NMR (400.13 MHz, CDCl_3) δ 8.09 (d, $J = 8.3$ Hz, 1H), 7.90–7.80 (m, 3H), 7.53–7.45 (m, 3H), 5.80 (dd, $J = 11.8, 3.2$ Hz, 1H), 4.69–4.60 (m, 1H), 4.58–4.47 (m, 1H), 4.08 (brs, 1H, OH), 1.26 (d, $J = 6.2$ Hz, 3H), 1.19 (d, $J = 6.1$ Hz, 3H), 1.18 (d, $J = 6.1$ Hz, 3H), 0.87 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 133.57 (d, $J = 1.3$ Hz), 133.54 (d, $J = 1.8$ Hz), 131.11 (d, $J = 6.1$ Hz), 128.55 (s), 128.41 (d, $J = 3.4$ Hz), 125.72 (s), 125.66 (d, $J = 6.1$ Hz), 125.46 (s), 125.32 (d, $J = 3.4$ Hz), 124.19 (s), 124.19 (s), 72.21 (d, $J = 7.5$ Hz), 71.70 (d, $J = 7.8$ Hz), 67.26 (d, $J = 163.5$ Hz), 24.24 (d, $J = 3.0$ Hz), 23.97 (d, $J = 4.9$ Hz), 23.92 (d, $J = 6.5$ Hz), 23.26 (d, $J = 5.6$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 20.21 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{17}\text{H}_{24}\text{O}_4\text{P}$: 323.1412, found 323.1411.

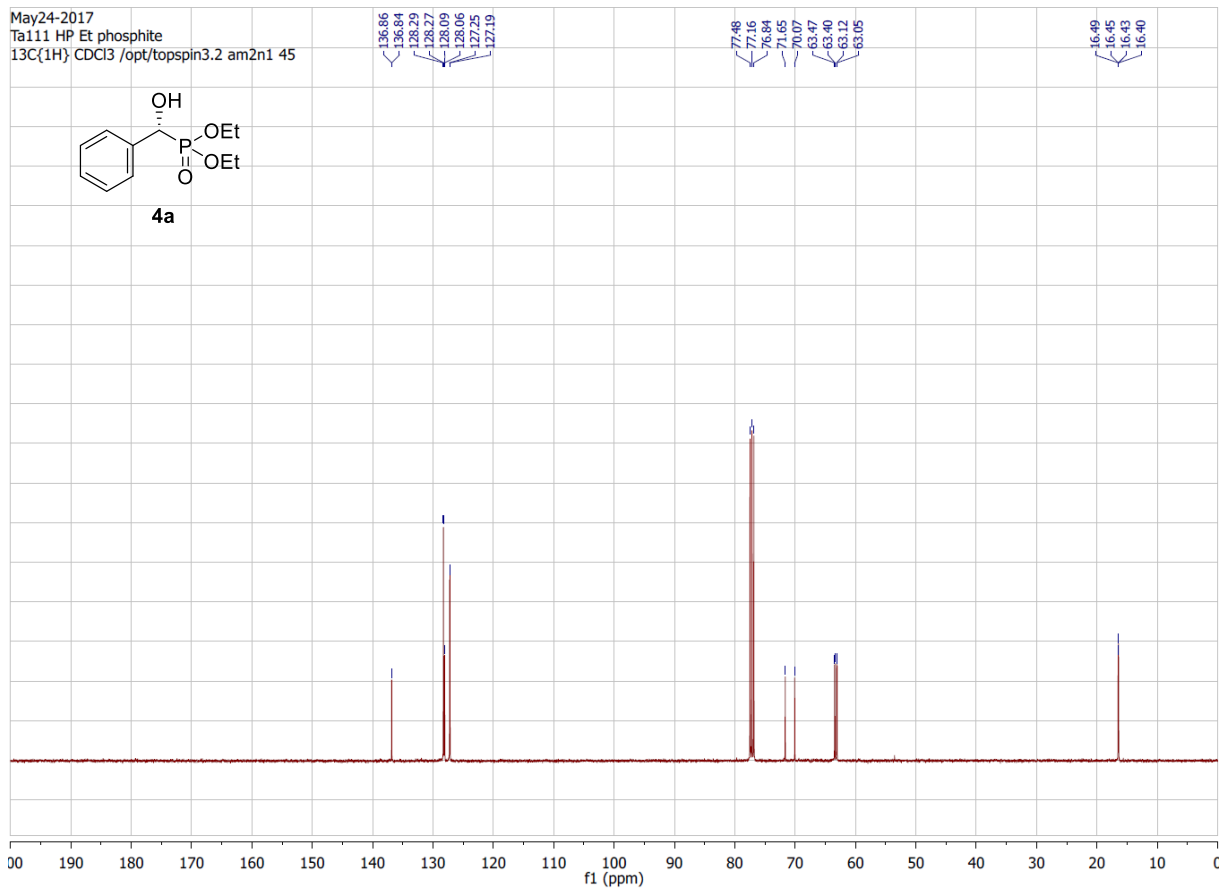
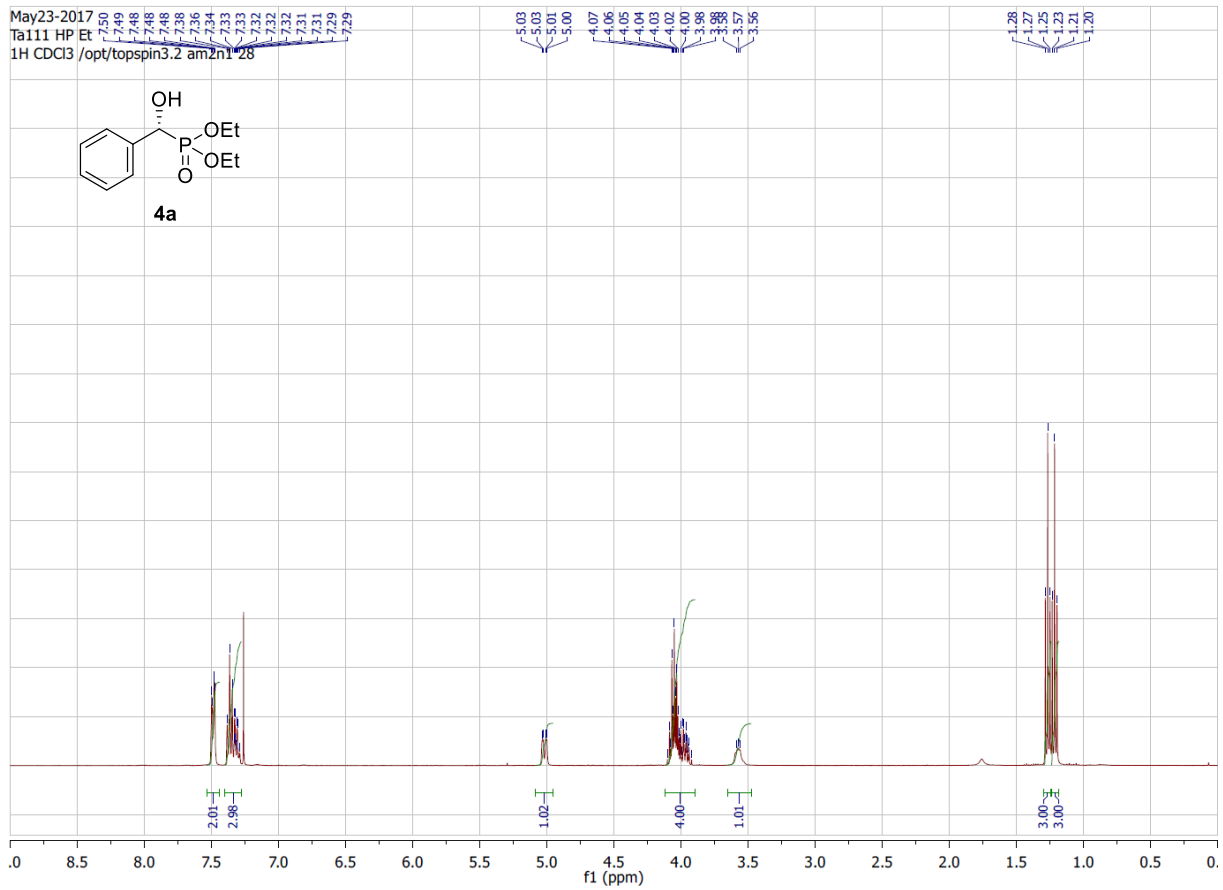


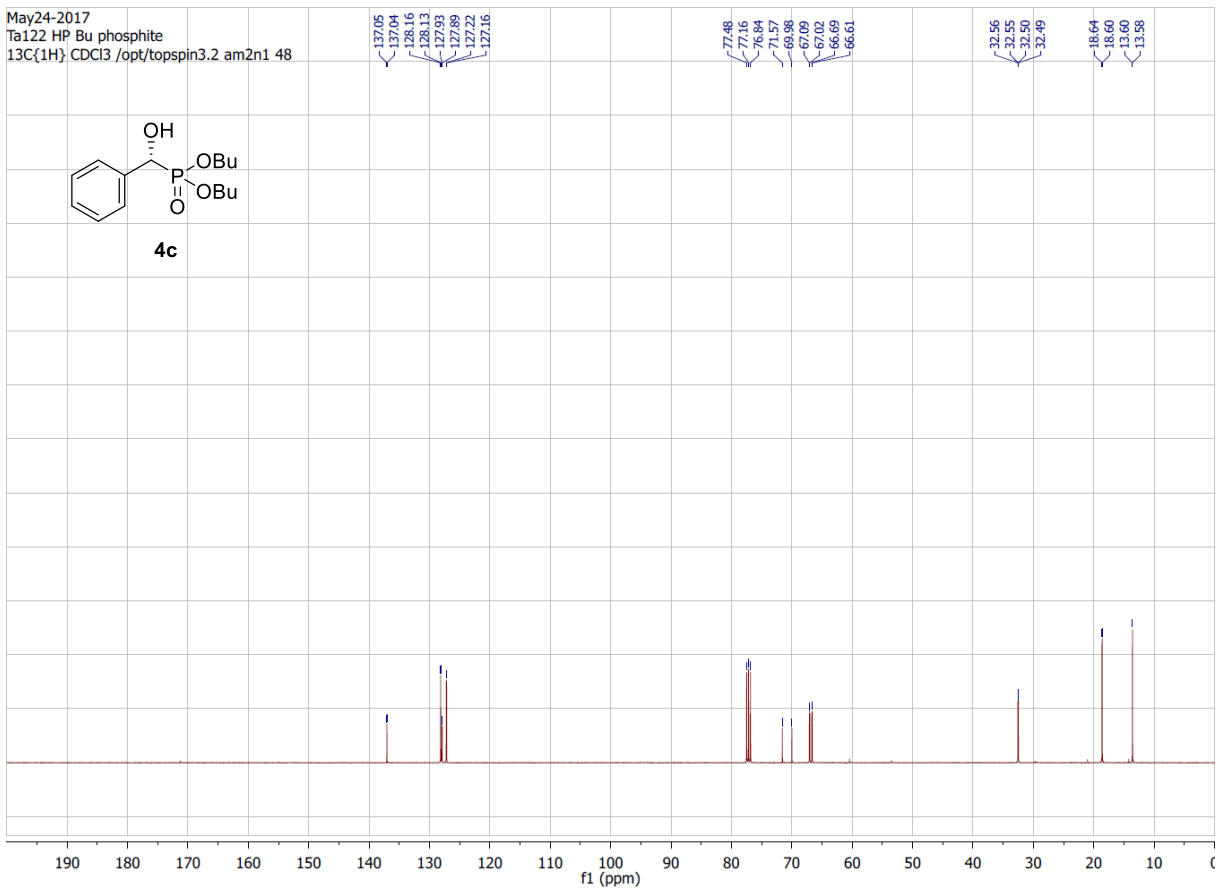
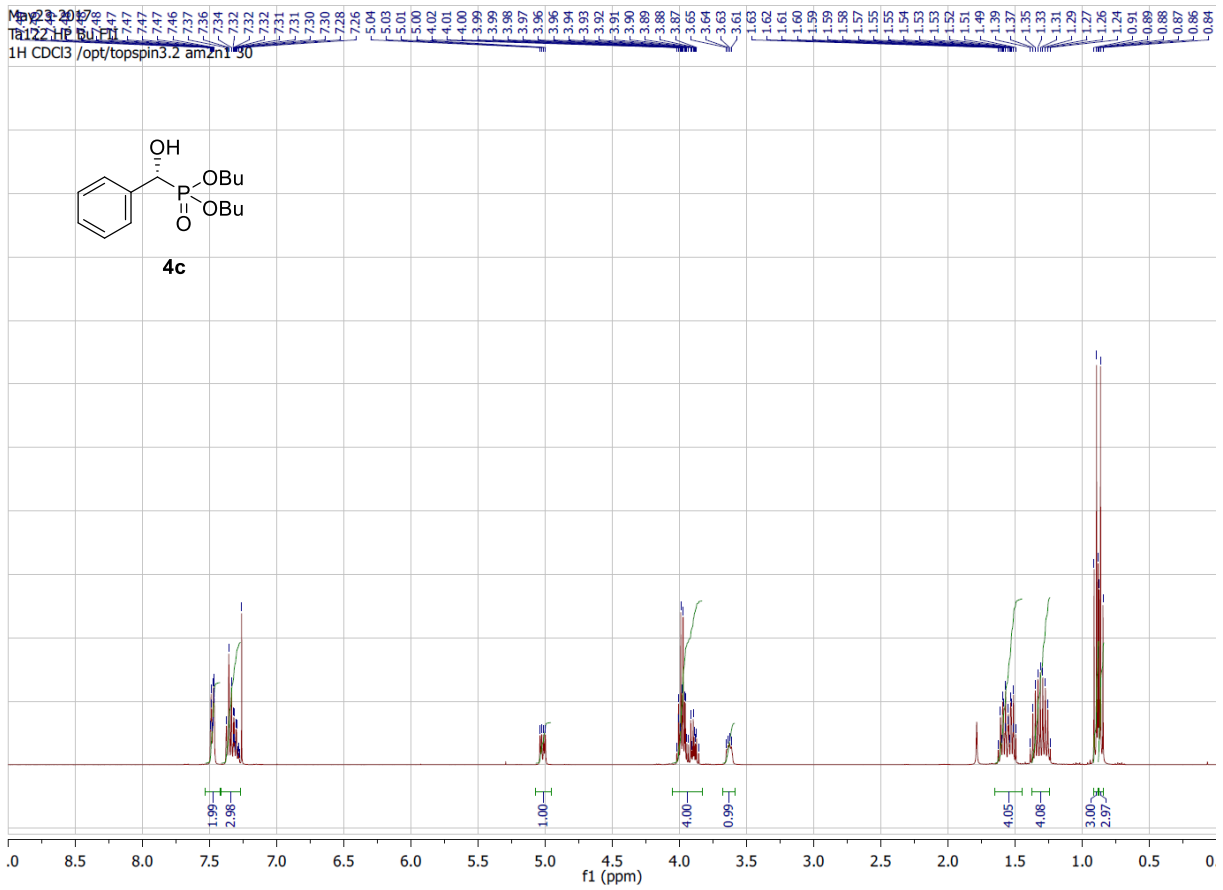
Diisopropyl (R)-(furan-2-yl(hydroxy)methyl)phosphonate (4p):

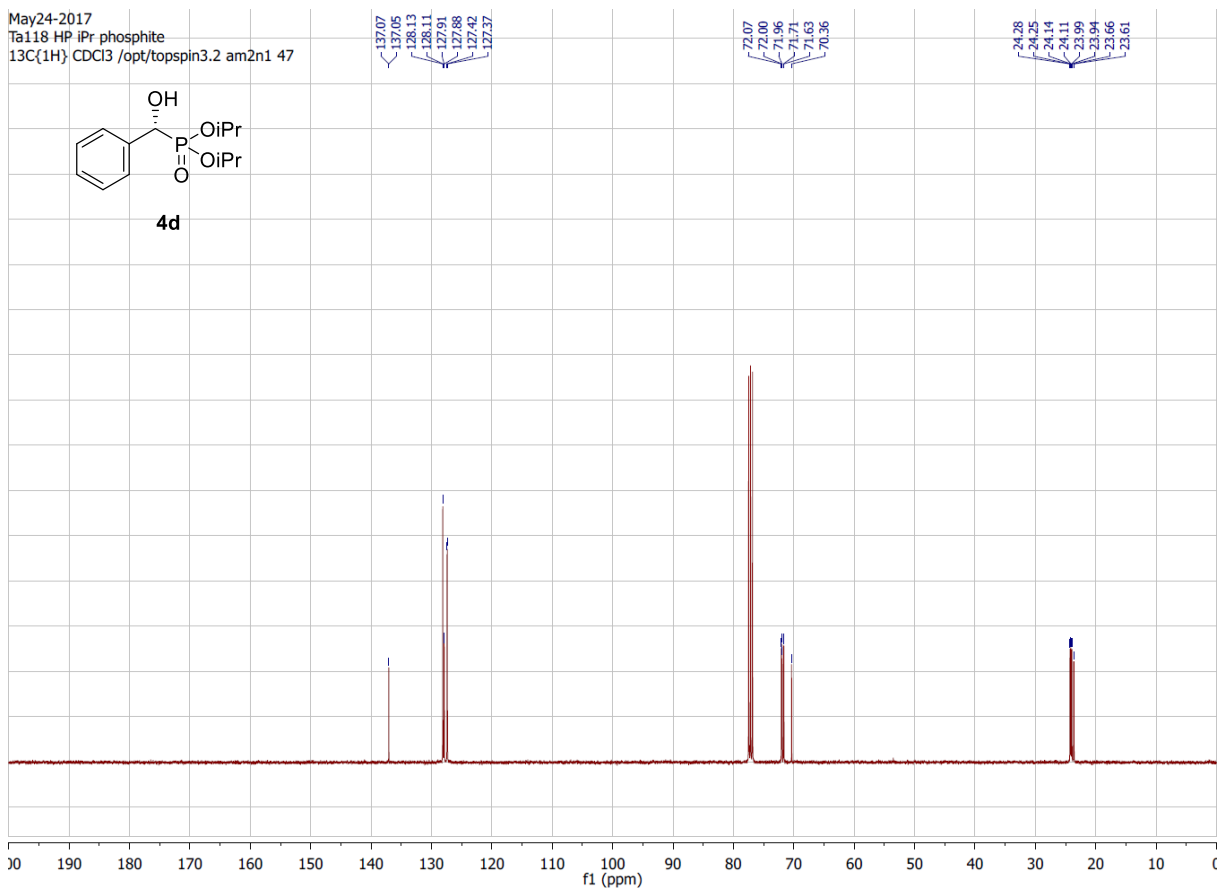
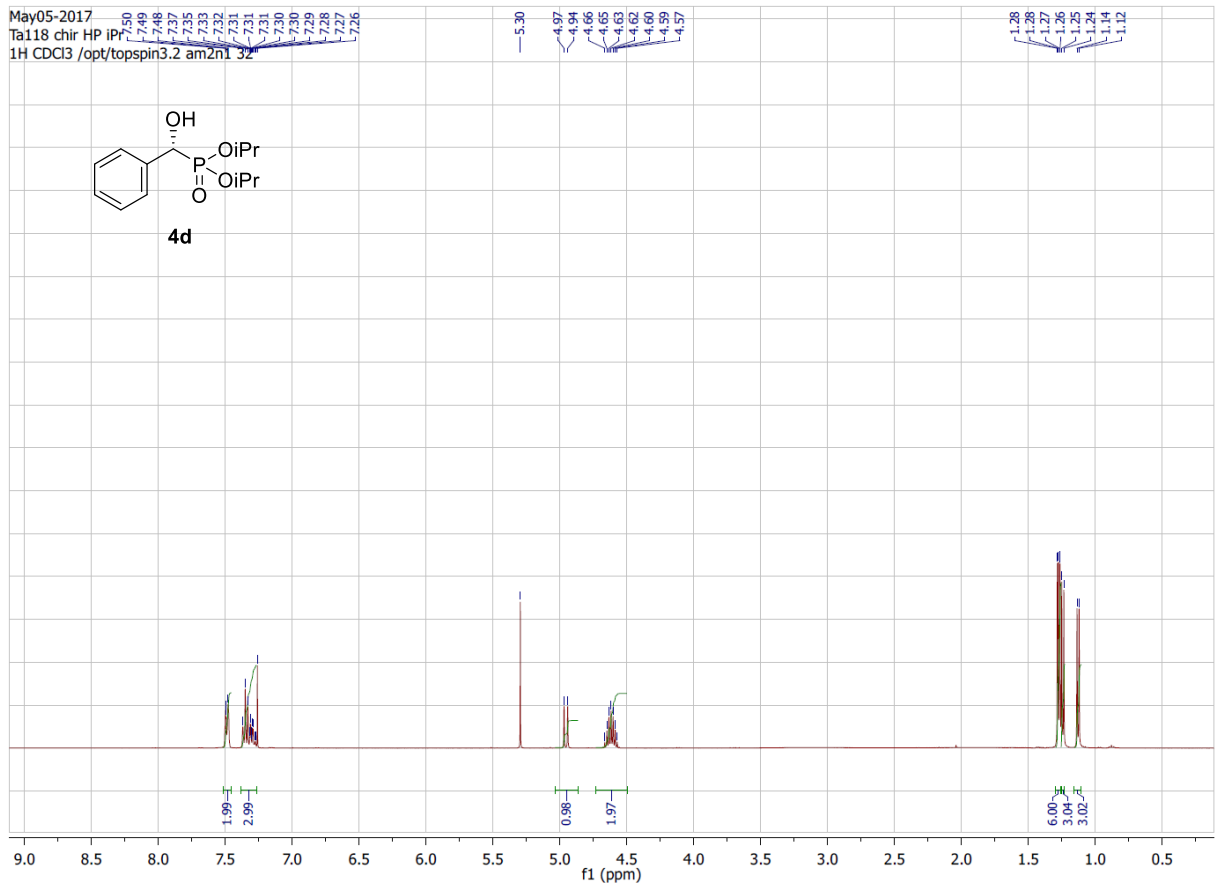
Yield = 96%; $[\alpha]^{24}_{\text{D}} = +12.16$ (c 1.03, CHCl_3). HPLC analysis: Chiralpak AS-H column, Hexane/*i*-PrOH 90:10, 1 mL/min, $\lambda = 195$ nm, $t_{\text{R}} = 8.10$ min (*R*, major), $t_{\text{R}} = 9.20$ min (*S*, minor); e.r. = 66:34. ^1H NMR (400.13 MHz, CDCl_3) δ 7.44 (d, $J = 0.8$ Hz, 1H), 6.53 (t, $J = 2.9$ Hz, 1H), 6.40 (dd, $J = 3.1, 1.9$ Hz, 1H), 4.95 (d, $J = 13.4$ Hz, 1H), 4.83–4.64 (m, 2H), 1.37–1.32 (m, 9H), 1.20 (d, $J = 6.2$ Hz, 3H). ^{13}C NMR (100.61 MHz, CDCl_3) δ 150.74 (d, $J = 2.5$ Hz), 142.36 (d, $J = 2.5$ Hz), 110.65 (d, $J = 1.9$ Hz), 109.09 (d, $J = 5.8$ Hz), 72.30 (d, $J = 7.2$ Hz), 71.88 (d, $J = 7.3$ Hz), 64.94 (d, $J = 168.7$ Hz), 24.23 (d, $J = 3.0$ Hz), 24.08 (d, $J = 3.6$ Hz), 23.88 (d, $J = 4.9$ Hz), 23.56 (d, $J = 5.4$ Hz). ^{31}P (CDCl_3 , 161.97 MHz) δ (ppm) = 17.56 (s). HRMS (ESI, $\text{M}+\text{H}^+$) m/z calcd for $\text{C}_{11}\text{H}_{20}\text{O}_5\text{P}$: 263.1048, found 263.1048.

