Supporting Information Appendix

Access to chiral α-substituted-β-hydroxy arylphosphonates enabled by biocatalytic dynamic reductive kinetic resolution

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Chemicals

Unless otherwise specified, all reagents and solvent were purchased from commercial sources and used as received. ^{1}H (400 MHz) and ^{13}C (100 MHz) NMR were recorded on a Bruker Avance 400 spectrometer in $CDCl_3$ using tetramethylsilane (TMS) as internal standards. Coupling constant (*J*) values are given in Hz. Products were purified by flash column chromatography on silica gel purchased from Qingdao Haiyang Chemical Co., Ltd. Optical rotations were measured by a Rudolph AUTOPOL I Automatic Polarimeter. HRMS were recorded on a Bruker micrOTOF spectrometer. HPLC analysis were performed with Daicel Chiralpak IA column (25 cm × 4.6 mm × 5 μm), Chiralpak IC column (25 cm × 4.6 mm × 5 μm), Chiralpak IF column (25 cm × 4.6 mm × 5 μm).

Molecular Biology

Reagents

Restriction enzymes (NdeI, NcoI, EcoRI and XhoI), PrimeSTAR® HS DNA Polymerase were purchased from TaKaRa (Japan). One Step Cloning Kit ClonExpress® II was purchased from Vazyme (Nanjing, China). PurePlasmid Mini Kit and Gel Extraction Kit were purchased from CWBIO (China). Chemically competent cells of *E. coli* DH5α and *E. coli* BL21 (DE3) were purchased from Transgen (China). Oligonucleotides were purchased from Genewiz (China) in standard, desalted form and used without further purification (Table S16). Synthetic genes (pET28a-KRED-F42, pET28a-CaADH, pET28a-KRED-30) were purchased from Genewiz (China) (Table S3). YDL124w was cloned into pET28a using the primers listed in Table S9. The rest of the enzymes in Table S3 were prepared as we previously described.[1, 2] All other reagents were purchased from Sangon Biotech (China) unless otherwise specified. LB medium contained yeast extract (5 g/L), tryptone (10 g/L), NaCl (10 g/L). Antibiotics were used at the following concentration: kanamycin: 50 μg/mL.

Cloning procedures

Cloning YDL124w into pET28a vector

PCR products were amplified from genomic DNA of *Saccharomyces cerevisiae* s288c using the PrimeSTAR® HS DNA Polymerase with a T100 Thermal Cycler. The reaction began with an initial denaturing step for 180 s at 98 °C followed by 30 cycles of 10 s at 98 °C, 15 s at 55 °C and 90 s at 72 °C with a final extension step at 72 °C for 300 s. The resulting PCR products were ligated with linearized vectors, which were double digested at appropriate restriction sites (NdeI/XhoI), through homologous recombination using the One Step Cloning Kit ClonExpress® II. In general, a 10 μL reaction mixture containing 2 μL of 5×CE II Buffer, 1 μL of Exnase II, 50-200 ng linearized vector and 20-200 ng PCR amplicon was incubated at 37 ºC for 30 min, and the resulting solution was used to transform chemically competent *E. coli* DH5α cells. Colony PCR and sequencing (Genewiz, China) were performed to confirm the sequence fidelity of the recombinant plasmids.

Enzymology

Reagents

Nickel(II)-nitrilotriacetic acid (Ni-NTA) agarose was purchased from Sangon. Amicon ultracentrifugal filters were purchased from EMB Millipore. PD-10 desalting columns were

purchased from GE Healthcare. Isopropylthio-β-D-galactoside (IPTG) was obtained from Sangon. Lysis buffer consisted of 50 mM NaPi, 300 mM NaCl, 10 mM imidazole, 10% glycerol, pH 7.5. Wash buffer consisted of 50 mM NaPi, 300 mM NaCl, 20 mM imidazole, 10% glycerol, pH 7.5. Elution buffer consisted of 50 mM NaPi, 300 mM NaCl, 250 mM imidazole, 10% glycerol, pH 7.5. Storage buffer consisted of 50 mM NaPi, 300 mM NaCl, 10% glycerol, pH 7.5.

Expression and purification of His_6-tagged recombinant proteins

An approximately 12 h culture of *E. coli* BL21 (DE3) cells freshly transformed with the appropriate plasmid and grown in LB medium supplemented with kanamycin (50 μg/mL) was diluted 1 : 100 into 0.5 L of the same medium in a 2 L flask. The culture was shaken at 37 °C until the optical density at 600 nm reached 0.6-0.8, then the flask was placed in an ice/water bath for ca. 30 min before the addition of isopropylthio-β-D-galactoside (IPTG) to a final concentration of 100 μM. The culture was shaken for an additional 12-14 h at 18 ºC. All the following purification steps were carried out at 4 °C. The cells (1.5-2 g wet mass from 0.5 L culture) were collected by centrifugation, and then resuspended in 20 mL of lysis buffer. The cells were lysed by sonication on ice and debris was removed by centrifugation at 37,000 x g for 30 min at 4 °C. The supernatant was loaded onto a column containing 2-3 mL of Ni-NTA resin previously equilibrated with lysis buffer. After equilibration of the resin with the lysate in an orbital shaker for ca. 30 min, the flow-through was discarded and the resin was washed with 2 × 20 mL of wash buffer. Resin-bound protein was eluted with elution buffer. Fractions of 1 mL were collected and the absorbance at 280 nm was measured by a NanoDrop One spectrophotometer. Fractions with strong absorbance at 280 nm were pooled and concentrated in an Amicon Ultra centrifugal filter unit with 10 kDa molecular weight cut off (MWCO) to a final volume of 2.5 mL. Imidazole and excess salt was removed by passing the protein solution through a PD-10 desalting column previously equilibrated with storage buffer. Protein was eluted with 3.5 mL of storage buffer and stored in aliquots at -80 ºC. The protein concentrations were measured by a NanoDrop One spectrophotometer with calculated extinction coefficient and molecular weight.

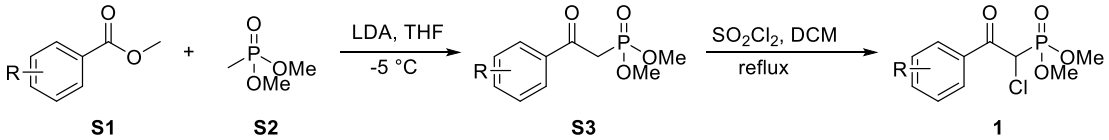
References

[1] Li, Z.; Wang, Z.; Wang, Y.; Wu, X.; Lu, H.; Huang, Z.; Chen, F. *Adv. Synth. Catal.* **2019**, *361*, 1859-1865.

[2] Wang, Z.; Wu, X.; Li, Z.; Huang, Z.; Chen, F. *Org. Biomol. Chem.* **2019**, *17*, 3575-3580.

General procedures for the synthesis of substrates

Method A

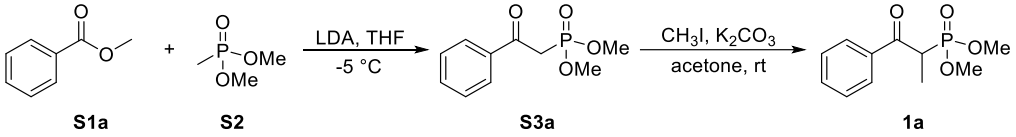


Scheme S1. General procedures for the synthesis of substrates using method A.[1, 2]

To a stirred solution of methyl benzoate **S1** (1 equiv.) and dimethyl methylphosphonate **S2** (1.1 equiv.) in THF (9 mL) under N_2 atmosphere at -5 ℃ was added LDA (2.1 equiv.) dropwise. After stirring for 0.5 h, the reaction was quenched with 6 M HCl to pH 4~5. The mixture was then extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **S3**, the NMR spectra of which were in accordance with the literature. Isolated yield: 54~80%.

To a solution of phosphonate **S3** (1 equiv.) in CH_2Cl_2 (20 mL) was added SO_2Cl_2 (1 equiv.) at room temperature. After stirring for 20 min at the same temperature, the resulting mixture was heated to reflux until gas evolution ceased. The mixture was then cooled to room temperature and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1.** Isolated yield: 60~85%.

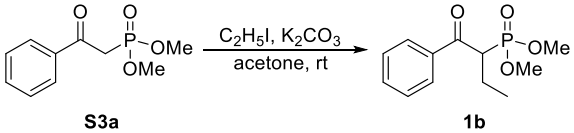
Method B



Scheme S2. General procedures for the synthesis of substrates using method B.[3]

To a stirred solution of **S3a** (1 equiv.) and K_2CO_3 (1.5 equiv.) in acetone (8 mL) was added CH_3I (1.5 equiv.) dropwise, and the resulting mixture was stirred at room temperature for 24 h. The reaction was quenched with saturated NH_4Cl and extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1a.** Isolated yield: 71%.

Method C

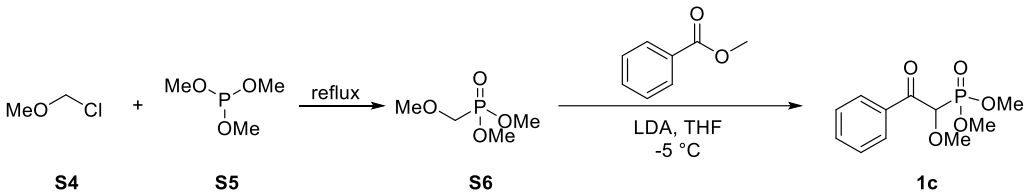


Scheme S3. General procedures for the synthesis of substrates using method C.[3]

To a stirred solution of **S3a** (1 equiv.) and K_2CO_3 (1.5 equiv.) in acetone (8 mL) was added C_2H_5I (1.5 equiv.) dropwise, and the resulting mixture was stirred at room temperature for 24 h. The reaction was quenched with saturated NH_4Cl and extracted with EtOAc (3 ×100 mL).

The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1b.** Isolated yield: 64%.

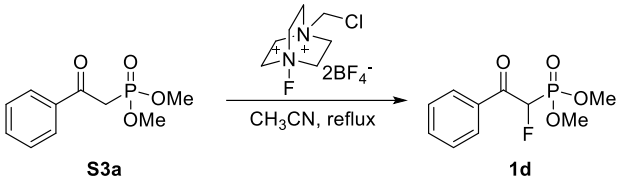
Method D



Scheme S4. General procedures for the synthesis of substrates using method D.[4]

A mixture of chloro(methoxy)methane **S4** (1.1 equiv.) and trimethyl phosphite **S5** (1 equiv.) was refluxed for 3 h. The resulting mixture was concentrated *in vacuo* to give dimethyl (methoxymethyl)phosphonate **S6**, which was used in the next step without further purification. To a stirred solution of methyl benzoate **S1** (1 equiv.) and **S6** (1.1 equiv.) in THF (9 mL) under N_2 atmosphere at -5 °C was added LDA (2.1 equiv.) dropwise. After 0.5 h, the reaction was quenched with 6 M HCl to pH 4~5. The mixture was then extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1c.** Isolated yield: 72%.

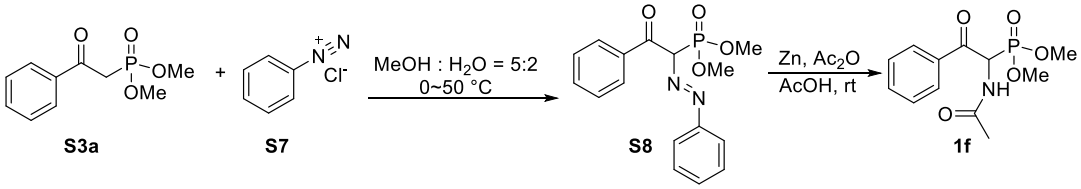
Method E



Scheme S5. General procedures for the synthesis of substrates using method E.[5]

A solution of phosphonate **S3a** (1 equiv.) and Selectfluor (2 equiv.) in CH_3CN (100 mL) was refluxed for 24 h. The reaction was quenched by saturated NH_4Cl (100 mL), and followed by the addition of EtOAc (100 mL). The layers were separated, and the aqueous phase was extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1d**. Isolated yield: 30%.

Method F



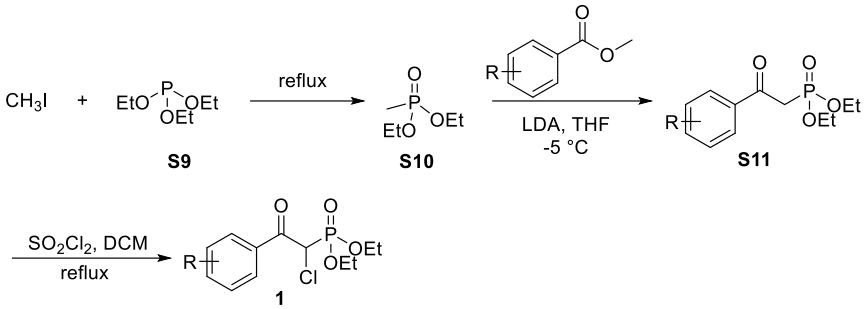
Scheme S6. General procedures for the synthesis of substrates using method F.[6]

To an ice-cooled solution of phosphonate **S3a** (1 equiv.) and benzenediazonium chloride **S7**

(1.1 equiv.), which was prepared *in situ* from aniline and sodium nitrite, in MeOH:H_2O = 5:2 (v:v) was added sodium acetate (5 equiv.). The resulting mixture was first stirred at 0 ℃ for 30 min, and then heated to 50 ℃. The reaction was kept at 50 ℃ until the complete consumption of phosphonate **S3a** as monitored by TLC. The crude product **S8** was collected by filtration and used in next step without purification.

A solution of Crude **S8** in AcOH (60 mL) was treated with Zn (6 equiv.) and Ac_2O (3.2 equiv.) at room temperature. After the complete consumption of **S8** as monitored by TLC, the formed solid was filtered and washed with AcOH. The filtrate was concentrated *in vacuo* and the residue was dissolved in water (50 mL), and extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1f**. Isolated yield: 40%.

Method G



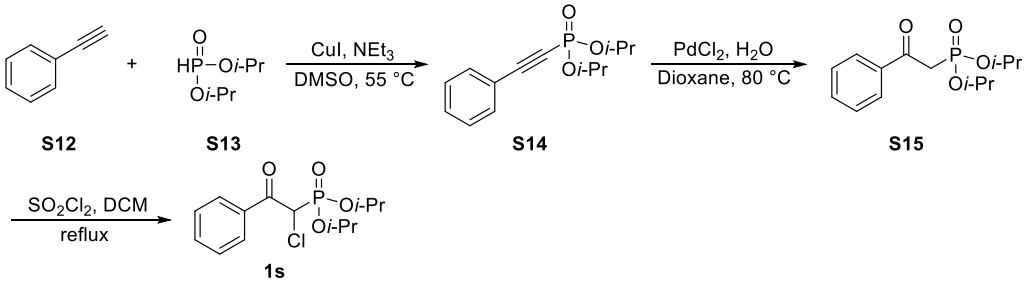
Scheme S7. General procedures for the synthesis of substrates using method G.[1, 2]

A mixture of CH_3I (1.1 equiv.) and triethyl phosphite **S9** (1 equiv.) was refluxed for 6 h, and was then concentrated *in vacuo* to yield diethyl methylphosphonate **S10**, which was used in the next step without further purification.

To a stirred solution of methyl benzoate **S1** (1 equiv.) and **S10** (1.1 equiv.) in THF (9 mL) under N_2 atmosphere at -5 ℃ was added LDA (2.1 equiv.) dropwise. After 0.5 h, the reaction was quenched with 6 M HCl to pH 4~5. The mixture was then extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **S11**. Isolated yields: 50~75%.

To a stirred solution of phosphonate **S11** (1 equiv.) in CH_2Cl_2 (20 mL) at room temperature was added SO_2Cl_2 (1 equiv.). After 20 min, the resulting mixture was heated to reflux until gas evolution ceased. The mixture was then cooled to room temperature and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1**. Isolated yields: 50~75%.

Method H

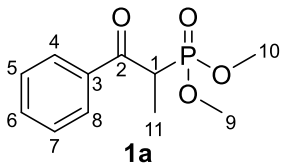


Scheme S8. General procedures for the synthesis of substrates using method H.[7, 8]

A mixture of ethynylbenzene **S12** (1.2 equiv.), diisopropyl phosphonate **S13** (1 equiv.), CuI (0.2 equiv.) and NEt_3 (0.3 equiv.) in DMSO (90 mL) was stirred at 55 ℃ for 2 days. After cooling to room temperature, brine was added. The resulting mixture was extracted with EtOAc (5 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **S14**.

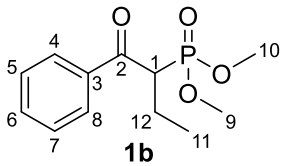
A mixture of **S14** (1 equiv.), H_2O (6 equiv.), and $PdCl_2$ (0.01 equiv.) in Dioxane (15 mL) was heated at 80 ℃ for 2 h. The reaction mixture was concentrated *in vacuo* and extracted with EtOAc (3 ×100 mL). The combined organic phases were dried over Na_2SO_4 and concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **S15**, the NMR spectra of which were in accordance with the literature.

To a stirred solution of phosphonate **S15** (1 equiv.) in CH_2Cl_2 (20 mL) at room temperature was added SO_2Cl_2 (1 equiv.). After 20 min, the resulting mixture was heated to reflux until gas evolution ceased. After cooling to room temperature, the mixture was concentrated *in vacuo.* The residue was purified by flash column chromatography to afford products **1s**. Isolated yield: 42%.



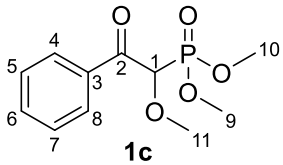
1a

dimethyl (1-oxo-1-phenylpropan-2-yl)phosphonate (1a) was synthesized through **Method B** as yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.96-7.44 (m, Ar-H, 5H), 4.16 (dq, C_1-H, J = 22.9, 7.1 Hz, 1H), 3.72 (d, C_9-H, J = 10.9 Hz, 3H), 3.68 (d, C_{10}-H, J = 10.9 Hz, 3H), 1.50 (dd, C_{11}-H, J = 18.1, 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 196.32 (d, J = 5 Hz), 136.49 (d, J = 2 Hz), 133.51, 128.79, 128.60, 53.32 (d, J = 6.7 Hz), 40.86 (d, J = 130 Hz), 12.40 (d, J = 7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 27.03. HRMS Calcd. For $C_{11}H_{15}NaO_4P^+$[M+Na^+]: 265.0600. Found: 265.0604.



1b

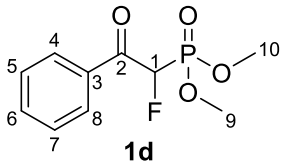
dimethyl (1-oxo-1-phenylbutan-2-yl)phosphonate (1b) was synthesized through **Method C** as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.98-7.48 (m, Ar-H, 5H), 4.06 (ddd, C_1-H, J = 22.6, 10.2, 4.1 Hz, 1H), 3.74 (d, C_9-H, J = 10.9 Hz, 3H), 3.68 (d, C_{10}-H, J = 10.9 Hz, 3H), 2.35-2.18 (m, C_{12}-H, 1H), 2.13-1.94 (m, C_{12}-H, 1H), 0.94 (t, C_{11}-H, J = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 196.30 (d, J = 6 Hz), 137.59 (d, J = 2 Hz), 133.50, 128.66, 128.62, 53.40 (d, J = 7 Hz), 53.24 (d, J = 7 Hz), 48.43 (d, J = 128 Hz), 21.46 (d, J = 6 Hz), 13.14 (d, J = 15 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 25.75. HRMS Calcd. For $C_{12}H_{17}NaO_4P^+$[M+Na^+]: 279.0757. Found: 279.0748.



1c

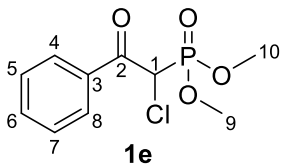
dimethyl (1-methoxy-2-oxo-2-phenylethyl)phosphonate (1c) was synthesized through **Method D** as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.10-7.48 (m, Ar-H, 5H), 5.02 (d, C_1-H, J = 19.3 Hz, 1H), 3.82 (d, C_9-H, J = 10.9 Hz, 3H), 3.76 (d, C_{10}-H, J = 10.8 Hz, 3H), 3.49 (s, C_{11}-H, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 194.46, 135.28, 133.90, 129.29, 128.52, 82.98 (d, J = 152 Hz), 60.36 (d, J = 13 Hz),

54.18 (d, J = 7 Hz), 53.96 (d, J = 6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 17.12. HRMS Calcd. For $C_{11}H_{15}NaO_5P^+$[M+Na^+]: 281.0549. Found: 281.0556.



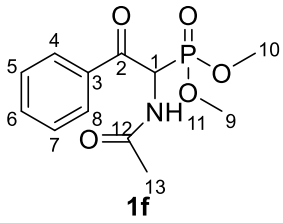
1d

dimethyl (1-fluoro-2-oxo-2-phenylethyl)phosphonate (1d) was synthesized through **Method** E as yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.03-7.50 (m, Ar-H, 5H), 6.05 (dd, C_1-H, J = 47.2, 13.4 Hz, 1H), 3.87 (d, C_9-H, J = 10.9 Hz, 3H), 3.80 (d, C_{10}-H, J = 10.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 191.08 (d, J = 170 Hz), 134.43, 134.04, 129.30 (d, J = 3 Hz), 128.70, 89.98 (dd, J = 196.4 Hz, 153.2Hz), 54.51 (d, J = 6 Hz), 54.42 (d, J = 6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 27.17 (d, J = 71 Hz). HRMS Calcd. For $C_{10}H_{12}FNaO_4P^+$[M+Na^+]: 269.0349. Found: 269.0351.



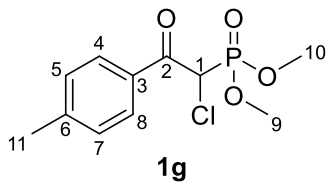
1e

dimethyl (1-chloro-2-oxo-2-phenylethyl)phosphonate (1e) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.99-7.47 (m, Ar-H, 5H), 5.48 (d, C_1-H, J = 15.8 Hz, 1H), 3.85 (d, C_9-H, J = 9 Hz, 3H). 3.82 (d, C_{10}-H, J = 9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 189.49 (d, J = 2 Hz), 134.49 (d, J = 2 Hz), 134.34, 129.34, 128.80, 54.92 (d, J = 7 Hz), 54.82 (d, J = 7 Hz), 51.86 (d, J = 145 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.88. HRMS Calcd. For $C_{10}H_{12}ClNaO_4P^+$[M+Na^+]: 285.0054. Found: 285.0052.



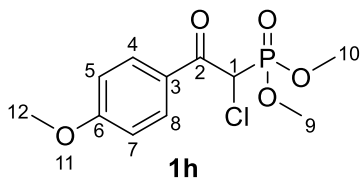
1f

dimethyl (1-acetamido-2-oxo-2-phenylethyl)phosphonate (1f) was synthesized through **Method F** as yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.05-7.48 (m, Ar-H, 5H), 7.20 (d, N-H, J = 8.7 Hz, 1H), 6.27 (dd, C_1-H, J = 21.2, 8.7 Hz, 1H), 3.73 (d, C_9-H, J =11 Hz, 3H), 3.68 (d, C_{10}-H, J = 11 Hz, 3H), 2.08 (s, C_{13}-H, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 192.67, 169.66 (d, J = 4 Hz), 134.81, 134.27, 129.27, 128.66, 53.94, 53.86, 52.86 (d, J = 143 Hz), 22.82. ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 19.08. HRMS Calcd. For $C_{12}H_{16}NNaO_5P^+$[M+Na^+]: 308.0658. Found: 308.0664.



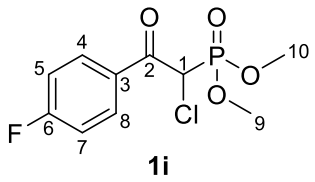
1g

dimethyl (1-chloro-2-oxo-2-(p-tolyl)ethyl)phosphonate (1g) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.89-7.27 (m, Ar-H, 4H), 5.45 (d, C_1-H, J = 15.7 Hz, 1H), 3.86 (d, C_9-H, J = 10.5 Hz, 3H), 3.83 (d, C_{10}-H, J = 10.5 Hz, 3H), 2.40 (s, C_{11}-H, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.95 (d, J = 2 Hz), 145.57, 131.96 (d, J = 2 Hz), 129.52, 129.50, 54.88 (d, J = 7 Hz), 54.78 (d, J = 7 Hz), 51.76 (d, J = 145 Hz), 21.81. ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 16.10. HRMS Calcd. For $C_{11}H_{14}ClNaO_4P^+$[M+Na^+]: 299.0210. Found: 299.0207.



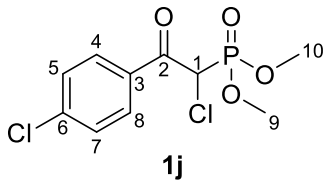
1h

dimethyl (1-chloro-2-(4-methoxyphenyl)-2-oxoethyl)phosphonate （1h） was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.15-6.75 (m, Ar-H, 4H), 5.42 (d, C_1-H, J = 15.6 Hz, 1H), 4.02-3.70 (m, $C_{9,\ 10,\ 12}$-H, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 187.65 (d, J = 2 Hz), 164.52, 131.92, 127.30 (d, J = 3 Hz), 114.03, 55.62, 54.90 (d, J = 6 Hz), 54.74 (d, J = 7 Hz), 51.70 (d, J = 145 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 16.28. HRMS Calcd. For $C_{11}H_{14}ClNaO_5P^+$[M+Na^+]: 315.0160. Found: 315.0157.



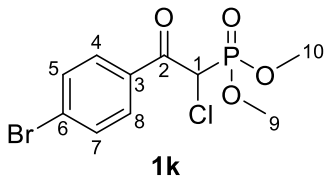
1i

dimethyl (1-chloro-2-(4-fluorophenyl)-2-oxoethyl)phosphonate (1i) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.08-7.13 (m, Ar-H, 4H), 5.41 (d, C_1-H, J = 16.1 Hz, 1H), 3.87 (d, C_9-H, J = 6.1 Hz, 3H), 3.84 (d, C_{10}-H, J = 6.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 187.97, 166.38 (d, J = 256 Hz), 132.32 (d, J = 9 Hz), 130.80, 116.05 (d, J = 22 Hz), 55.04 (d, J = 7 Hz), 54.84 (d, J = 7 Hz), 52.06 (d, J = 144 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.65. HRMS Calcd. For $C_{10}H_{11}ClFNaO_4P^+$[M+Na^+]: 302.9960. Found: 302.9957.



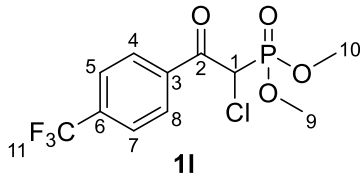
1j

dimethyl (1-chloro-2-(4-chlorophenyl)-2-oxoethyl)phosphonate (1j) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.96-7.43 (m, Ar-H, 4H), 5.41 (d, C_1-H, J = 16.2 Hz, 1H), 3.86 (d, C_9-H, J = 7.5 Hz, 3H), 3.83 (d, C_{10}-H, J = 7.5 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.41 (d, J = 2 Hz), 140.97, 132.71 (d, J = 2 Hz), 130.84, 129.13, 55.04 (d, J = 6 Hz), 54.87 (d, J = 7 Hz), 52.12 (d, J = 145 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.53. HRMS Calcd. For $C_{10}H_{11}Cl_2NaO_4P^+$[M+Na^+]: 318.9664. Found: 318.9662.



1k

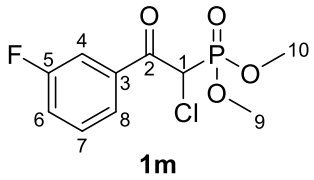
dimethyl (2-(4-bromophenyl)-1-chloro-2-oxoethyl)phosphonate (1k) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.89-7.61 (m, Ar-H, 4H), 5.40 (d, C_1-H, J = 16.2 Hz, 1H), 3.87 (d, C_9-H, J = 7.6 Hz, 3H), 3.84 (d, C_{10}-H, J = 7.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.64 (d, J = 2 Hz), 133.13 (d, J = 2 Hz), 132.14, 130.88, 129.84, 55.06 (d, J = 7 Hz), 54.88 (d, J = 6 Hz), 52.12 (d, J = 145 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.48. HRMS Calcd. For $C_{10}H_{11}{}^{79}BrClNaO_4P^+$[M+$Na^+$]: 362.9159. Found: 362.9157.



1l

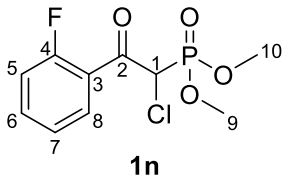
dimethyl (1-chloro-2-oxo-2-(4-(trifluoromethyl)phenyl)ethyl)phosphonate (1l) was synthesized through **Method A** as pink solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.14-7.74 (m, Ar-H, 4H), 5.44 (d, C_1-H, J = 16.5 Hz, 1H), 3.88 (d, C_9-H, J = 7.9 Hz, 3H), 3.85 (d, C_{10}-H, J = 7.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.90 (d, J = 2 Hz), 137.14, 135.30 (q, J = 32 Hz), 129.79, 125.79 (q, J = 7 Hz), 123.34 (q, J = 271 Hz), 55.10 (d, J = 7 Hz), 54.90 (d, J = 7 Hz), 52.44 (d, J = 144 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.15. HRMS Calcd.

For $C_{11}H_{11}ClF_3NaO_4P^+$[M+Na$^+$]: 352.9928. Found: 352.9922.