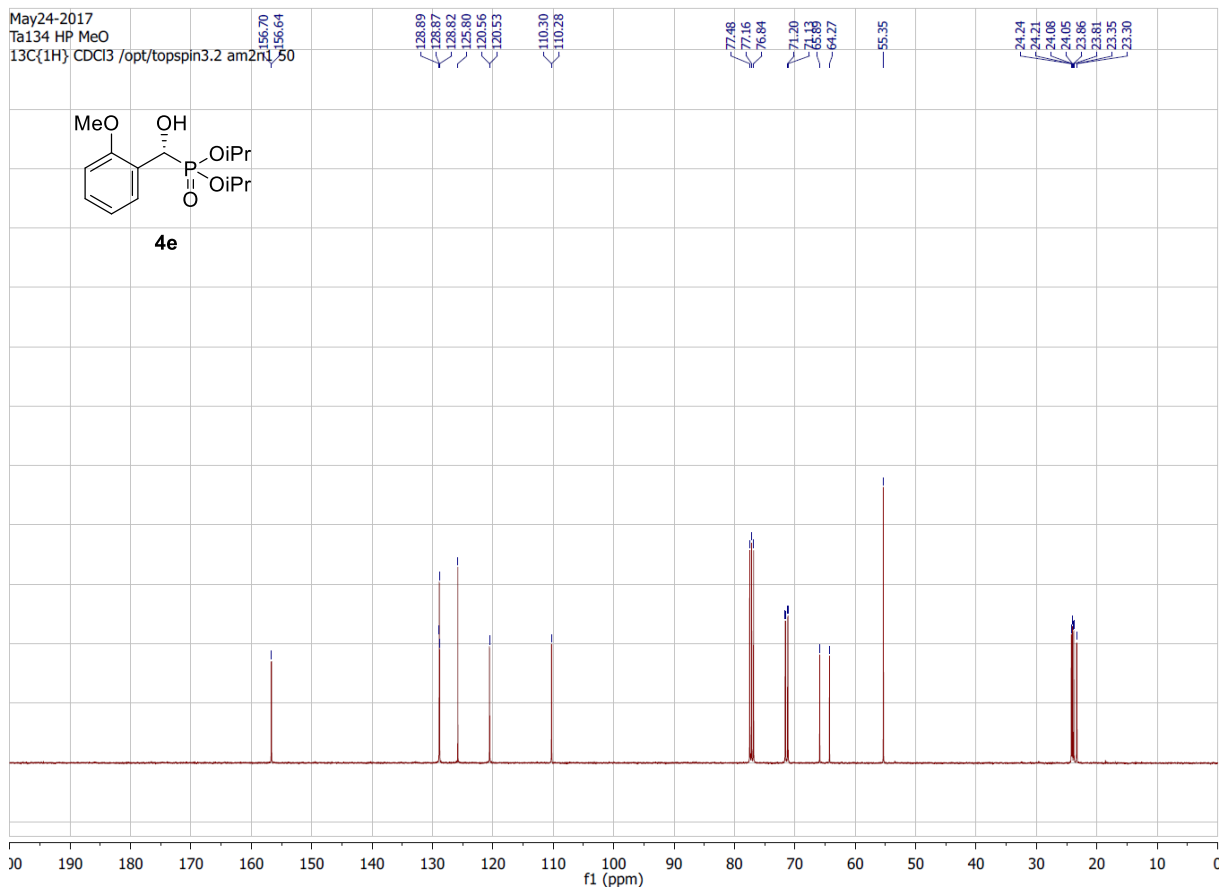
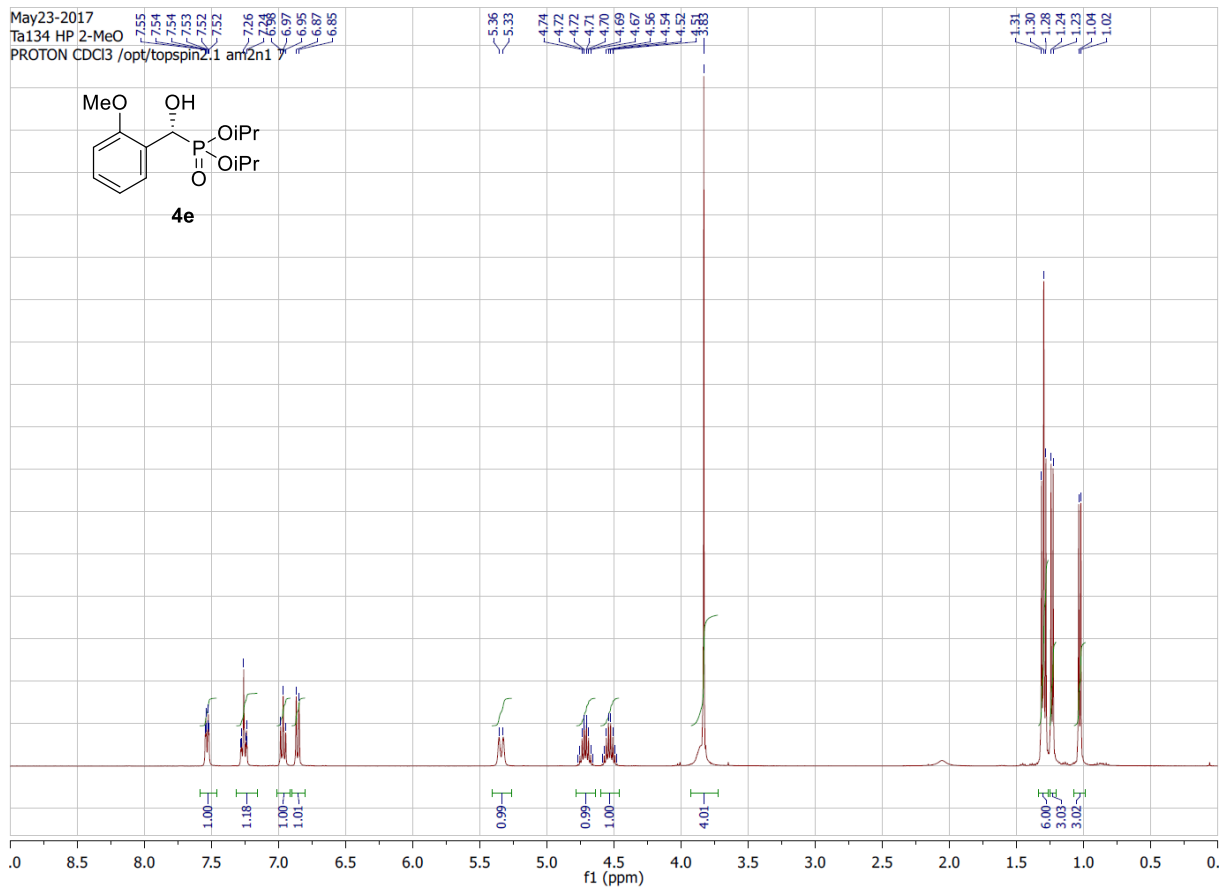
IV. ¹H and ¹³C NMR Spectra of phosphorylation products 4a-p

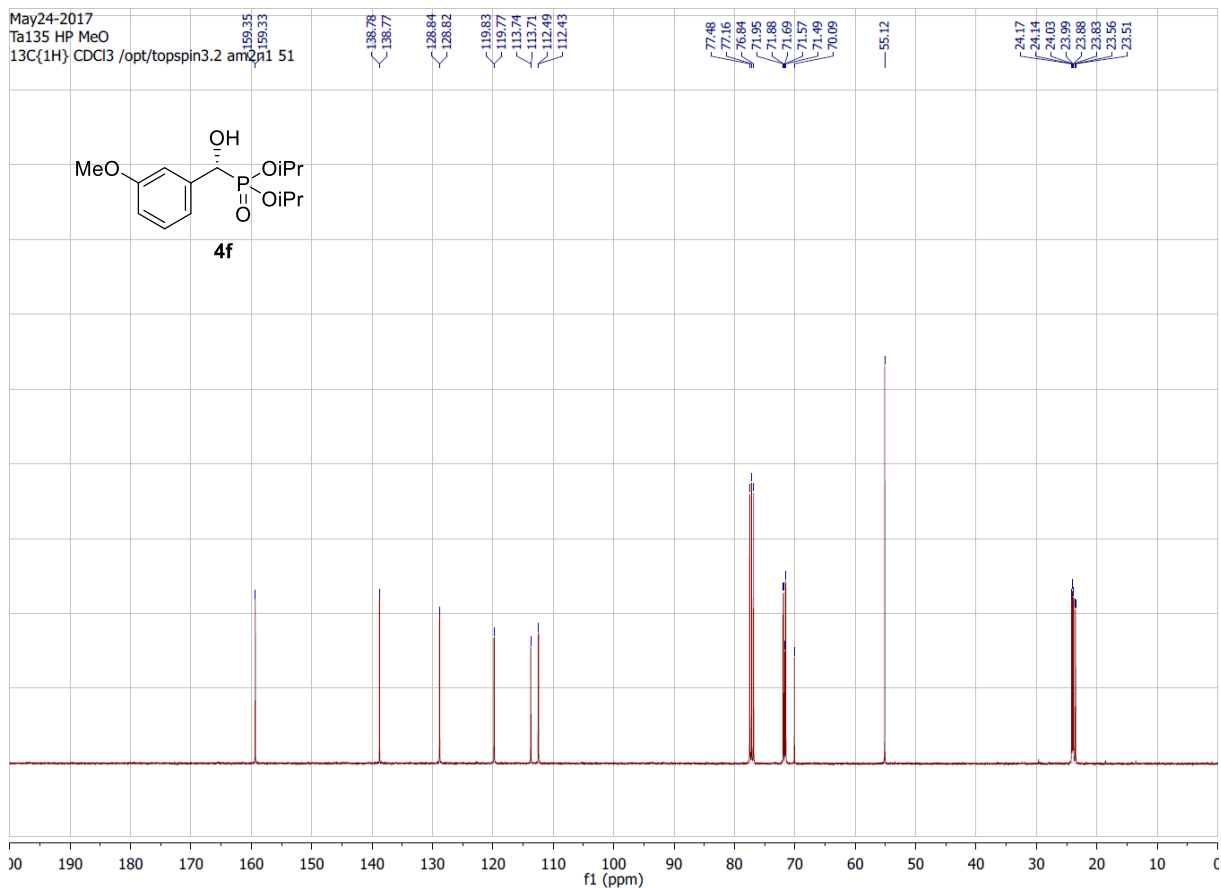
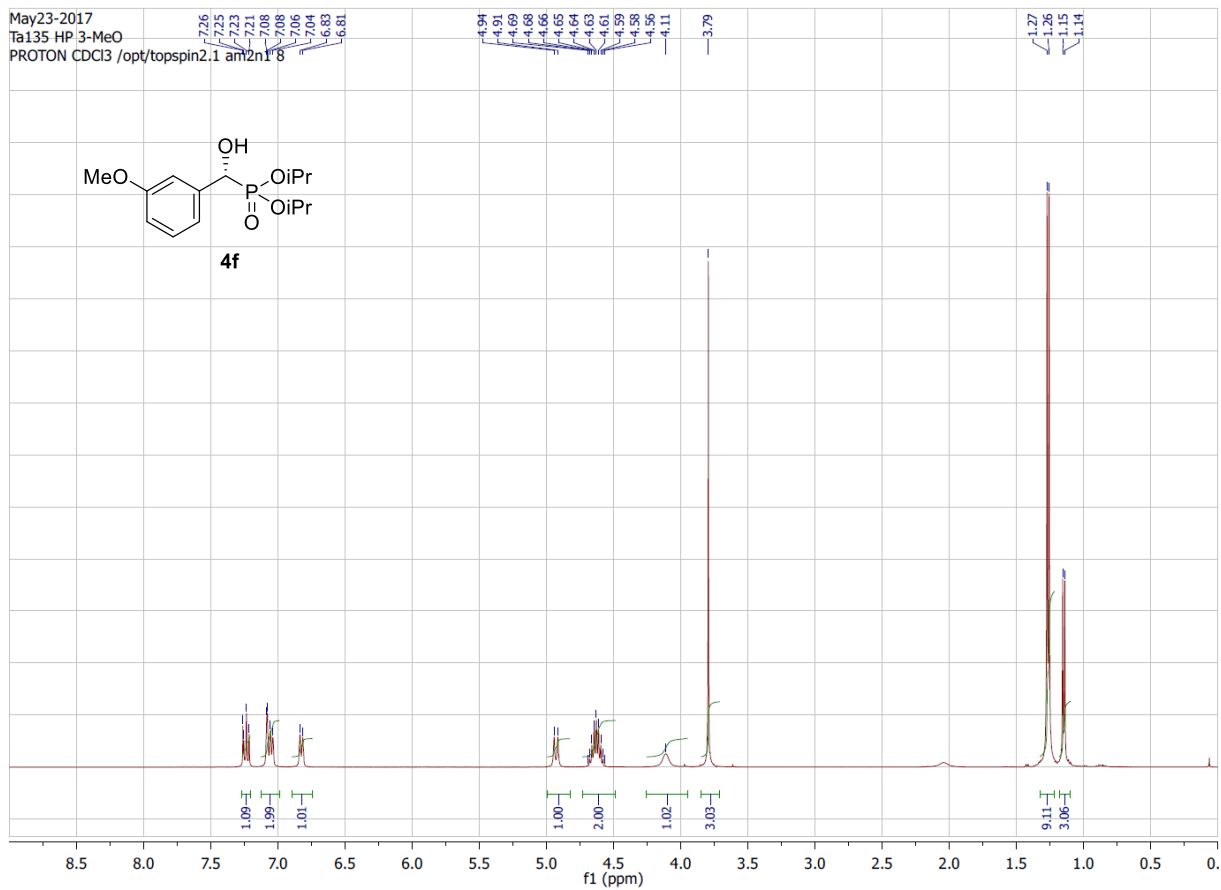


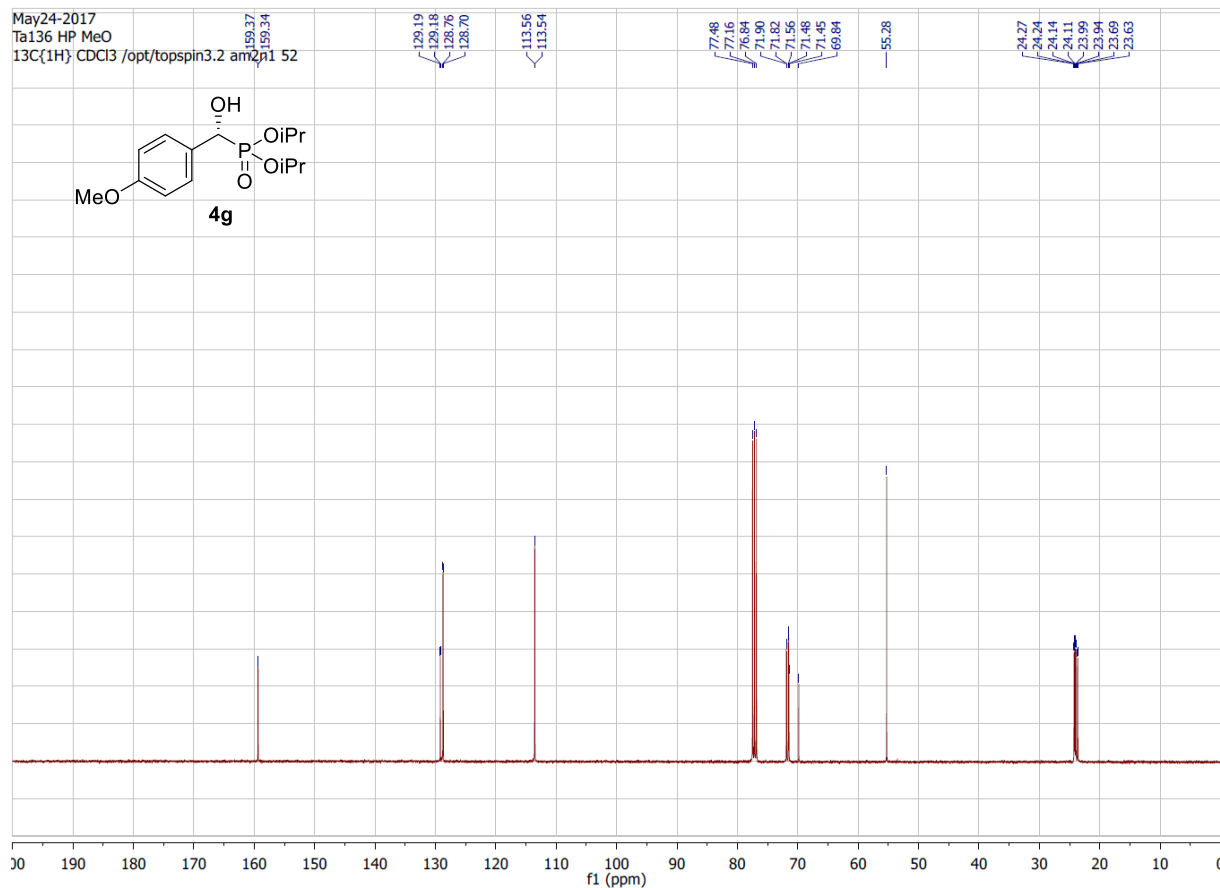
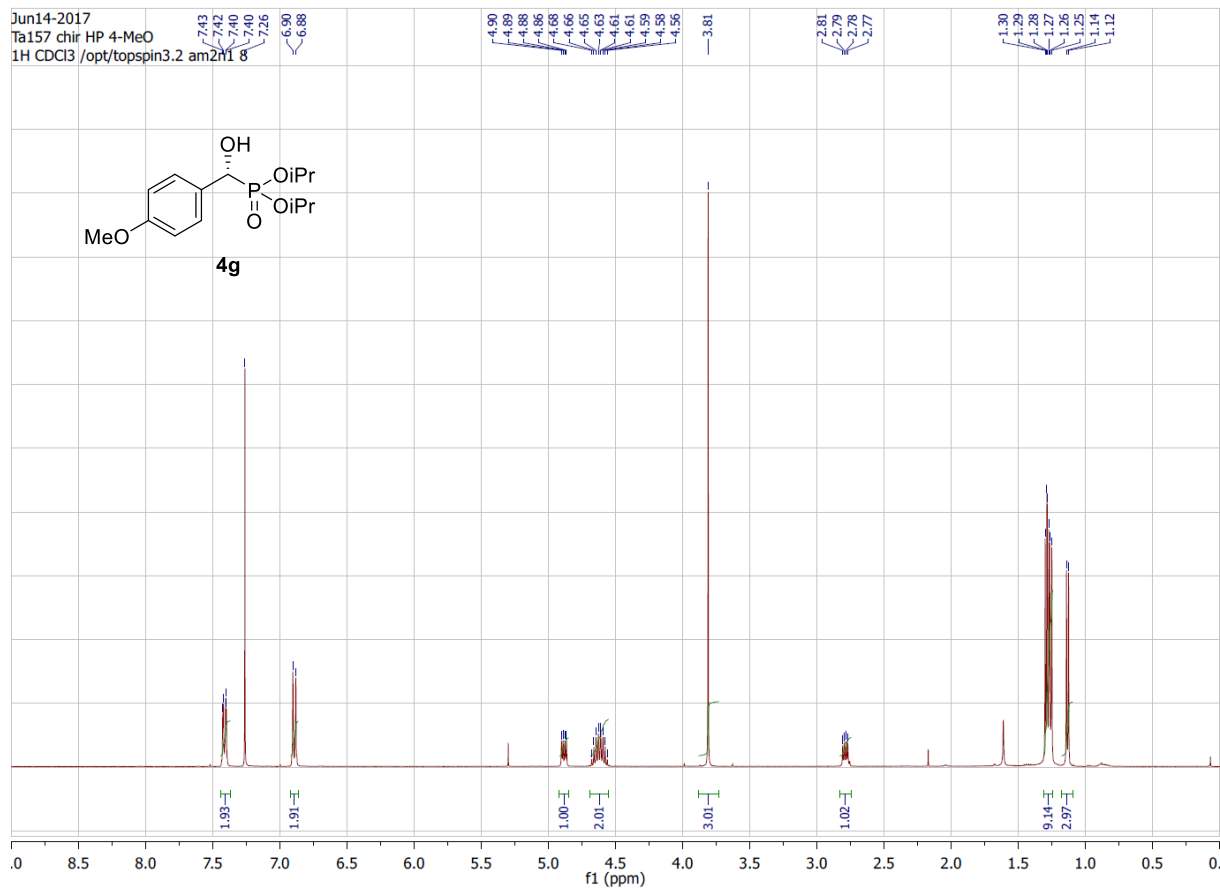


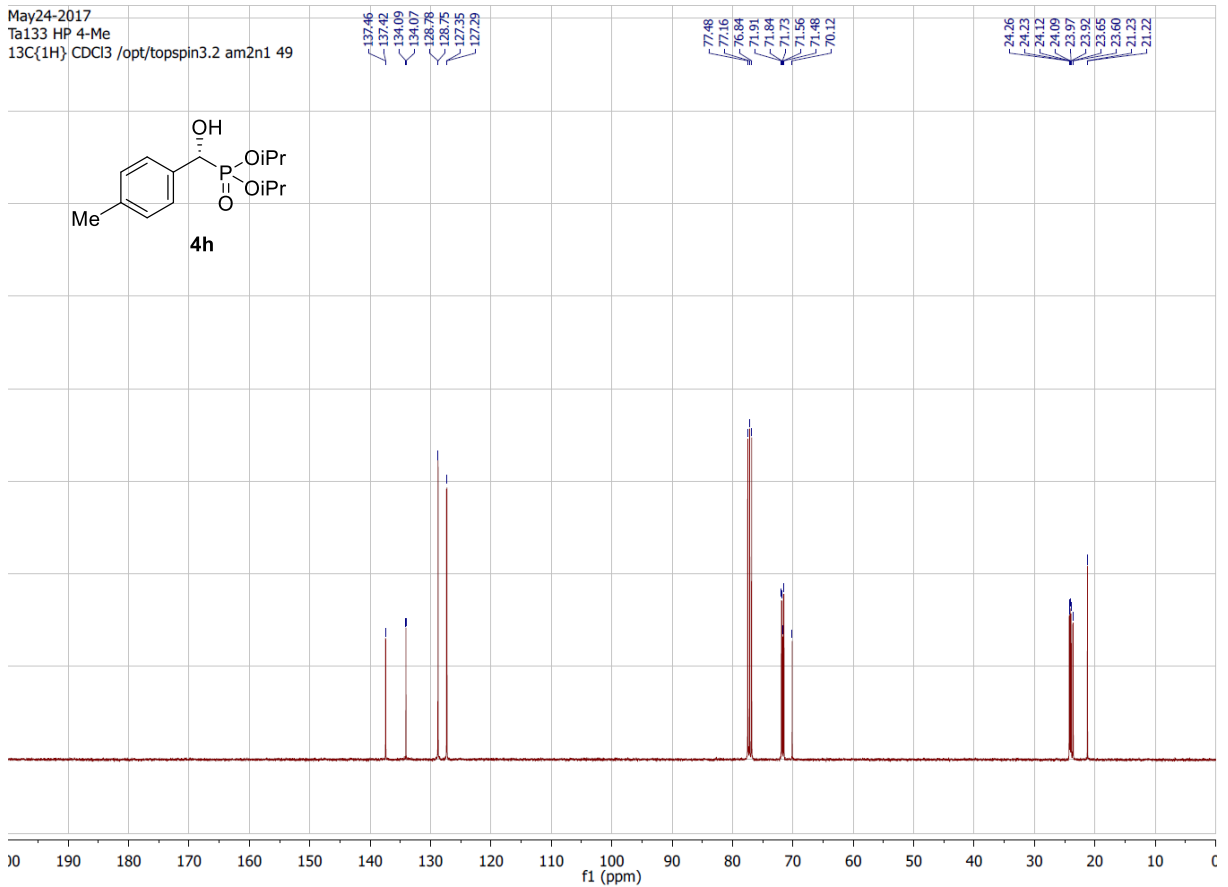
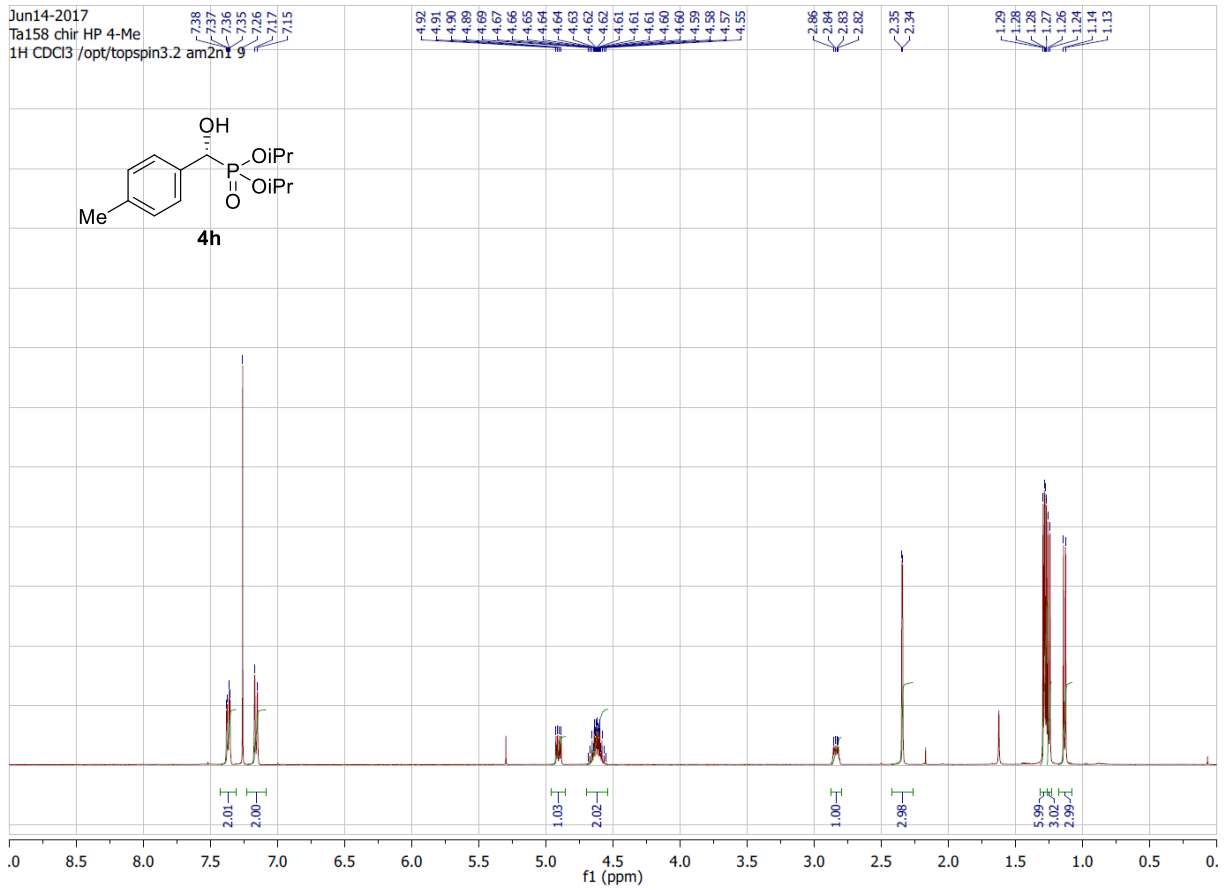


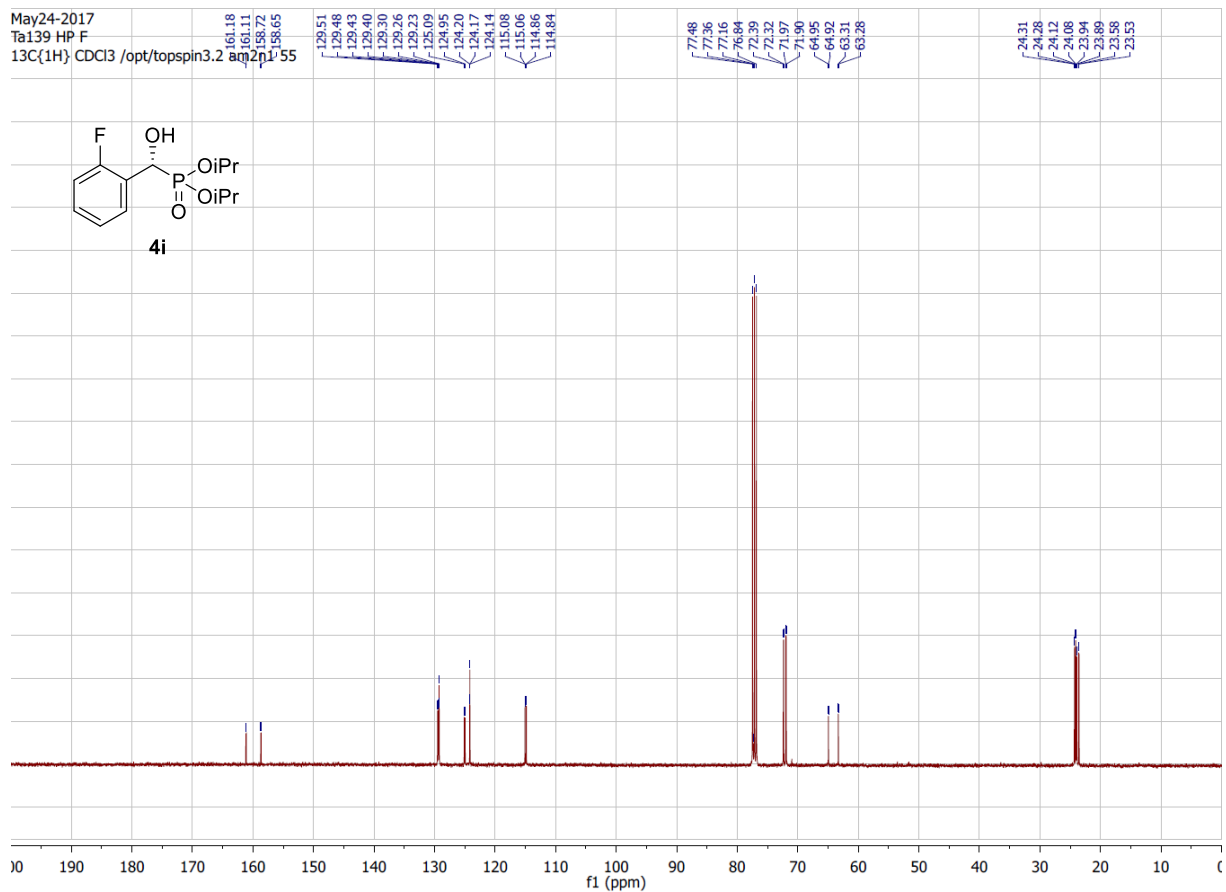
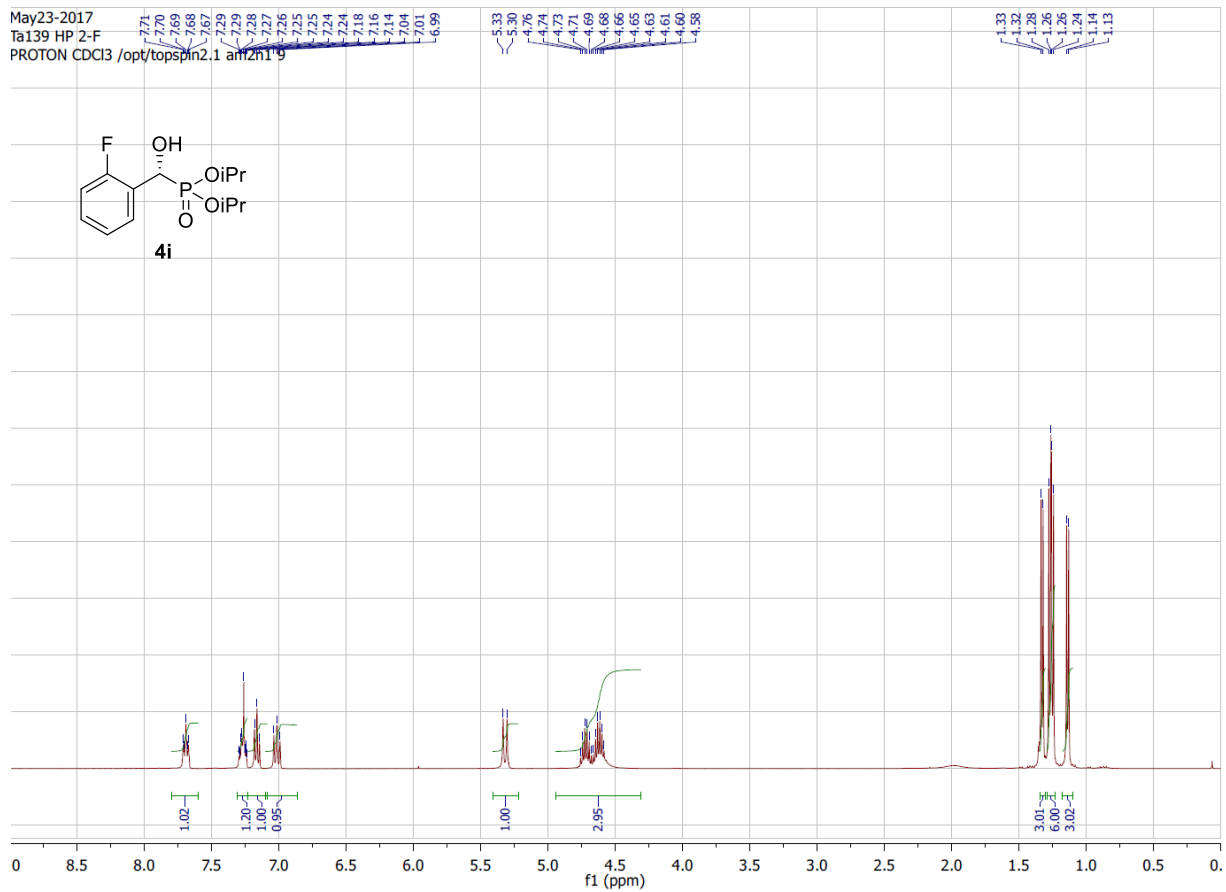


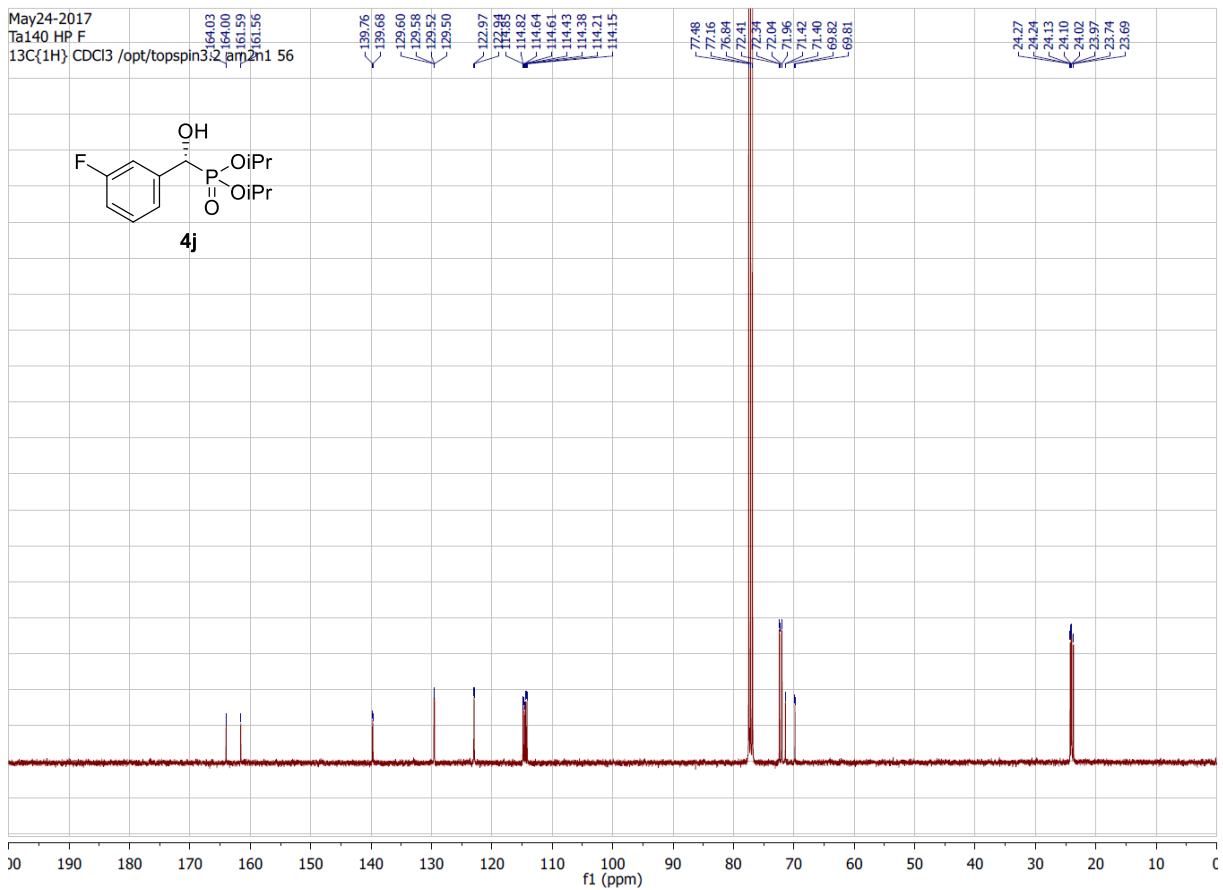
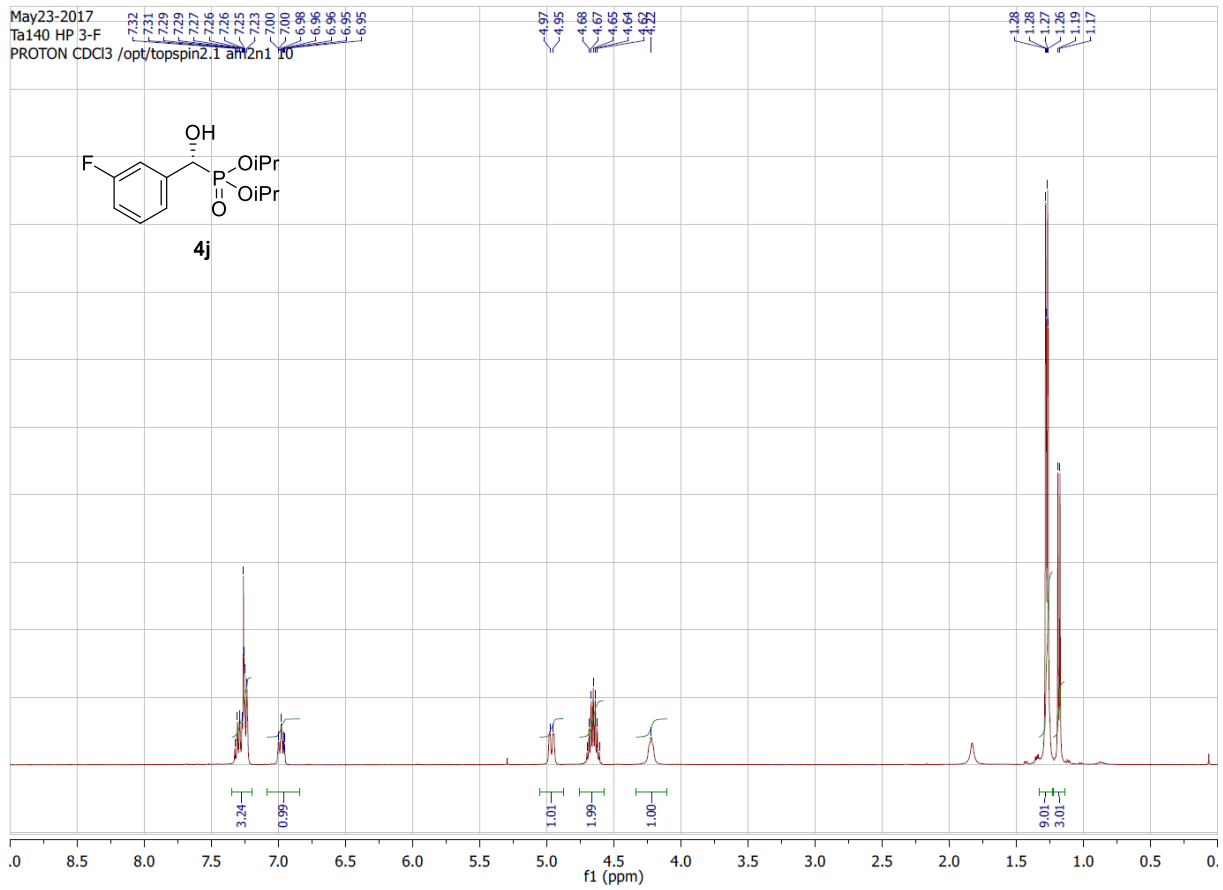