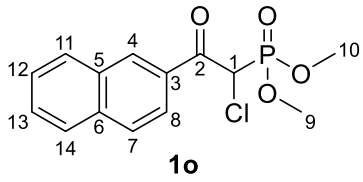
1m

dimethyl (1-chloro-2-(3-fluorophenyl)-2-oxoethyl)phosphonate (1m) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.80-7.29 (m, Ar-H, 4H), 5.41 (d, C_1-H, J = 16.1 Hz, 1H), 3.87 (d, C_9-H, J = 8.9 Hz, 3H), 3.84 (d, C_{10}-H, J = 8.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.49 (d, J = 2.3 Hz), 162.69 (d, J = 248.8 Hz), 136.43 (dd, J = 6.5, 2.7 Hz), 130.49 (d, J = 7.7 Hz), 125.21 (d, J = 3.1 Hz), 121.41 (d, J = 21.5 Hz), 116.09 (d, J = 23.1 Hz), 55.02 (d, J = 6.8 Hz), 54.88 (d, J = 6.9 Hz), 52.05 (d, J = 145.6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.37. HRMS Calcd. For $C_{10}H_{11}ClFNaO_4P^+$[M+Na$^+$]: 302.9960. Found: 302.9955.



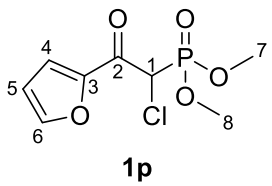
1n

dimethyl (1-chloro-2-(2-fluorophenyl)-2-oxoethyl)phosphonate (1n) was synthesized through **Method A** as red solid. ^{1}H NMR (400 MHz, $CDCl_3$ δ/ppm 7.90-7.15 (m, Ar-H, 4H), 5.61 (dd, J = 17.1, 3.3 Hz, 1H), 3.86 (d, J = 11.0 Hz, 3H), 3.83 (d, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 187.39 (dd, J = 7.2, 3.1 Hz), 161.36 (d, J = 254.3 Hz), 135.90 (d, J = 9.3 Hz), 131.49 (d, J = 1.8 Hz), 124.93 (d, J = 3.2 Hz), 123.76 (dd, J = 11.8, 1.7 Hz), 116.66 (d, J = 23.8 Hz), 56.65 (d, J = 10.2 Hz), 55.22 (d, J = 10.1 Hz), 54.80 (d, J = 6.6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.43. HRMS Calcd. For $C_{10}H_{11}ClFNaO_4P^+$[M+Na$^+$]: 302.9960. Found: 302.9956.



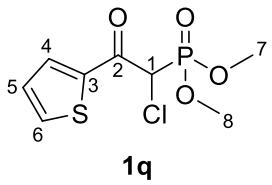
1o

dimethyl (1-chloro-2-(naphthalen-2-yl)-2-oxoethyl)phosphonate (1o) was synthesized through **Method A** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.56-7.54 (m, Ar-H, 7H), 5.66 (d, C_1-H, J = 15.8 Hz, 1H), 3.89 (d, C_9-H, J = 11.0 Hz, 3H), 3.86 (d, C_{10}-H, J = 11.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 189.39 (d, J = 2.1 Hz), 136.01, 132.26, 131.81 (d, J = 2.8 Hz), 131.74, 129.95, 129.35, 128.78, 127.82, 127.15, 124.31, 54.97 (d, J = 3.0 Hz), 54.90 (d, J = 3.1 Hz), 51.92 (d, J = 146.0 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 16.07. HRMS Calcd. For $C_{14}H_{14}ClNaO_4P^+$[M+Na$^+$]: 335.0210. Found: 335.0201.



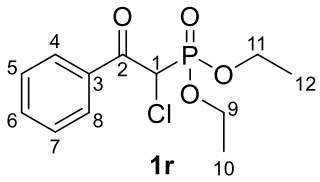
1p

dimethyl (1-chloro-2-(furan-2-yl)-2-oxoethyl)phosphonate (1p) was synthesized through **Method A** as yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.67-6.60 (m, Ar-H, 3H), 5.34 (d, C_1-H, J = 16.0 Hz, 1H), 3.86 (d, C_7-H, J = 11.1 Hz, 3H), 3.83 (d, C_8-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 177.49 (d, J = 2.4 Hz), 150.38 (d, J = 2.9 Hz), 148.01, 120.61, 113.29, 54.94 (d, J = 3.9 Hz), 54.87 (d, J = 4.3 Hz), 51.50 (d, J = 144.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.40. HRMS Calcd. For $C_8H_{10}ClNaO_5P^+$[M+Na$^+$]: 274.9847. Found: 274.9841.



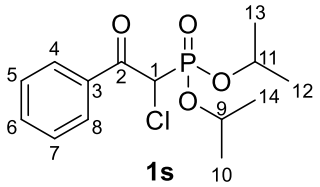
1q

dimethyl (1-chloro-2-oxo-2-(thiophen-2-yl)ethyl)phosphonate (1q) was synthesized through **Method A** as yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.92-7.14 (m, Ar-H, 3H), 5.26 (d, C_1-H, J = 15.7 Hz, 1H), 3.86 (d, C_7-H, J = 7.5 Hz, 3H), 3.84 (d, C_8-H, J = 7.7 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 181.83 (d, J = 1.9 Hz), 141.02 (d, J = 2.8 Hz), 136.41, 134.99, 128.65, 55.03 (d, J = 6.8 Hz), 54.90 (d, J = 6.9 Hz), 52.74 (d, J = 144.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 15.40. HRMS Calcd. For $C_8H_{10}ClNaO_4PS^+$[M+Na$^+$]: 290.9618. Found: 290.9594.



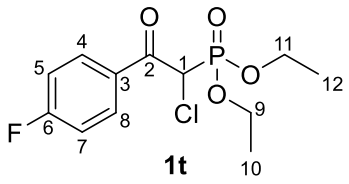
1r

diethyl (1-chloro-2-oxo-2-phenylethyl)phosphonate (1r) was synthesized through **Method G** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.01 -7.45 (m, Ar-H, 5H), 5.47 (d, C_1-H, J = 16.2 Hz, 1H), 4.29-4.15 (m, $C_{9,\ 11}$-H, 4H), 1.31 (t, C_{10}-H, J = 6.8 Hz, 3H), 1.24 (t, C_{12}-H, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 189.60 (d, J = 2.2 Hz), 134.83 (d, J = 2.2 Hz), 134.16, 129.35, 128.69, 64.64 (d, J = 6.9 Hz), 64.53 (d, J = 6.7 Hz), 52.71 (d, J = 143.6 Hz), 16.30 (d, J = 5.9 Hz), 16.20 (d, J = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 13.20. HRMS Calcd. For $C_{12}H_{16}ClNaO_4P^+$[M+Na$^+$]: 313.0367. Found: 313.0367.



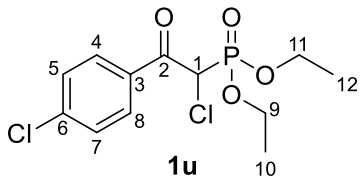
1s

diisopropyl (1-chloro-2-oxo-2-phenylethyl)phosphonate (1s) was synthesized through **Method H** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.00 -7.44 (m, Ar-H, 5H), 5.41 (d, C_1-H, J = 16.7 Hz, 1H), 4.85-4.72 (m, $C_{9,\ 11}$-H, 2H), 1.33 (d, C_{10}-H, J = 6.2 Hz, 3H), 1.29 (d, C_{12}-H, J = 6.2 Hz, 3H), 1.27 (d, C_{13}-H, J = 6.2 Hz, 3H), 1.20 (d, C_{14}-H, J = 6.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 189.71 (d, J = 2.1 Hz), 135.11 (d, J = 1.7 Hz), 133.97, 129.39, 128.58, 73.72 (d, J = 7.2 Hz), 73.56 (d, J = 7.2 Hz), 53.46 (d, J = 144.4 Hz), 24.13 (d, J = 3.4 Hz), 23.96 (d, J = 3.4 Hz), 23.63 (d, J = 6.0 Hz), 23.55 (d, J = 5.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 11.24. HRMS Calcd. For $C_{14}H_{20}ClNaO_4P^+$[M+Na$^+$]: 341.0680. Found: 341.0666.



1t

diethyl (1-chloro-2-(4-fluorophenyl)-2-oxoethyl)phosphonate (1t) was synthesized through **Method G** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.11-7.14 (m, Ar-H, 4H), 5.42 (d, C_1-H, J = 16.5 Hz, 1H), 4.30-4.17 (m, $C_{9,\ 11}$-H, 4H), 1.33 (t, C_{10}-H, J = 7.1 Hz, 3H), 1.28 (t, C_{12}-H, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.07, 166.26 (d, J = 259.2 Hz), 132.29 (dd, J = 9.6, 2.0 Hz), 131.19, 115.96, 115.94, 115.74, 115.72, 64.61 (d, J = 2.7 Hz), 64.56 (d, J = 2.7 Hz), 52.93 (d, J = 143.4 Hz), 16.24 (d, J = 6.0 Hz), 16.15 (d, J = 5.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 13.02. HRMS Calcd. For $C_{12}H_{15}ClFNaO_4P^+$[M+Na$^+$]: 331.0273. Found: 331.0276.



diethyl (1-chloro-2-(4-chlorophenyl)-2-oxoethyl)phosphonate (1u) was synthesized through **Method G** as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 8.00-7.46 (m, Ar-H, 4H), 5.41 (d, C_1-H, J = 16.6 Hz, 1H), 4.31-4.18 (m, $C_{9,\ 11}$-H, 4H), 1.34 (t, C_{10}-H, J = 7.1 Hz, 3H), 1.28 (t, C_{12}-H, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 188.53 (d, J = 1.9 Hz), 140.78, 133.02 (d, J = 2.1 Hz), 130.87, 129.01, 64.70 (d, J = 6.9 Hz), 52.96 (d, J = 143.2 Hz), 16.31 (d, J = 5.7 Hz), 16.22 (d, J = 5.6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 12.90. HRMS Calcd. For $C_{12}H_{15}Cl_2NaO_4P^+$[M+Na^+]: 346.9977. Found: 346.9977.

References

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Table S1. The details of genes used in this study.

Name	Accession No.	Source	aa
YHR104w	NP_011972	*Saccharomyces cerevisiae*	327
YDR368w	NP_010656	*Saccharomyces cerevisiae*	312
YGL039w	NP_011476	*Saccharomyces cerevisiae*	348
YNL331c	NP_014068.1	*Saccharomyces cerevisiae*	376
YOL151w	NP_014490.1	*Saccharomyces cerevisiae*	342
YDL124w	NP_010159.1	*Saccharomyces cerevisiae*	312
RasADH	EU485985	*Ralstonia sp.* DSMZ 6428	250
KmCR2	XP_022675166.1	*Kluyveromyces marxianus CBS4857*	341
SsCR	AF160799.1	*Sporidiobolus salmonicolor*	343
LkADH	WP_054768785.1	*Lactobacillus kefiri*	252
SyADH	EU427523.1	*Sphingobium yanoikuyae*	263
KRED-F42	WP_023468191.1	*Exiguobacterium sp.* MH3	249
CaADH	WP_010890687.1	*Clostridium acetobutylicum*	251
KRED-30	AHC30841.1	*Chryseobacterium sp.* CA49	244

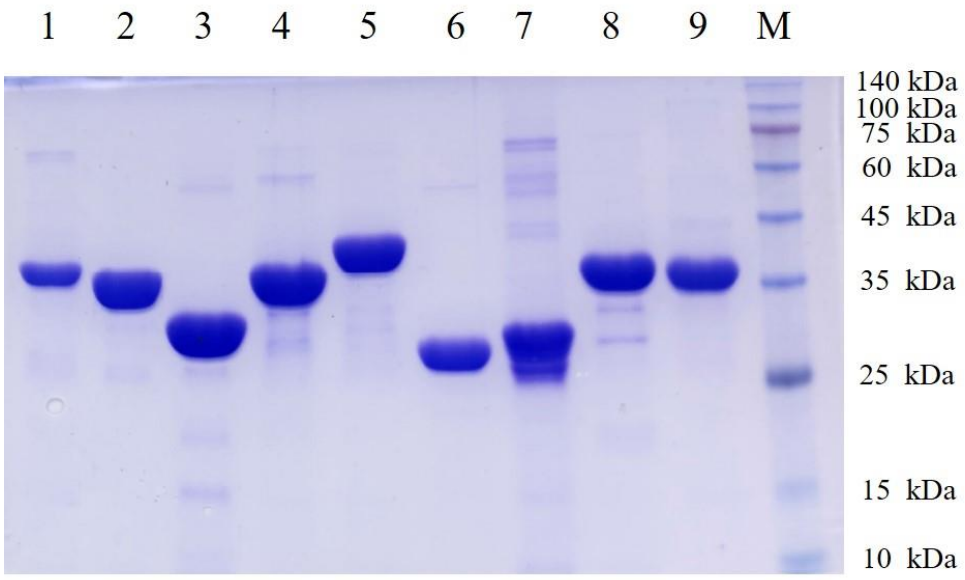


Figure S1. SDS-PAGE analysis of His_6-KREDs after IMAC purification. Coomassie staining. M: RealBand 3-color Regular Range Protein Marker (Sangon Biotech, China). Lane 1: His_6-SsCR. Lane 2: His_6-YDL124w. Lane 3: His_6-LkADH. Lane 4: His_6-YHR104w. Lane 5: His_6-YNL331c. Lane 6: His_6-KRED-30. Lane 7: His_6-CaADH. Lane 8: His_6-YOL151w. Lane 9: His_6-YGL039w.

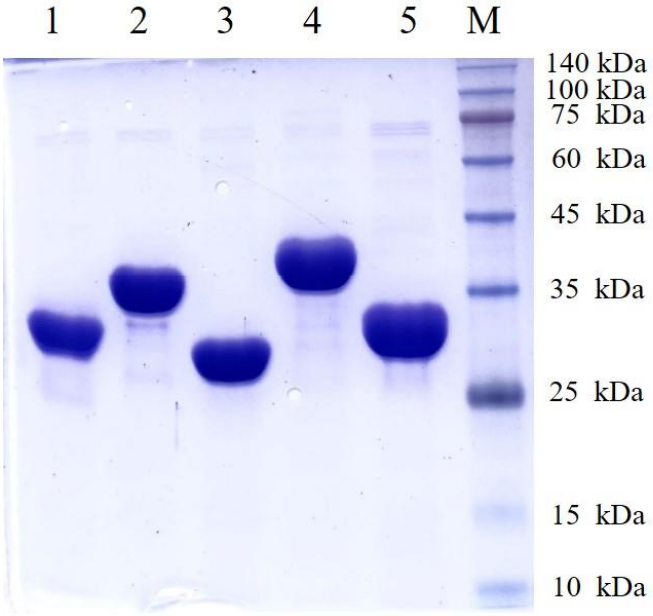
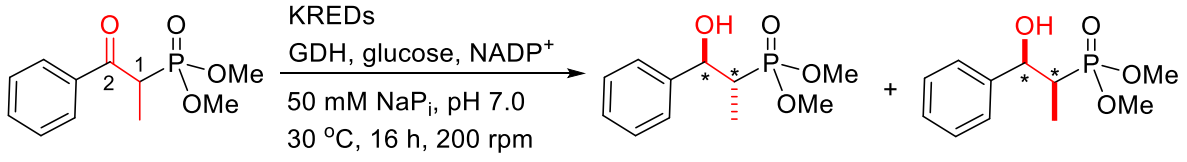


Figure S2. SDS-PAGE analysis of His_6-KREDs after IMAC purification. Coomassie staining. M: RealBand 3-color Regular Range Protein Marker (Sangon Biotech, China). Lane 1: His_6-SyADH. Lane 2: His_6-YDR368w. Lane 3: His_6-KRED-F42. Lane 4: His_6-KmCR2. Lane 5: His_6-RasADH.

Screen KREDs against reduction of ketone 1a-1f

To a solution of 10 mM ketone substrate, 20 mM glucose and 0.2 mM $NADP^+$ in NaP_i buffer (50 mM, pH 7.0), were added KRED and glucose dehydrogenase (GDH) (1 mg/mL each). The 5 mL Eppendorf tube containing 1 mL of the above mixture was shaken at 200 rpm and 30 ℃ for 16 h. The reaction mixture was extracted with EtOAc (5 mL) and the organic layer was dried and concentrated and subjected to ^{1}H NMR and chiral HPLC analyses.

Table S2. Screen KREDs on reduction of α-substituted-β-keto phosphonates 1a[a]

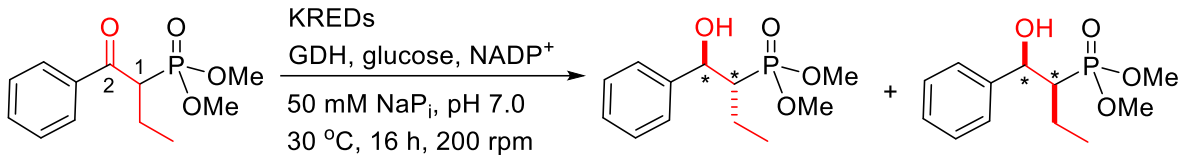


1a *anti*-**2a** *syn*-**2a**

	Conv. (%)[b]	Stereoisomer I (%)[c]	Stereoisomer II (%)[c]	Stereoisomer III (%)[c]	Stereoisomer IV (%)[c]	*dr* (*anti*: *syn*)[c]	*ee anti* (%)[d]	*ee syn* (%)[d]
RasADH	90.6	1.82	6.03	0	92.14	11.7:1	>99	n.d.[e]
KmCR2	61.6	5.57	0.10	93.90	0.42	16.6:1	>99	n.d.
YDR368W	N.R.[f]	0	0	0	0	/	/	/
KRED-F42	N.R.	0	0	0	0	/	/	/
YDL124W	N.R.	0	0	0	0	/	/	/
SyADH	12.4	2.13	4.20	3.14	90.53	14.8:1	93	n.d.
YNL331c	>99	41.34	0.13	54.41	4.11	1.4:1	86	>99
YHR104w	N.R.	0	0	0	0	/	/	/
YOL151w	N.R.	0	0	0	0	/	/	/
CaADH	10.1	2.01	97.99	0	0	<1:>99	n.d.	96
SsCR	12.2	37.40	7.06	55.54	0	1.2:1	>99	68
YGL039w	11.8	78.68	0.10	12.52	8.80	1:3.7	17	>99
LkADH	3.1	7.09	0	58.28	34.63	13.1:1	25	/
KRED-30	9.1	8.82	24.57	40.16	26.50	2:1	20	47

[a] Reaction conditions (1 mL): **1a** (10 mM), glucose (20 mM), $NADP^+$ (0.2 mM), purified KREDs and GDH (1 mg/mL each) in NaP_i buffer (50 mM, pH 7.0). Reaction mixtures were incubated at 30 ℃ with 200 rpm shaking for 16 h. [b] The reaction conversion was determined by ^{1}H NMR. [c] The percentage and the *dr* were determined by chiral HPLC analysis and the relative configuration of the product (syn or anti) was assigned based on the coupling constant observed in ^{1}H NMR. [d] The ee was determined by chiral HPLC analysis. [e] n.d.: not determined. [f] N.R.: no reaction.

Table S3. Screen KREDs on reduction of α-substituted-β-keto phosphonates 1b[a]

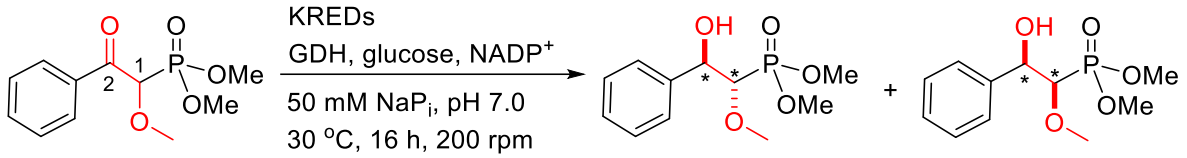


1b *anti*-**2b** *syn*-**2b**

	Conv. (%)[b]	Stereoisomer I (%)[c]	Stereoisomer II (%)[c]	Stereoisomer III (%)[c]	Stereoisomer IV (%)[c]	*dr* (*anti*: *syn*)[c]	*ee* *anti* (%)[d]	*ee* *syn* (%)[d]
RasADH	N.R.[e]	0	0	0	0	/	/	/
KmCR2	N.R.	0	0	0	0	/	/	/
YDR368W	N.R.	0	0	0	0	/	/	/
KRED-F42	N.R.	0	0	0	0	/	/	/
YDL124W	N.R.	0	0	0	0	/	/	/
SyADH	N.R.	0	0	0	0	/	/	/
YNL331c	>99	38.03	0.38	60.23	1.36	1.6:1	96	98
YHR104w	N.R.	0	0	0	0	/	/	/
YOL151w	N.R.	0	0	0	0	/	/	/
CaADH	N.R.	0	0	0	0	/	/	/
SsCR	N.R.	0	0	0	0	/	/	/
YGL039w	N.R.	0	0	0	0	/	/	/
LkADH	N.R.	0	0	0	0	/	/	/
KRED-30	N.R.	0	0	0	0	/	/	/

[a] Reaction conditions (1 mL): **1b** (10 mM), glucose (20 mM), $NADP^+$ (0.2 mM), purified KREDs and GDH (1 mg/mL each) in NaP_i buffer (50 mM, pH 7.0). Reaction mixtures were incubated at 30 ℃ with 200 rpm shaking for 16 h. [b] The reaction conversion was determined by ^1H NMR. [c] The percentage and the *dr* were determined by chiral HPLC analysis and the relative configuration of the product (syn or anti) was assigned based on the coupling constant observed in ^1H NMR. [d] The ee was determined by chiral HPLC analysis. [e] N.R.: no reaction.

Table S4. Screen KREDs on reduction of α-substituted-β-keto phosphonates 1c[a]

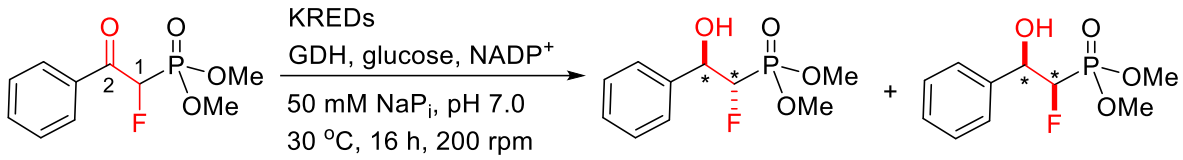


1c *anti*-**2c** *syn*-**2c**

	Conv. (%)[b]	Stereoisomer I (%)[c]	Stereoisomer II (%)[c]	Stereoisomer III (%)[c]	Stereoisomer IV (%)[c]	*dr* (*anti*:*syn*)[c]	*ee* *anti* (%)[d]	*ee* *syn* (%)[d]
RasADH	31.5	0	71.87	0	28.13	2.6:1	>99	>99
KmCR2	7.4	47.77	49.03	3.20	0	30.2:1	*racemic*	n.d.[e]
YDR368W	13.8	0	0	0	>99	<1:>99	n.d.	>99
KRED-F42	32.0	0	60.32	0	39.68	1.5:1	>99	>99
YDL124W	9.9	0	0	36.20	63.80	<1:>99	n.d.	28
SyADH	7.4	0	46.57	0	53.43	1:1.1	>99	>99
YNL331c	>99	31.24	0.20	68.10	0.47	1:2.2	99	99
YHR104w	7.4	0	0	0	>99	<1:>99	n.d.	>99
YOL151w	13.0	3.11	87.33	0	9.57	9.5:1	93	>99
CaADH	9.9	0	58.31	0	41.69	1.4:1	>99	>99
SsCR	15.2	2.81	56.90	0.56	39.74	1.5:1	90.6	97
YGL039w	9.9	0	>99	0	0	>99:<1	>99	n.d.
LkADH	7.4	10.43	6.96	30.37	52.25	1:4.8	17	26
KRED-30	33.3	5.19	9.80	6.73	78.28	1:5.7	31	84

[a] Reaction conditions (1 mL): **1c** (10 mM), glucose (20 mM), $NADP^+$ (0.2 mM), purified KREDs and GDH (1 mg/mL each) in NaP_i buffer (50 mM, pH 7.0). Reaction mixtures were incubated at 30 °C with 200 rpm shaking for 16 h. [b] The reaction conversion was determined by ^1H NMR. [c] The percentage and the *dr* were determined by chiral HPLC analysis and the relative configuration of the product (syn or anti) was assigned based on the coupling constant observed in ^1H NMR. [d] The ee was determined by chiral HPLC analysis. [e] n.d.: not determined.

Table S5. Screen KREDs on reduction of α-substituted-β-keto phosphonates 1d[a]

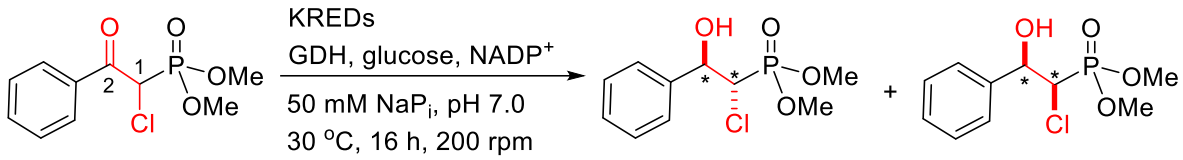


1d *anti*-**2d** *syn*-**2d**

	Conv. (%)[b]	Stereoisomer I (%)[c]	Stereoisomer II (%)[c]	Stereoisomer III (%)[c]	Stereoisomer IV (%)[c]	*dr* (*anti*: *syn*)[c]	*ee anti* (%)[d]	*ee syn* (%)[d]
RasADH	>99	8.10	79.50	5.06	7.35	7.1:1	82	18
KmCR2	>99	65.33	0.51	8.22	25.95	1.9:1	98	52
YDR368W	69.4	3.52	0	0	96.48	1:27.4	n.d.[e]	>99
KRED-F42	>99	0.66	17.62	81.72	0	1:4.5	93	>99
YDL124W	>99	0	98.85	1.15	0	86.3:1	>99	n.d.
SyADH	>99	12.30	73.97	11.62	2.11	6.3:1	72	69
YNL331c	>99	32.01	9.61	7.37	51.01	1:1.4	54	75
YHR104w	30.6	2.78	93.62	3.60	0	26.7:1	94	n.d.
YOL151w	>99	48.04	13.87	9.60	28.49	1.6:1	55	50
CaADH	>99	19.54	13.99	60.18	6.29	1:2	16	81
SsCR	>99	16.42	10.35	5.06	68.17	1:2.7	23	86
YGL039w	>99	35.75	2.15	0	62.10	1:1.6	89	>99
LkADH	75.2	86.43	0.08	0.22	13.27	6.4:1	>99	97
KRED-30	>99	19.00	0.21	21.55	59.24	1:4.2	98	47

[a] Reaction conditions (1 mL): **1d** (10 mM), glucose (20 mM), $NADP^+$ (0.2 mM), purified KREDs and GDH (1 mg/mL each) in NaP_i buffer (50 mM, pH 7.0). Reaction mixtures were incubated at 30 ℃ with 200 rpm shaking for 16 h. [b] The reaction conversion was determined by ^1H NMR. [c] The percentage and the *dr* were determined by chiral HPLC analysis and the relative configuration of the product (syn or anti) was assigned based on the coupling constant observed in ^1H NMR. [d] The ee was determined by chiral HPLC analysis. [e] n.d.: not determined.

Table S6. Screen KREDs on reduction of α-substituted-β-keto phosphonates 1e[a]

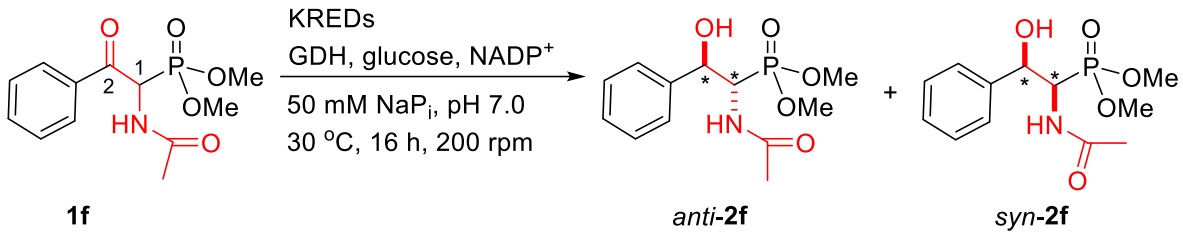


1e *anti*-**2e** *syn*-**2e**

	Conv. (%)[b]	Stereoisomer I (%)[c]	Stereoisomer II (%)[c]	Stereoisomer III (%)[c]	Stereoisomer IV (%)[c]	*dr* (*anti*: *syn*)[c]	*ee anti* (%)[d]	*ee syn* (%)[d]
RasADH	>99	0.50	8.45	2.99	88.06	7.7:1	99	65
KmCR2	>99	96.31	3.56	0.14	0	26.1:1	>99	n.d.[e]
YDR368W	25.5	1.09	98.91	0	0	1:90.6	n.d.	>99
KRED-F42	71.9	11.30	4.07	61.22	23.41	1:1.9	35	88
YDL124W	47.4	0.52	32.56	7.50	59.42	1.5:1	98	62
SyADH	91.7	10.31	1.16	3.30	85.23	21.4:1	78	n.d.
YNL331c	>99	15.62	57.85	0.20	26.33	1:1.4	26	>99
YHR104w	N.R.[f]	0	0	0	0	/	/	/
YOL151w	24.2	83.21	11.89	4.90	0	5:1	>99	42
CaADH	25.5	22.07	6.38	57.85	13.71	1:1.8	23	80
SsCR	>99	34.03	65.96	0	0	1:1.9	>99	>99
YGL039w	>99	25.57	70.14	0.09	4.20	1:2.4	72	>99
LkADH	39.4	99.47	0.53	0	0	>99:<1	>99	n.d.
KRED-30	>99	29.14	7.10	7.93	55.83	5.6:1	31	6

[a] Reaction conditions (1 mL): **1e** (10 mM), glucose (20 mM), $NADP^+$ (0.2 mM), purified KREDs and GDH (1 mg/mL each) in NaP_i buffer (50 mM, pH 7.0). Reaction mixtures were incubated at 30 ℃ with 200 rpm shaking for 16 h. [b] The reaction conversion was determined by ^1H NMR. [c] The percentage and the *dr* were determined by chiral HPLC analysis and the relative configuration of the product (syn or anti) was assigned based on the coupling constant observed in ^1H NMR. [d] The ee was determined by chiral HPLC analysis. [e] n.d.: not determined. [f] N.R.: no reaction.