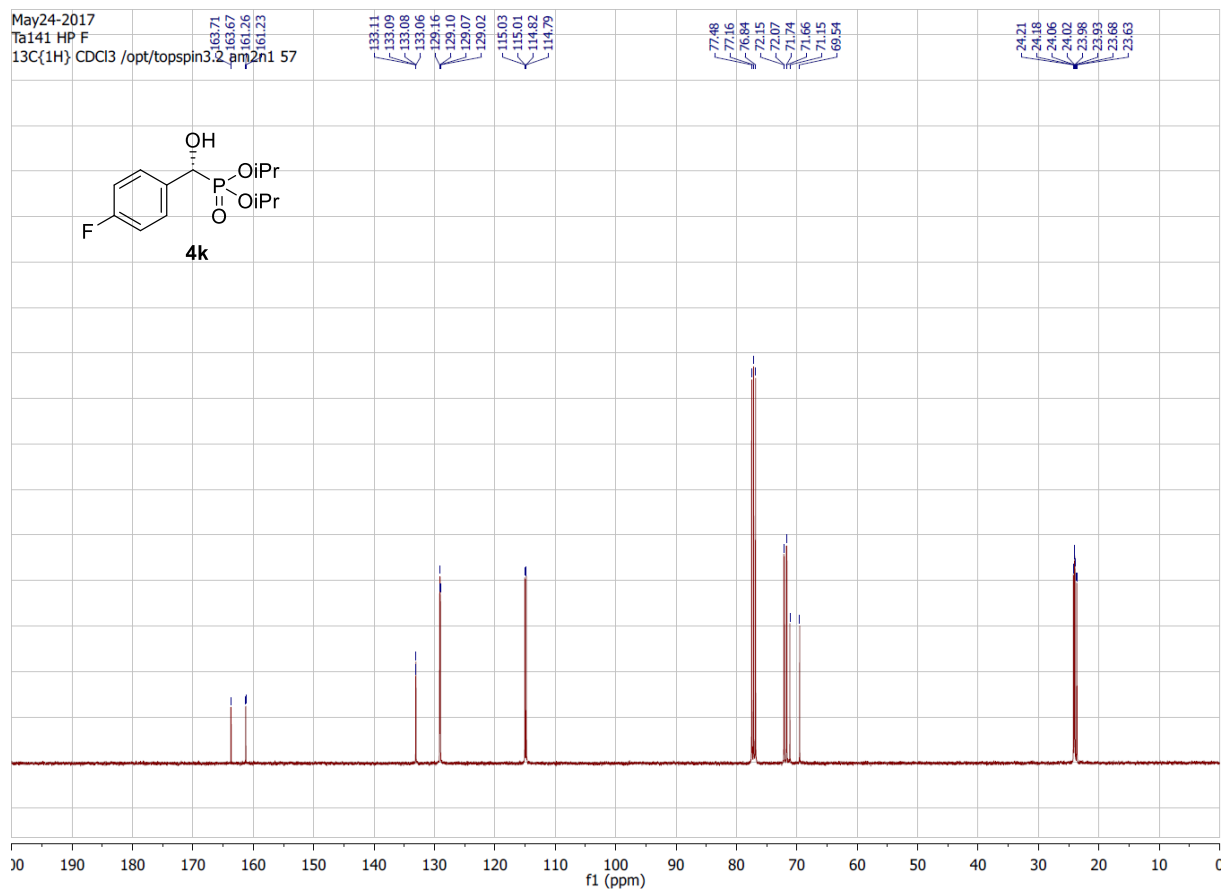
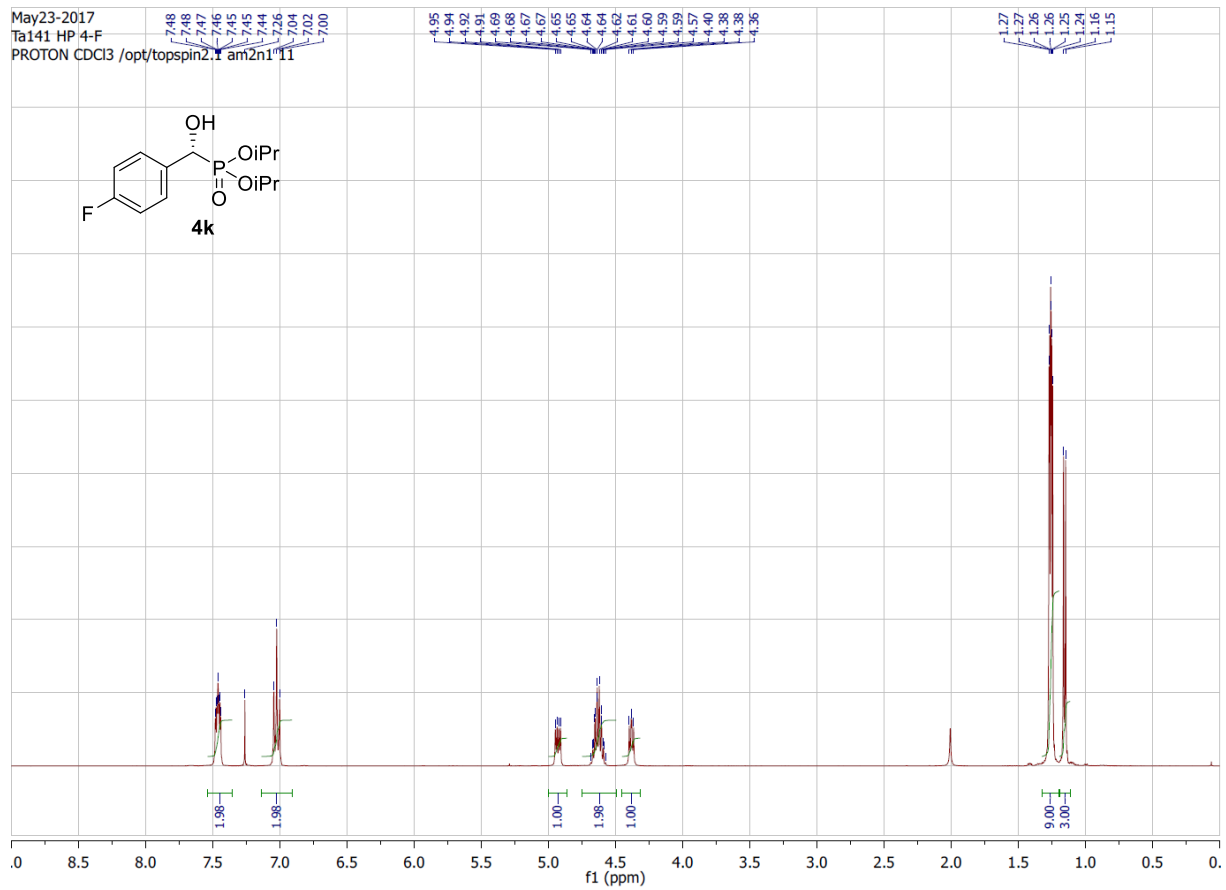


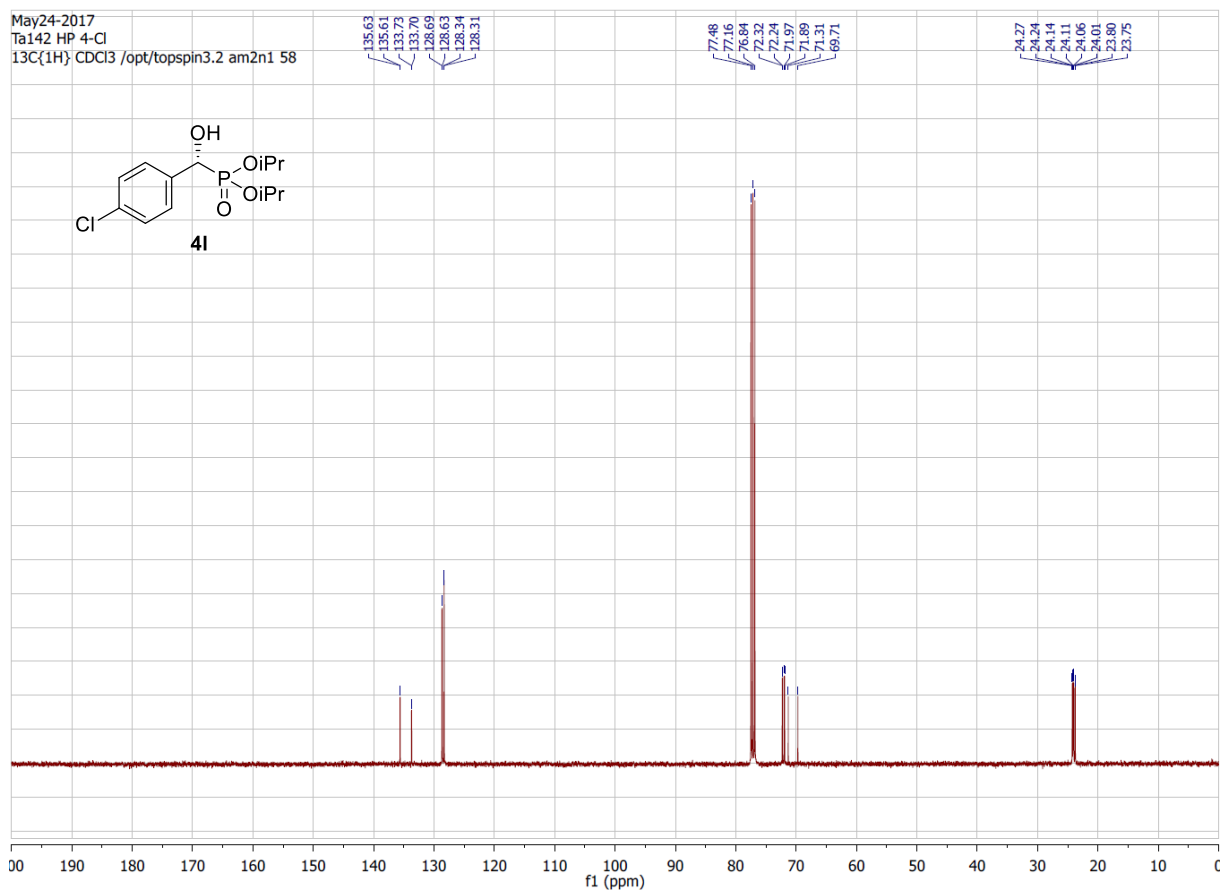
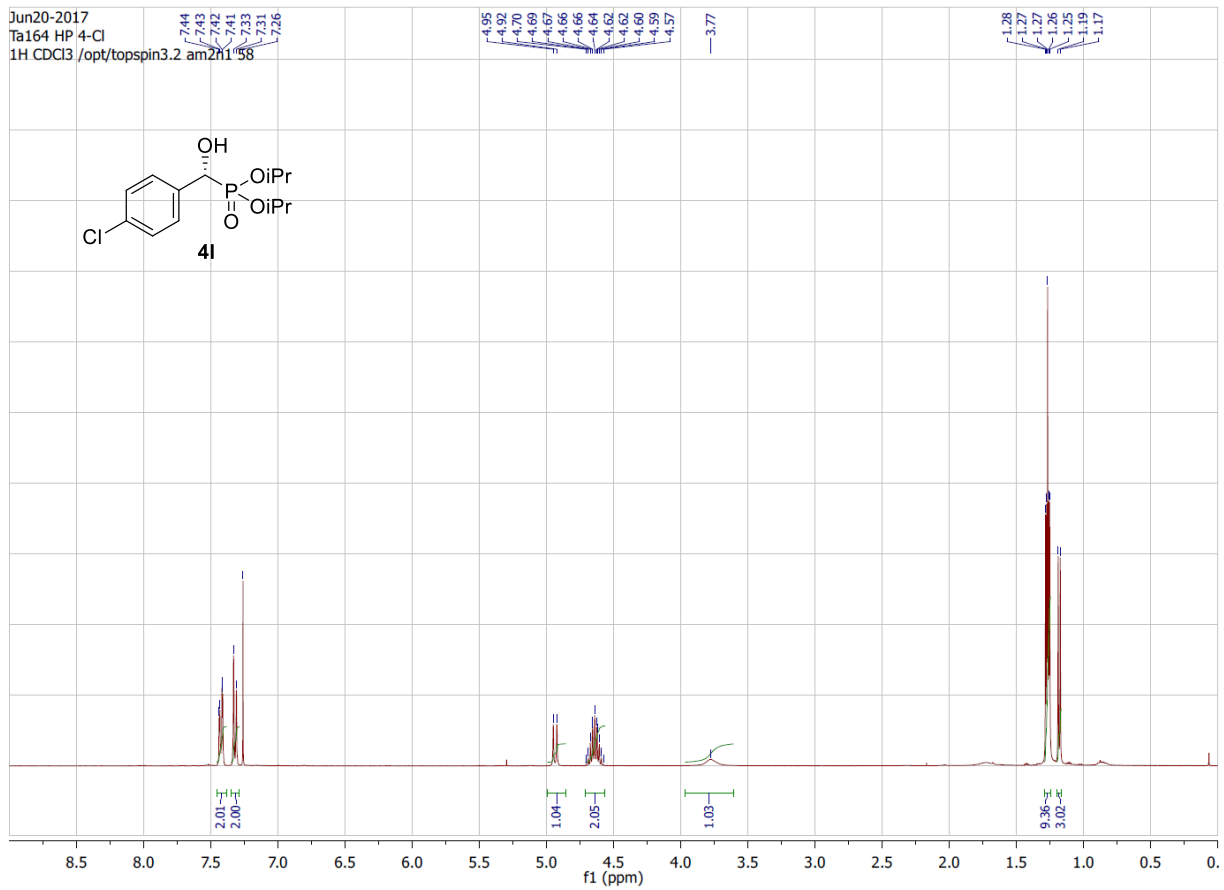


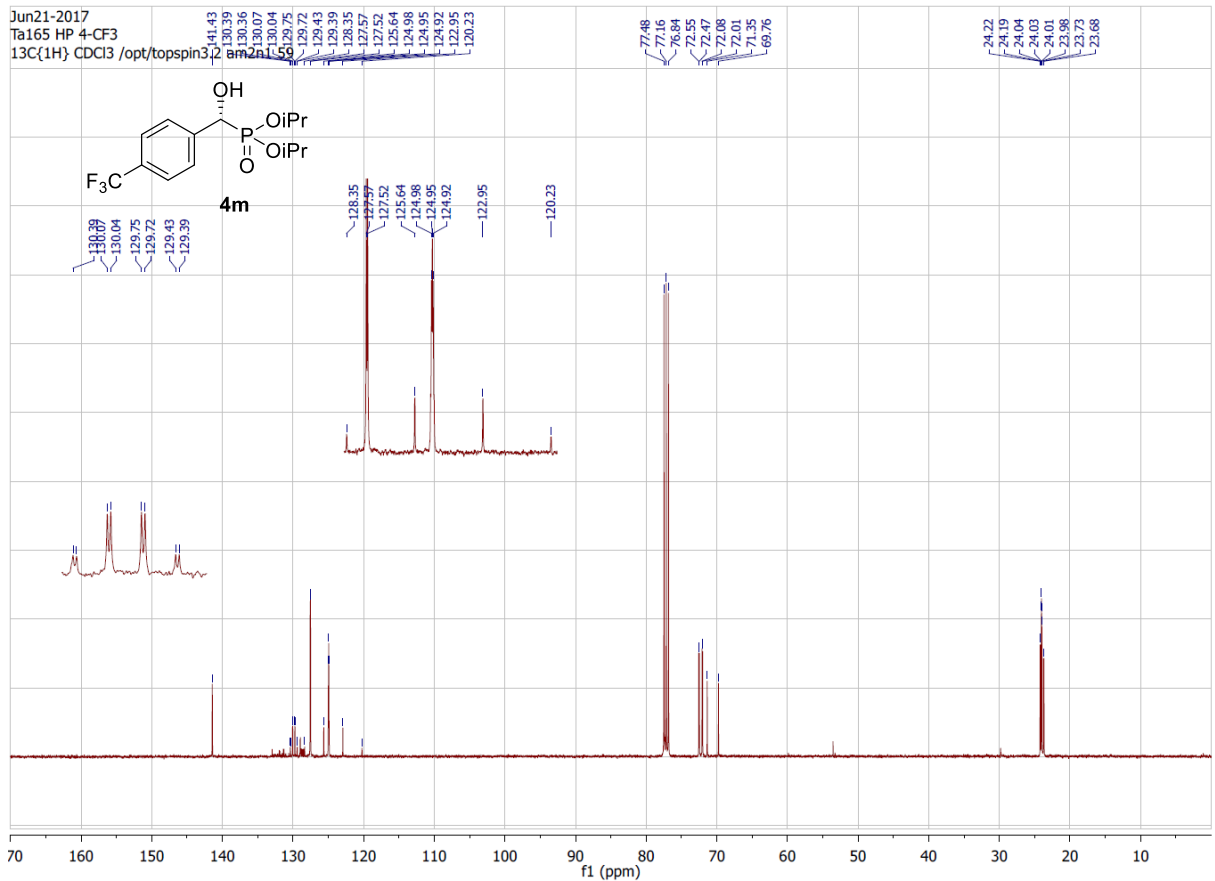
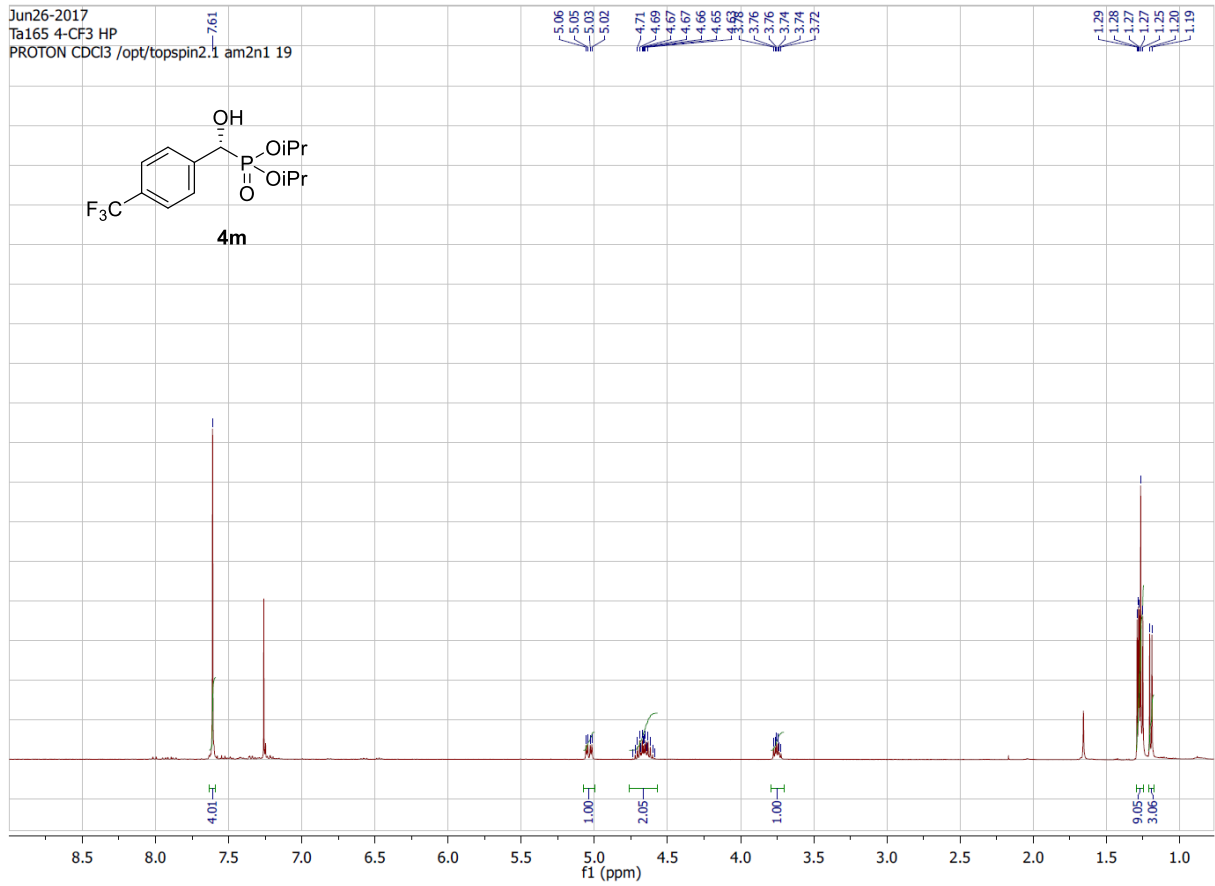


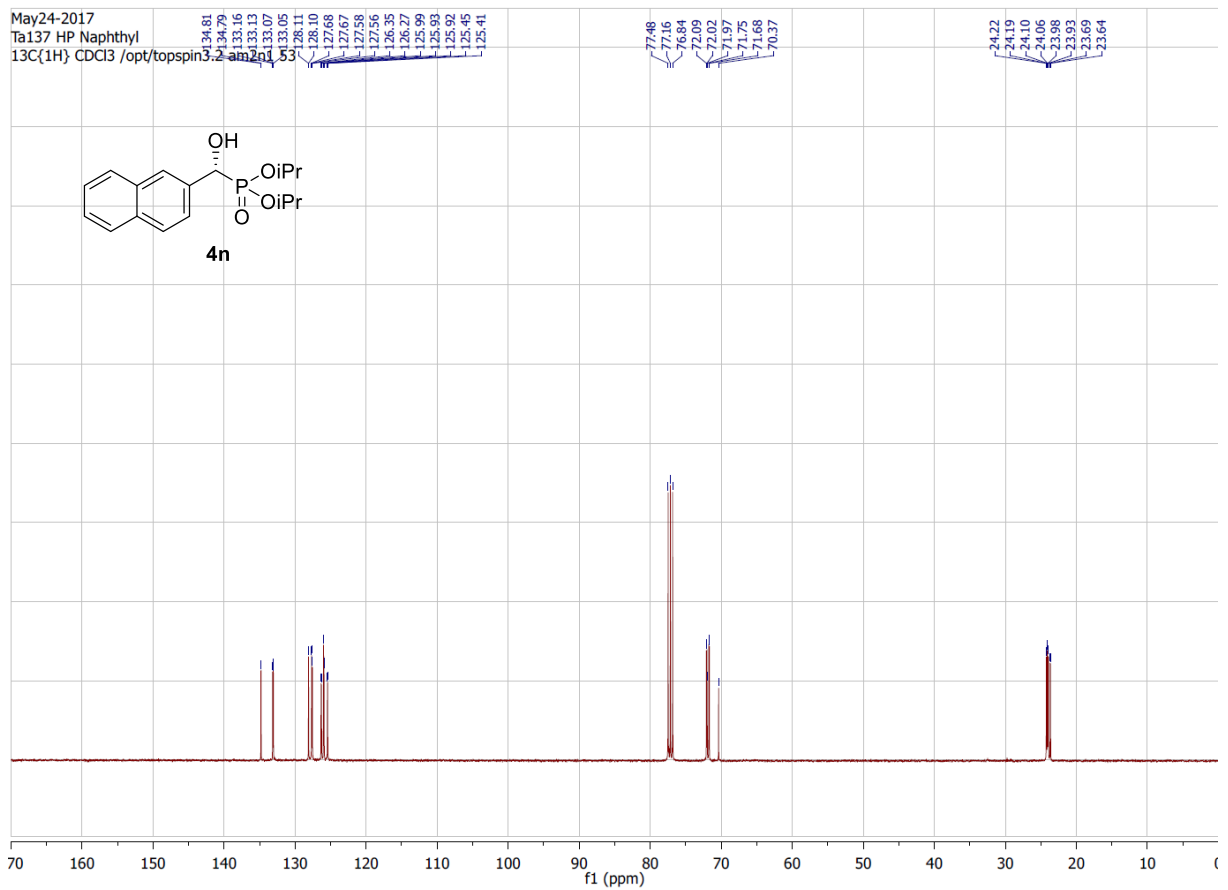
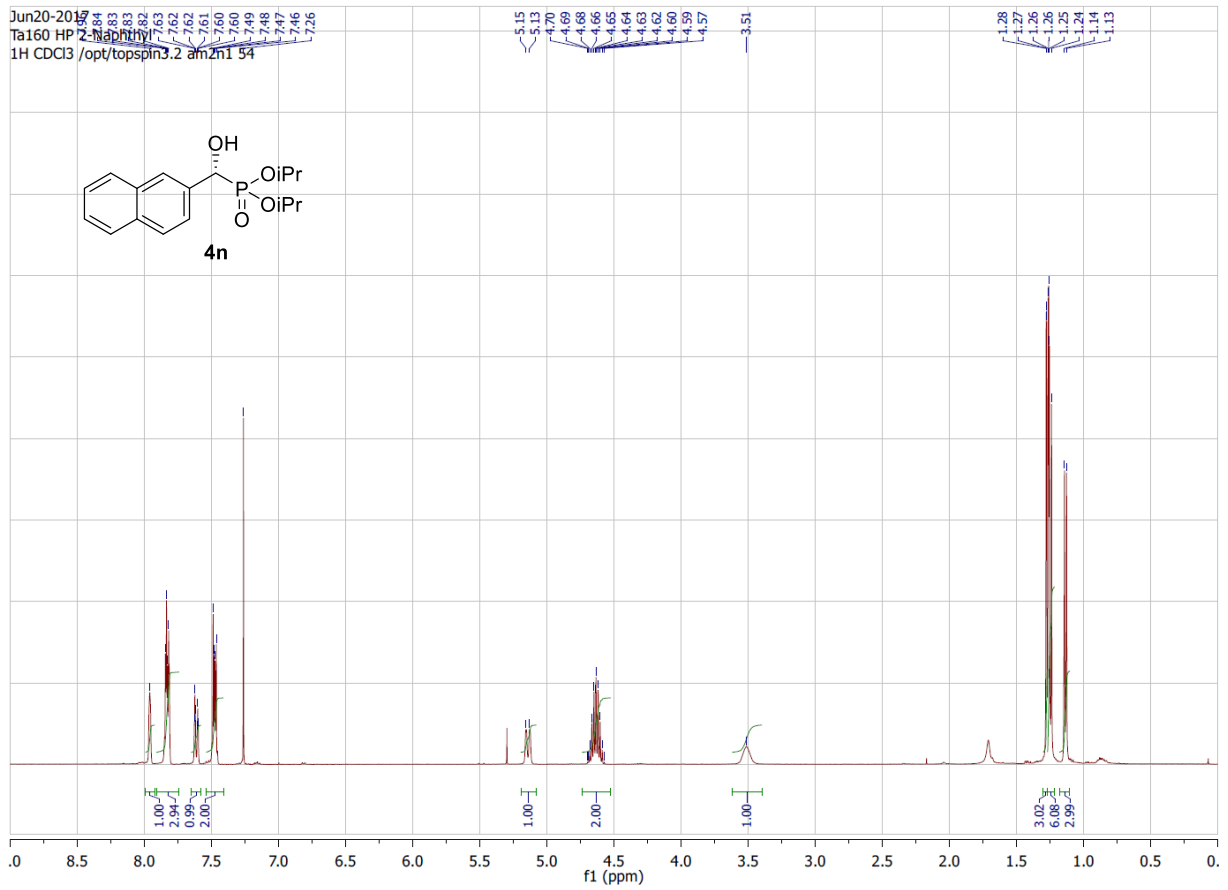


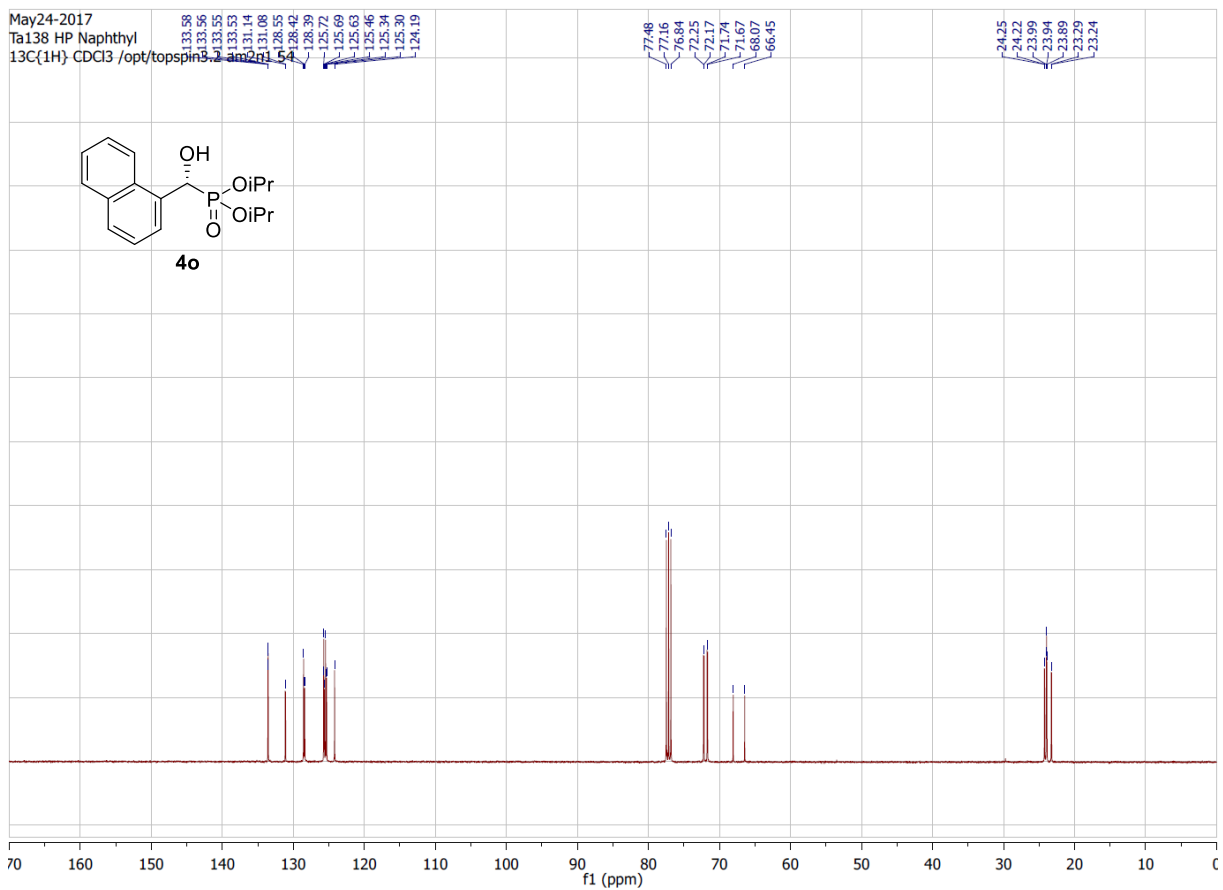
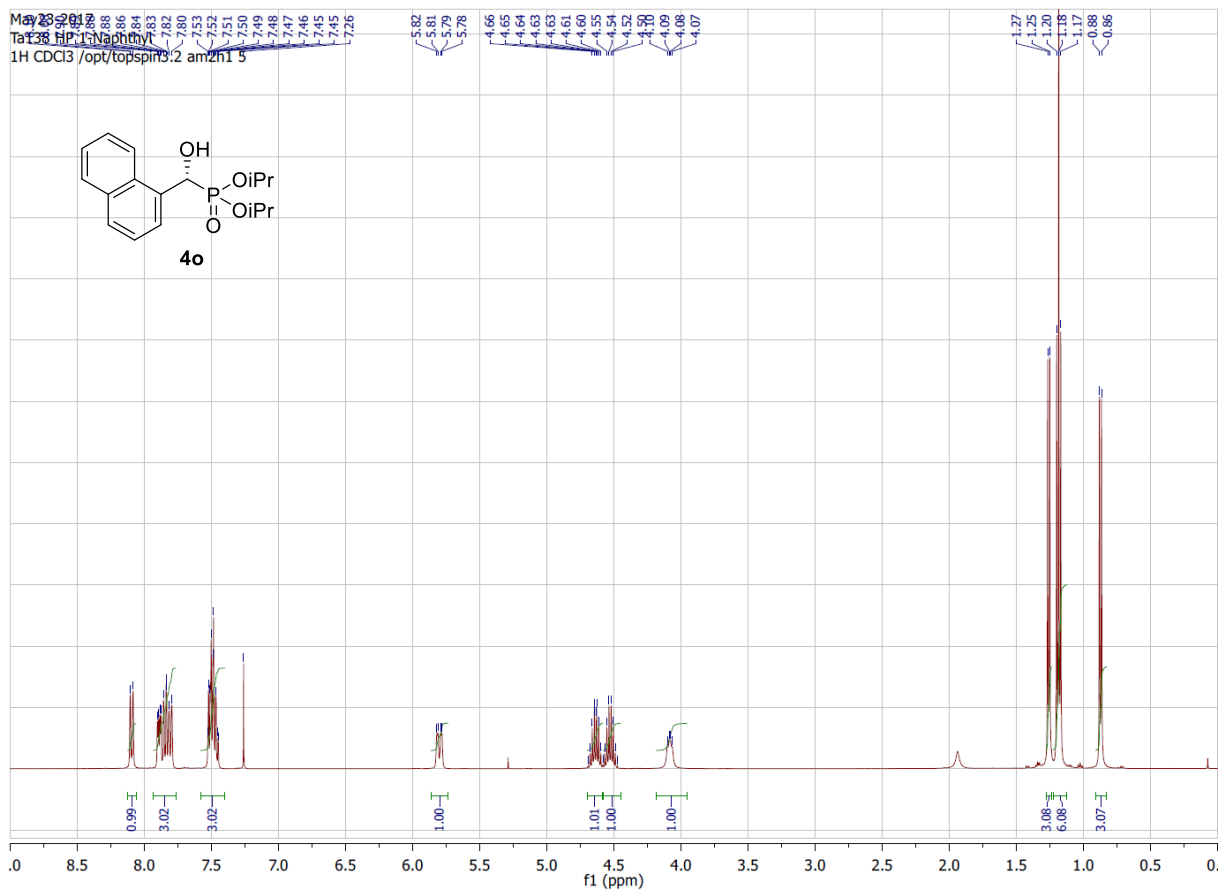


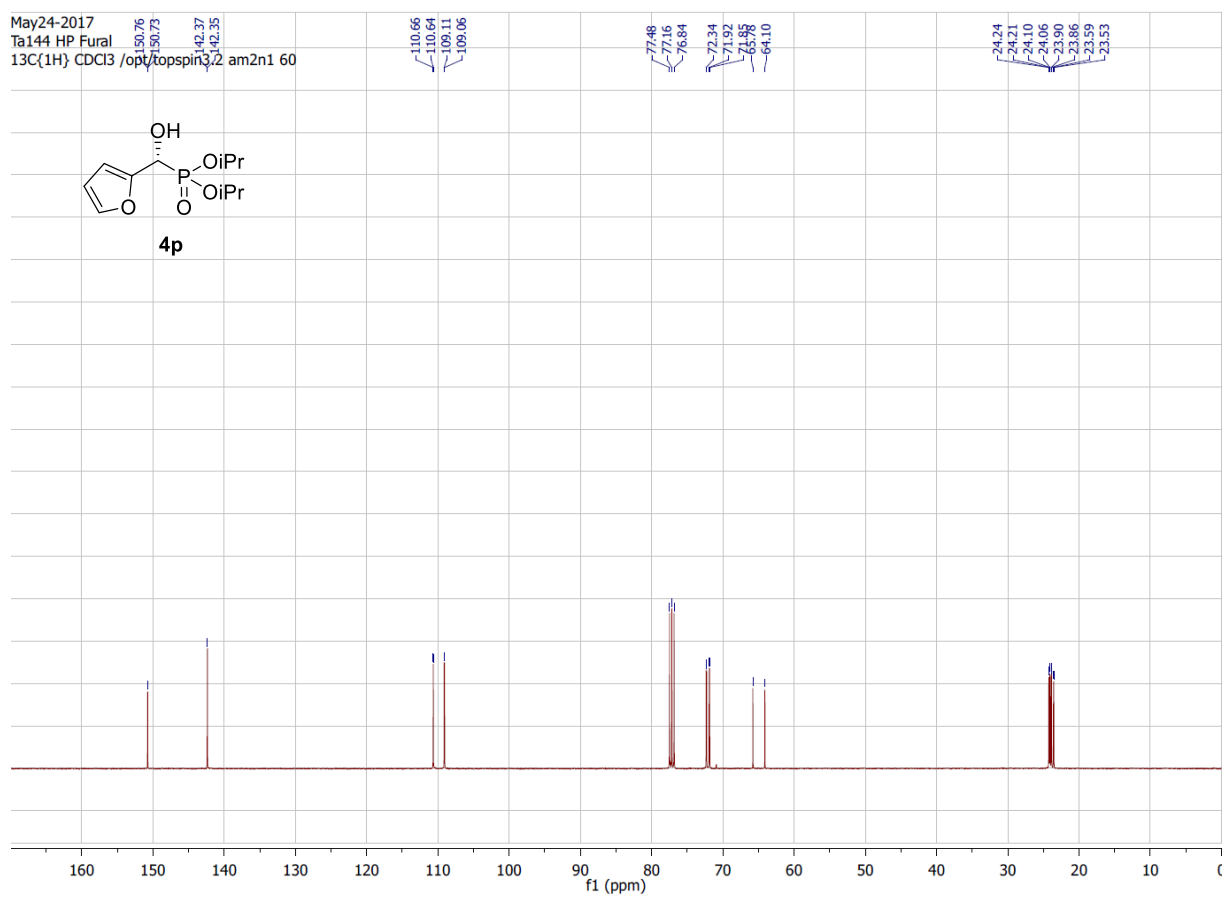
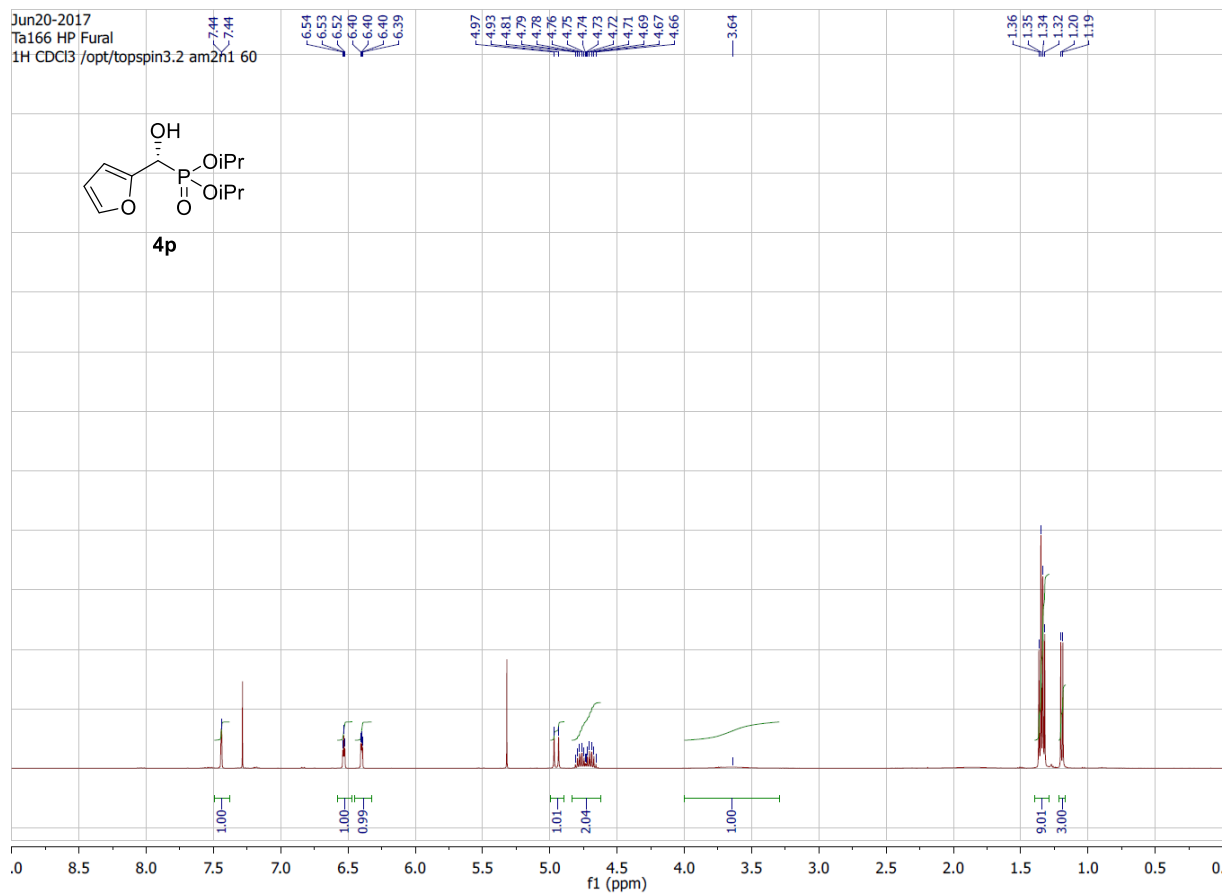