Table S7. Screen KREDs on reduction of α-substituted-β-keto phosphonates 1f[a]



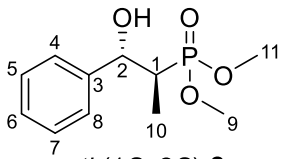
1f *anti*-**2f** *syn*-**2f**

	Conv. (%)[b]	Stereoisomer I (%)[c]	Stereoisomer II (%)[c]	Stereoisomer III (%)[c]	Stereoisomer IV (%)[c]	*dr* (*anti*: *syn*)[c]	*ee* *anti* (%)[d]	*ee* *syn* (%)[d]
RasADH	N.R.[e]	0	0	0	0	/	/	/
KmCR2	N.R.	0	0	0	0	/	/	/
YDR368W	N.R.	0	0	0	0	/	/	/
KRED-F42	N.R.	0	0	0	0	/	/	/
YDL124W	N.R.	0	0	0	0	/	/	/
SyADH	N.R.	0	0	0	0	/	/	/
YNL331c	>99	0	99.68	0.17	0.14	>99:<1	>99	n.d.
YHR104w	N.R.	0	0	0	0	/	/	/
YOL151w	N.R.	0	0	0	0	/	/	/
CaADH	N.R.	0	0	0	0	/	/	/
SsCR	N.R.	0	0	0	0	/	/	/
YGL039w	N.R.	0	0	0	0	/	/	/
LkADH	N.R.	0	0	0	0	/	/	/
KRED-30	N.R.	0	0	0	0	/	/	/

[a] Reaction conditions (1 mL): **1f** (10 mM), glucose (20 mM), $NADP^+$ (0.2 mM), purified KREDs and GDH (1 mg/mL each) in NaP_i buffer (50 mM, pH 7.0). Reaction mixtures were incubated at 30 °C with 200 rpm shaking for 16 h. [b] The reaction conversion was determined by ^1H NMR. [c] The percentage and the *dr* were determined by chiral HPLC analysis and the relative configuration of the product (syn or anti) was assigned based on the coupling constant observed in ^1H NMR. [d] The ee was determined by chiral HPLC analysis. [e] N.R.: no reaction.

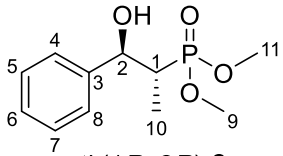
KRED-catalyzed DYRKR in semi-preparative scale using cell-free extract (CFE)

The semi-preparative scale reaction was carried out with ketone (125 mg), glucose (1 g), $NADP^+$ (50 mg), 35 mL 30% (w/v) CFE of KREDs in NaP_i buffer (50 mM, pH 7.0), 10 mL 15% (w/v) CFE of GDH in NaP_i buffer (50 mM, pH 7.0) and 5 mL DMSO at 30 °C and 900 rpm for 24 h. Silica gel was added to the reaction mixture and subjected to centrifugation. The supernatant was extracted with EtOAc. The organic layer was then washed with brine and dried with anhydrous Na_2SO_4, then filtered, and the filtrate was evaporated to dryness. The product was purified by flash chromatography. The *dr* was determined by chiral HPLC analysis and the relative configuration of the product (*syn* or *anti*) was assigned based on the coupling constant observed in ^1H NMR. The ee was determined by chiral HPLC analysis, and the absolute configuration was assigned by X-ray crystallography.



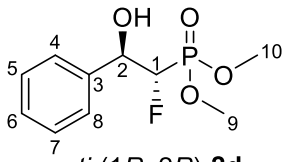
anti-(1*S*, 2*S*)-**2a**

***anti*-(1*S*, 2*S*)-dimethyl (1-hydroxy-1-phenylpropan-2-yl)phosphonate (*anti*-(1*S*, 2*S*)-2a)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 70.6% yield as white solid.^1H NMR (400 MHz, $CDCl_3$) δ/ppm 7.37-7.28 (m, Ar-H, 5H), 4.74 (dd, C_2-H, *J* = 10.3, 10.3 Hz, 1H), 4.49 (br, O-H,1H), 3.84 (d, C_9-H, *J* = 10.6 Hz, 3H), 3.76 (d, C_{11}-H, *J* = 10.8 Hz, 3H), 2.27 (ddq, C_1-H, *J* = 16.8, 9.4, 7.4 Hz, 1H), 0.90 (dd, C_{10}-H, *J* = 17.5, 7.3 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 141.42 (d, *J* = 15.5 Hz), 128.41, 128.05, 126.88, 74.76 (d, *J* = 3.6 Hz), 52.77 (d, *J* = 6.7 Hz), 38.81 (d, *J* = 135.6 Hz), 11.79 (d, *J* = 5.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 35.96. $[\alpha]_{25}^{D}$ = 27.18 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IF, 250 × 4.6 mm column, hexane/2-propanol 93:7, 0.8 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=14.2 min, t_2=15.7 min, t_3=21.0 min (major), t_4=22.2 min. *ee* = 99.0%, *dr* = 12.7:1. HRMS Calcd. For $C_{11}H_{17}NaO_4P^+[M+Na^+]$: 267.0757. Found: 267.0748.



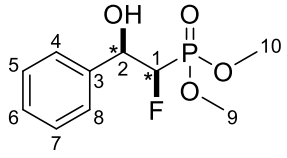
anti-(1*R*, 2*R*)-**2a**

***anti*-(1*R*, 2*R*)-dimethyl (1-hydroxy-1-phenylpropan-2-yl)phosphonate (*anti*-(1*R*, 2*R*)-2a)** which catalyzed by RasADH was purified by chromatography on silica gel with 55.5% yield as white solid. ^1H NMR (400 MHz, $CDCl_3$) δ/ppm 7.43-7.22 (m, Ar-H, 5H), 4.75 (dd, C_2-H, *J* = 11.1, 9.4 Hz, 1H), 4.47 (s, O-H, 1H), 3.85 (d, C_9-H, *J* = 10.5 Hz, 3H), 3.77 (d, C_{10}-H, *J* = 10.7 Hz, 3H), 2.28 (ddq, C_1-H, *J* = 16.9, 9.4, 7.4 Hz, 1H), 0.90 (dd, C_{10}-H, *J* = 17.5, 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 141.39 (d, *J* = 15.6 Hz), 128.43, 128.07, 126.88, 74.79 (d, *J* = 3.7 Hz), 52.78 (d, *J* = 7.4 Hz), 38.82 (d, *J* = 135.6 Hz), 11.81 (d, *J* = 5.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 35.97. $[\alpha]_{25}^{D}$ = -23.18 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IF, 250 × 4.6 mm column, hexane/2-propanol 93:7, 0.8 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=14.2 min, t_2=15.7 min, t_3=21.0 min, t_4=22.2 min (major). *ee* = >99%, *dr* = 26.3:1. HRMS Calcd. For $C_{11}H_{17}NaO_4P^+[M+Na^+]$: 267.0757. Found: 267.0751.



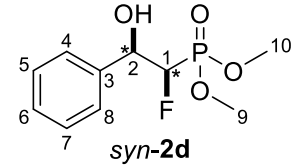
anti-(1*R*, 2*R*)-**2d**

***anti*-(1*R*, 2*R*)-dimethyl (1-fluoro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*R*, 2*R*)-2d)** which catalyzed by YDL124w was purified by chromatography on silica gel with 71.4% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.53-7.30 (m, Ar-H, 5H), 5.18-5.08 (m, C_2-H, 1H), 4.79 (ddd, C_1-H, J = 45.4, 7.8, 2.1 Hz, 1H), 4.18-3.96 (br, O-H, 1H), 3.85 (d, C_9-H, J = 10.6 Hz, 3H), 3.74 (d, C_{10}-H, J = 10.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.70 (dd, J = 9.8, 2.1 Hz), 128.52, 128.46, 126.88, 89.74 (dd, J = 189.4, 162.9 Hz), 71.92 (dd, J = 22.3, 1.6 Hz), 54.23 (dd, J = 6.9, 2.0 Hz), 53.30 (d, J = 6.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 19.93 (d, J = 73.4 Hz). $[\alpha]_{25}^{D}$ = -59.96 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 0.3 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=43.3 min, t_2=85.6 min (major), t_3=95.4 min, t_4=104.4 min. *ee* = 73.4%, *dr* = 6.7:1. HRMS Calcd. For $C_{10}H_{14}FNaO_4P^+$[M+Na^+]: 271.0506. Found: 271.0491.



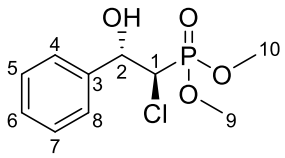
syn-**2d**
catalyzd by YDR368w

***syn*-dimethyl (1-fluoro-2-hydroxy-2-phenylethyl)phosphonate (*syn*-2d)** which catalyzed by YDR368w was purified by chromatography on silica gel with 35.7% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.51-7.32 (m, Ar-H, 5H), 5.19 (ddd, C_2-H, J = 25.3, 4.1, 4.1 Hz, 1H), 4.89 (ddd, C_1-H, J = 45.2, 5.6, 3.7 Hz, 1H), 3.85 (d, C_9-H, J = 10.7 Hz, 3H), 3.71 (d, C_{10}-H, J = 10.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.30 (dd, J = 9.7, 3.4 Hz), 128.50, 128.47, 126.91, 90.93 (dd, J = 190.5, 165.9 Hz), 72.26 (dd, J = 18.6, 2.6 Hz), 54.35 (dd, J = 6.4, 1.5 Hz), 52.92 (d, J = 7.0 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 18.85 (d, J = 78.3 Hz). $[\alpha]_{25}^{D}$ = 56.10 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 0.3 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=43.3 min, t_2=85.6 min, t_3=95.4 min, t_4=104.4 min (major). *ee* = 98.6%, *dr* = 18.6:1. HRMS Calcd. For $C_{10}H_{14}FNaO_4P^+$[M+Na^+]: 271.0506. Found: 271.0499.



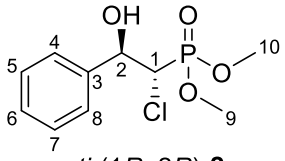
syn-**2d**
catalyzed by KRED-F42

***syn*-dimethyl (1-fluoro-2-hydroxy-2-phenylethyl)phosphonate (*syn*-2d)** which catalyzed by KRED-F42 was purified by chromatography on silica gel with 78.6% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ /ppm7.60-7.17 (m, Ar-H, 5H), 5.19 (ddd, C_2-H, J = 25.5, 4.2, 4.2 Hz, 1H), 4.89 (ddd, C_1-H, J = 45.3, 5.7, 3.6 Hz, 1H), 3.85 (d, C_9-H, J = 10.7 Hz, 3H), 3.71 (d, C_{10}-H, J = 10.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.30 (dd, J = 9.6, 3.5 Hz), 128.50, 128.46, 126.91, 126.87, 90.94 (dd, J = 190.4, 165.9 Hz), 72.25 (dd, J = 18.6, 2.6 Hz), 54.35 (dd, J = 6.3, 1.4 Hz), 52.93 (d, J = 6.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 18.86 (d, J = 78.3 Hz). $[\alpha]_{25}^{D}$ = -249.41 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 0.3 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=43.3 min, t_2=85.6 min, t_3=95.4 min (major), t_4=104.4 min. *ee* > 99%, *dr* = 5.6:1. HRMS Calcd. For $C_{10}H_{14}FNaO_4P^+$[M+Na^+]: 271.0506. Found: 271.0489.



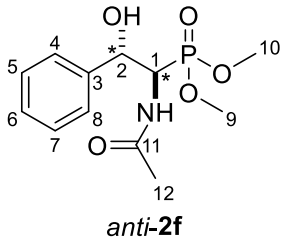
anti-(1*S*, 2*S*)-**2e**

***anti*-(1*S*, 2*S*)- dimethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*S*, 2*S*)-2e)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 79.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.49-7.30 (m, Ar-H, 5H), 5.01 (dd, C_2-H, J = 10.1, 10.1 Hz, 1H), 4.25 (br, O-H, 1H), 4.07 (dd, C_1-H, J = 8.8, 8.8Hz, 1H), 3.91 (d, C_9-H, J = 10.7 Hz, 3H), 3.77 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 139.44 (d, J = 10.7 Hz), 128.59, 128.33, 127.16, 74.59, 54.90 (d, J = 7.3 Hz), 54.11 (d, J = 152.1 Hz), 53.83 (d, J = 6.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.26. $[\alpha]_{25}^{D}$ = 35.17 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=11.6 min (major), t_2=14.9 min, t_3=16.6 min, t_4=44.5 min. *ee* > 99%, *dr* = 21.5:1. HRMS Calcd. For $C_{10}H_{14}ClNaO_4P^+$[M+Na^+]: 287.0210. Found: 287.0207.



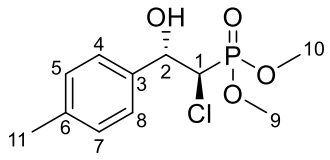
anti-(1*R*, 2*R*)-**2e**

***anti*-(1*R*, 2*R*)- dimethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*R*, 2*R*)-2e)** which catalyzed by RasADH was purified by chromatography on silica gel with 66.7% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.53-7.30 (m, Ar-H, 5H), 5.04 (dd, C_2-H, J = 11.7, 8.4 Hz, 1H), 4.37 (br, O-H, 1H), 4.10 (dd, C_1-H, J = 8.9, 8.9 Hz, 1H), 3.92 (d, C_9-H, J = 10.6 Hz, 1H), 3.79 (d, C_{10}-H, J = 11.0 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 139.42 (d, J = 10.8 Hz), 128.60, 128.33, 127.16, 74.60, 54.91 (d, J = 7.0 Hz), 54.09 (d, J = 151.3 Hz), 53.84 (d, J = 6.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.25. $[\alpha]_{25}^{D}$ = -34.97 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=11.6 min, t_2=14.9 min, t_3=16.6 min, t_4=44.5 min (major). *ee* = 99.6%, *dr* = 9.8:1. HRMS Calcd. For $C_{10}H_{14}ClNaO_4P^+$[M+Na^+]: 287.0210. Found: 287.0208.



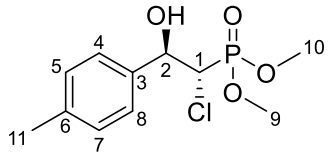
anti-**2f**

***anti*-dimethyl (1-acetamido-2-hydroxy-2-phenylethyl)phosphonate (*anti*-2f)** which catalyzed by YNL331c was purified by chromatography on silica gel with 82.6% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.94-7.65 (m, Ar-H, 5H), 7.08 (d, N-H, J = 9.8 Hz, 1H), 5.46 (dd, C_2-H, J = 21.9, 5.3 Hz, 1H), 5.32 (ddd, C_1-H, J = 15.5, 9.9, 5.3 Hz, 1H), 4.14 (d, C_9-H, J = 10.8 Hz, 3H), 3.87 (d, C_{10}-H, J = 11.0 Hz, 3H), 2.41 (s, C_{12}-H, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 169.71 (d, J = 5.1 Hz), 139.46 (d, J = 5.1 Hz), 128.26, 127.98, 126.26, 74.05 (d, J = 1.9 Hz), 53.43 (d, J = 7.0 Hz), 52.99 (d, J = 6.8 Hz), 51.19 (d, J = 151.6 Hz)., 22.94. ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 25.84. $[\alpha]_{25}^{D}$ = -1.0 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=28.7 min, t_2=31.0 min (major), t_3=34.6 min, t_4=41.3 min. *ee* > 99.6%, *dr* = 31.2:1. HRMS Calcd. For $C_{12}H_{18}NNaO_5P^+$[M+Na^+]: 310.0815. Found: 310.0817.



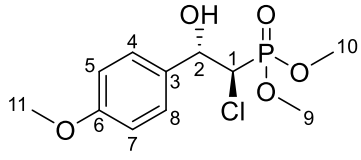
anti-(1*S*, 2*S*)-**2g**

***anti*-(1*S*, 2*S*)-2gimethyl (1-chloro-2-hydroxy-2-(p-tolyl)ethyl)phosphonate *anti*-(1*S*, 2*S*)-2g** which catalyzed by KmCR2 was purified by chromatography on silica gel with 56.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.35-7.13 (m, Ar-H, 4H), 4.97 (ddd, C_2-H, J = 11.6, 8.5, 3.3 Hz, 1H), 4.20 (d, O-H, J = 3.6 Hz, 1H), 4.06 (dd, C_1-H, J = 8.9, 8.9 Hz, 1H), 3.90 (d, C_9-H, J = 10.7 Hz, 3H), 3.78 (d, C_{10}-H, J = 11.0 Hz, 3H), 2.35 (s, C_{11}-H, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.41, 136.44 (d, J = 11.2 Hz), 129.04, 127.05, 74.45, 54.88 (d, J = 7.1 Hz), 54.07 (d, J = 150.9 Hz), 53.85 (d, J = 6.8 Hz), 21.23. ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.41. $[\alpha]_{25}^{D}$ = 25.18 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=14.9 min (major), t_2=18.9 min, t_3=24.7 min, t_4=45.8 min. *ee* = 99.0%, *dr* = 47.2:1. HRMS Calcd. For $C_{11}H_{16}ClNaO_4P^+$[M+Na^+]: 301.0367. Found: 301.0374.



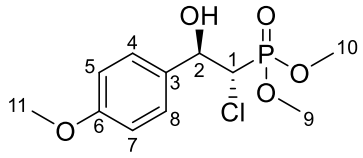
anti-(1*R*, 2*R*)-**2g**

***anti*-(1*R*, 2*R*)-2gimethyl (1-chloro-2-hydroxy-2-(p-tolyl)ethyl)phosphonate *anti*-(1*R*, 2*R*)-2g** which catalyzed by RasADH was purified by chromatography on silica gel with 77.8% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.44-7.05 (m, Ar-H, 4H), 5.05-4.95 (m, C_2-H, 1H), 4.32 (d, O-H, J = 3.7 Hz, 1H), 4.08 (dd, C_1-H, J = 8.9, 8.9 Hz, 1H), 3.91 (d, C_9-H, J = 10.7 Hz, 3H), 3.80 (d, C_{10}-H, J = 10.9 Hz, 3H), 2.37 (s, C_{11}-H, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.35, 136.60 (d, J = 10.9 Hz), 129.01, 127.09, 74.36, 54.83 (d, J = 7.0 Hz), 54.23 (d, J = 151.6 Hz), 53.86 (d, J = 6.8 Hz), 21.24. ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.41. $[\alpha]_{25}^{D}$ = -23.58 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=14.9 min, t_2=18.9 min, t_3=24.7 min, t_4=45.8 min (major). *ee* = 99.7%, *dr* = 11.4:1. HRMS Calcd. For $C_{11}H_{16}ClNaO_4P^+$[M+Na^+]: 301.0367. Found: 301.0373.



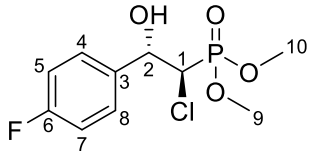
anti-(1*S*, 2*S*)-**2h**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-hydroxy-2-(4-methoxyphenyl)ethyl)phosphonate (*anti*-(1*S*, 2*S*)-2h)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 42.9% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.42-6.74 (m, 4H), 4.96 (dd, C_2-H, J = 10.9, 8.6 Hz, 1H), 4.18 (br, O-H, 1H), 4.04 (dd, C_1-H, J = 8.9, 8.9 Hz, 1H), 3.91 (d, C_9-H, J = 10.7 Hz, 3H), 3.81 (s, C_{11}-H, 3H), 3.79 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 159.77, 131.59 (d, J = 11.3 Hz), 128.38, 113.71, 74.15, 55.28, 54.86 (d, J = 7.0 Hz), 54.22 (d, J = 150.5 Hz), 53.87 (d, J = 6.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.41. $[\alpha]_{25}^{D}$ = 21.78 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 70:30, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=12.2 min (major), t_2=15.3 min, t_3=19.2 min, t_4=40.2 min. *ee* = 88.0%, *dr* = 9.8:1. HRMS Calcd. For $C_{11}H_{16}ClNaO_5P^+$[M+Na^+]: 317.0316. Found: 317.0317.



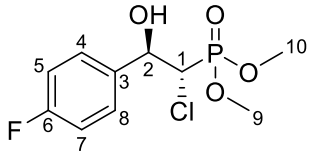
anti-(1*R*, 2*R*)-**2h**

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-hydroxy-2-(4-methoxyphenyl)ethyl)phosphonate (*anti*-(1*R*, 2*R*)-2h)** which catalyzed by RasADH was purified by chromatography on silica gel with 79.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.45-6.63 (m, Ar-H, 4H), 4.96 (ddd, C_2-H, *J* = 10.9, 8.5, 2.5 Hz, 1H), 4.24 (d, O-H, *J* = 3.5 Hz, 1H), 4.04 (dd, C_1-H, *J* = 8.9, 8.9 Hz, 1H), 3.89 (d, C_9-H, *J* = 10.7 Hz, 3H), 3.80 (s, C_{11}-H), 3.79 (d, C_{10}-H, *J* = 11.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 159.76, 131.61 (d, *J* = 11.1 Hz), 128.38, 113.70, 74.14, 55.28, 54.85 (d, *J* = 7.0 Hz), 54.25 (d, *J* = 150.8 Hz), 53.87 (d, *J* = 6.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.39. $[\alpha]_{25}^{D}$ = -23.98 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 70:30, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=12.2 min, t_2=15.3 min, t_3=19.2 min, t_4=40.2 min (major). *ee* = 99.8%, *dr* = 20.6:1. HRMS Calcd. For $C_{11}H_{16}ClNaO_5P^+$[M+Na^+]: 317.0316. Found: 317.0316.



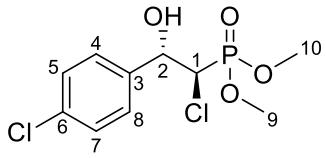
anti-(1*S*, 2*S*)-**2i**

***anti*- (1*S*, 2*S*)-dimethyl (1-chloro-2-(4-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*- (1*S*, 2*S*)-2i)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 75.5% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.51-6.93 (m, Ar-H, 4H), 5.02 (dd, C_2-H, *J* = 9.7, 9.7 Hz, 1H), 4.49 (br, O-H, 1H), 4.03 (dd, C_1-H, *J* = 8.9, 8.9 Hz, 1H), 3.92 (d, C_9-H, *J* = 10.7 Hz, 3H), 3.81 (d, C_{10}-H, *J* = 10.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 162.76 (d, *J* = 247.0 Hz), 35.28 (dd, *J* = 11.2, 3.2 Hz), 128.94 (d, *J* = 8.2 Hz), 115.21 (d, *J* = 21.6 Hz), 73.87, 54.95 (d, *J* = 7.0 Hz), 54.10 (d, *J* = 151.3 Hz), 53.91 (d, *J* = 6.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.04. $[\alpha]_{25}^{D}$ = 30.18 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=8.1 min (major), t_2=9.9 min, t_3=10.6 min, t_4=36.0 min. *ee* = 98.9%, *dr* = 13.2:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na^+]: 305.0116. Found: 305.0132.



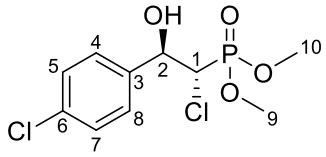
anti-(1*R*, 2*R*)-**2i**

***anti*- (1*R*, 2*R*)-dimethyl (1-chloro-2-(4-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*- (1*R*, 2*R*)-2i)** which catalyzed by RasADH was purified by chromatography on silica gel with 89.0% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.50-7.02 (m, Ar-H, 4H), 5.02 (dd, C_2-H, *J* = 10.9, 8.6 Hz, 1H), 4.47 (br, O-H, 1H), 4.03 (dd, C_1-H, *J* = 8.9, 8.9 Hz, 1H), 3.93 (d, C_9-H, *J* = 10.7 Hz, 1H), 3.82 (d, C_{10}-H, *J* = 10.9 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 1 162.77 (d, *J* = 246.9 Hz), 135.26 (dd, *J* = 11.1, 3.1 Hz), 128.94 (d, *J* = 8.4 Hz), 115.21 (d, *J* = 21.6 Hz), 73.89, 54.96 (d, *J* = 7.2 Hz), 54.08 (d, *J* = 151.2 Hz), 53.91 (d, *J* = 6.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.04. $[\alpha]_{25}^{D}$ = -33.38 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=8.1 min, t_2=9.9 min, t_3=10.6 min, t_4=36.0 min (major). *ee* = 99.6%, *dr* = 6.7:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na^+]: 305.0116. Found: 305.0114.



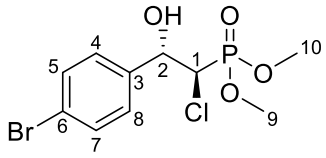
anti-(1*S*, 2*S*)-**2j**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-(4-chlorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*S*, 2*S*)-2j)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 64.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.43-7.30 (m, Ar-H, 4H), 4.98 (dd, C_2-H, J = 11.2, 8.5 Hz, 1H), 4.44 (br, O-H, 1H), 3.99 (dd, C_1-H, J = 8.9, 8.9 Hz, 1H), 3.91 (d, C_9-H, J = 10.7 Hz, 3H), 3.79 (d, C_{10}-H, J = 10.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 137.90 (d, J = 11.3 Hz), 134.39, 128.59, 128.49, 73.94, 55.01 (d, J = 7.2 Hz), 53.93 (d, J = 6.8 Hz), 53.87 (d, J = 151.1 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.94. $[\alpha]_{25}^{D}$ = 24.58 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.5 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=19.6 min (major), t_2=24.6 min, t_3=25.8 min, t_4=82.3 min. *ee* = 88.8%, *dr* = 11.2:1. HRMS Calcd. For $C_{10}H_{13}Cl_2NaO_4P^+$[M+Na^+]: 320.9821. Found: 320.9822.



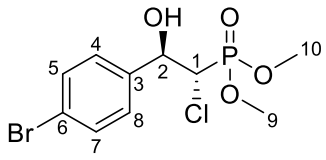
anti-(1*R*, 2*R*)-**2j**

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(4-chlorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2j)** which catalyzed by RasADH was purified by chromatography on silica gel with 66.7% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.49-7.30 (m, Ar-H, 4H), 5.01 (dd, C_2-H, J = 11.0, 8.5 Hz, 1H), 4.57 (br, O-H, 1H), 4.03 (dd, C_1-H, J = 9.5, 8.4 Hz, 1H), 3.92 (d, C_9-H, J = 10.7 Hz, 3H), 3.81 (d, C_{10}-H, J = 10.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.00 (d, J = 11.2 Hz), 128.61, 128.46, 73.89, 54.97 (d, J = 7.0 Hz), 53.98 (d, J = 151.6 Hz), 53.92 (d, J = 6.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.92. $[\alpha]_{25}^{D}$ = -16.39 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.5 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=19.6 min, t_2=24.6 min, t_3=25.8 min, t_4=82.3 min (major). *ee* = 99.7%, *dr* = 7.4:1. HRMS Calcd. For $C_{10}H_{13}Cl_2NaO_4P^+$[M+Na^+]: 320.9821. Found: 320.9822.



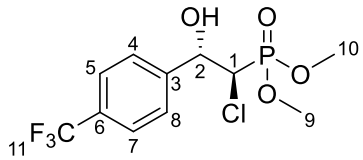
anti-(1*S*, 2*S*)-**2k**

***anti*-(1*S*, 2*S*)-dimethyl (2-(4-bromophenyl)-1-chloro-2-hydroxyethyl)phosphonate (*anti*-(1*S*, 2*S*)-2k)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 50.9% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.58-7.28 (m, Ar-H, 4H), 4.97 (ddd, C_2-H, J = 11.4, 8.6, 2.7 Hz, 1H), 4.41 (d, O-H, J = 3.5 Hz, 1H), 3.99 (dd, C_1-H, J = 8.9, 8.9 Hz, 1H), 3.92 (d, C_9-H, J = 10.7 Hz, 3H), 3.79 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.47 (d, J = 11.3 Hz), 131.43, 128.92, 122.55, 73.98, 55.00 (d, J = 7.0 Hz), 53.93 (d, J = 6.9 Hz), 53.85 (d, J = 151.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.92. $[\alpha]_{25}^{D}$ = 14.39 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.7 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=14.2 min (major), t_2=17.8 min, t_3=18.7 min, t_4=56.1 min. *ee* = 90.0%, *dr* = 15.1:1. HRMS Calcd. For $C_{10}H_{13}{}^{79}BrClNaO_4P^+$[M+$Na^+$]: 364.9316. Found: 364.9318.



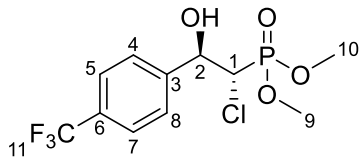
anti-(1*R*, 2*R*)-**2k**

***anti*-(1*R*, 2*R*)-dimethyl (2-(4-bromophenyl)-1-chloro-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2k)** which catalyzed by RasADH was purified by chromatography on silica gel with 68.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.55-7.30 (m, Ar-H, 4H), 4.99 (dd, C_2-H, *J* = 9.8, 9.8 Hz, 1H), 4.55 (br, O-H, 1H), 4.02 (dd, C_1-H, *J* = 9.5, 8.4 Hz, 1H), 3.92 (d, C_9-H, *J* = 10.7 Hz, 3H), 3.81 (d, C_{10}-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.51 (d, *J* = 11.1 Hz), 131.42, 128.93, 122.54, 73.96, 54.98 (d, *J* = 7.2 Hz), 53.93 (d, *J* = 6.8 Hz), 53.89 (d, *J* = 151.5 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.89. $[\alpha]_{25}^{D}$ = -13.59 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.7 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=14.2 min, t_2=17.8 min, t_3=18.7 min, t_4=56.1 min (major). *ee* = 99.8%, *dr* = 10.9:1. HRMS Calcd. For $C_{10}H_{13}{}^{79}BrClNaO_4P^+$[M+$Na^+$]: 364.9316. Found: 364.9319.



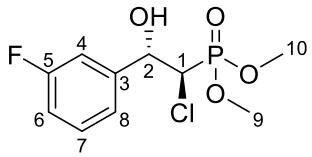
anti-(1*S*, 2*S*)-**2l**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-hydroxy-2-(4-(trifluoromethyl)phenyl)ethyl)phosphonate (*anti*-(1*S*, *2S*)-2l)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 51.7% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.75-7.45 (m, Ar-H, 4H), 5.06 (dd, C_2-H, *J* = 9.8, 9.8 Hz, 1H), 4.56 (d, O-H, *J* = 3.6 Hz, 1H), 4.02 (dd, C_1-H, *J* = 9.5, 8.5 Hz, 1H), 3.93 (d, C_9-H, *J* = 10.7 Hz, 3H), 3.79 (d, C_{10}-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 143.58 (d, *J* = 10.9 Hz), 130.60 (q, *J* = 32.4 Hz), 127.69, 125.18 (q, *J* = 3.7 Hz), 124.03 (q, *J* = 272.0 Hz), 73.90, 54.98 (d, *J* = 7.0 Hz), 53.98 (d, *J* = 153.0 Hz), 53.93 (d, *J* = 6.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.76. $[\alpha]_{25}^{D}$ = 12.79 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 90:10, 0.5 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=16.5 min (major), t_2=19.0 min, t_3=20.0 min, t_4=61.8 min. *ee* = 86.8%, *dr* = 12.3:1. HRMS Calcd. For $C_{11}H_{13}ClF_3NaO_4P^+$[M+$Na^+$]: 355.0084. Found: 355.0085.



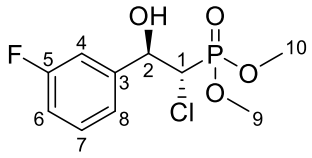
anti-(1*R*, 2*R*)-**2l**

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-hydroxy-2-(4-(trifluoromethyl)phenyl)ethyl)phosphonate (*anti*-(1*R*, *2R*)-2l)** which catalyzed by RasADH was purified by chromatography on silica gel with 77.1% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.72-7.47 (m, Ar-H, 4H), 5.09 (dd, C_2-H, *J* = 11.5, 8.4 Hz, 1H), 4.65 (d, O-H, *J* = 3.6 Hz, 1H), 4.05 (dd, C_1-H, *J* = 9.5, 8.4 Hz, 1H), 3.94 (d, C_9-H, *J* = 10.7 Hz, 3H), 3.81 (d, C_{10}-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 143.61 (d, *J* = 10.8 Hz), 130.58 (q, *J* = 32.4 Hz), 127.70, 124.02 (q, *J* = 272.1 Hz), 125.16 (q, *J* = 3.8 Hz), 73.87, 54.95 (d, *J* = 7.2 Hz), 54.01 (d, *J* = 152.9 Hz), 53.92 (d, *J* = 6.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.73. $[\alpha]_{25}^{D}$ = -19.79 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 90:10, 0.5 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=16.5 min, t_2=19.0 min, t_3=20.0 min, t_4=61.8 min (major). *ee* = 99.3%, *dr* = 9.8:1. HRMS Calcd. For $C_{11}H_{13}ClF_3NaO_4P^+$[M+$Na^+$]: 355.0084. Found: 355.0085.



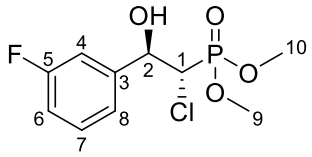
anti-(1*S*, 2*S*)-**2m**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-(3-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*S*, 2*S*)-2m)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 69.1% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.40-6.94 (m, Ar-H, 4H), 5.02 (dd, C_2-H, J = 9.9, 9.9 Hz, 1H), 4.64 (br, O-H, 1H), 4.05 (dd, C_1-H, J = 9.5, 8.3 Hz, 1H), 3.92 (d, C_9-H, J = 10.6 Hz, 3H), 3.80 (d, C_{10}-H, J = 11.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 162.72 (d, J = 246.2 Hz), 142.09 (dd, J = 11.0, 7.0 Hz), 129.75 (d, J = 8.1 Hz), 123.00 (d, J = 3.0 Hz), 115.45 (d, J = 21.1 Hz), 114.14 (d, J = 22.3 Hz), 74.00 (d, J = 2.0 Hz), 54.96 (d, J = 7.0 Hz), 53.93 (d, J = 152.1 Hz), 53.90 (d, J = 6.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.89. $[\alpha]_{25}^{D}$ = 31.38 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 95:5, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=24.8 min (major), t_2=33.4 min, t_3=36.6 min, t_4=118.9 min. *ee* > 99%, *dr* = 15.3:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na$^+$]: 305.0116. Found: 305.0106.



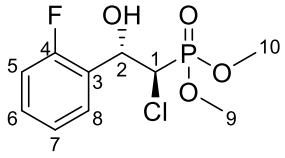
anti-(1*R*, 2*R*)-**2m**
catalyzed by RasADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(3-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2m)** which catalyzed by RasADH was purified by chromatography on silica gel with 73.9% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.47-6.93 (m, Ar-H, 4H), 5.03 (dd, C_2-H, J = 10.1, 10.1 Hz, 1H), 4.57 (br, O-H, 1H), 4.04 (dd, C_1-H, J = 9.0, 9.0 Hz, 1H), 3.93 (d, C_9-H, J = 10.7 Hz, 3H), 3.81 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 162.99 (d, J = 245.9 Hz), 142.63 (dd, J = 10.8, 6.9 Hz), 130.05 (d, J = 8.0 Hz), 123.38 (d, J = 2.9 Hz), 115.72 (d, J = 21.1 Hz), 114.48 (d, J = 22.3 Hz), 74.19 (d, J = 1.9 Hz), 55.22 (d, J = 7.2 Hz), 54.45 (d, J = 152.8 Hz), 54.24 (d, J = 6.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.90. $[\alpha]_{25}^{D}$ = -21.38 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 95:5, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=24.8 min, t_2=33.4 min, t_3=36.6 min, t_4=118.9 min (major). *ee* = 99.7%, *dr* = 9.4:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na$^+$]: 305.0116. Found: 305.0115.



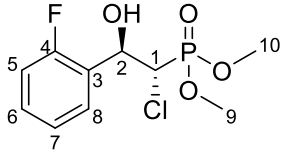
anti-(1*R*, 2*R*)-**2m**
catalyzed by SyADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(3-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2m)** which catalyzed by SyADH was purified by chromatography on silica gel with 96.1% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.41-6.94 (m, Ar-H, 4H), 5.02 (dd, C_2-H, J = 11.5, 8.4 Hz, 1H), 4.72-4.47 (m, O-H, 1H), 4.04 (dd, C_1-H, J = 9.5, 8.4 Hz, 1H), 3.93 (d, C_9-H, J = 10.7 Hz, 1H), 3.81 (d, C_{10}-H, J = 11.0 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 162.72 (d, J = 246.2 Hz), 142.04 (dd, J = 11.0, 7.1 Hz), 129.77 (d, J = 8.2 Hz), 122.99 (d, J = 3.0 Hz), 115.48 (d, J = 21.2 Hz), 114.14 (d, J = 22.2 Hz), 74.02 (d, J = 2.0 Hz), 54.99 (d, J = 7.1 Hz), 53.91 (d, J = 6.9 Hz), 53.86 (d, J = 151.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.91. $[\alpha]_{25}^{D}$ = -29.38 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 95:5, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=24.8 min, t_2=33.4 min, t_3=36.6 min, t_4=118.9 min (major). *ee* = 93.7%, *dr* = 14.7:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na$^+$]: 305.0116. Found: 305.0117.



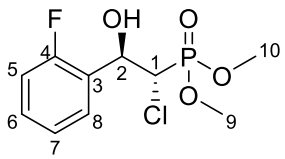
anti-(1*S*, 2*S*)-**2n**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-(2-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*S*, 2*S*)-2n)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 70.7% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.65-6.91 (m, Ar-H, 4H), 5.34 (dd, C_2-H, J = 16.8, 7.6 Hz, 1H), 4.37 (br, O-H, 1H), 4.25 (dd, C_1-H, J = 9.7, 7.6 Hz, 1H), 3.94 (d, C_9-H, J = 10.7 Hz, 3H), 3.68 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 160.28 (d, J = 246.8 Hz), 130.02 (d, J = 8.4 Hz), 128.43 (d, J = 3.9 Hz), 126.86 (dd, J = 12.3, 9.7 Hz), 124.29 (d, J = 3.9 Hz), 115.30 (d, J = 21.9 Hz), 69.23, 55.07 (d, J = 7.0 Hz), 53.66 (d, J = 6.9 Hz), 53.16 (d, J = 152.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.95. $[\alpha]_{25}^{D}$ = 24.78 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.8 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=13.2 min, t_2=14.6 min, t_3=16.1 min (major), t_4=26.4 min. *ee* = 99.8%, *dr* > 99:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na^+]: 305.0116. Found: 305.0116.



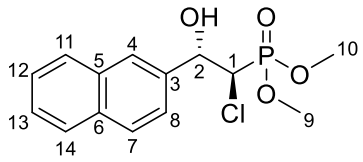
anti-(1*R*, 2*R*)-**2n**
catalyzed by RasADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(2-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2n)** which catalyzed by RasADH was purified by chromatography on silica gel with 66.7% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.61-7.04 (m, Ar-H, 4H), 5.37 (dd, C_2-H, J = 16.3, 12.3 Hz, 1H), 4.49 (d, O-H, J = 5.1 Hz, 1H), 4.27 (dd, C_1-H, J = 9.7, 7.6 Hz, 1H), 3.95 (d, C_9-H, J = 10.7 Hz, 3H), 3.70 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 160.27 (d, J = 246.6 Hz), 130.02 (d, J = 8.4 Hz), 128.42 (d, J = 3.9 Hz), 126.84 (dd, J = 12.8, 9.5 Hz), 124.29 (d, J = 3.5 Hz), 115.30 (d, J = 21.9 Hz), 69.25, 55.07 (d, J = 7.0 Hz), 53.65 (d, J = 6.9 Hz), 53.15 (dd, J = 152.7, 2.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.94. $[\alpha]_{25}^{D}$ = -18.59 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.8 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=13.2 min, t_2=14.6 min, t_3=16.1 min, t_4=26.4 min (major). *ee* = 99.7%, *dr* = 5.1:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na^+]: 305.0116. Found: 305.0117.



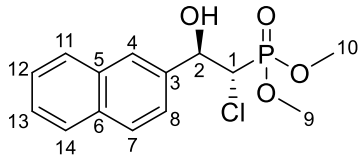
anti-(1*R*, 2*R*)-**2n**
catalyzed by SyADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(2-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2n)** which catalyzed by SyADH was purified by chromatography on silica gel with 93.7% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.64-6.81 (m, Ar-H, 4H), 5.37 (dd, C_2-H, J = 16.5, 7.6 Hz, 1H), 4.51 (br, O-H, 1H), 4.27 (dd, C_1-H, J = 9.7, 7.6 Hz, 1H), 3.95 (d, C_9-H, J = 10.7 Hz, 3H), 3.70 (d, C_{10}-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 160.30 (d, J = 246.7 Hz), 130.05 (d, J = 8.5 Hz), 128.37 (d, J = 3.9 Hz), 126.71 (dd, J = 13.0, 9.4 Hz), 124.31 (d, J = 3.5 Hz), 115.32 (d, J = 21.7 Hz), 69.38, 55.13 (d, J = 7.0 Hz), 53.75 (d, J = 2.4 Hz), 53.62 (d, J = 6.9 Hz), 52.24 (d, J = 2.5 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.96. $[\alpha]_{25}^{D}$ = -28.98 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 85:15, 0.8 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=13.2 min, t_2=14.6 min, t_3=16.1 min, t_4=26.4 min (major). *ee* = 97.4%, *dr* = 23.4:1. HRMS Calcd. For $C_{10}H_{13}ClFNaO_4P^+$[M+Na^+]: 305.0116. Found: 305.0116.



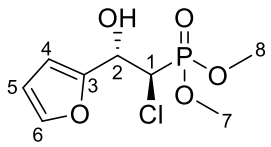
anti-(1*R*, 2*R*)-**2o**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-hydroxy-2-(naphthalen-2-yl)ethyl)phosphonate (*anti*-(1*S*, 2*S*)-2o)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 58.0% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.96-7.45 (m, Ar-H, 7H), 5.21 (dd, C_2-H, *J* = 11.7, 8.5 Hz, 1H), 4.52 (br, O-H, 1H), 4.21 (dd, C_1-H, *J* = 8.9, 8.9 Hz, 1H), 3.94 (d, C_9-H, *J* = 10.7 Hz, 3H), 3.78 (d, C_{10}-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 136.74 (d, *J* = 10.9 Hz), 133.43, 132.99, 128.21 (d, *J* = 6.0 Hz), 127.73, 126.90, 126.32 (d, *J* = 3.1 Hz), 124.27, 74.82, 54.96 (d, *J* = 7.1 Hz), 53.97 (d, *J* = 151.2 Hz), 53.87 (d, *J* = 6.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.29. $[\alpha]_{25}^{D}$ = 17.79 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=13.2 min (major), t_2=17.4 min, t_3=19.7 min, t_4=38.6 min. *ee* > 99%, *dr* = 29.2:1. HRMS Calcd. For $C_{14}H_{16}ClNaO_4P^+$[M+Na^+]: 337.0367. Found: 337.0366.



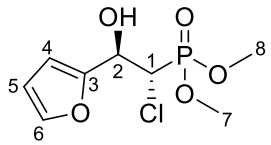
anti-(1*R*, 2*R*)-**2o**

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-hydroxy-2-(naphthalen-2-yl)ethyl)phosphonate (*anti*-(1*R*, 2*R*)-2o)** which catalyzed by RasADH was purified by chromatography on silica gel with 68.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.99-7.43 (m, Ar-H, 4H), 5.21 (dd, C_2-H, *J* = 11.8, 8.5 Hz, 1H), 4.48 (br, O-H, 1H), 4.21 (dd, C_1-H, *J* = 8.9, 8.9 Hz, 1H), 3.95 (d, C_9-H, *J* = 10.6 Hz, 3H), 3.78 (d, C_{10}-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 136.71 (d, *J* = 11.0 Hz), 133.44, 132.99, 128.21 (d, *J* = 7.0 Hz), 127.73, 126.90, 126.32 (d, *J* = 3.2 Hz), 124.25, 74.84, 54.98 (d, *J* = 7.0 Hz), 53.93 (d, *J* = 151.1 Hz), 53.87 (d, *J* = 6.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.29. $[\alpha]_{25}^{D}$ = -29.38 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=13.2 min, t_2=17.4 min, t_3=19.7 min, t_4=38.6 min (major). *ee* = 99.3%, *dr* = 10.7:1. HRMS Calcd. For $C_{14}H_{16}ClNaO_4P^+$[M+Na^+]: 337.0367. Found: 337.0371.



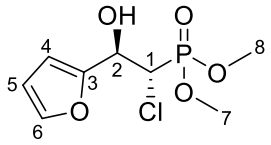
anti-(1*S*, 2*S*)-**2p**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-(furan-2-yl)-2-hydroxyethyl)phosphonate (*anti*-(1*S*, 2*S*)-2p)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 72.2% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.54-6.15 (m, Ar-H, 3H), 5.08 (dd, C_2-H, *J* = 9.8, 9.8 Hz, 1H), 4.51 (br, O-H, 1H), 4.35 (dd, C_1-H, *J* = 9.0, 9.0 Hz, 1H), 3.87 (d, C_7-H, *J* = 10.7 Hz, 3H), 3.77 (d, C_8-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 151.79 (d, *J* = 11.0 Hz), 142.67, 110.38, 109.03, 68.88, 54.97 (d, *J* = 6.9 Hz), 53.89 (d, *J* = 6.8 Hz), 51.86 (d, *J* = 153.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 22.72. $[\alpha]_{25}^{D}$ = 7.59 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IA, 250 × 4.6 mm column, hexane/2-propanol 95:5, 0.4 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=40.9 min (major), t_2=47.2 min, t_3=49.8 min, t_4=52.5 min. *ee* > 99%, *dr* > 99:1. HRMS Calcd. For $C_8H_{12}ClNaO_5P^+$[M+Na^+]: 277.0003. Found: 276.9999.



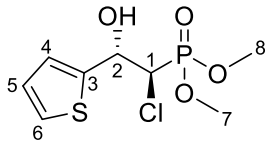
anti-(1*R*, 2*R*)-**2p**
catalyzed by RasADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(furan-2-yl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2p)** which catalyzed by RasADH was purified by chromatography on silica gel with 69.0% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.50-6.26 (m, Ar-H, 3H), 5.09 (dd, C_2-H, J = 8.5, 8.5 Hz, 1H), 4.44-4.39 (br, O-H, 1H), 4.36 (dd, C_1-H, J = 9.7, 8.0 Hz, 1H), 3.91 (d, C_7-H, J = 10.7 Hz, 3H), 3.79 (d, C_8-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 151.83 (d, J = 10.8 Hz), 142.66, 110.38, 109.01, 68.84, 54.97 (d, J = 7.1 Hz), 53.89 (d, J = 6.7 Hz), 51.88 (d, J = 153.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.72. $[\alpha]_{25}^{D}$ = 2.4 (c = 0.5, $CHCl_3$). HPLC Chiracel® IA, 250 × 4.6 mm column, hexane/2-propanol 95:5, 0.4 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=40.9 min, t_2=47.2 min (major), t_3=49.8 min, t_4=52.5 min. *ee* = 65.4%, *dr* = 4.4:1. HRMS Calcd. For $C_8H_{12}ClNaO_5P^+$[M+Na^+]: 277.0003. Found: 276.9997.



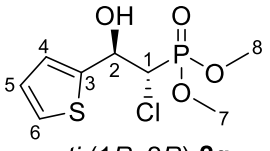
anti-(1*R*, 2*R*)-**2p**
catalyzed by SyADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-(furan-2-yl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2p)** which catalyzed by SyADH was purified by chromatography on silica gel with 62.7% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.56-6.24 (m, Ar-H, 3H), 5.09 (dd, C_2-H, J = 12.9, 12.9 Hz, 1H), 4.40 (br, O-H, 1H), 4.35 (dd, C_1-H, J = 9.7, 8.0 Hz, 1H), 3.91 (d, C_7-H, J = 10.7 Hz, 3H), 3.79 (d, C_8-H, J = 11.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.82 (d, J = 11.1 Hz), 142.66, 110.38, 109.02, 68.85, 54.96 (d, J = 7.0 Hz), 53.89 (d, J = 6.8 Hz), 51.88 (d, J = 153.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.71. $[\alpha]_{25}^{D}$ = -7.39 (c = 0.5, $CHCl_3$). HPLC Chiracel® IA, 250 × 4.6 mm column, hexane/2-propanol 95:5, 0.4 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=40.9 min, t_2=47.2 min (major), t_3=49.8 min, t_4=52.5 min. *ee* = 99.4%, *dr* > 99:1. HRMS Calcd. For $C_8H_{12}ClNaO_5P^+$[M+Na^+]: 277.0003. Found: 276.9994.



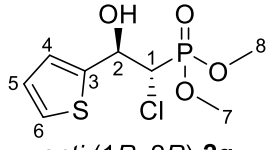
anti-(1*S*, 2*S*)-**2q**

***anti*-(1*S*, 2*S*)-dimethyl (1-chloro-2-hydroxy-2-(thiophen-2-yl)ethyl)phosphonate (*anti*-(1*S*, 2*S*)-2q)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 72.2% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.40-6.70 (m, Ar-H, 3H), 5.30 (dd, C_2-H, J = 9.3, 9.3 Hz, 1H), 4.37 (br, O-H, 1H), 4.08 (dd, C_1-H, J = 9.5, 8.2 Hz, 1H), 3.89 (d, C_7-H, J = 10.7 Hz, 3H), 3.80 (d, C_8-H, J = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 143.02 (d, J = 12.1 Hz), 126.50, 126.47, 125.82, 70.93, 54.90 (d, J = 6.9 Hz), 54.77 (d, J = 151.8 Hz), 54.01 (d, J = 6.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.54. $[\alpha]_{25}^{D}$ = 12.79 (c = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=12.9 min (major), t_2=17.7 min, t_3=19.1 min, t_4=61.7 min. *ee* > 99%, *dr* = 18.4:1. HRMS Calcd. For $C_8H_{12}ClNaO_4PS^+$[M+Na^+]: 292.9775. Found: 292.9773.



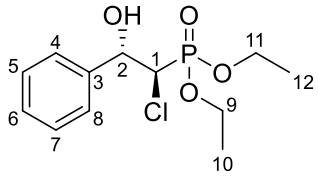
anti-(1*R*, 2*R*)-**2q**
catalyzed by RasADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-hydroxy-2-(thiophen-2-yl)ethyl)phosphonate (*anti*-(1*R*, 2*R*)-2q)** which catalyzed by RasADH was purified by chromatography on silica gel with 77.8% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.47-6.78 (m, Ar-H, 3H), 5.32 (ddd, C_2-H, *J* = 9.5, 7.6, 3.2 Hz, 1H), 4.65 (d, O-H, *J* = 4.0 Hz, 1H), 4.11 (dd, C_1-H, *J* = 9.6, 8.1 Hz, 1H), 3.88 (d, C_7-H, *J* = 10.7 Hz, 3H), 3.81 (d, C_8-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 143.03 (d, *J* = 11.9 Hz), 126.47, 126.45, 125.79, 70.93, 54.88 (d, *J* = 7.0 Hz), 54.78 (d, *J* = 152.0 Hz), 53.98 (d, *J* = 8.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.51. $[\alpha]_{25}^{D}$ = 2.4 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=12.9 min, t_2=17.7 min, t_3=19.1 min, t_4=61.7 min (major). *ee* = 93.5%, *dr* = 1.9:1. HRMS Calcd. For $C_8H_{12}ClNaO_4PS^+$[M+Na^+]: 292.9775. Found: 292.9771.



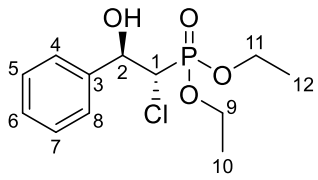
anti-(1*R*, 2*R*)-**2q**
catalyzed by SyADH

***anti*-(1*R*, 2*R*)-dimethyl (1-chloro-2-hydroxy-2-(thiophen-2-yl)ethyl)phosphonate (*anti*-(1*R*, 2*R*)-2q)** which catalyzed by SyADH was purified by chromatography on silica gel with 51.6% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.54-6.64 (m, Ar-H, 3H), 5.37-5.29 (m, C_2-H, 1H), 4.60 (br, O-H, 1H), 4.11 (dd, C_1-H, *J* = 8.9, 8.9 Hz, 1H), 3.88 (d, C_7-H, *J* = 10.7 Hz, 3H), 3.81 (d, C_8-H, *J* = 11.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 143.00 (d, *J* = 12.1 Hz), 126.48, 126.46, 125.80, 70.96, 54.88 (d, *J* = 7.0 Hz), 54.74 (d, *J* = 151.6 Hz), 53.98 (d, *J* = 6.7 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.50. $[\alpha]_{25}^{D}$ = -7.79 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=12.9 min, t_2=17.7 min, t_3=19.1 min, t_4=61.7 min (major). *ee* = 96.1%, *dr* = 21.7:1. HRMS Calcd. For $C_8H_{12}ClNaO_4PS^+$[M+Na^+]: 292.9775. Found: 292.9775.



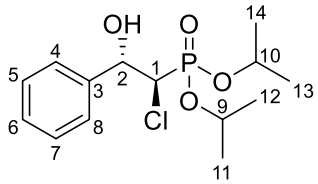
anti-(1*S*, 2*S*)-**2r**

***anti*-(1*S*,2*S*)-diethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*S*, 2*S*)-2r)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 79.4% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.56-7.30 (m, Ar-H, 5H), 5.02 (dd, C_2-H, *J* = 11.8, 8.4 Hz, 1H), 4.57 (br, O-H, 1H), 4.37-4.10 (m, $C_{9, 11}$-H, 4H), 4.06 (dd, C_1-H, *J* = 8.8, 8.8 Hz, 1H), 1.41 (t, C_{10}-H, *J* = 7.1 Hz, 3H), 1.31 (t, C_{12}-H, *J* = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 139.51 (d, *J* = 10.9 Hz), 128.50, 128.26, 127.21, 74.61, 64.63 (d, *J* = 7.1 Hz), 63.67 (d, *J* = 6.8 Hz), 54.28 (d, *J* = 150.3 Hz), 16.45 (d, *J* = 5.8 Hz), 16.24 (d, *J* = 6.0 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 21.50. $[\alpha]_{25}^{D}$ = 29.58 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=10.7 min (major), t_2=13.8 min, t_3=17.1 min, t_4=61.1 min. *ee* > 99%, *dr* = 24.5:1. HRMS Calcd. For $C_{12}H_{18}ClNaO_4P^+$[M+Na^+]: 315.0523. Found: 315.0516.



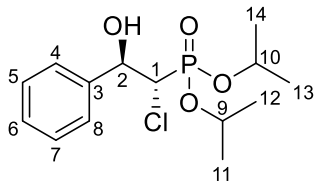
anti-(1*R*, 2*R*)-**2r**

***anti*-(1*R*,2*R*)-diethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*R*, 2*R*)-2r)** which catalyzed by RasADH was purified by chromatography on silica gel with 92.2% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.53-7.31 (m, Ar-H, 5H), 5.02 (dd, C_2-H, *J* = 11.9, 8.4 Hz, 1H), 4.55 (br, O-H, 1H), 4.38-4.09 (m, $C_{9, 11}$-H, 4H), 4.05 (dd, C_1-H, *J* = 8.8, 8.8 Hz, 1H), 1.41 (t, C_{10}-H, *J* = 7.1 Hz, 3H), 1.32 (t, C_{12}-H, *J* = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 139.49 (d, *J* = 10.9 Hz), 128.50, 128.26, 127.21, 74.61, 64.63 (d, *J* = 7.2 Hz), 63.67 (d, *J* = 6.8 Hz), 54.25 (d, *J* = 150.1 Hz), 16.45 (d, *J* = 5.8 Hz), 16.24 (d, *J* = 5.8 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 19.85. $[\alpha]_{25}^{D}$ = -23.98 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=10.7 min, t_2=13.8 min, t_3=17.1 min, t_4=61.1 min (major). *ee* = 99.8%, *dr* = 22.3:1. HRMS Calcd. For $C_{12}H_{18}ClNaO_4P^+$[M+Na^+]: 315.0523. Found: 315.0534.



anti-(1*S*, 2*S*)-**2s**

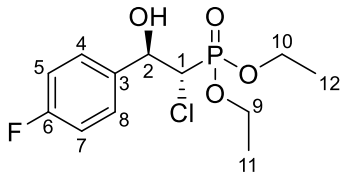
***anti*-(1*S*, 2*S*)-diisopropyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*S*, 2*S*)-2s)** which catalyzed by KmCR2 was purified by chromatography on silica gel with 92.2% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.53-7.31 (m, Ar-H, 5H), 4.97 (dd, C_2-H, *J* = 10.7, 9.1 Hz, 1H), 4.90 (dq, C_9-H, *J* = 12.6, 6.3 Hz, 1H), 4.78 (dq, C_{10}-H, *J* = 12.2, 6.3 Hz, 1H), 3.96 (dd, C_1-H, *J* = 8.7, 8.7 Hz, 1H), 1.44 (d, C_{11}-H, *J* = 3.1 Hz, 3H), 1.43 (d, C_{12}-H, *J* = 3.2 Hz, 3H), 1.37 (d, C_{13}-H, *J* = 6.2 Hz, 3H), 1.31 (d, C_{14}-H, *J* = 6.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 139.59 (d, *J* = 11.6 Hz), 128.46, 128.22, 127.34, 74.58, 73.66 (d, *J* = 7.3 Hz), 72.96 (d, *J* = 7.0 Hz), 54.50 (d, *J* = 150.4 Hz), 24.14 (d, *J* = 3.5 Hz), 23.99 (d, *J* = 3.9 Hz), 23.87 (d, *J* = 5.3 Hz), 23.76 (d, *J* = 4.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 19.85. $[\alpha]_{25}^{D}$ = 55.76 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=7.7 min, t_2=9.3 min (major), t_3=10.6 min, t_4=15.3 min. *ee* = 99.8%, *dr* = 68.4:1. HRMS Calcd. For $C_{14}H_{22}ClNaO_4P^+$[M+Na^+]: 343.0836. Found: 343.0836.



anti-(1*R*, 2*R*)-**2s**

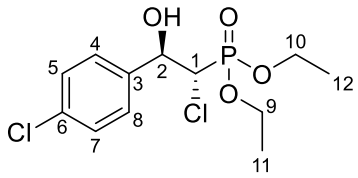
***anti*-(1*R*, 2*R*)-diisopropyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti*-(1*R*, 2*R*)-2s)** which catalyzed by RasADH was purified by chromatography on silica gel with 87.4% yield as white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.50-7.31 (m, Ar-H, 5H), 4.97 (dd, C_2-H, *J* = 11.0, 8.8 Hz, 1H), 4.90 (dq, C_9-H, *J* = 12.6, 6.3 Hz, 1H), 4.77 (dp, C_{10}-H, *J* = 12.5, 6.4 Hz, 1H), 3.96 (dd, C_1-H, *J* = 8.7, 8.7 Hz, 1H), 1.44 (d, C_{11}-H, *J* = 3.2 Hz, 3H), 1.43 (d, C_{12}-H, *J* = 3.4 Hz, 3H), 1.37 (d, C_{13}-H, *J* = 6.2 Hz, 3H), 1.31 (d, C_{14}-H, *J* = 6.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 139.58 (d, *J* = 11.5 Hz), 128.46, 128.22, 127.34, 74.58, 73.66 (d, *J* = 7.3 Hz), 72.95 (d, *J* = 7.0 Hz), 54.48 (d, *J* = 150.3 Hz), 24.14 (d, *J* = 3.6 Hz), 23.99 (d, *J* = 3.9 Hz), 23.88 (d, *J* = 5.3 Hz), 23.76 (d, *J* = 4.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 18.16. $[\alpha]_{25}^{D}$ = -70.95 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=7.7 min, t_2=9.3 min, t_3=10.6 min, t_4=15.3

min (major). *ee* = 94.6%, *dr* = 48.1:1. HRMS Calcd. For $C_{14}H_{22}ClNaO_4P^+$[M+Na^+]: 343.0836. Found: 343.0835.



anti-(1*R*, 2*R*)-**2t**

***anti*-(1*R*, 2*R*)-diethyl (1-chloro-2-(4-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2t)** which catalyzed by RasADH was purified by chromatography on silica gel with 79.5% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.54-6.88 (m, Ar-H, 4H), 4.99 (dd, C_2-H, *J* = 10.9, 8.5 Hz, 1H), 4.68 (br, O-H, 1H), 4.37-4.10 (m, $C_{9,\ 10}$-H, 4H), 3.98 (dd, C_1-H, *J* = 8.8, 8.8 Hz, 1H), 1.40 (t, C_{11}-H, *J* = 7.0 Hz, 3H), 1.33 (t, C_{12}-H, *J* = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 162.73 (d, *J* = 246.7 Hz), 135.37 (dd, *J* = 11.2, 3.2 Hz), 129.00 (d, *J* = 8.2 Hz), 115.11 (d, *J* = 21.6 Hz), 73.85, 64.66 (d, *J* = 7.0 Hz), 63.77 (d, *J* = 6.8 Hz), 54.32 (d, *J* = 150.0 Hz), 16.44 (d, *J* = 5.8 Hz), 16.26 (d, *J* = 6.0 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 19.62. $[\alpha]_{25}^{D}$ = -58.36 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=7.6 min, t_2=9.2 min, t_3=11.6 min, t_4=51.4 min (major). *ee* = 94.7%, *dr* = 11.9:1. HRMS Calcd. For $C_{12}H_{17}ClFNaO_4P^+$[M+Na^+]: 333.0429. Found: 333.0422.