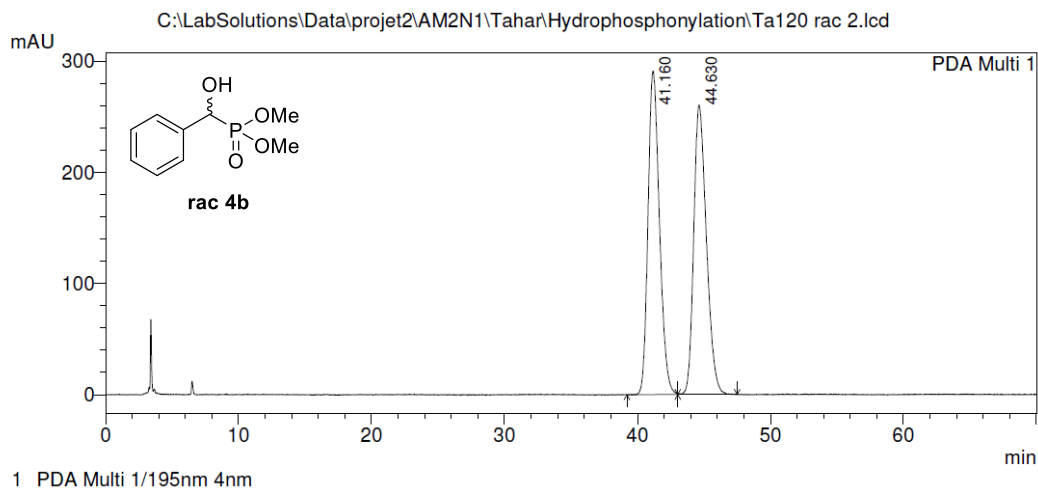






V. HPLC chromatogram of phosphorylation products 4a-p

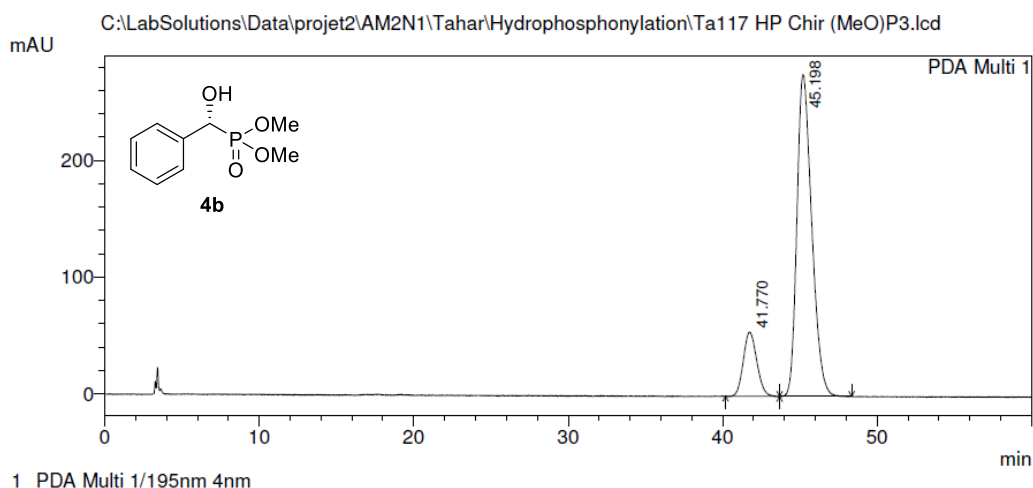
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta120 rac 2.lcd
 Sample Name : Ta120 rac 2
 Vial # : 1
 Injection Volume : 20 uL
 Data File Name : Ta120 rac 2.lcd
 Method File Name : IC 90-10 70min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 04/05/2017 17:58:53



PeakTable

Peak#	Ret. Time	Area	Height	Area %
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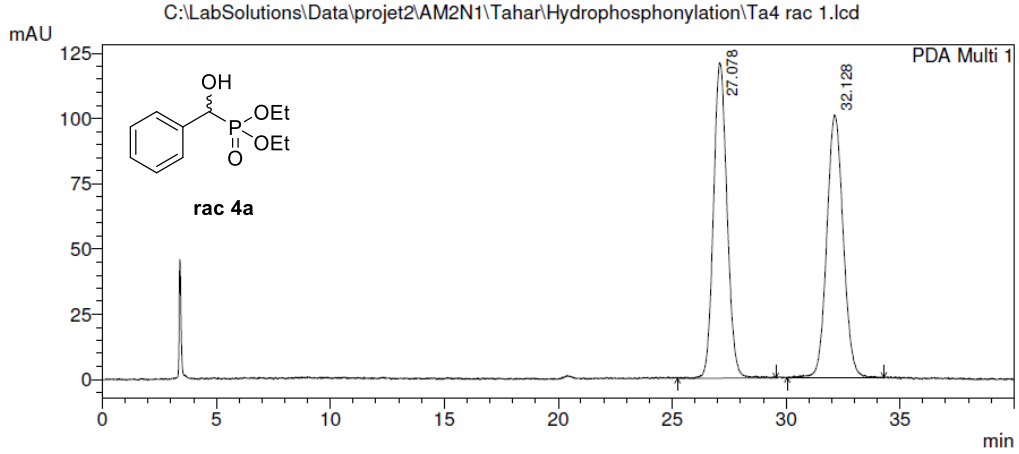
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta117 HP Chir (MeO)P3.lcd
 Sample Name : Ta117 HP Chir (MeO)P3
 Vial # : 5
 Injection Volume : 10 uL
 Data File Name : Ta117 HP Chir (MeO)P3.lcd
 Method File Name : IC 90-10 60min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 23/05/2017 12:02:10



PeakTable

Peak#	Ret. Time	Area	Height	Area %
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Sample Name : Ta4 rac 1
 Vial # : 1
 Injection Volume : 12 uL
 Data File Name : Ta4 rac 1.lcd
 Method File Name : IC 90-10 40min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 04/05/2017 11:36:05

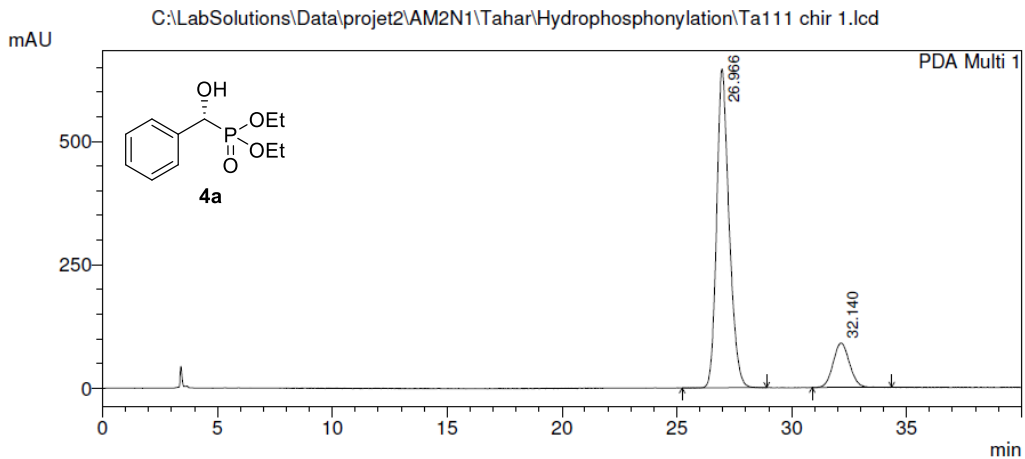


1 PDA Multi 1/195nm 4nm

PeakTable

Peak#	Ret. Time	Area	Height	Area %
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Sample Name : Ta111 chir 1
 Vial # : 2
 Injection Volume : 16 uL
 Data File Name : Ta111 chir 1.lcd
 Method File Name : IC 90-10 40min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 04/05/2017 12:16:32

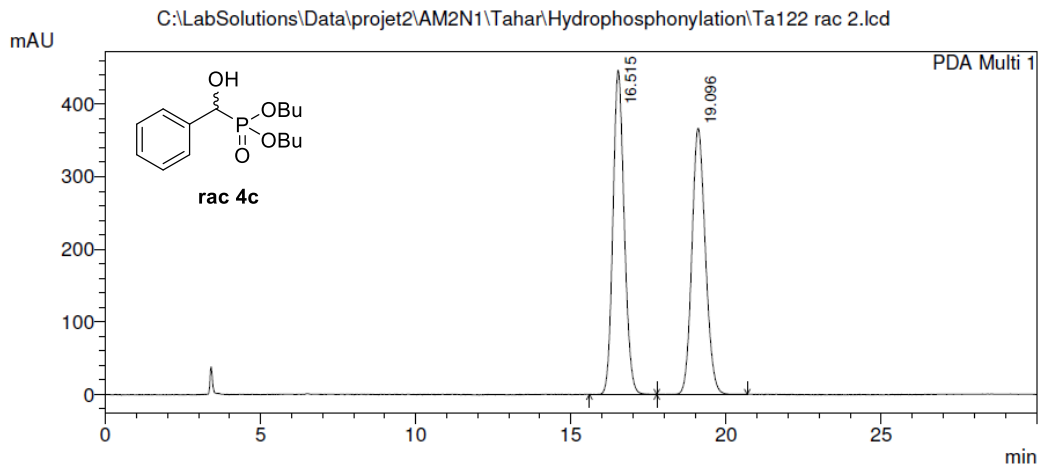


1 PDA Multi 1/195nm 4nm

PeakTable

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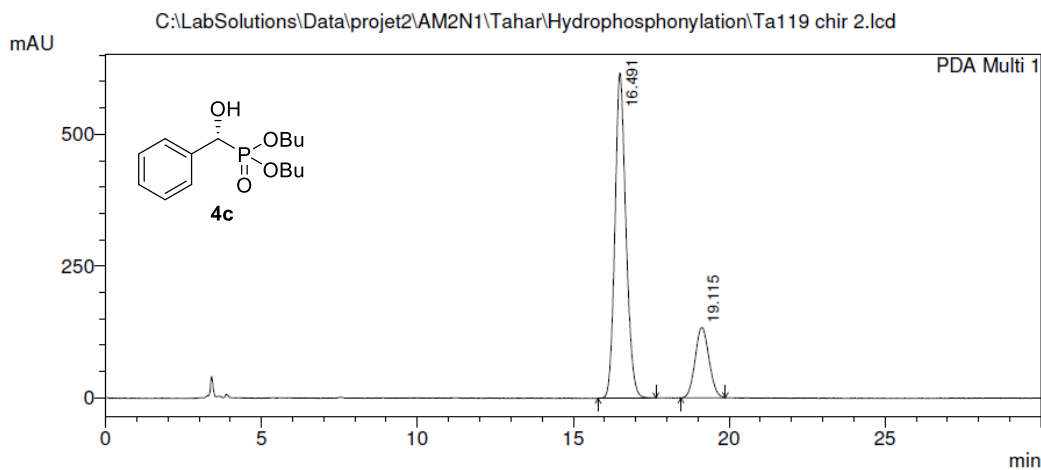
Sample Name : C:\LabSolutions\Data\proj2\AM2N1\Tahar\Hydrophosphonylation\Ta122 rac 2.lcd
 Vail # : Ta122 rac 2
 Injection Volume : 5
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 Data Acquired : Default.lcr
 : 04/05/2017 21:20:42



PeakTable

Peak#	Ret. Time	Area	Height	Area %
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Total		22368005	812981	100.000

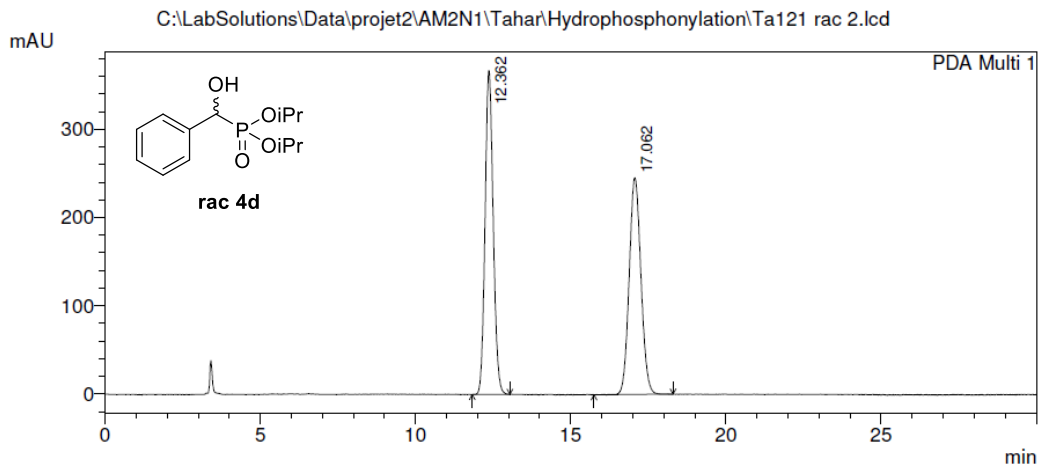
Sample Name : C:\LabSolutions\Data\proj2\AM2N1\Tahar\Hydrophosphonylation\Ta119 chir 2.lcd
 Vail # : Ta119 chir 2
 Injection Volume : 6
 Data File Name : 12 uL
 Method File Name : Ta119 chir 2.lcd
 Report File Name : IC 90-10 30min 1.0 mL min.lcm
 Data Acquired : Default.lcr
 : 04/05/2017 21:51:07



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	16.491	15101682	616175	78.521
2	19.115	4130916	133744	21.479
Total		19232598	749919	100.000

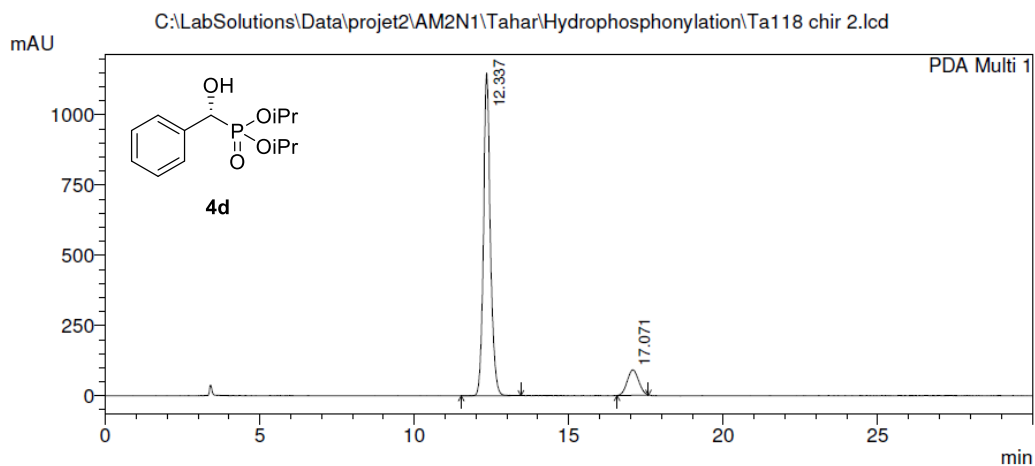
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta121 rac 2.lcd
 Sample Name : Ta121 rac 2
 Vail # : 3
 Injection Volume : 12 uL
 Data File Name : Ta121 rac 2.lcd
 Method File Name : IC 90-10 30min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 04/05/2017 20:19:47



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	12.362	6688097	366979	50.958
2	17.062	6436522	245507	49.042
Total		13124619	612486	100.000

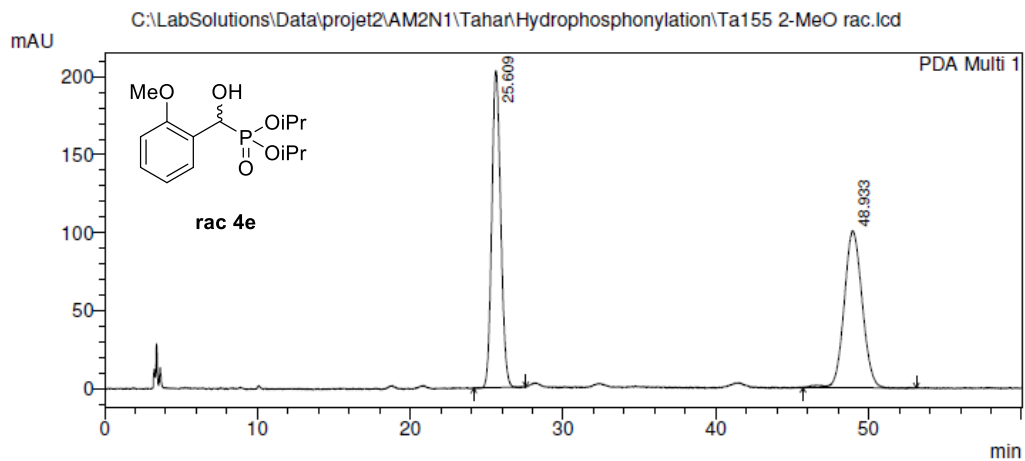
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta118 chir 2.lcd
 Sample Name : Ta118 chir 2
 Vail # : 4
 Injection Volume : 12 uL
 Data File Name : Ta118 chir 2.lcd
 Method File Name : IC 90-10 30min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 04/05/2017 20:50:15



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	12.337	17776715	1148528	88.443
2	17.071	2323016	90336	11.557
Total		20099732	1238865	100.000

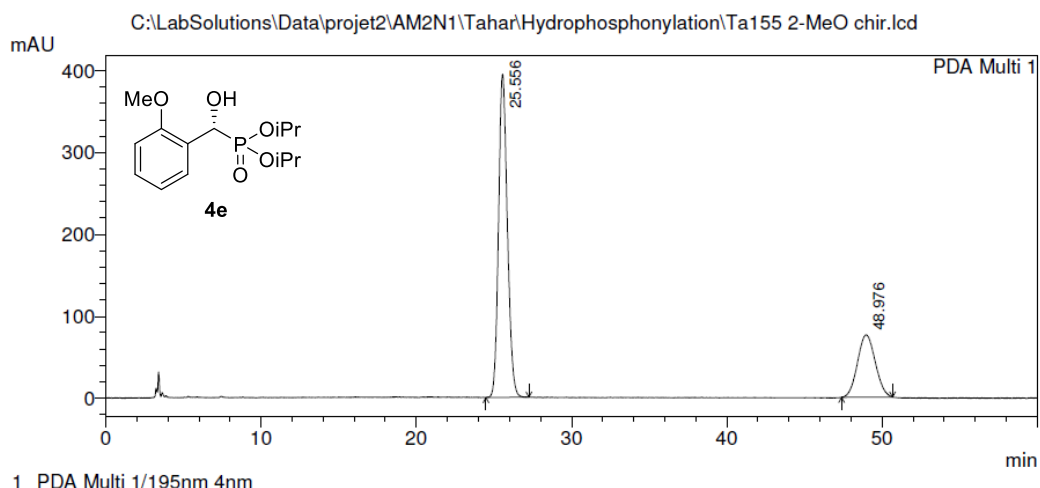
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta155 2-MeO rac.lcd
 Sample Name : Ta155 2-MeO rac
 Vail # : 11
 Injection Volume : 12 uL
 Data File Name : Ta155 2-MeO rac.lcd
 Method File Name : IC 90-10 60min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 23:33:30



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	25.609	8212843	202857	49.954
2	48.933	8227899	100659	50.046
Total		16440742	303517	100.000

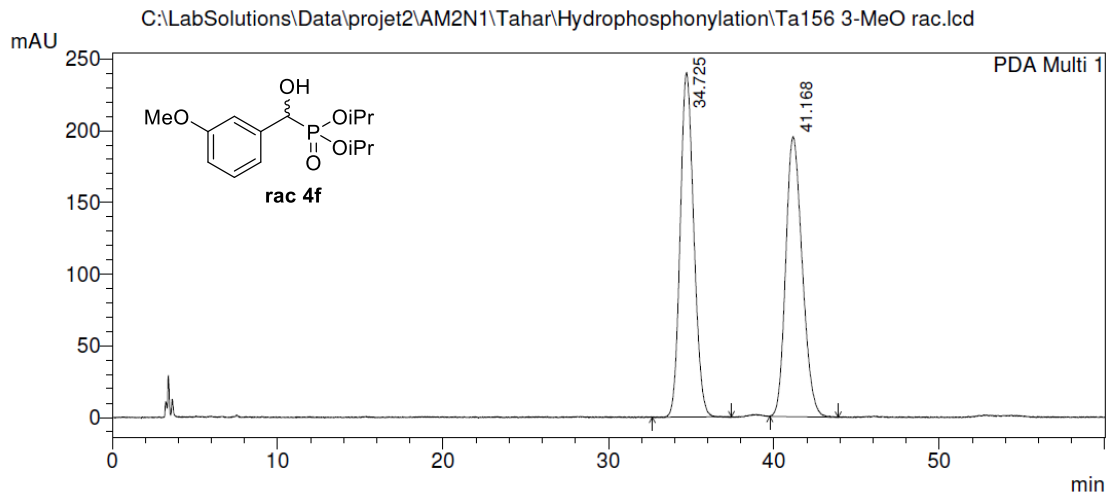
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta155 2-MeO chir.lcd
 Sample Name : Ta155 2-MeO chir
 Vail # : 12
 Injection Volume : 12 uL
 Data File Name : Ta155 2-MeO chir.lcd
 Method File Name : IC 90-10 60min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 21/06/2017 00:33:57



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	25.556	15641107	394720	72.099
2	48.976	6052799	76296	27.901
Total		21693906	471015	100.000