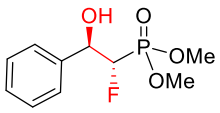


anti-(1*R*, 2*R*)-**2u**

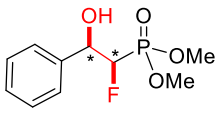
***anti*-(1*R*, 2*R*)-diethyl (1-chloro-2-(4-chlorophenyl)-2-hydroxyethyl)phosphonate (*anti*-(1*R*, 2*R*)-2u)** which catalyzed by RasADH was purified by chromatography on silica gel with 68.4% yield as yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ/ppm 7.49-7.34 (m, Ar-H, 4H), 4.99 (dd, C_2-H, *J* = 11.3, 8.5 Hz, 1H), 4.68 (br, O-H, 1H), 4.39-4.10 (m, $C_{9,\ 10}$-H, 4H), 3.98 (dd, C_1-H, *J* = 8.8, 8.8 Hz, 1H), 1.41 (t, C_{11}-H, *J* = 7.1 Hz, 3H), 1.33 (t, C_{12}-H, *J* = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ/ppm 138.04 (d, *J* = 11.3 Hz), 128.65, 128.41, 127.81, 73.92, 64.75 (d, *J* = 7.1 Hz), 63.81 (d, *J* = 6.8 Hz), 54.10 (d, *J* = 150.3 Hz), 16.45 (d, *J* = 5.8 Hz), 16.25 (d, *J* = 6.0 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ/ppm 19.56. $[\alpha]_{25}^{D}$ = -32.78 (*c* = 0.5, $CHCl_3$). HPLC Chiracel® IC, 250 × 4.6 mm column, hexane/2-propanol 80:20, 1.0 mL/min flow rate, 215 nm UV lamp, 30 °C, t_1=7.6 min, t_2=8.8 min, t_3=11.5 min, t_4=46.0 min (major). *ee* = 98.8%, *dr* = 13.8:1. HRMS Calcd. For $C_{12}H_{17}Cl_2NaO_4P^+$[M+Na^+]: 349.0134. Found: 349.0120.

Table S8. Biological tests.

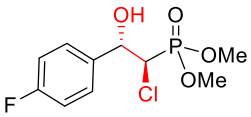
Test Strain	Compounds with weak inhibitory activity
Bacillus subtilis 168 (labeled as 090)	#17: *anti*-(1*S*, 2*S*)-**2r**, #28: *anti*-(1*S*, 2*S*)-**2s**, #35: *anti*-(1*R*, 2*R*)-**2u**
Staphylococcus aureus CMCC(B) 26003 (labeled as 031)	#30: *anti*-(1*S*, 2*R*)-**2d**, #31: *syn*-**2d**, #20: *anti*-(1*S*, 2*S*)-**2i**, #19: *anti*-(1*R*, 2*R*)-**2l**, #32: *anti*-(1*R*, 2*R*)-**2p**, #33: *anti*-(1*R*, 2*R*)-**2q**, #28: *anti*-(1*S*, 2*S*)-**2s**, #38: *anti*-(1*R*, 2*R*)-**2s**, #35: *anti*-(1*R*, 2*R*)-**2u**
E. coli BL21 (labeled as 033)	#35: *anti*-(1*R*, 2*R*)-**2u**
Pseudomonas aeruginosa CICC10351 (labeled as 029)	#11: *anti*-(1*S*, 2*S*)-**2p**, #35: *anti*-(1*R*, 2*R*)-**2u**



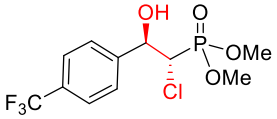
#30: *anti*-(1*S*, 2*R*)-**2d**



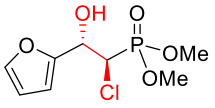
#31: *syn*-**2d**



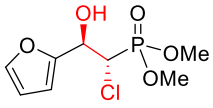
#20: *anti*-(1*S*, 2*S*)-**2i**



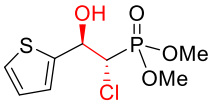
#19: *anti*-(1*R*, 2*R*)-**2l**



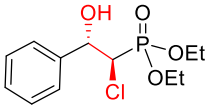
#11: *anti*-(1*S*, 2*S*)-**2p**



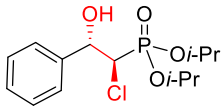
#32: *anti*-(1*R*, 2*R*)-**2p**



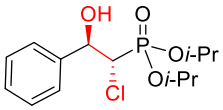
#33: *anti*-(1*R*, 2*R*)-**2q**



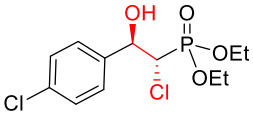
#17: *anti*-(1*S*, 2*S*)-**2r**



#28: *anti*-(1*S*, 2*S*)-**2s**

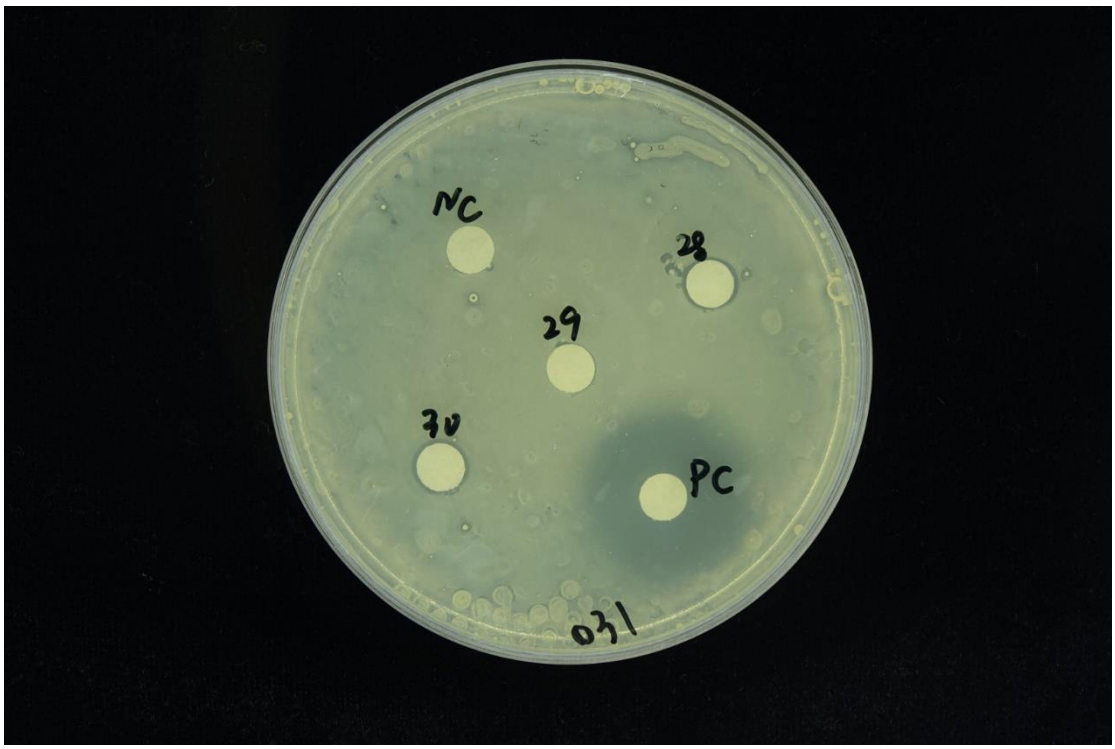


#38: *anti*-(1*R*, 2*R*)-**2s**



#35: *anti*-(1*R*, 2*R*)-**2u**

Antibacterial activities of the synthesized compounds were evaluated by using a paper disc diffusion assay (Mearns-Spragg et al., 1998). A sterile paper disc (6 mm in diameter) saturated with 5 μL of DMSO-dissolved tested compounds (20 μg/μL) was placed on LB agar plates inoculated with test organisms, including *Pseudomonas aeruginosa* CICC10351, *Staphylococcus aureus* CMCC(B) 26003, *Bacillus subtilis* 168 and *E. coli* BL21. Chloramphenicol (25 μg) was used as the positive control and 5 μL of DMSO was used as the negative control. Plates were incubated at 30 °C (or 37 °C for *E. coli*) overnight.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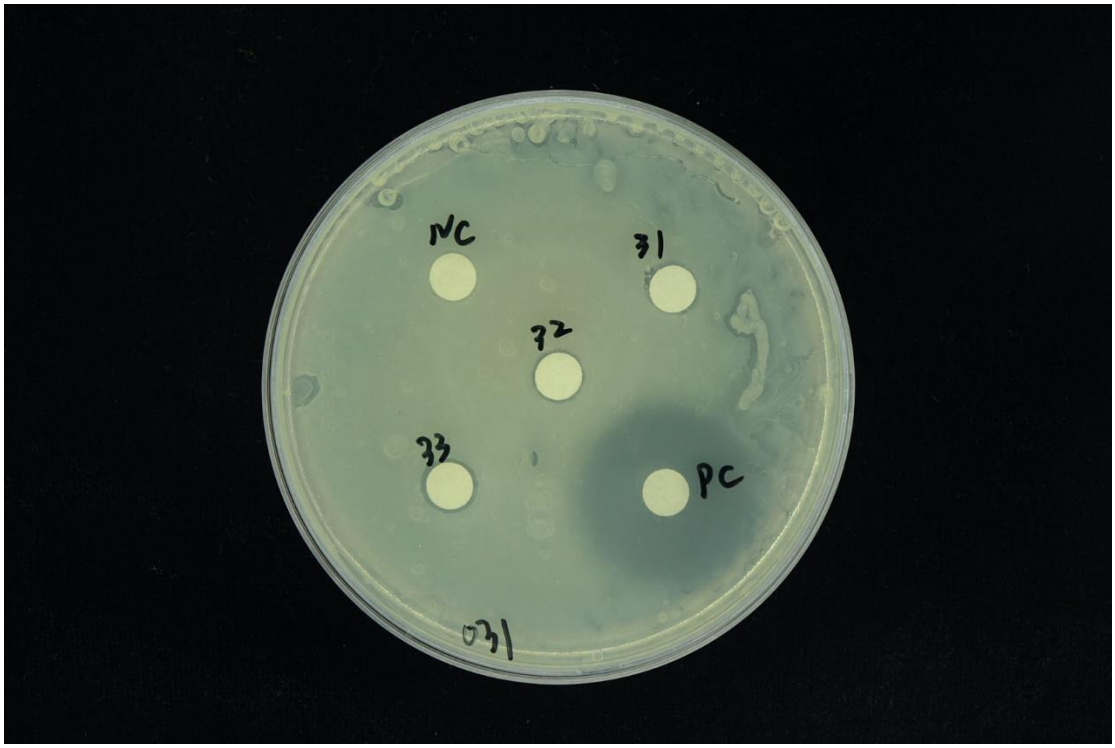
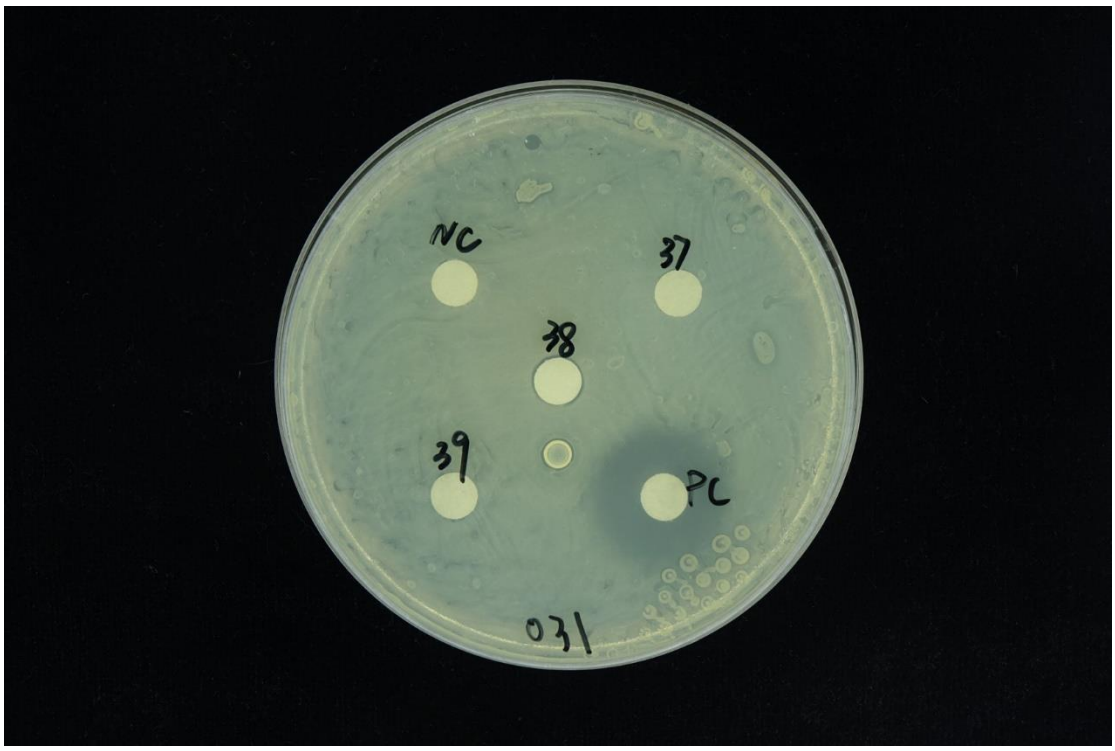
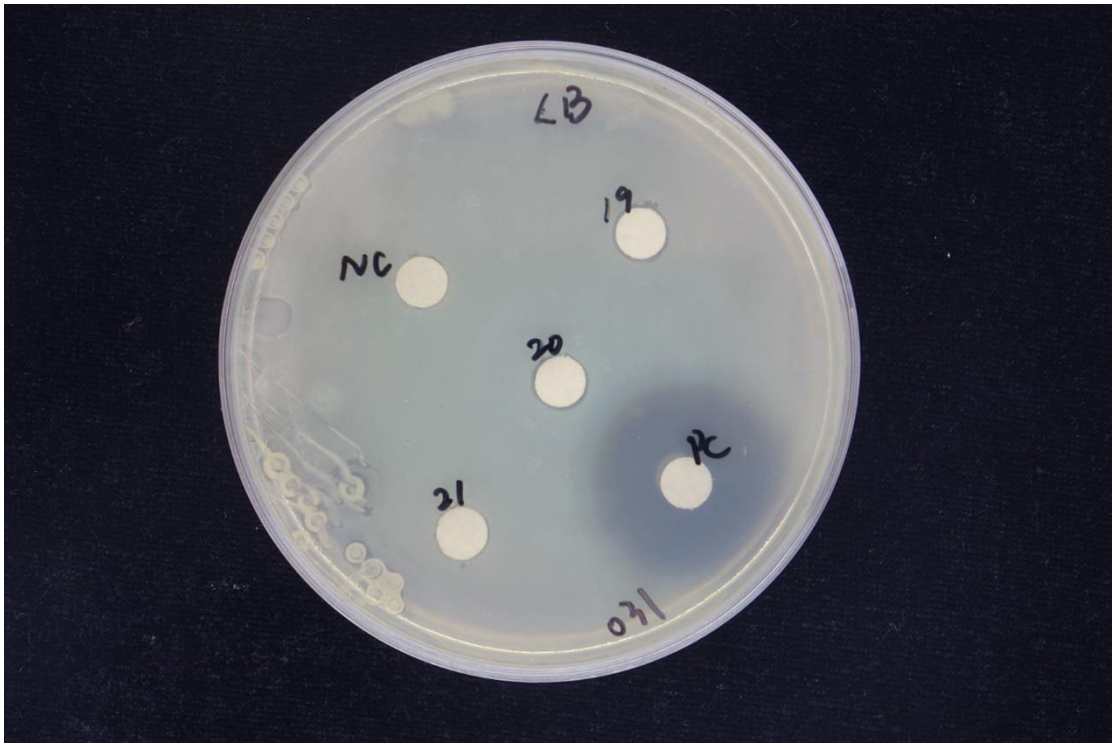
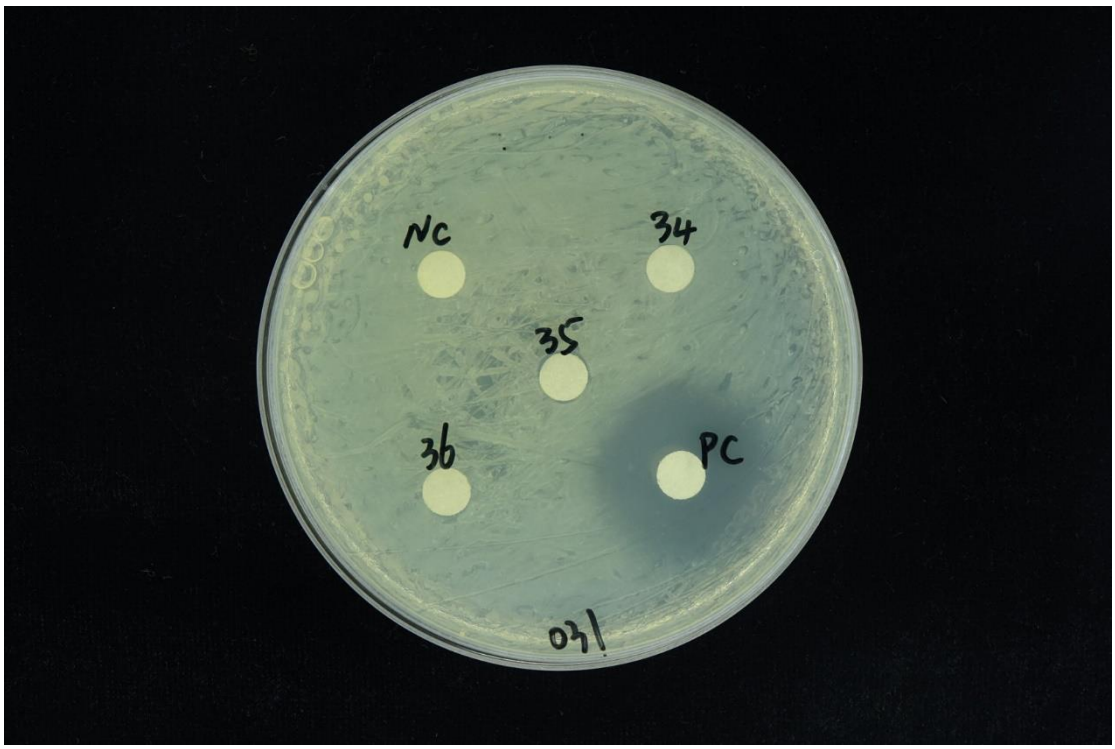
28
29
30
PC
031


NC
31
32
33
PC
031


NC
37
38
39
PC
031


LB
19
NC
20
PC
21
031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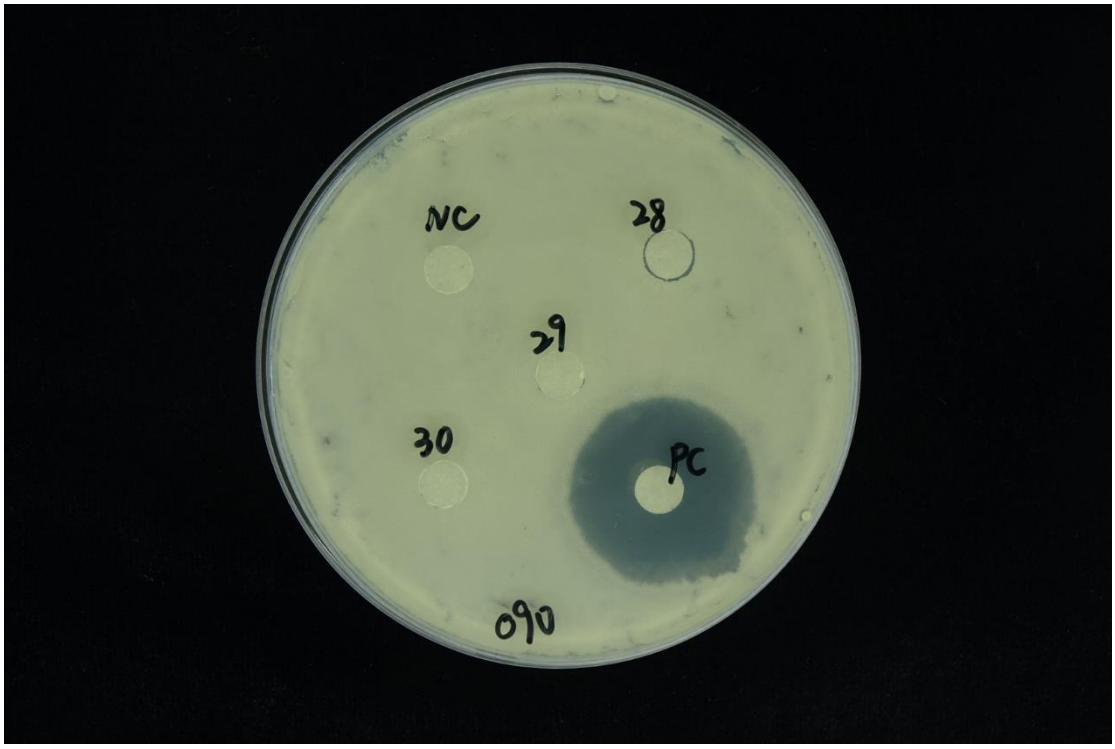
35
36
PC
031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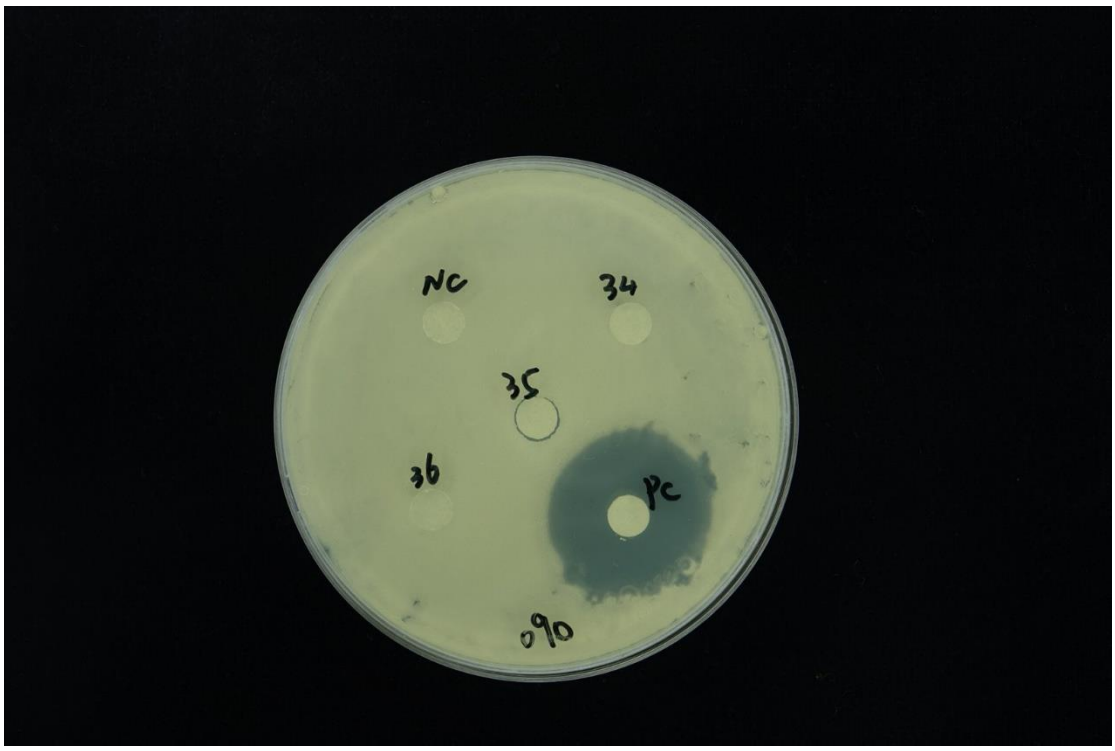
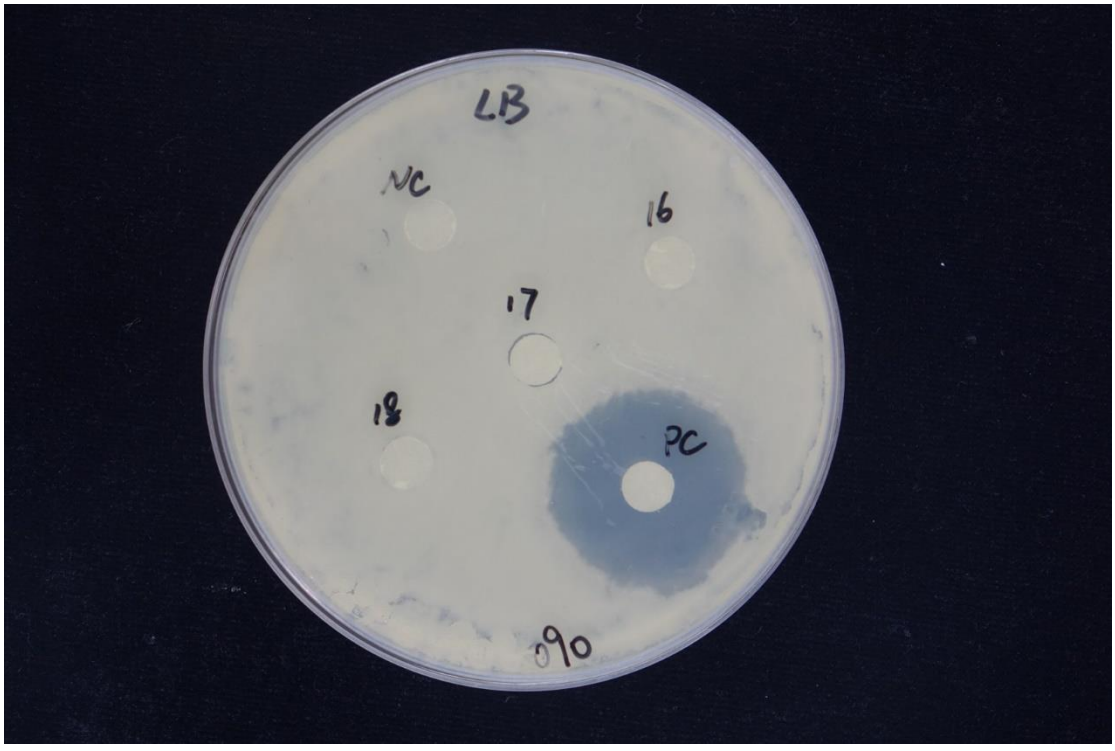
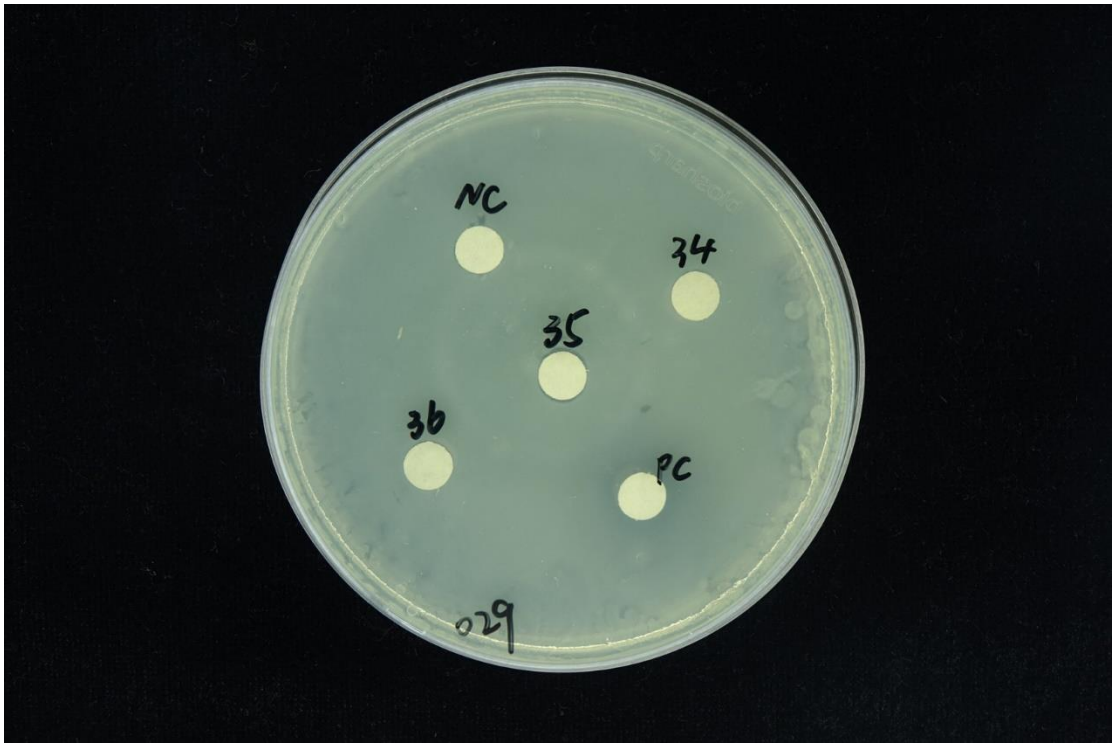
28
29
30
PC
090


NC
34
35
36
PC
090


LB
NC
16
17
18
PC
090


NC
34
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PC
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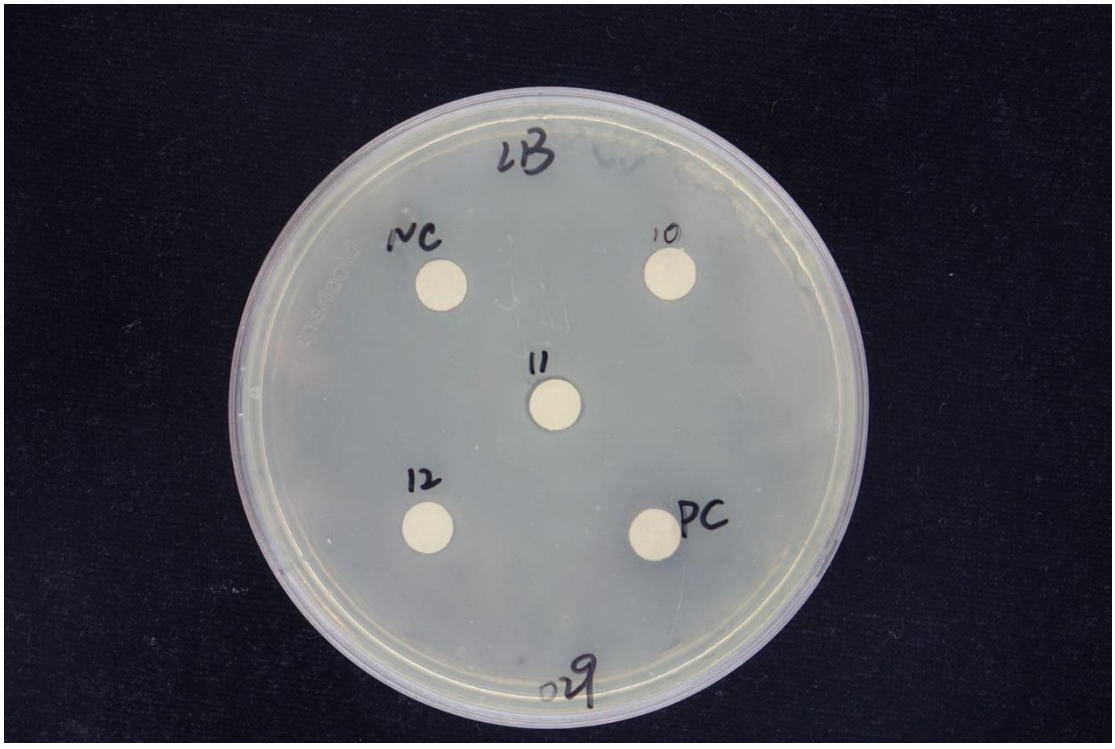
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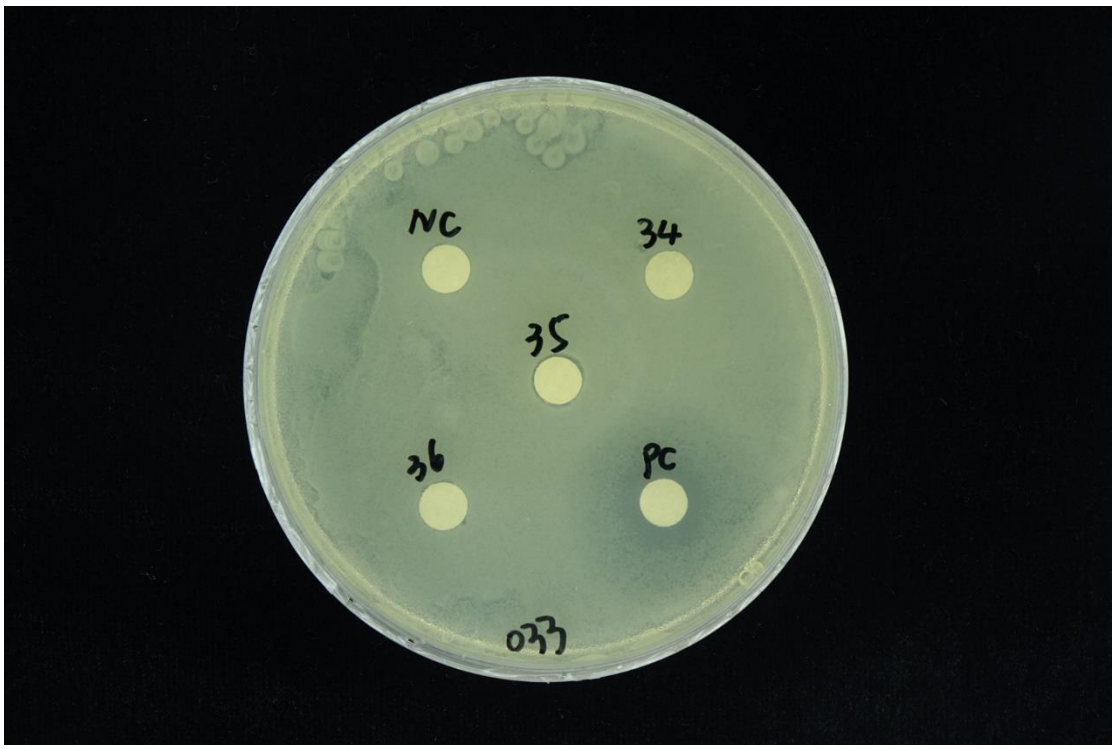
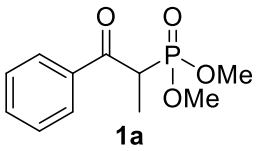

NC
34
35
36
PC
033

Table S9. List of oligonucleotides used in this study

Name	Sequence (5'→3')[a]
pET28a-NdeI-YDL124w_fw	cggcctggtgccgcgcggcagccatATGTCATTTCACCAACAGTTCT
pET28a-XhoI-YDL124w_rc	agtggtggtggtggtggtgctcgagTTATACTTTTTGAGCAGCGTAGT

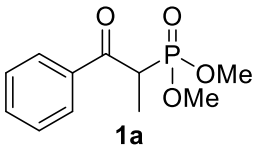
[a]Nucleotides colored in red indicate cleavage sites

Compound **1a**, ^{1}H NMR



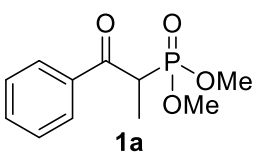
1a

Compound **1a**, ^{13}C NMR



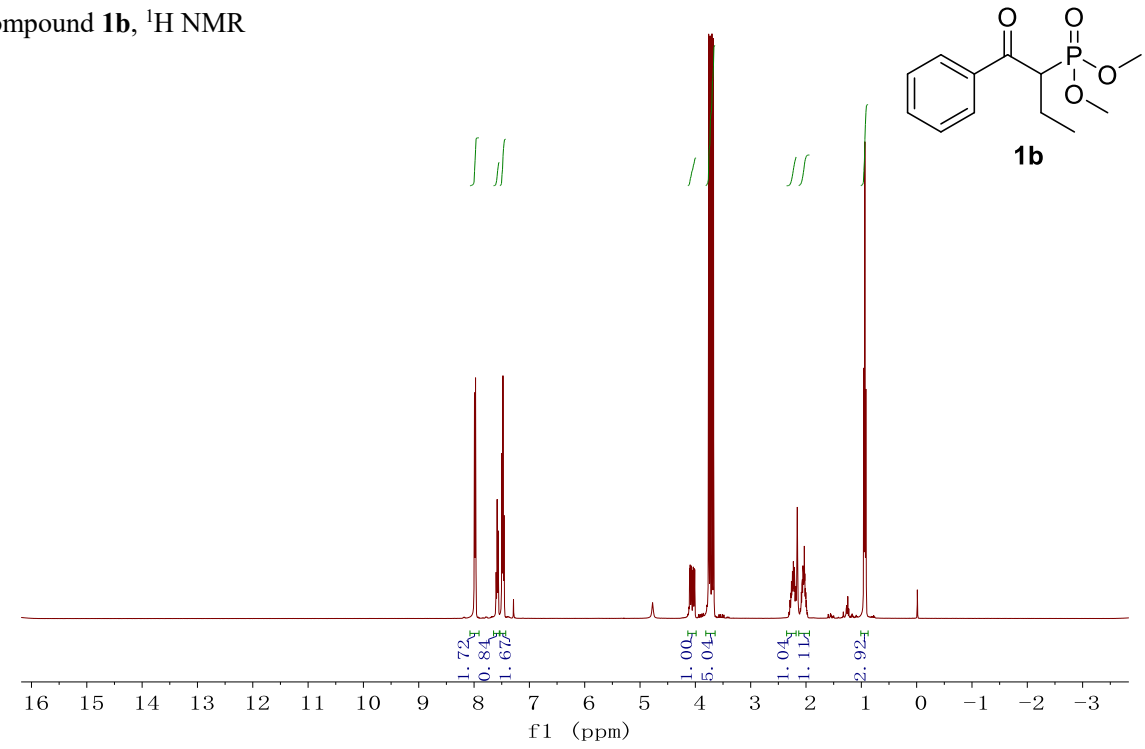
1a

Compound **1a**, ^{31}P NMR

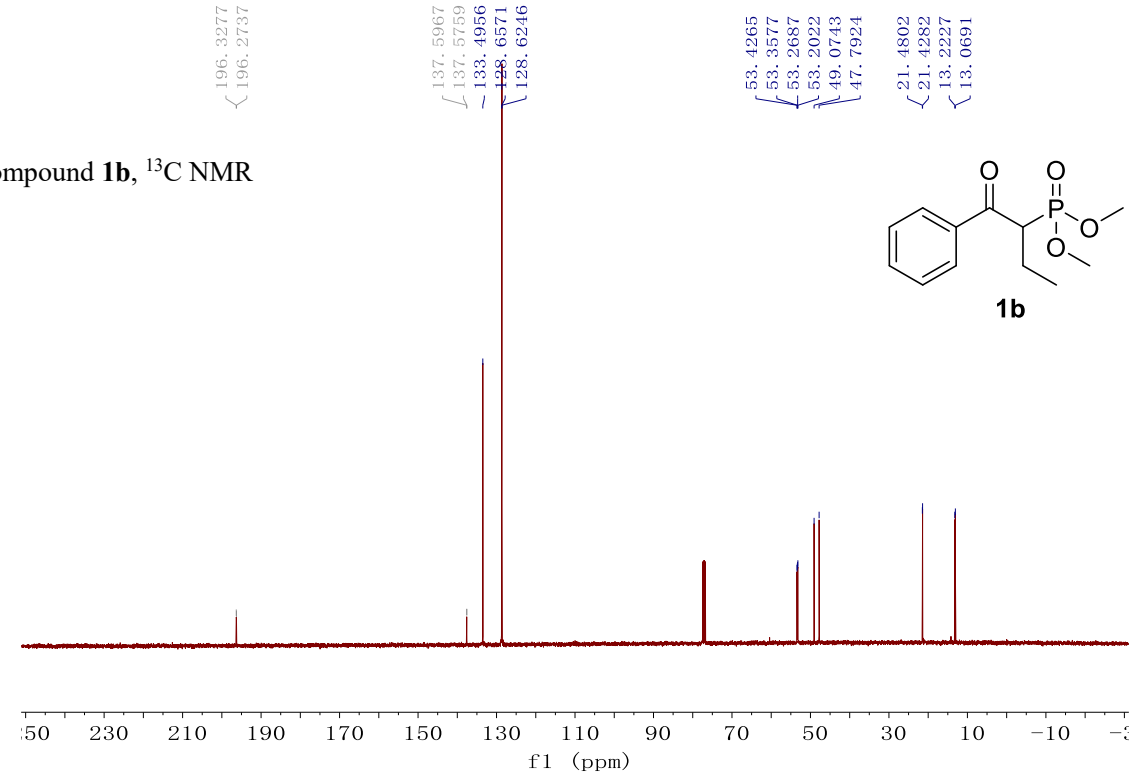


1a

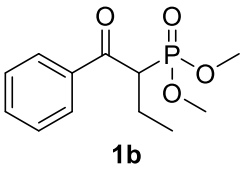
Compound **1b**, ^{1}H NMR



Compound **1b**, ^{13}C NMR

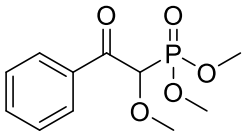


Compound **1b**, ^{31}P NMR



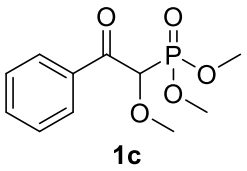
1b

Compound **1c**, ^{1}H NMR



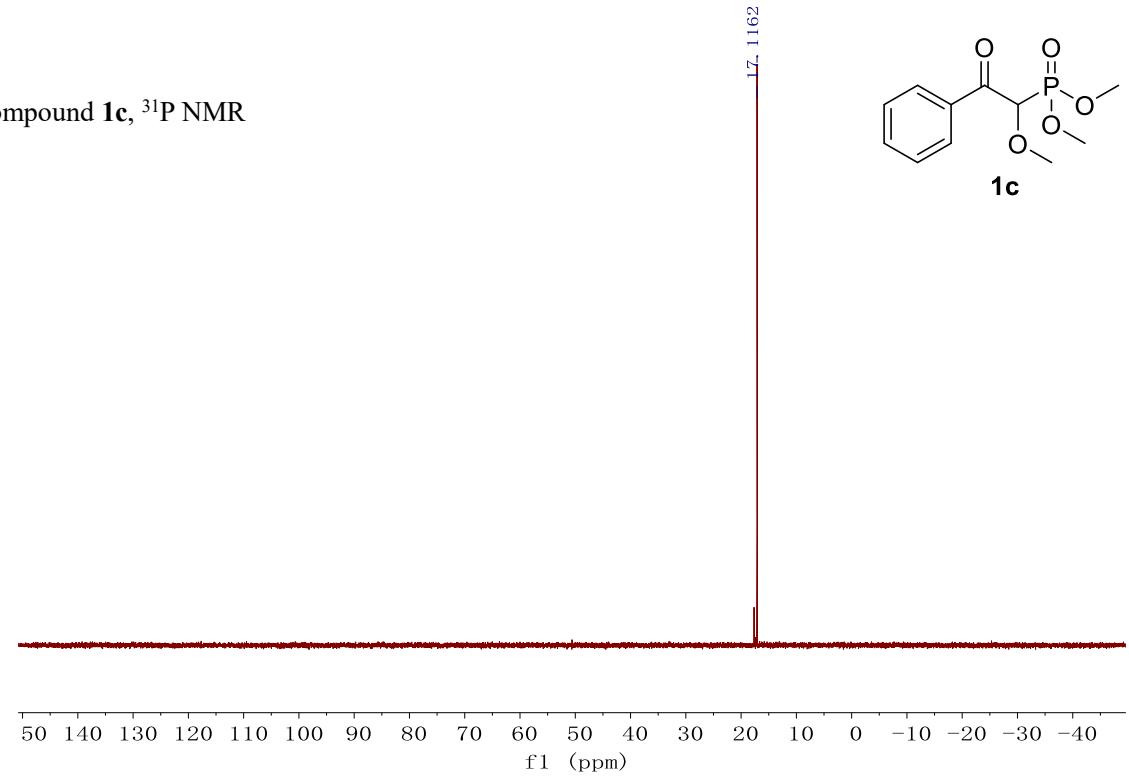
1c

Compound **1c**, ^{13}C NMR



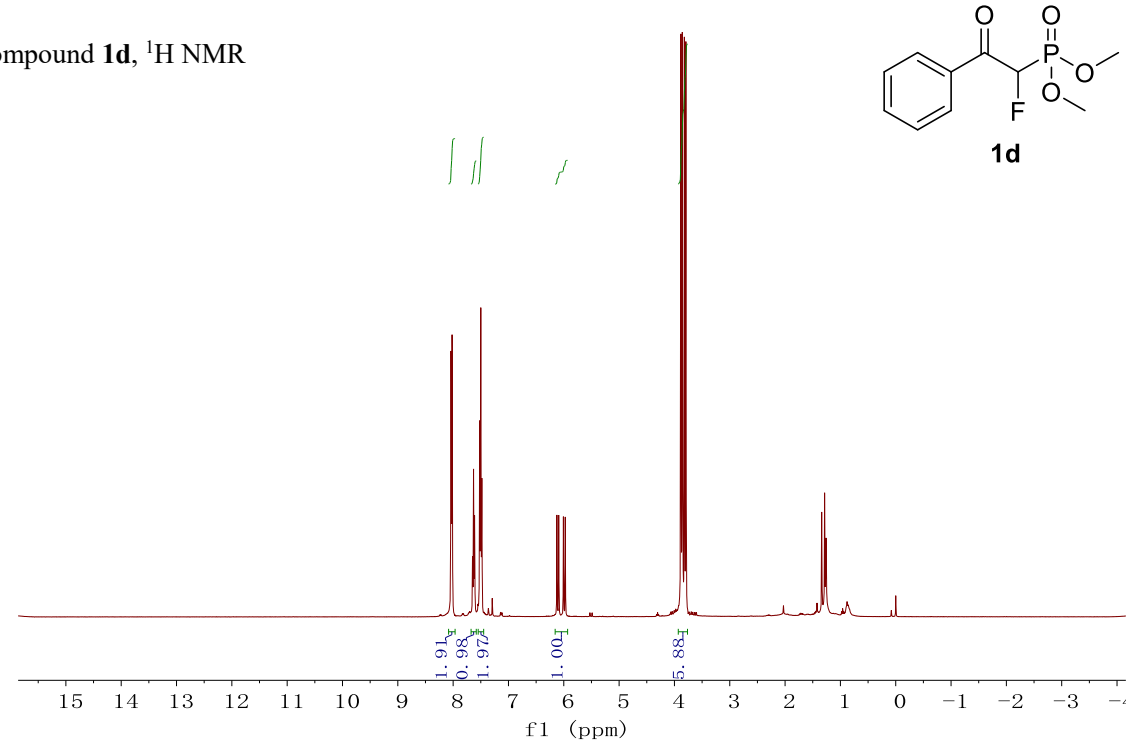
1c

Compound **1c**, ^{31}P NMR



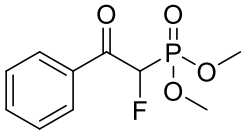
1c

Compound **1d**, ^{1}H NMR



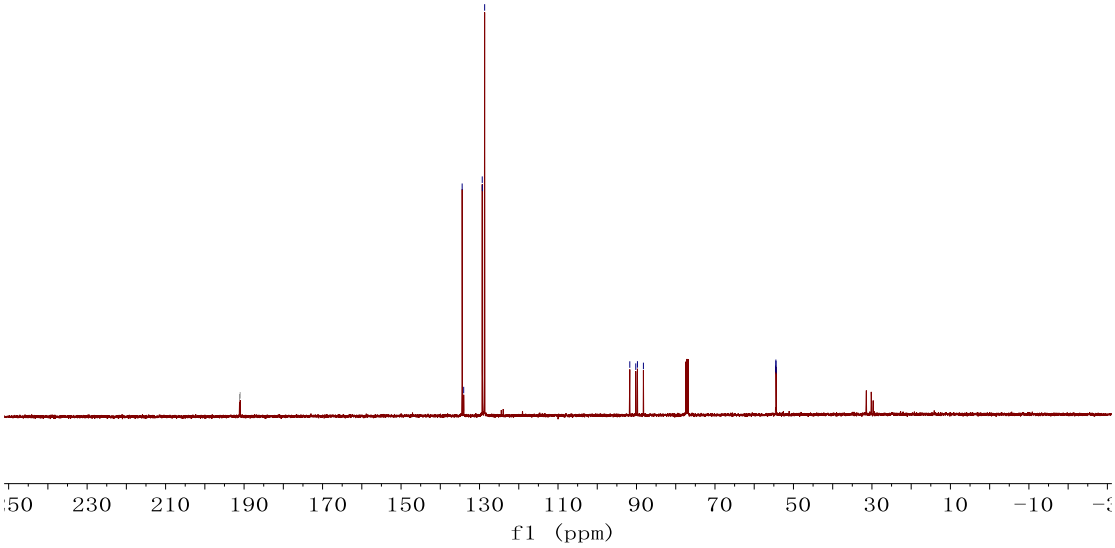
1d

191.1586
190.9949
134.4267
134.0364
129.3085
129.2752
128.6968
91.7082
90.1858
89.7563
88.2346
54.5445
54.4777
54.4540
54.3877