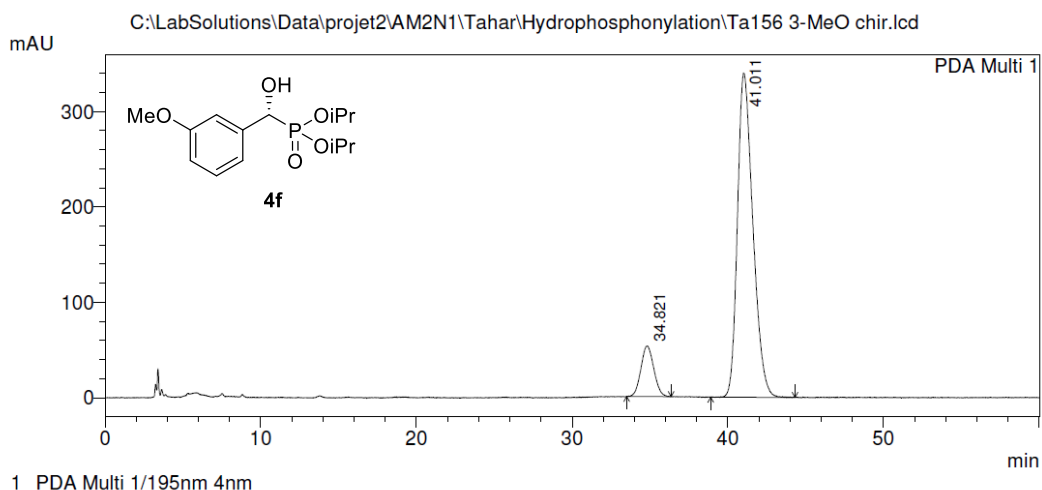
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta156 3-MeO rac.lcd
 Sample Name : Ta156 3-MeO rac
 Vail # : 9
 Injection Volume : 12 uL
 Data File Name : Ta156 3-MeO rac.lcd
 Method File Name : IC 90-10 60min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 21:32:33



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	34.725	13729534	240463	50.230
2	41.168	13603590	195595	49.770
Total		27333124	436059	100.000

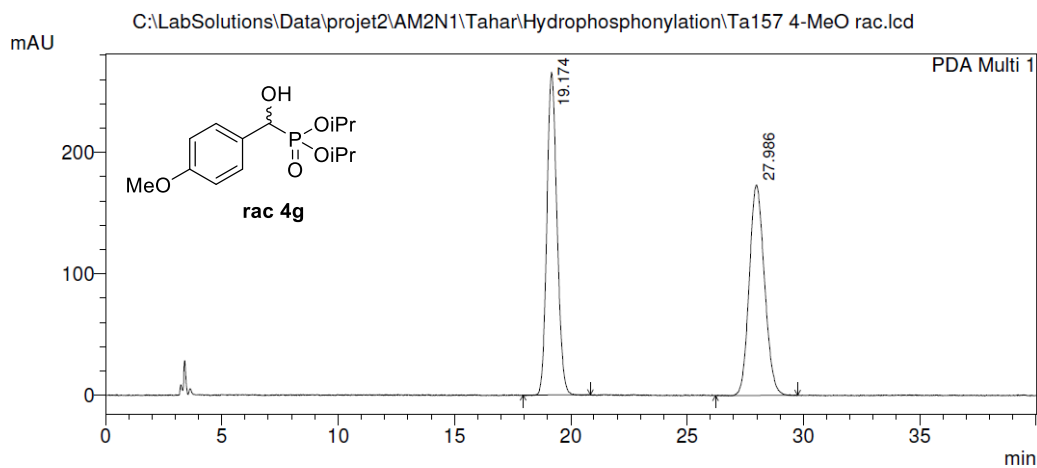
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta156 3-MeO chir.lcd
 Sample Name : Ta156 3-MeO chir
 Vail # : 10
 Injection Volume : 12 uL
 Data File Name : Ta156 3-MeO chir.lcd
 Method File Name : IC 90-10 60min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 22:33:01



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	34.821	3050956	53011	11.511
2	41.011	23454606	340123	88.489
Total		26505562	393134	100.000

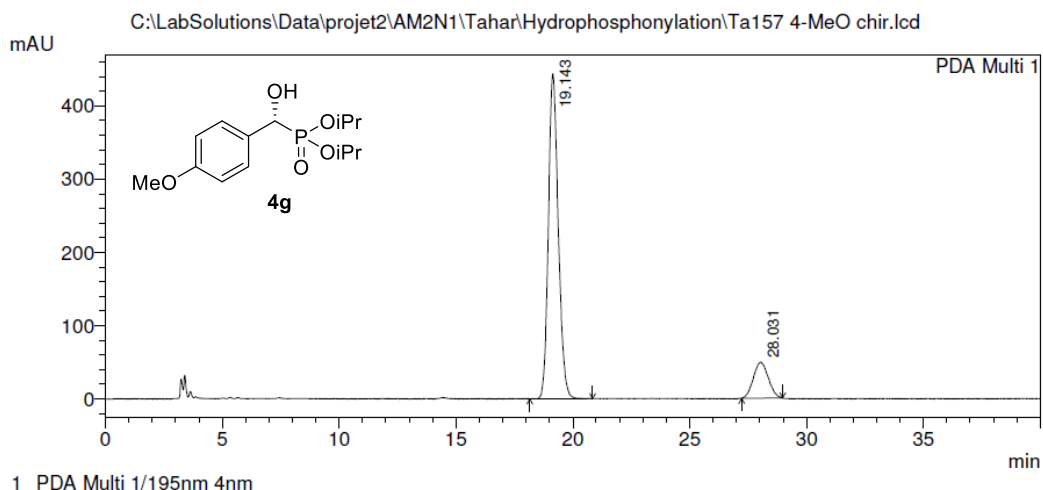
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta157 4-MeO rac.lcd
 Sample Name : Ta157 4-MeO rac
 Vail # : 7
 Injection Volume : 12 uL
 Data File Name : Ta157 4-MeO rac.lcd
 Method File Name : IC 90-10 40min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 20:11:37



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	19.174	8015197	266049	50.370
2	27.986	7897333	173523	49.630
Total		15912531	439573	100.000

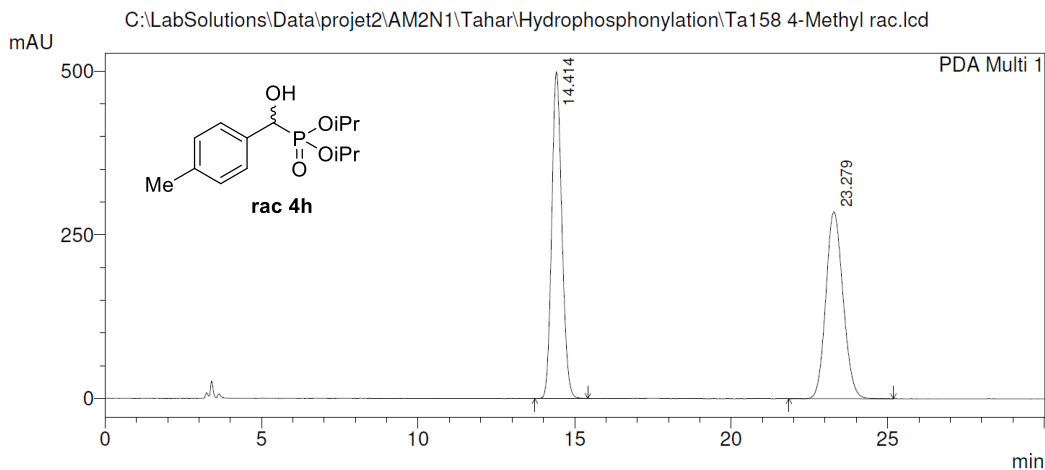
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta157 4-MeO chir.lcd
 Sample Name : Ta157 4-MeO chir
 Vail # : 8
 Injection Volume : 12 uL
 Data File Name : Ta157 4-MeO chir.lcd
 Method File Name : IC 90-10 40min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 20:52:05



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	19.143	13031807	443553	85.667
2	28.031	2180380	49292	14.333
Total		15212187	492845	100.000

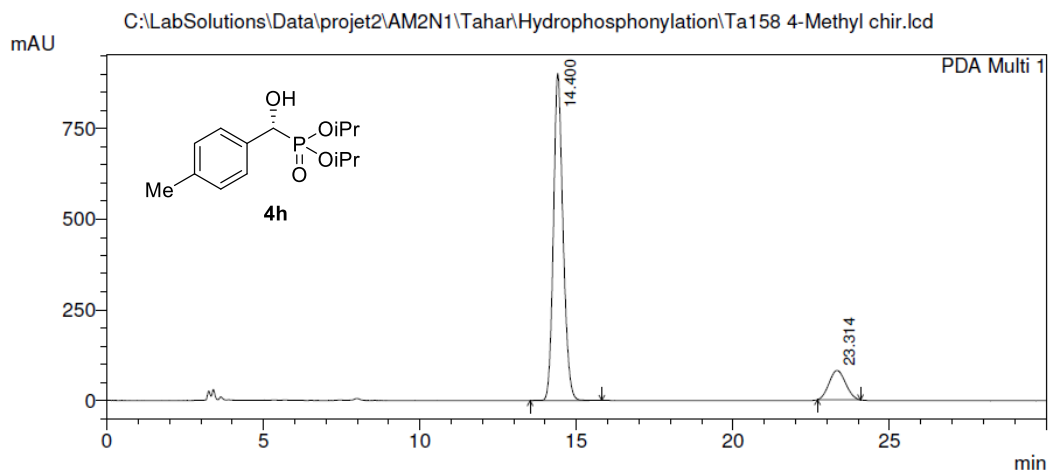
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta158 4-Methyl rac.lcd
 Sample Name : Ta158 4-Methyl rac
 Vail # : 5
 Injection Volume : 12 uL
 Data File Name : Ta158 4-Methyl rac.lcd
 Method File Name : IC 90-10 30min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 19:10:39



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	14.414	11202520	499419	50.628
2	23.279	10924534	285423	49.372
Total		22127054	784842	100.000

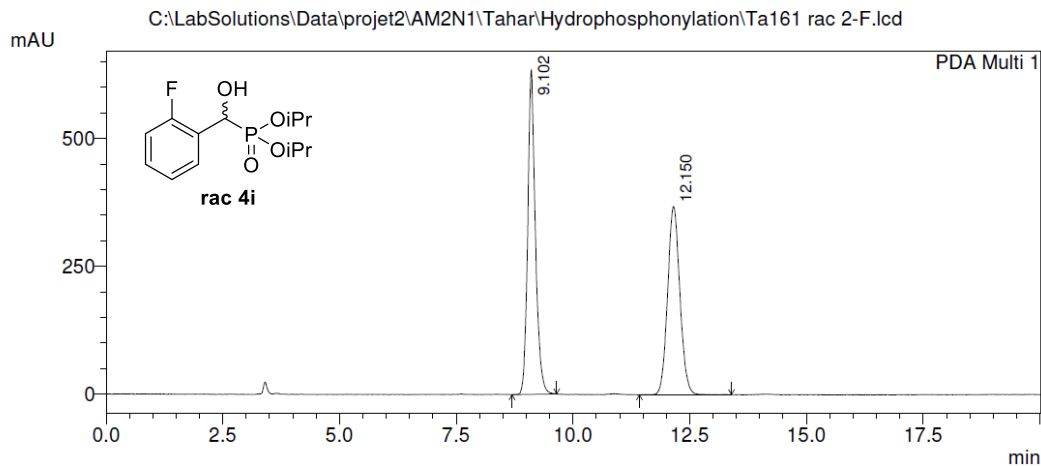
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta158 4-Methyl chir.lcd
 Sample Name : Ta158 4-Methyl chir
 Vail # : 6
 Injection Volume : 12 uL
 Data File Name : Ta158 4-Methyl chir.lcd
 Method File Name : IC 90-10 30min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 19:41:09



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	14.400	19214283	902031	86.592
2	23.314	2975034	80957	13.408
Total		22189317	982988	100.000

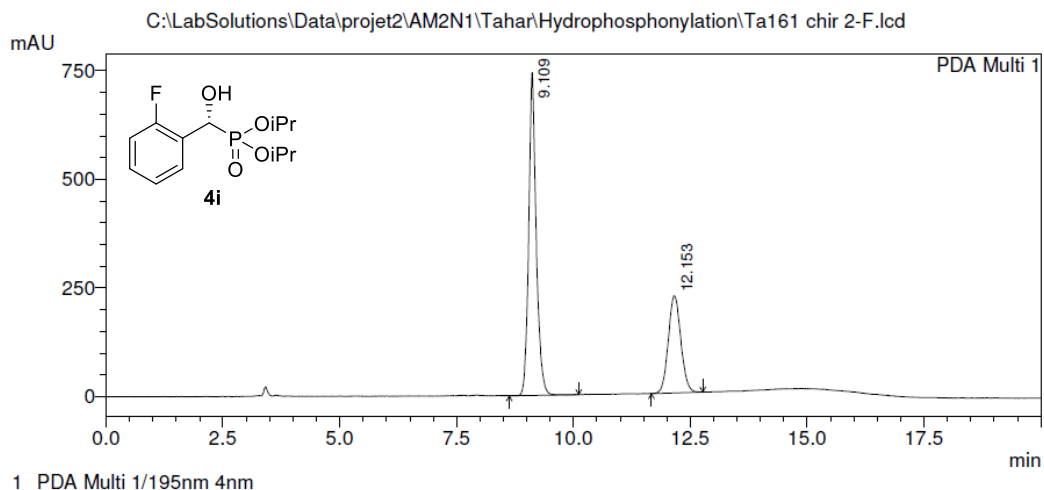
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta161 rac 2-F.lcd
 Sample Name : Ta161 rac 2-F
 Vail # : 1
 Injection Volume : 9 uL
 Data File Name : Ta161 rac 2-F.lcd
 Method File Name : IC 90-10 20min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 12:19:07



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	9.102	7228657	636211	51.788
2	12.150	6729463	368507	48.212
Total		13958120	1004718	100.000

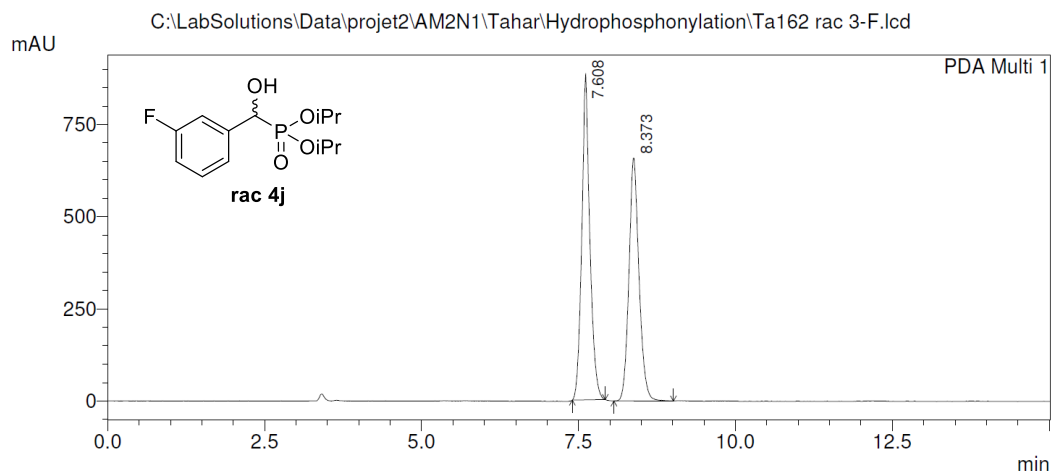
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta161 chir 2-F.lcd
 Sample Name : Ta161 chir 2-F
 Vail # : 2
 Injection Volume : 9 uL
 Data File Name : Ta161 chir 2-F.lcd
 Method File Name : IC 90-10 20min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 12:39:35



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	9.109	8263565	742970	66.481
2	12.153	4166462	223998	33.519
Total		12430026	966968	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta162 rac 3-F.lcd
 Sample Name : Ta162 rac 3-F
 Vail # : 3
 Injection Volume : 9 uL
 Data File Name : Ta162 rac 3-F.lcd
 Method File Name : IC 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 13:00:03

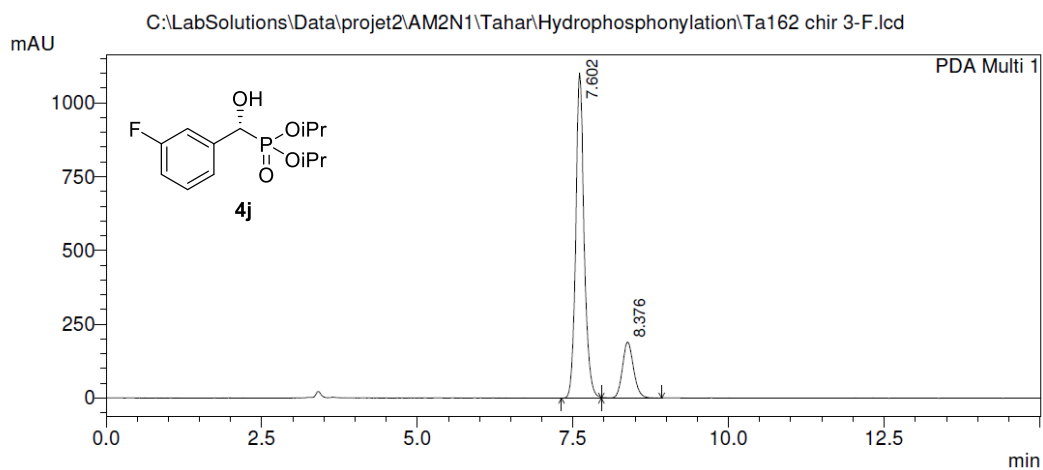


1 PDA Multi 1/195nm 4nm

PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	7.608	7861871	885309	51.450
2	8.373	7418733	658652	48.550
Total		15280604	1543961	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta162 chir 3-F.lcd
 Sample Name : Ta162 chir 3-F
 Vail # : 4
 Injection Volume : 9 uL
 Data File Name : Ta162 chir 3-F.lcd
 Method File Name : IC 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 13:15:31

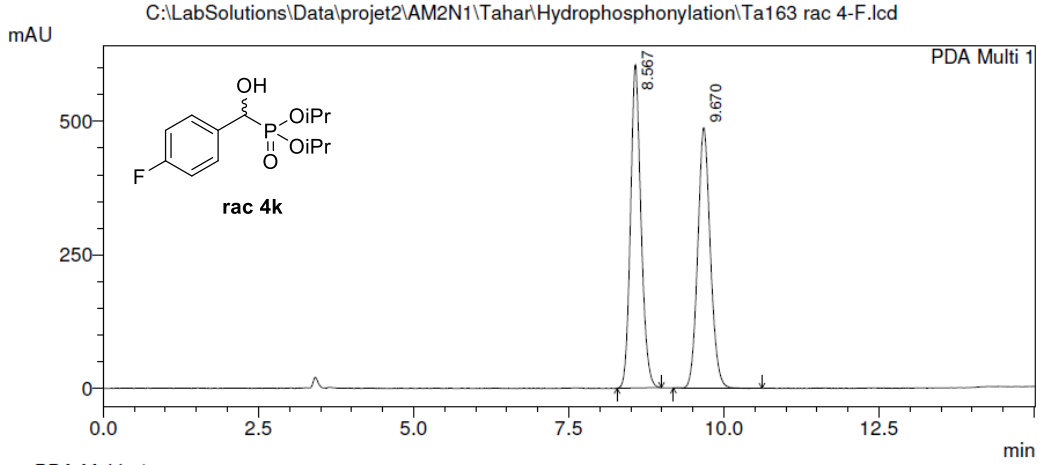


1 PDA Multi 1/195nm 4nm

PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	7.602	10305783	1101493	81.215
2	8.376	2383703	189995	18.785
Total		12689487	1291488	100.000

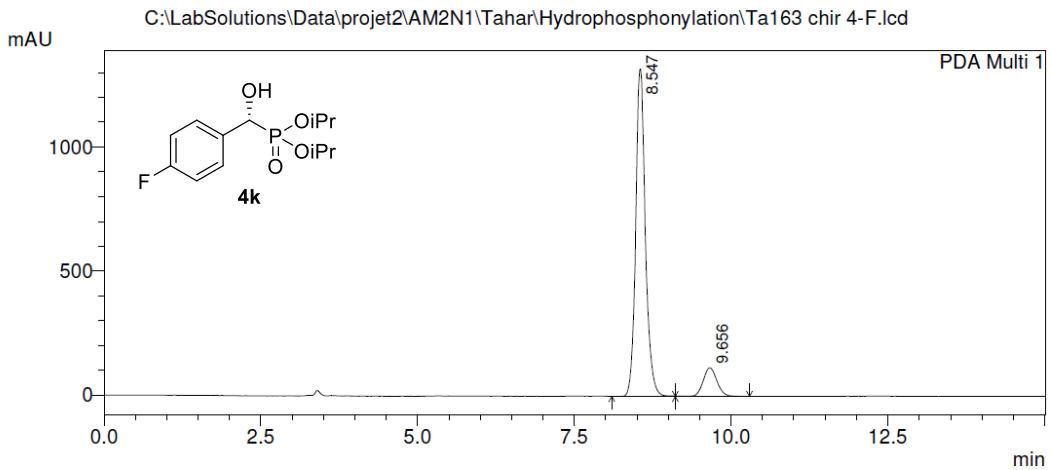
C:\LabSolutions\Data\proj2\AM2N1\Tahar\Hydrophosphonylation\Ta163 rac 4-F.lcd
 Sample Name : Ta163 rac 4-F
 Vial # : 5
 Injection Volume : 9 uL
 Data File Name : Ta163 rac 4-F.lcd
 Method File Name : IC 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 13:30:58



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	8.567	7177471	605535	50.917
2	9.670	6918870	488002	49.083
Total		14096341	1093537	100.000

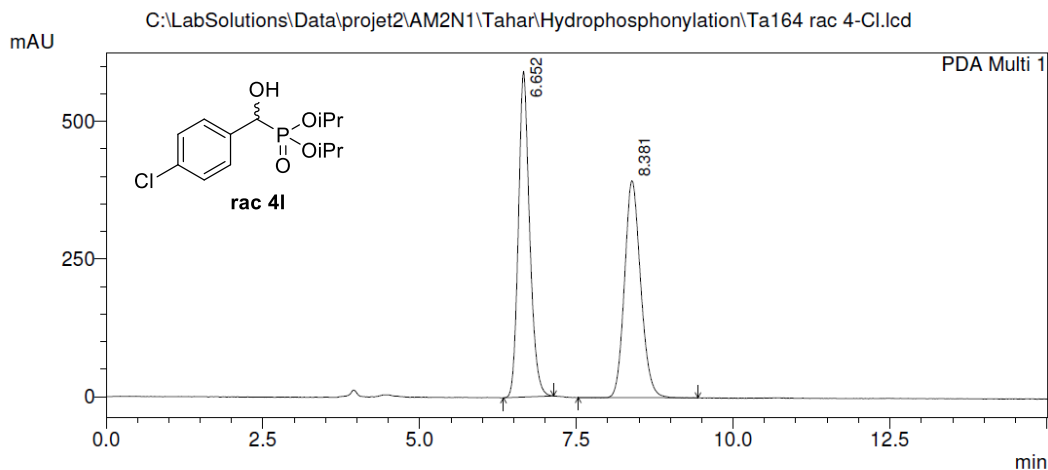
C:\LabSolutions\Data\proj2\AM2N1\Tahar\Hydrophosphonylation\Ta163 chir 4-F.lcd
 Sample Name : Ta163 chir 4-F
 Vial # : 6
 Injection Volume : 9 uL
 Data File Name : Ta163 chir 4-F.lcd
 Method File Name : IC 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 13:46:28



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	8.547	14140058	1319686	88.969
2	9.656	1753201	115741	11.031
Total		15893259	1435427	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta164 rac 4-Cl.lcd
 Sample Name : Ta164 rac 4-Cl
 Vail # : 1
 Injection Volume : 9 uL
 Data File Name : Ta164 rac 4-Cl.lcd
 Method File Name : AS-H 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 10:04:22

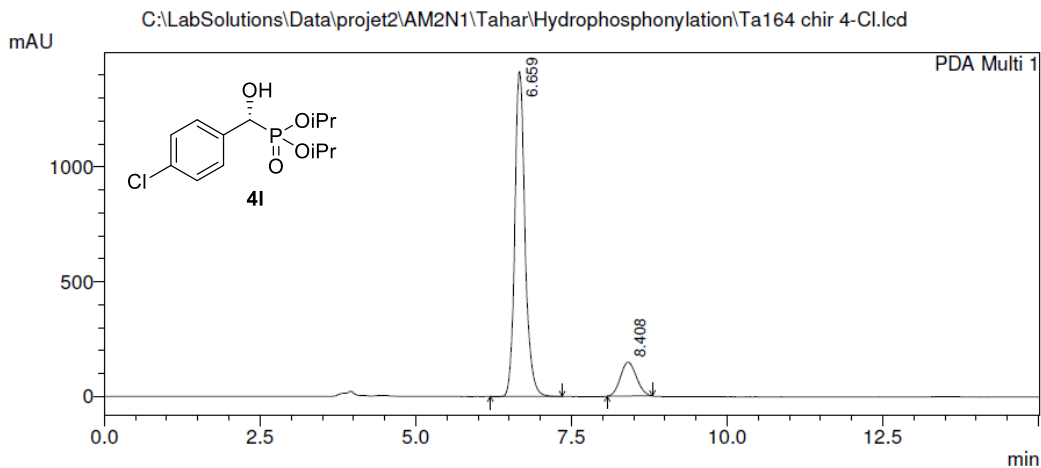


PeakTable

PDA Ch1 195nm 4nm

Peak#	Ret. Time	Area	Height	Area %
1	6.652	7438333	590925	51.193
2	8.381	7091714	393934	48.807
Total		14530047	984859	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta164 chir 4-Cl.lcd
 Sample Name : Ta164 chir 4-Cl
 Vail # : 2
 Injection Volume : 9 uL
 Data File Name : Ta164 chir 4-Cl.lcd
 Method File Name : AS-H 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 10:19:55

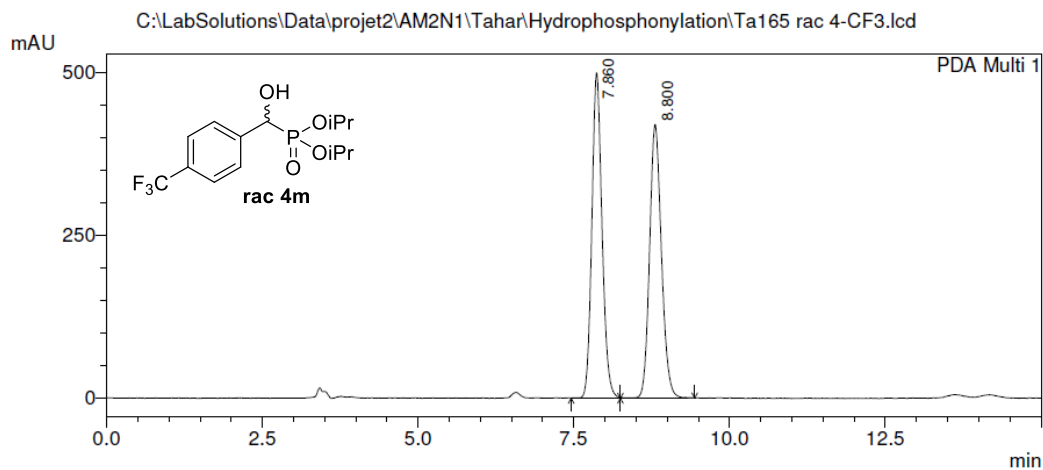


PeakTable

PDA Ch1 195nm 4nm

Peak#	Ret. Time	Area	Height	Area %
1	6.659	16203204	1417271	85.955
2	8.408	2647703	147780	14.045
Total		18850906	1565051	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta165 rac 4-CF3.lcd
 Sample Name : Ta165 rac 4-CF3
 Vail # : 7
 Injection Volume : 9 uL
 Data File Name : Ta165 rac 4-CF3.lcd
 Method File Name : IC 95-5 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 14:35:10

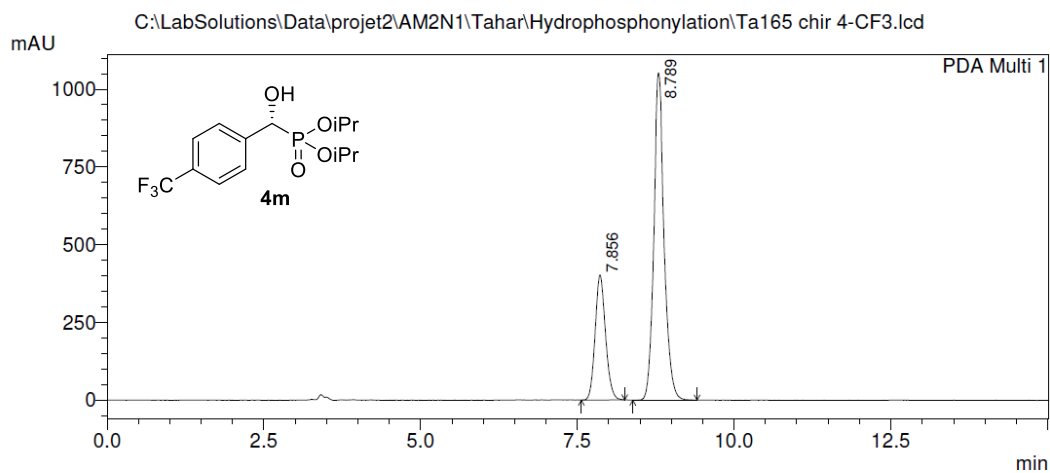


1 PDA Multi 1/195nm 4nm

PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	7.860	5671921	499621	50.500
2	8.800	5559678	419930	49.500
Total		11231598	919550	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta165 chir 4-CF3.lcd
 Sample Name : Ta165 chir 4-CF3
 Vail # : 8
 Injection Volume : 9 uL
 Data File Name : Ta165 chir 4-CF3.lcd
 Method File Name : IC 95-5 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 14:50:37

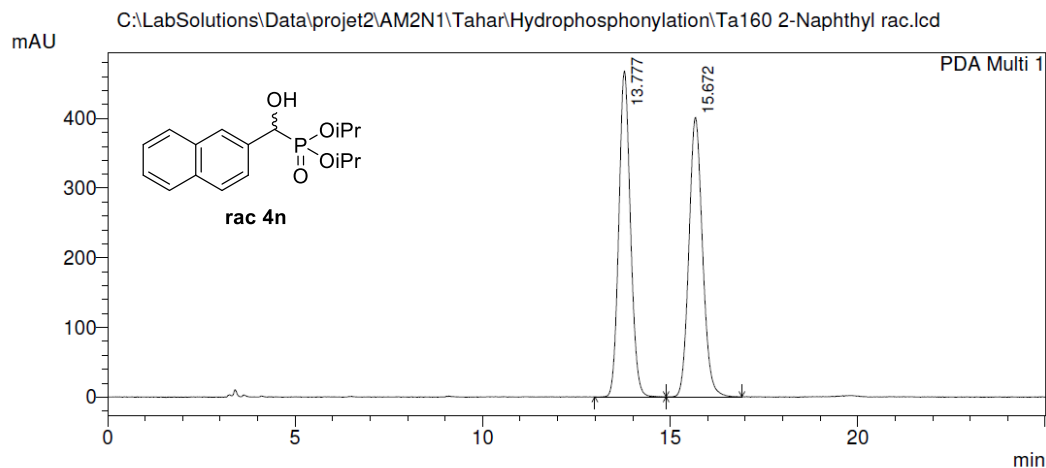


1 PDA Multi 1/195nm 4nm

PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	7.856	4618824	402751	27.928
2	8.789	11919363	1052148	72.072
Total		16538187	1454899	100.000

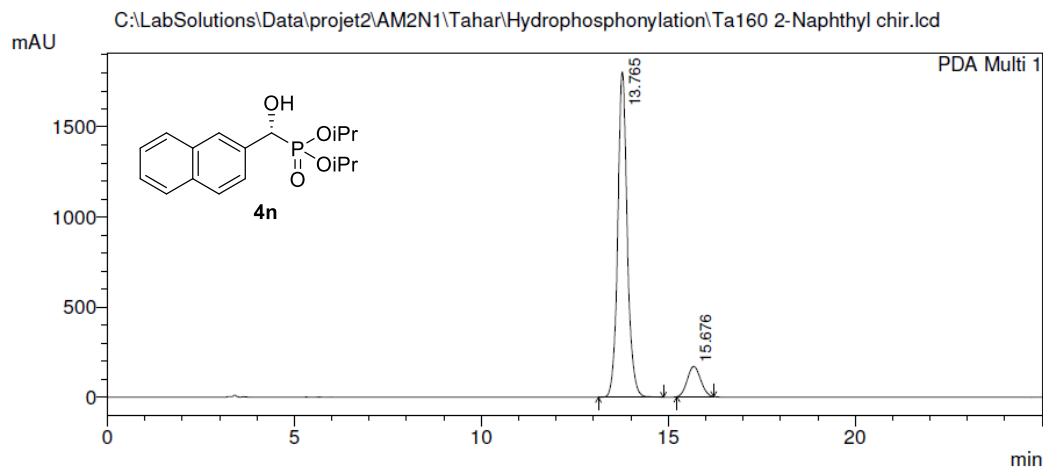
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta160 2-Naphthyl rac.lcd
 Sample Name : Ta160 2-Naphthyl rac
 Vail # : 1
 Injection Volume : 4 uL
 Data File Name : Ta160 2-Naphthyl rac.lcd
 Method File Name : IC 90-10 25min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 17:18:51



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	13.777	10065690	467846	49.864
2	15.672	10120522	401351	50.136
Total		20186213	869196	100.000

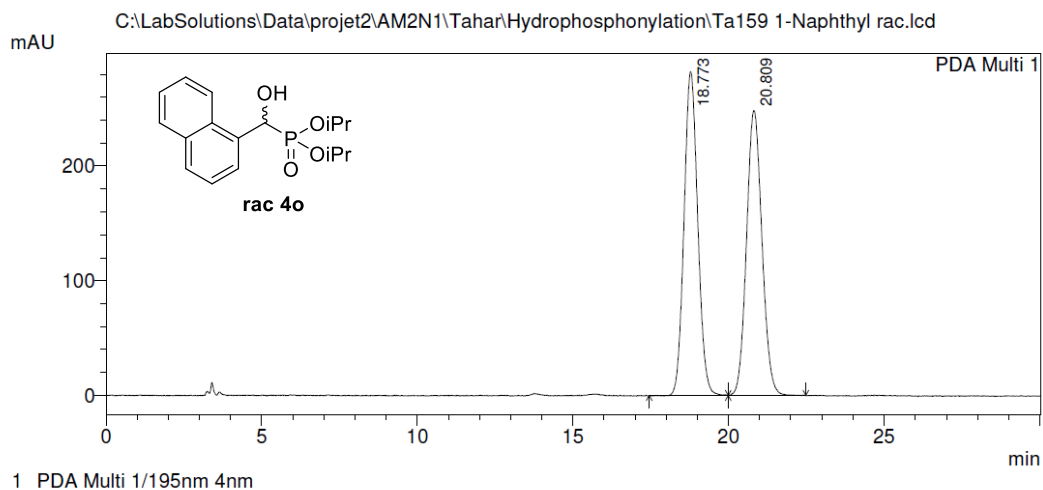
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta160 2-Naphthyl chir.lcd
 Sample Name : Ta160 2-Naphthyl chir
 Vail # : 2
 Injection Volume : 4 uL
 Data File Name : Ta160 2-Naphthyl chir.lcd
 Method File Name : IC 90-10 25min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 17:44:18



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	13.765	32192049	1804889	88.517
2	15.676	4176366	168239	11.483
Total		36368415	1973128	100.000

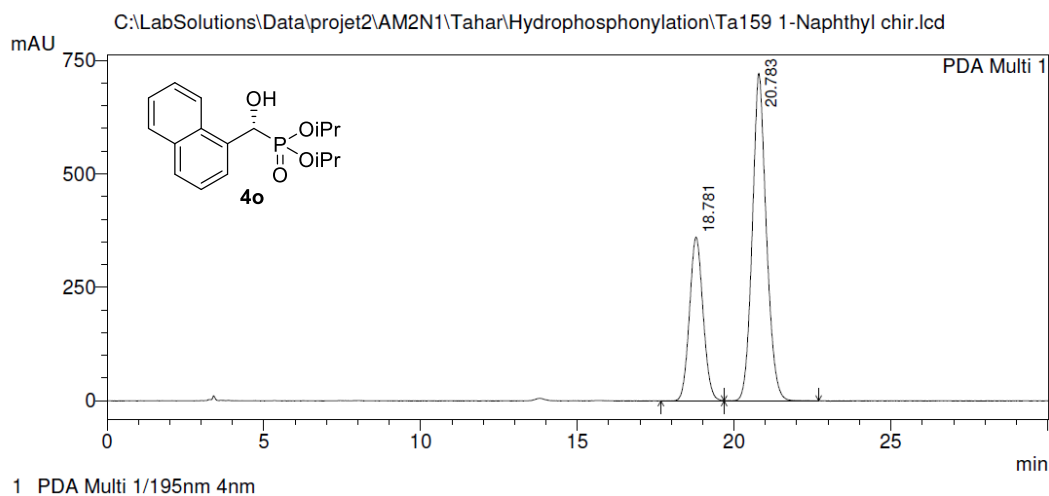
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta159 1-Naphthyl rac.lcd
 Sample Name : Ta159 1-Naphthyl rac
 Vial # : 3
 Injection Volume : 4 uL
 Data File Name : Ta159 1-Naphthyl rac.lcd
 Method File Name : IC 90-10 30min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 18:09:45



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	18.773	8616140	282107	50.132
2	20.809	8570597	248400	49.868
Total		17186737	530507	100.000

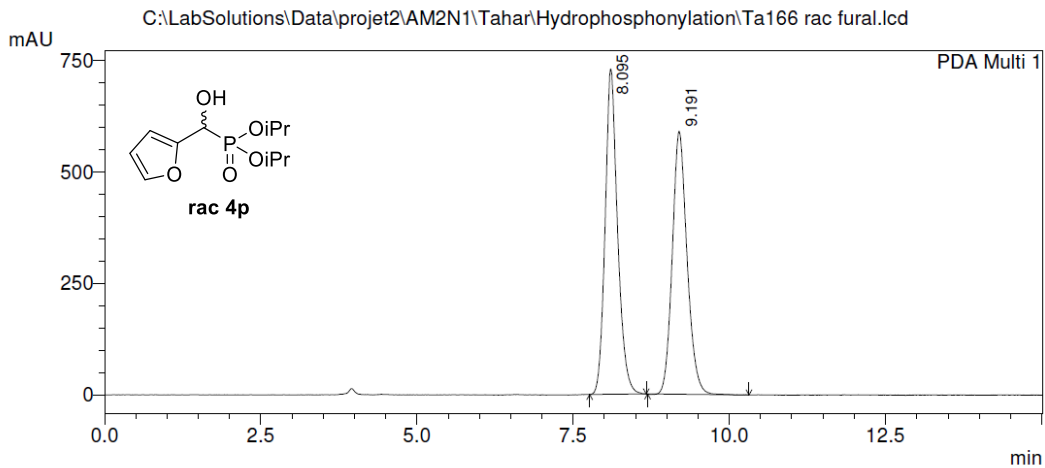
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta159 1-Naphthyl chir.lcd
 Sample Name : Ta159 1-Naphthyl chir
 Vial # : 4
 Injection Volume : 4 uL
 Data File Name : Ta159 1-Naphthyl chir.lcd
 Method File Name : IC 90-10 30min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 20/06/2017 18:40:13



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	18.781	10867848	360975	32.585
2	20.783	22484389	721960	67.415
Total		33352237	1082935	100.000

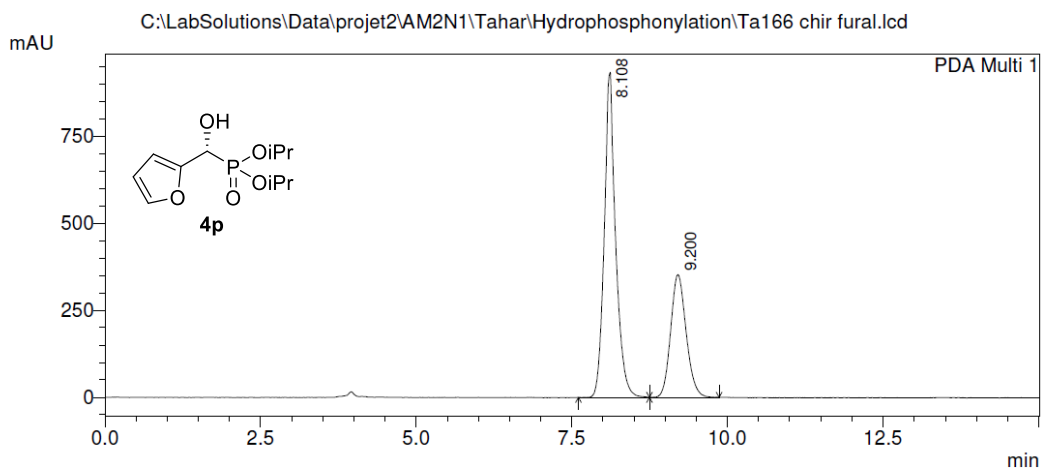
C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta166 rac fural.lcd
 Sample Name : Ta166 rac fural
 Vail # : 3
 Injection Volume : 9 uL
 Data File Name : Ta166 rac fural.lcd
 Method File Name : AS-H 90-10 45min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 10:35:22



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	8.095	10080925	729456	51.029
2	9.191	9674325	590515	48.971
Total		19755250	1319971	100.000

C:\LabSolutions\Data\projet2\AM2N1\Tahar\Hydrophosphonylation\Ta166 chir fural.lcd
 Sample Name : Ta166 chir fural
 Vail # : 4
 Injection Volume : 9 uL
 Data File Name : Ta166 chir fural.lcd
 Method File Name : AS-H 90-10 15min 1.0 mL min.lcm
 Report File Name : Default.lcr
 Data Acquired : 19/06/2017 10:50:48



PeakTable

Peak#	Ret. Time	Area	Height	Area %
1	8.108	11816767	933993	65.971
2	9.200	6095294	352847	34.029
Total		17912061	1286840	100.000