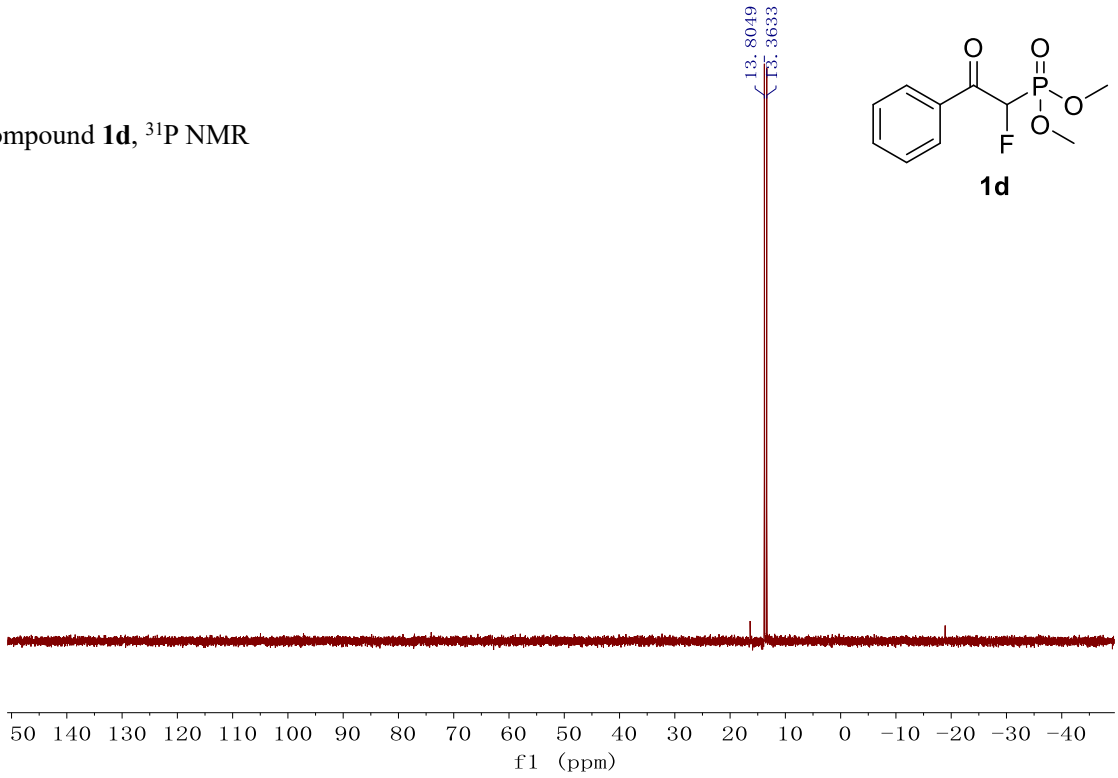


1d

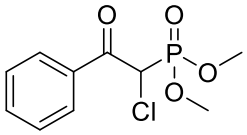
Compound **1d**, ^{13}C NMR



Compound **1d**, ^{31}P NMR

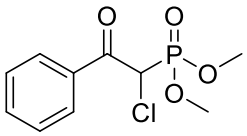


Compound **1e**, ^{1}H NMR



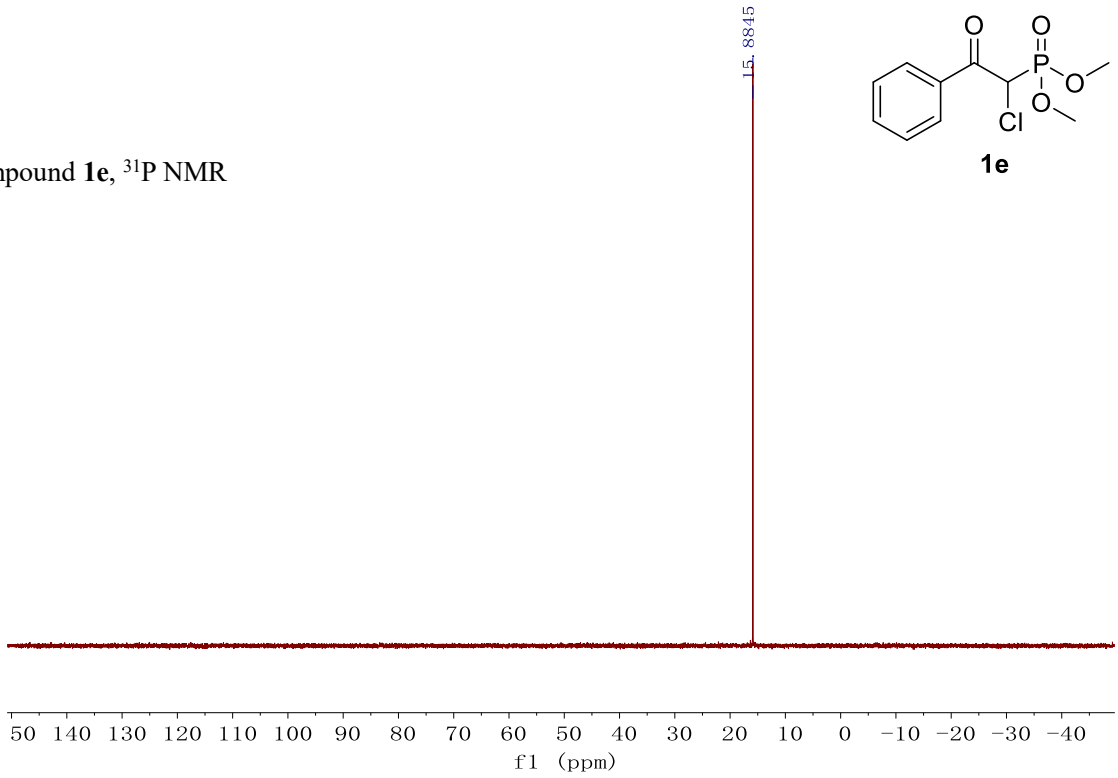
1e

Compound **1e**, ^{13}C NMR



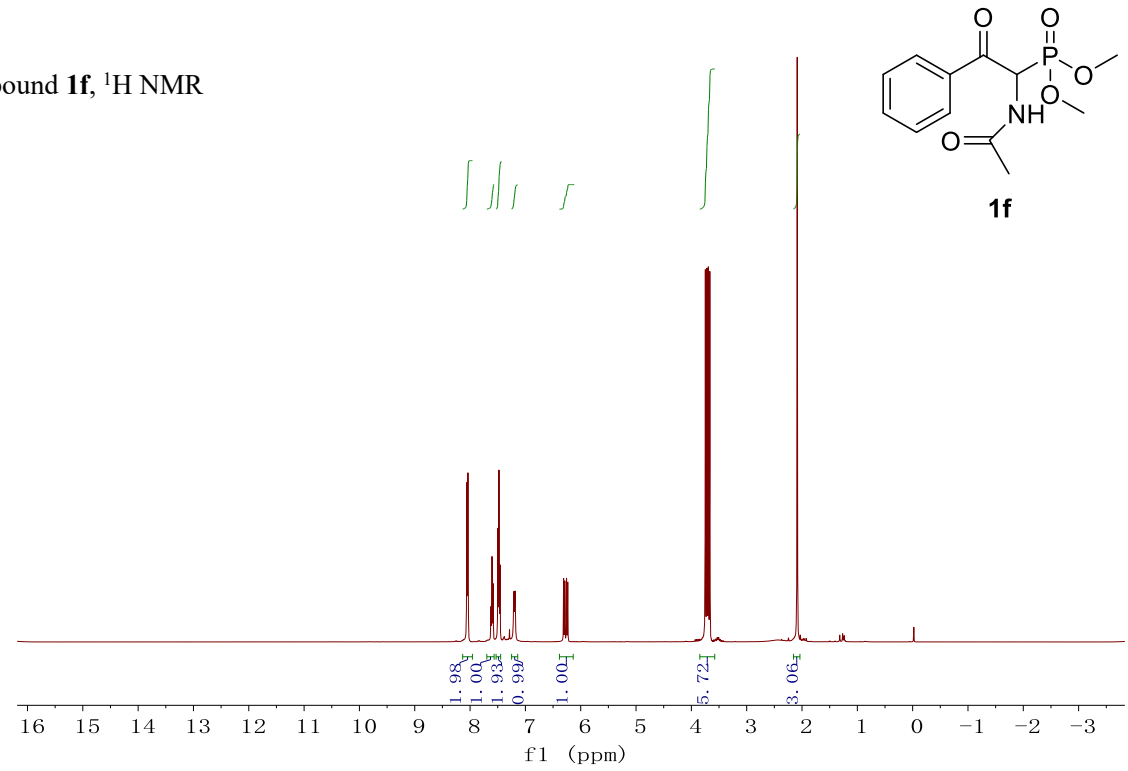
1e

Compound **1e**, ^{31}P NMR



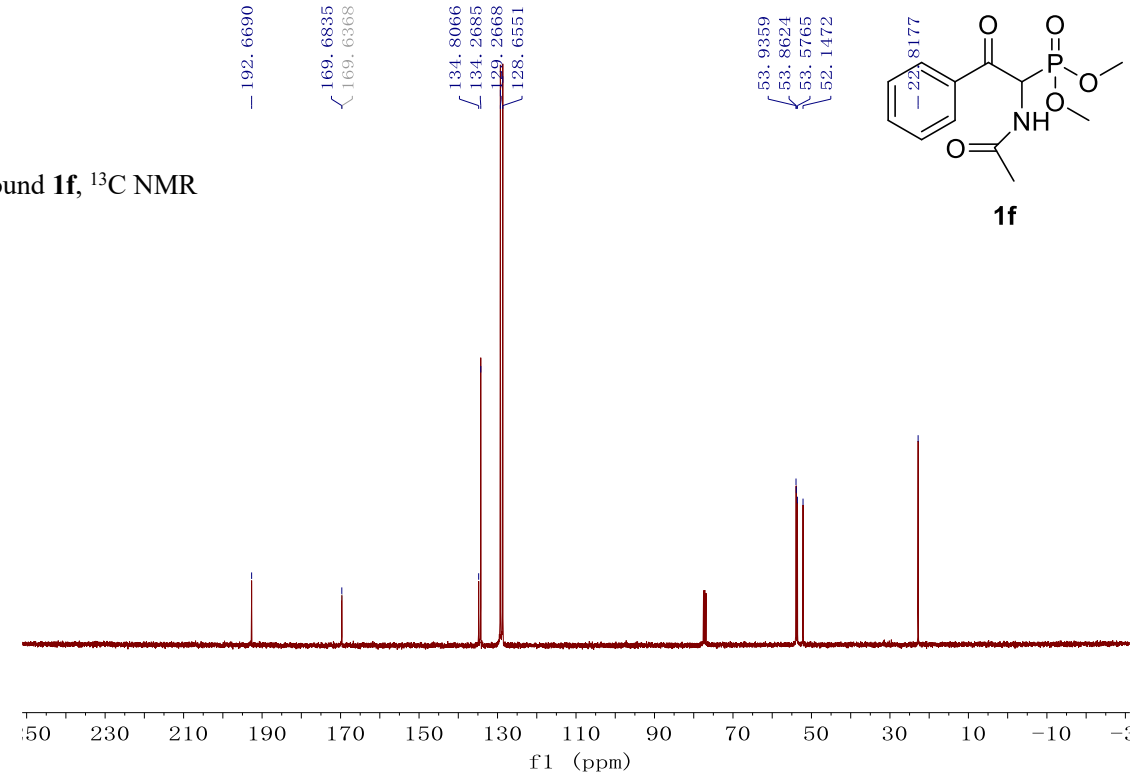
1e

Compound **1f**, ^{1}H NMR



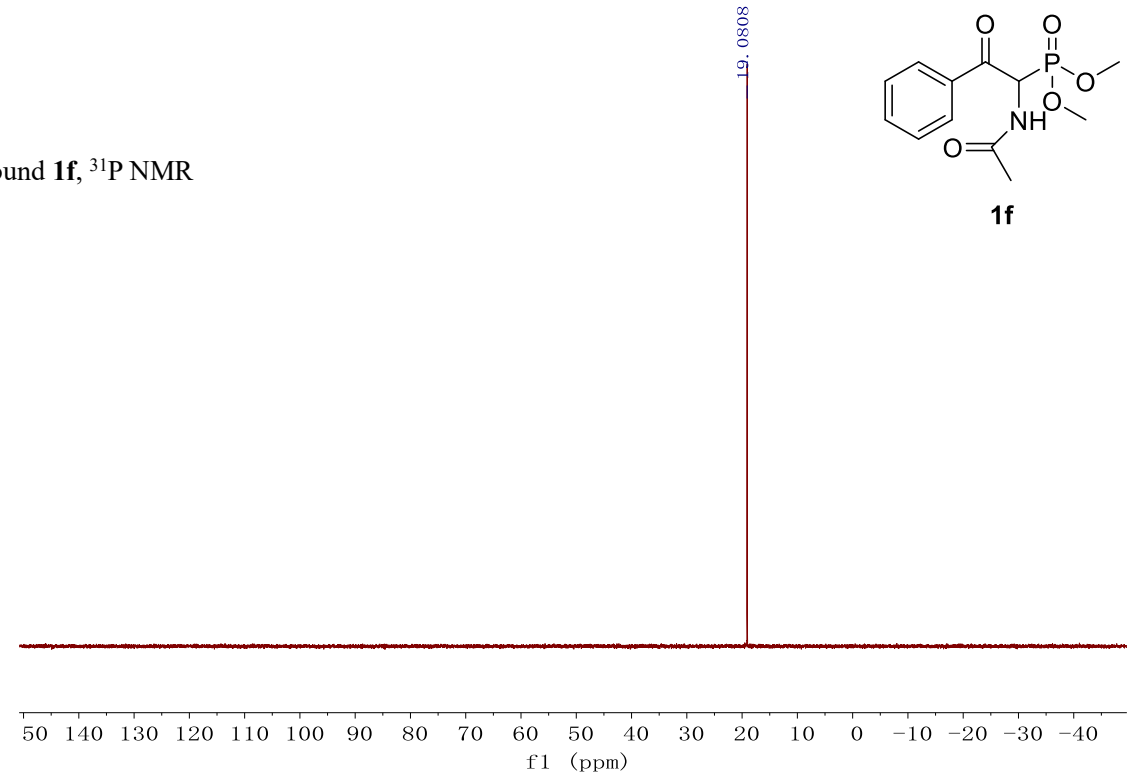
1f

Compound **1f**, ^{13}C NMR



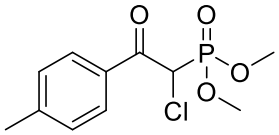
1f

Compound **1f**, ^{31}P NMR



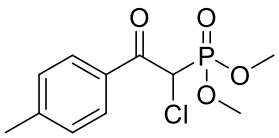
1f

Compound **1g**, ^{1}H NMR



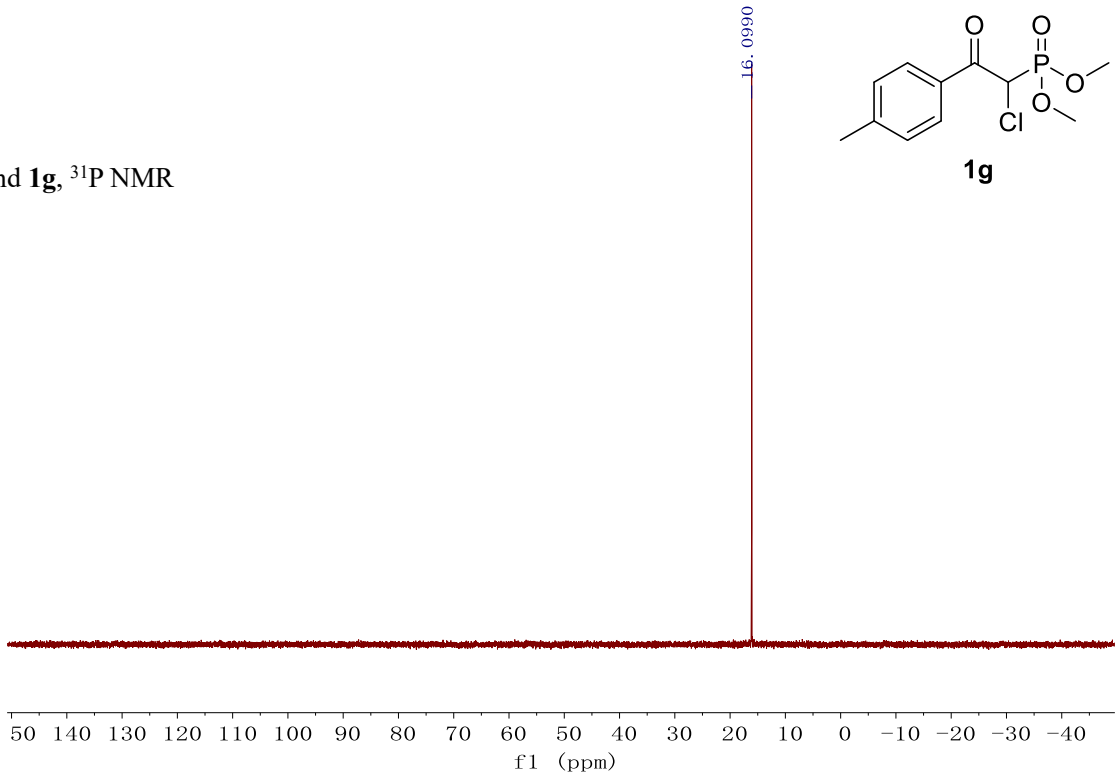
1g

Compound **1g**, ^{13}C NMR



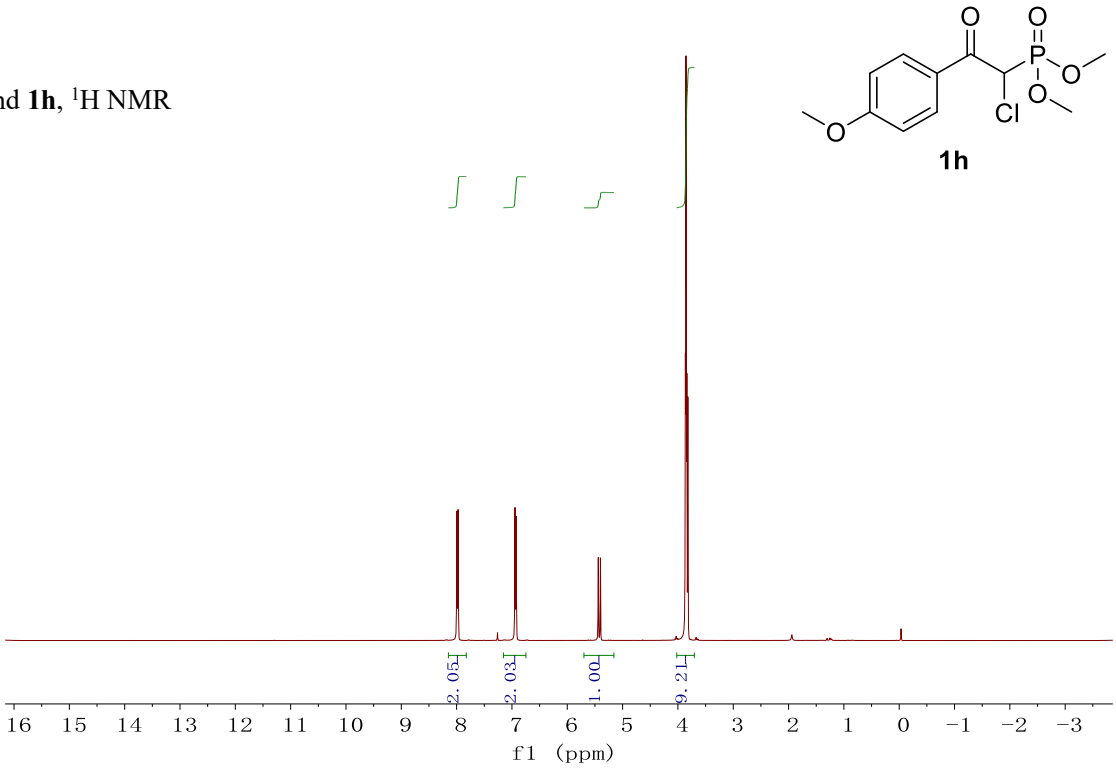
1g

Compound **1g**, ^{31}P NMR



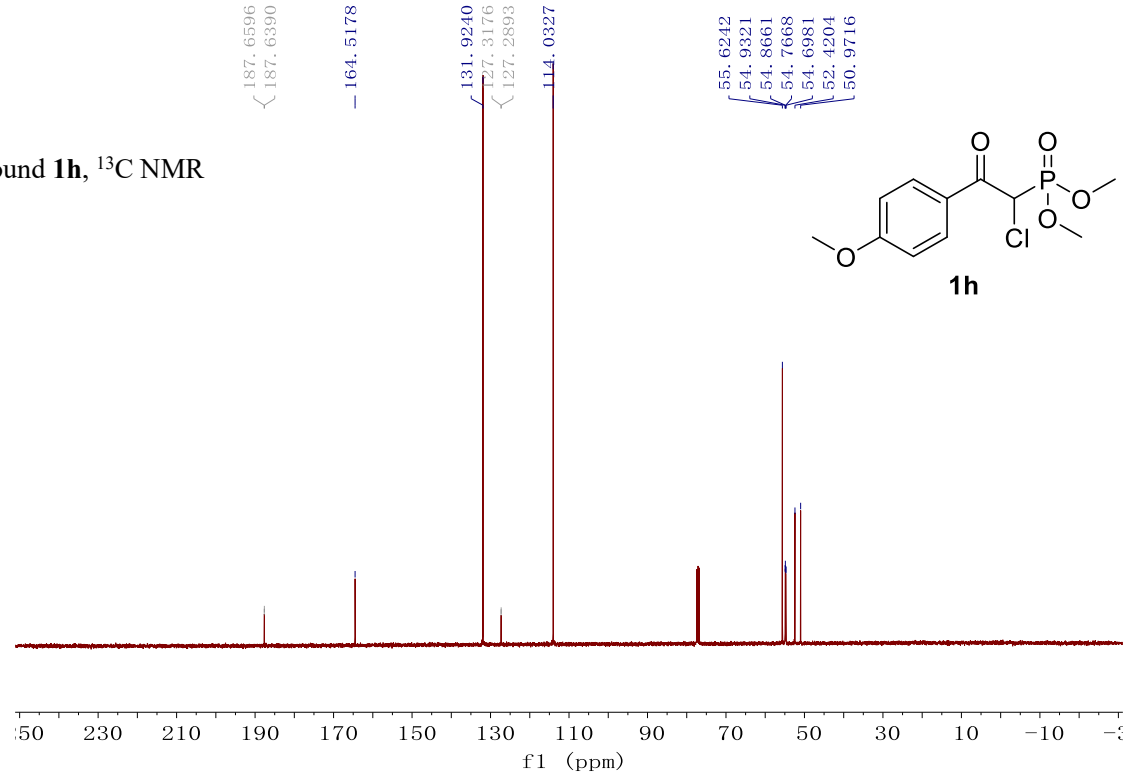
1g

Compound **1h**, ^{1}H NMR



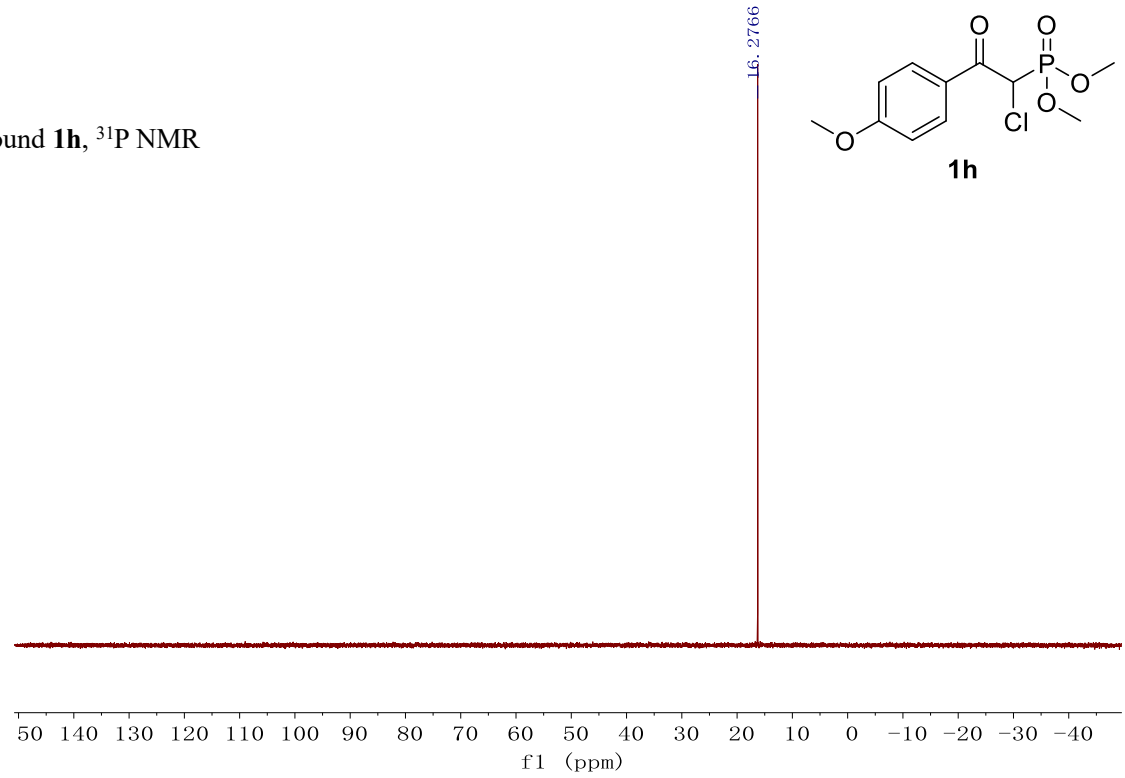
1h

Compound **1h**, ^{13}C NMR



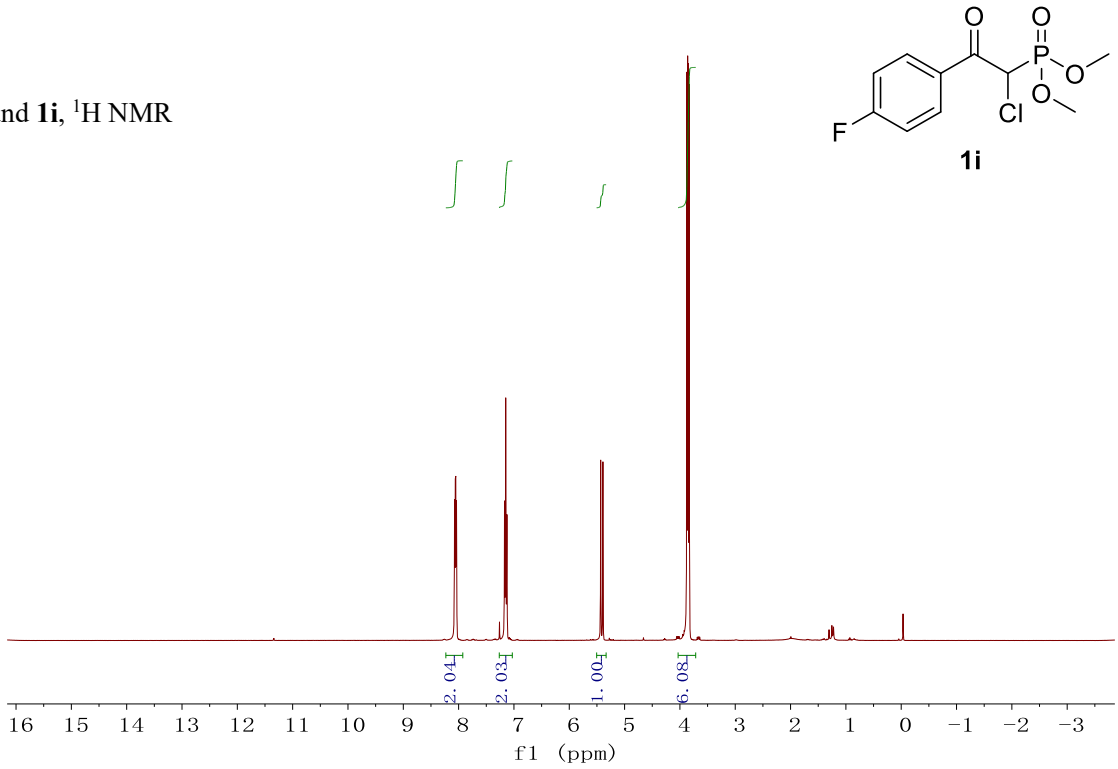
1h

Compound **1h**, ^{31}P NMR

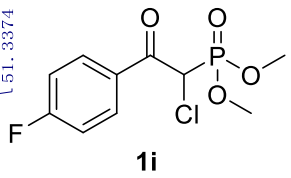


1h

Compound **1i**, ^{1}H NMR

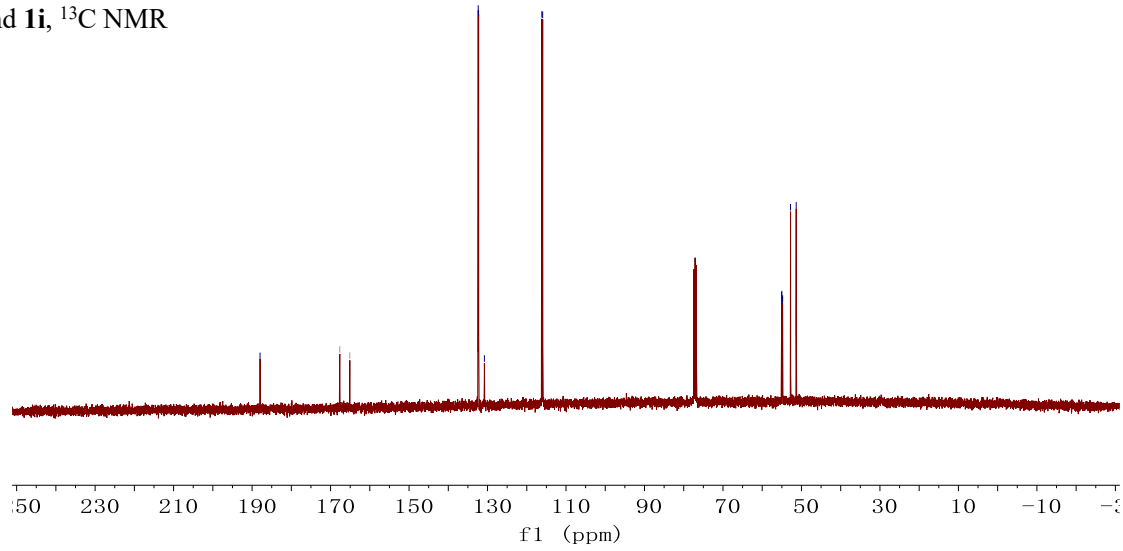


1i

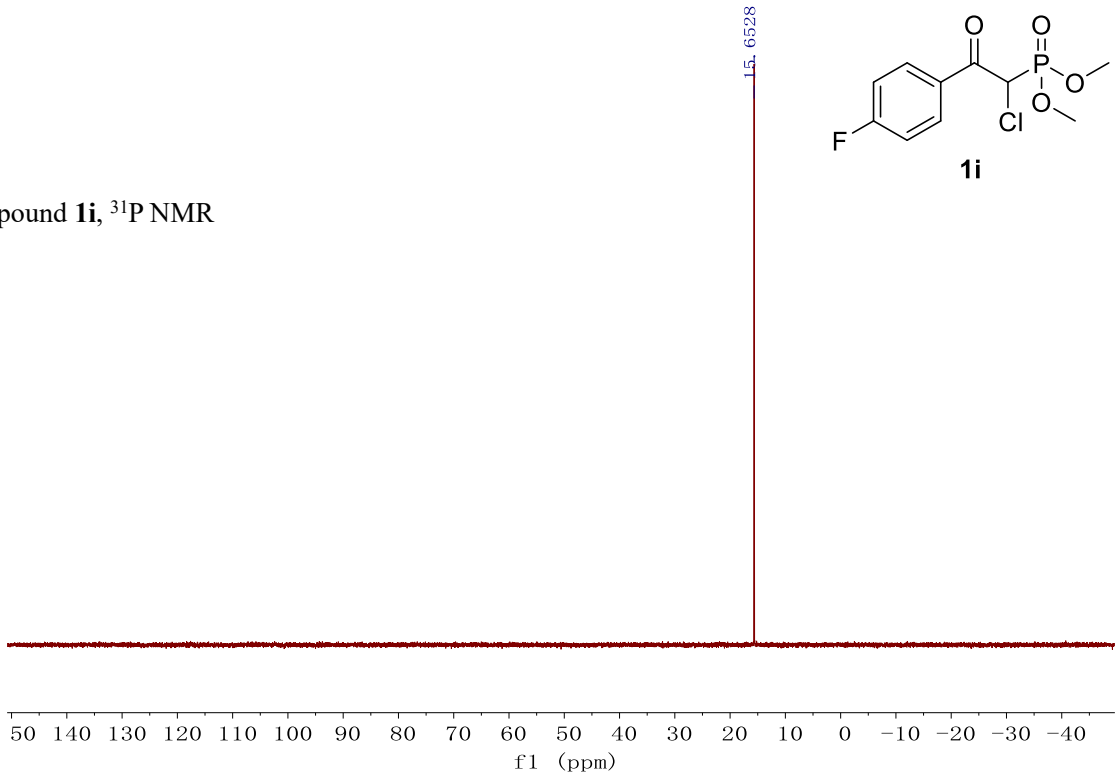


1i

Compound **1i**, ^{13}C NMR

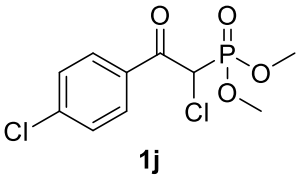


Compound **1i**, ^{31}P NMR



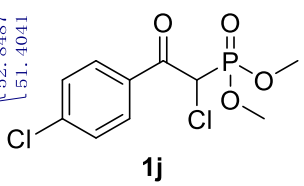
1i

Compound **1j**, ^{1}H NMR



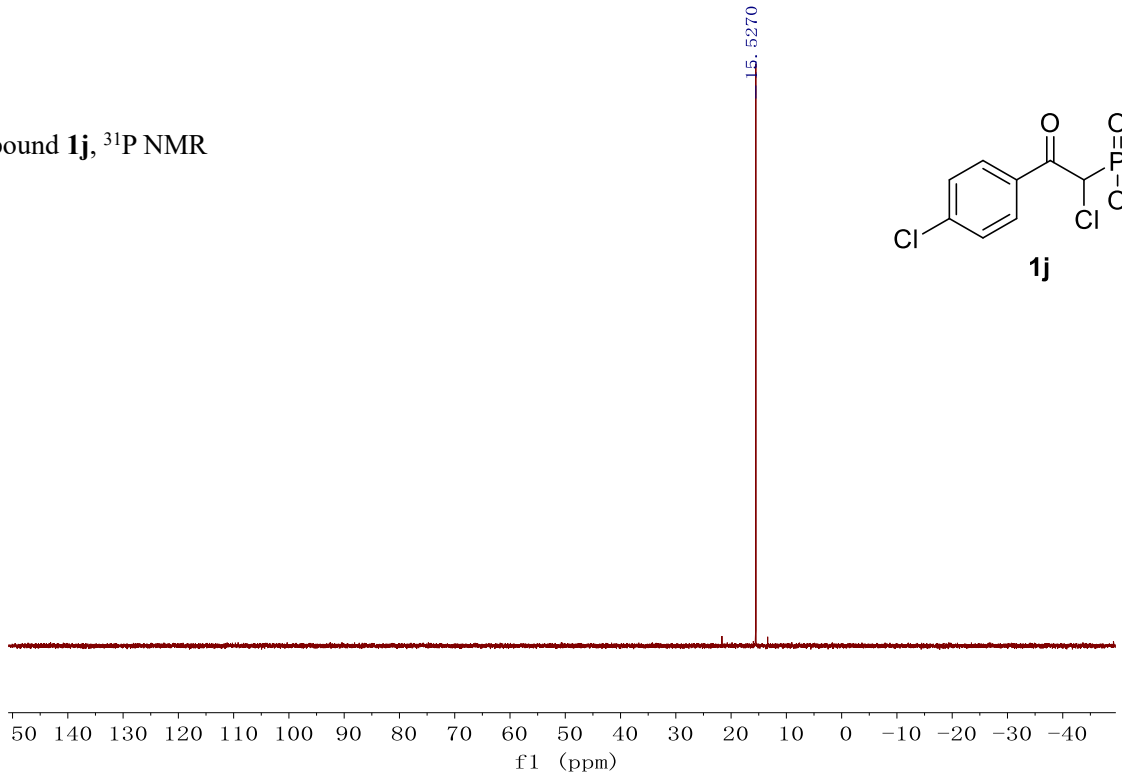
1j

Compound **1j**, ^{13}C NMR



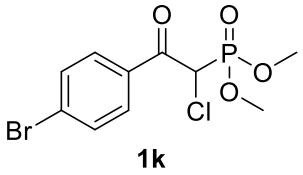
1j

Compound **1j**, ^{31}P NMR



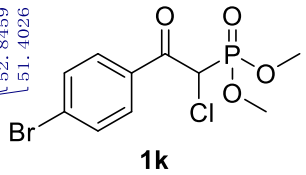
1j

Compound **1k**, ^{1}H NMR



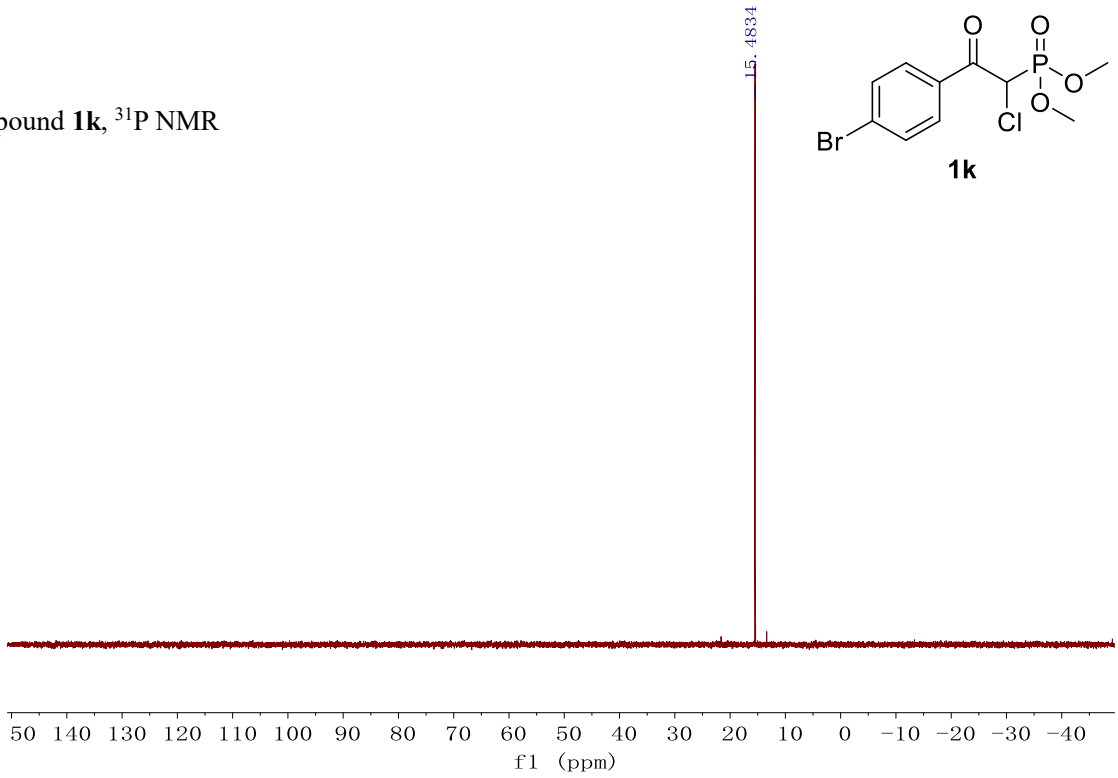
1k

Compound **1k**, ^{13}C NMR



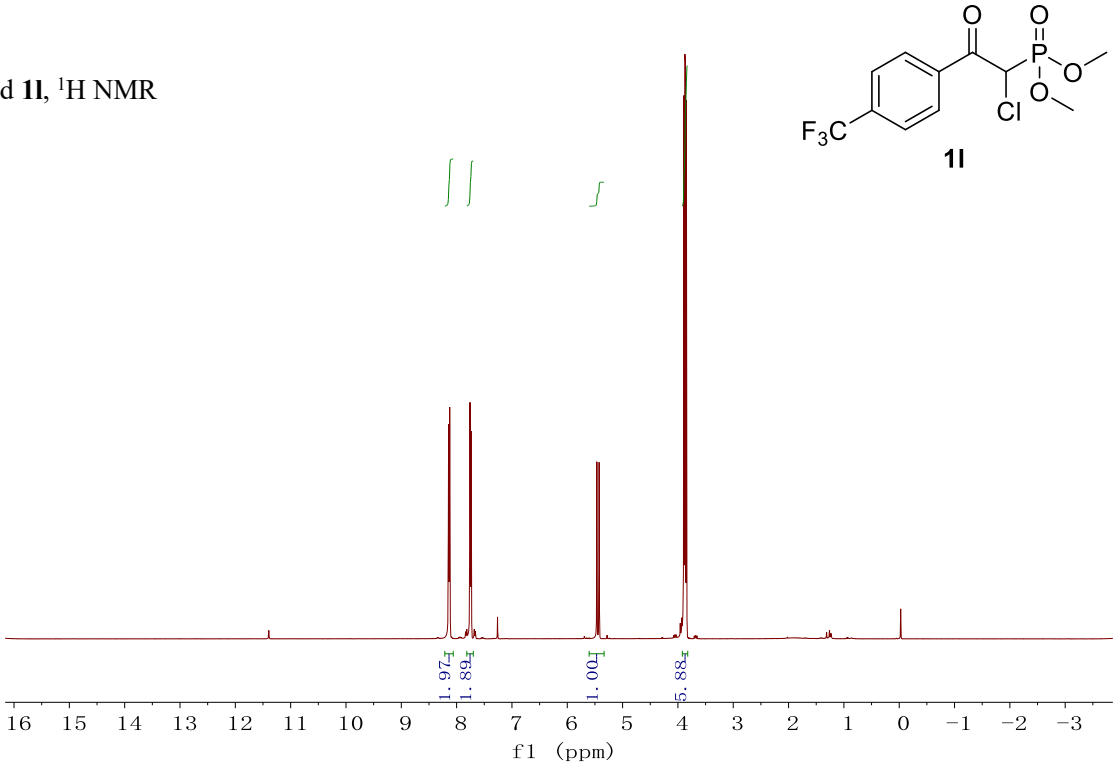
1k

Compound **1k**, ^{31}P NMR

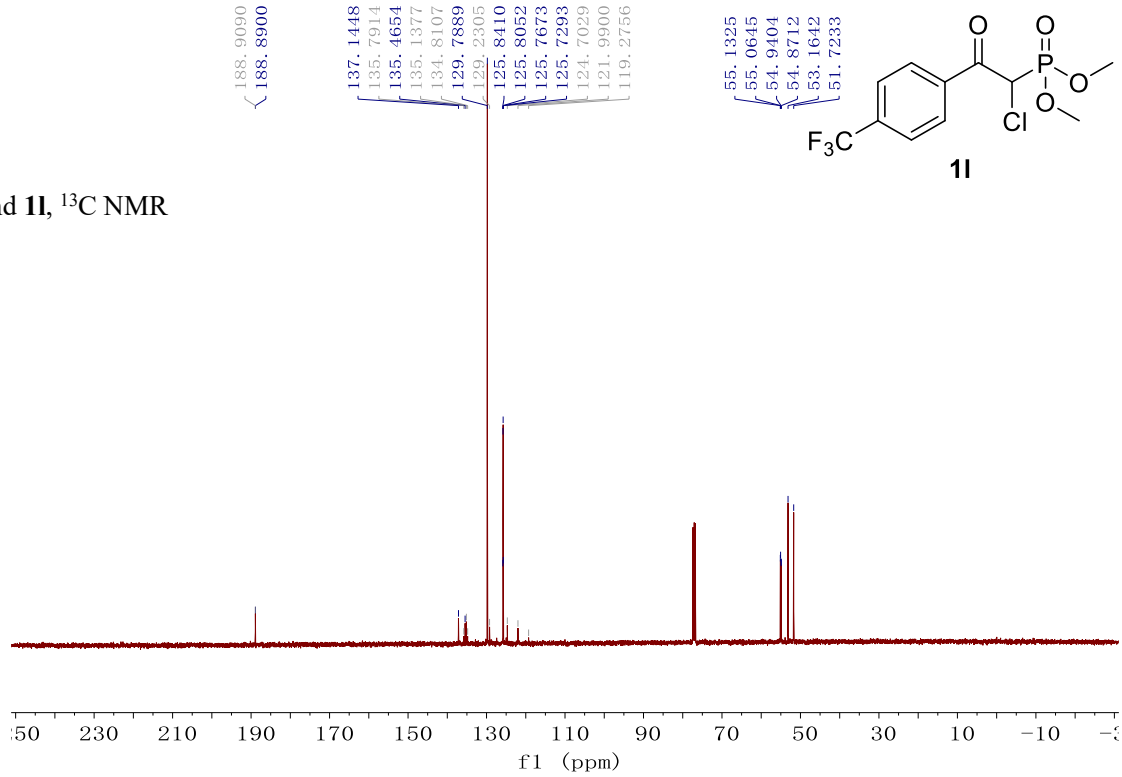


1k

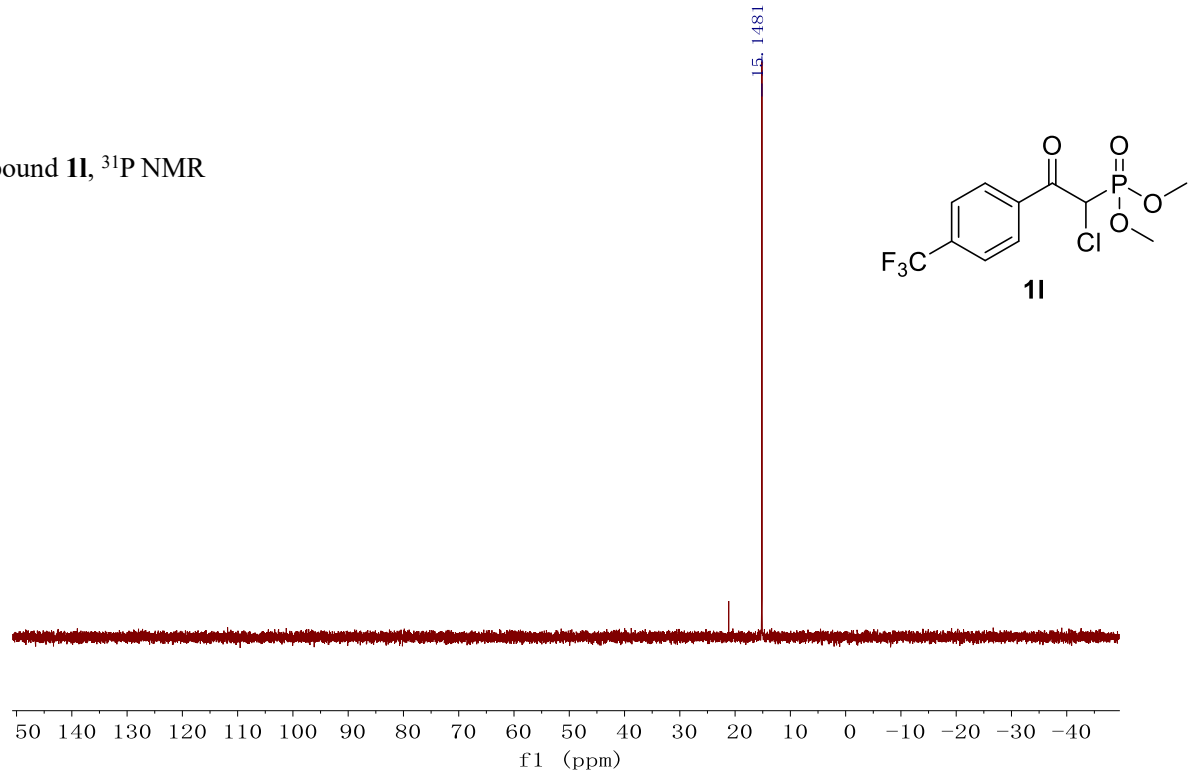
Compound **1l**, ^{1}H NMR



Compound **1l**, ^{13}C NMR

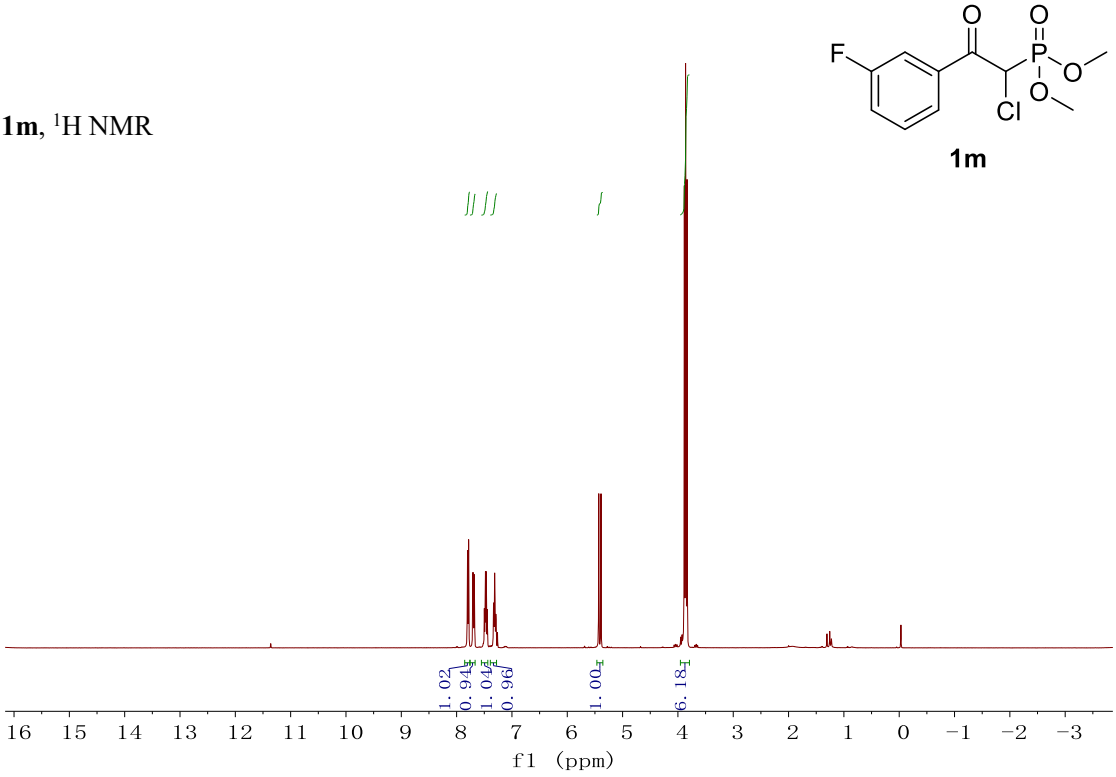


Compound **1l**, ^{31}P NMR



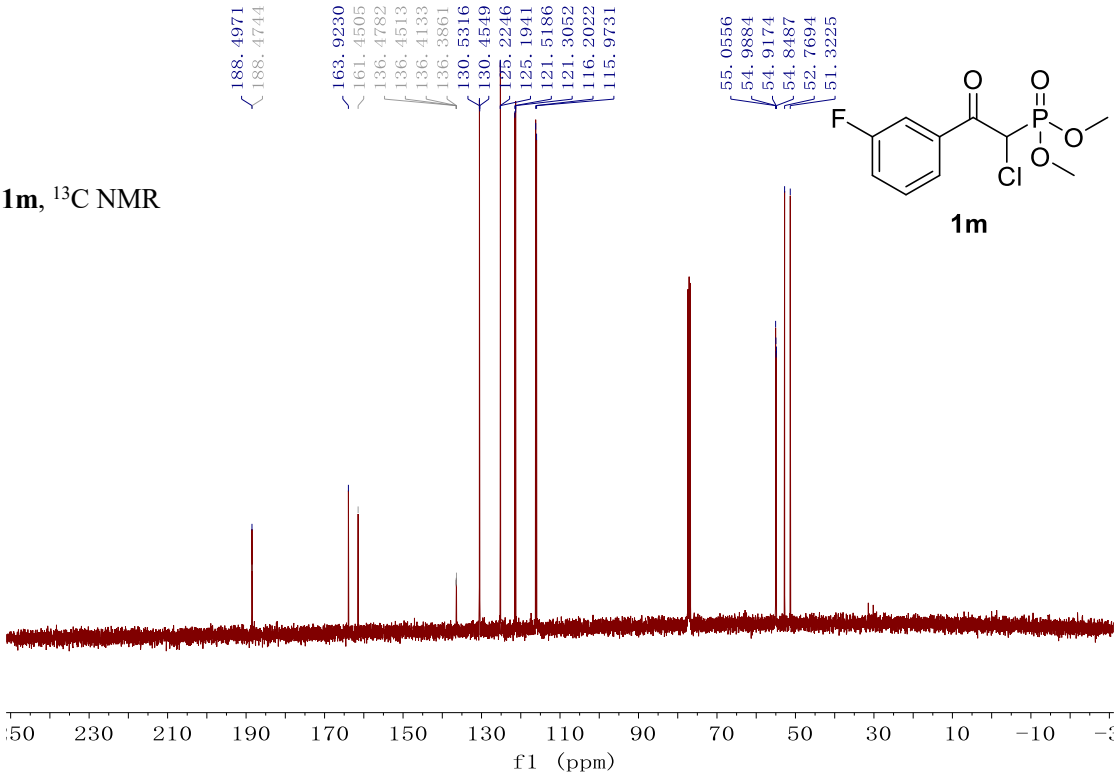
1l

Compound **1m**, ^{1}H NMR



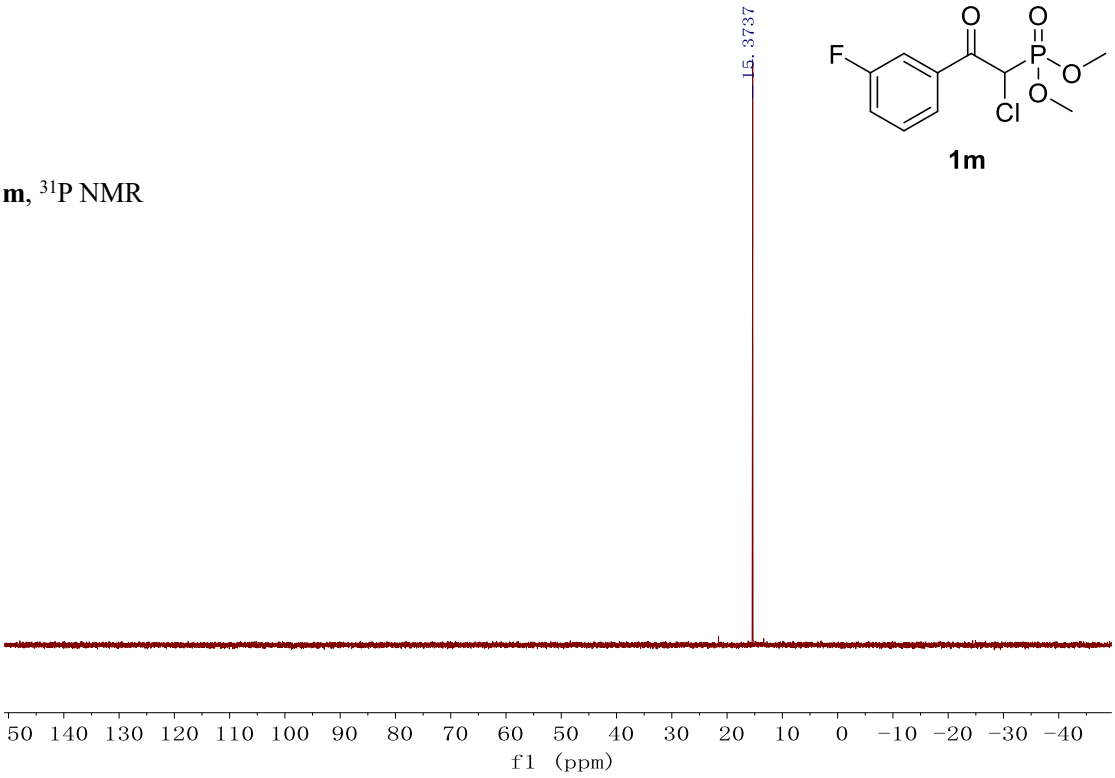
1m

Compound **1m**, ^{13}C NMR

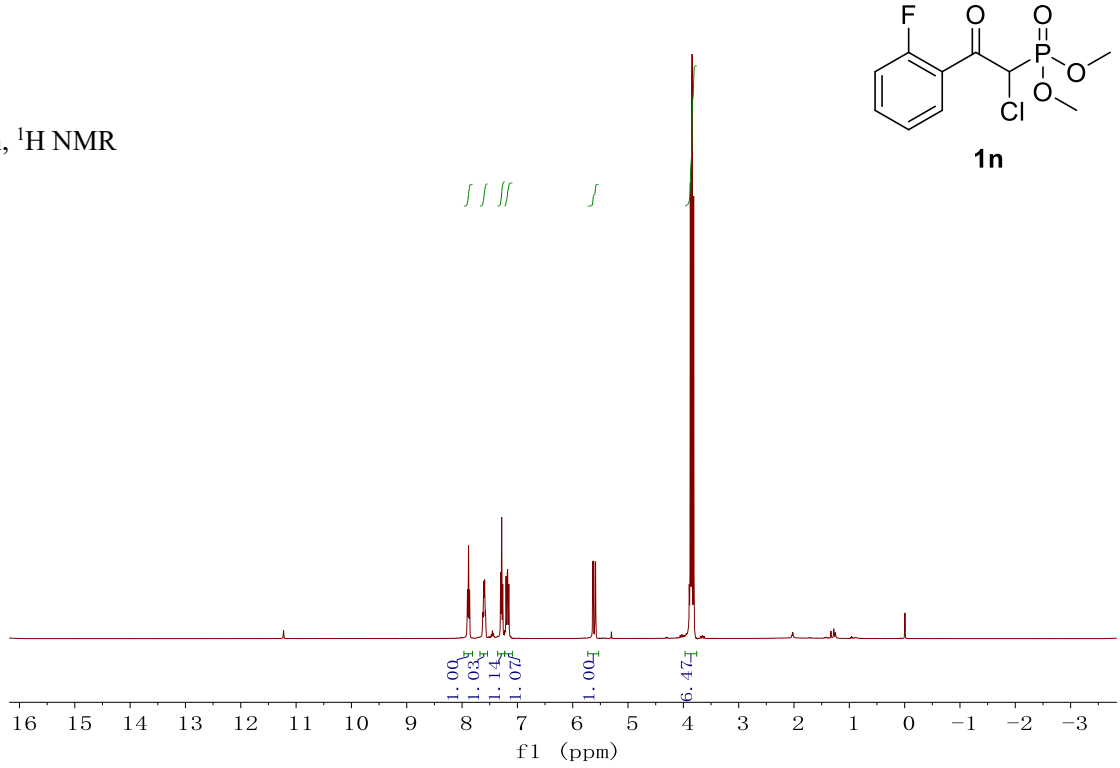


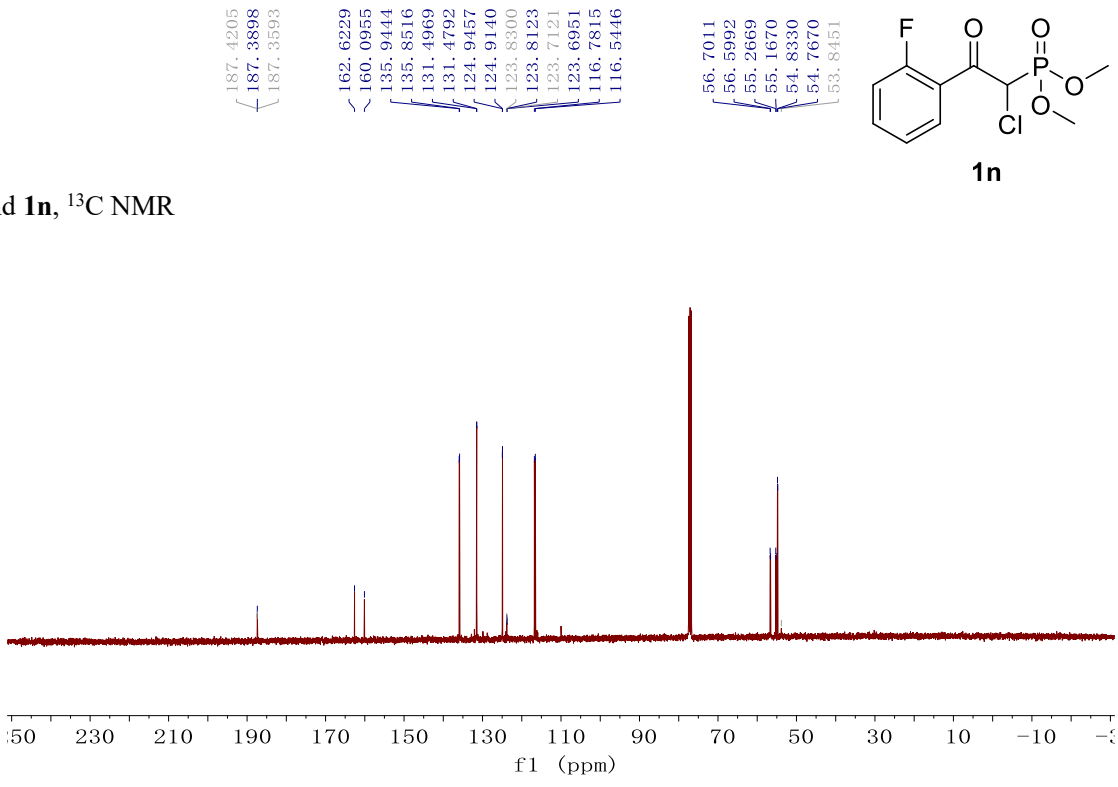
1m

Compound **1m**, ^{31}P NMR



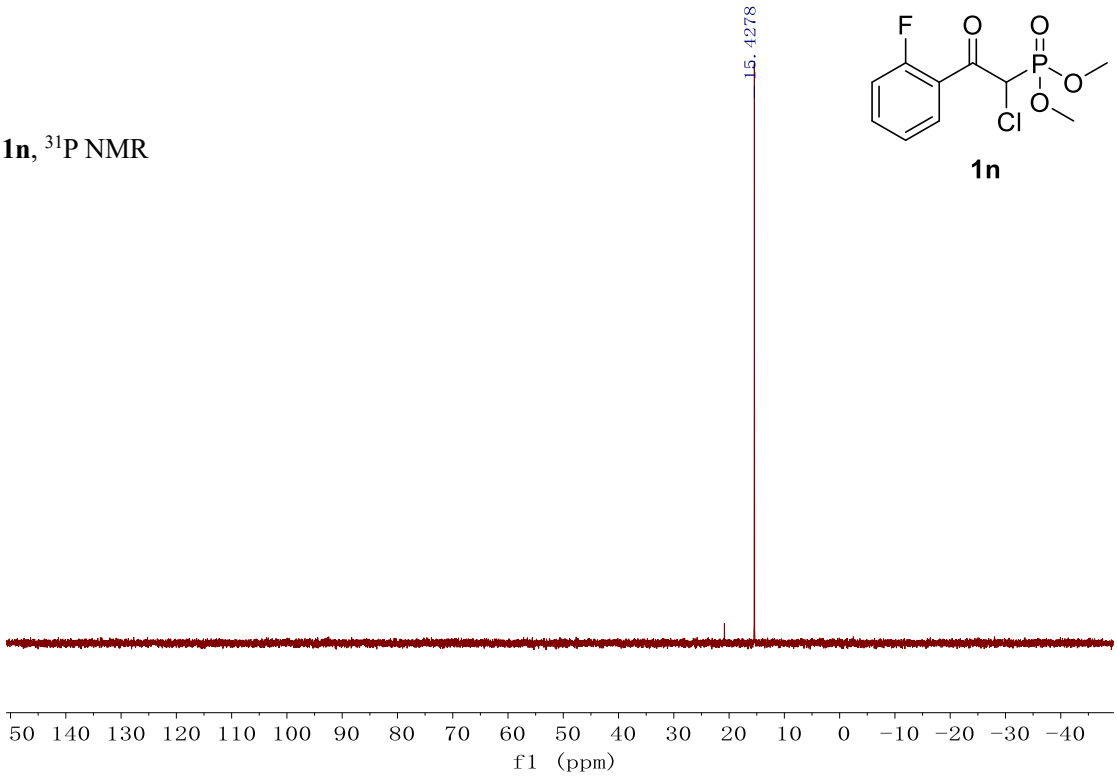
Compound **1n**, ^{1}H NMR





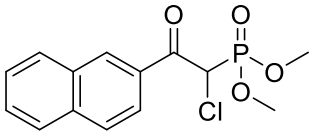
Compound **1n**, ^{13}C NMR

Compound **1n**, ^{31}P NMR



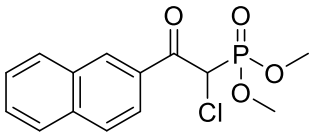
1n

Compound **1o**, ^{1}H NMR

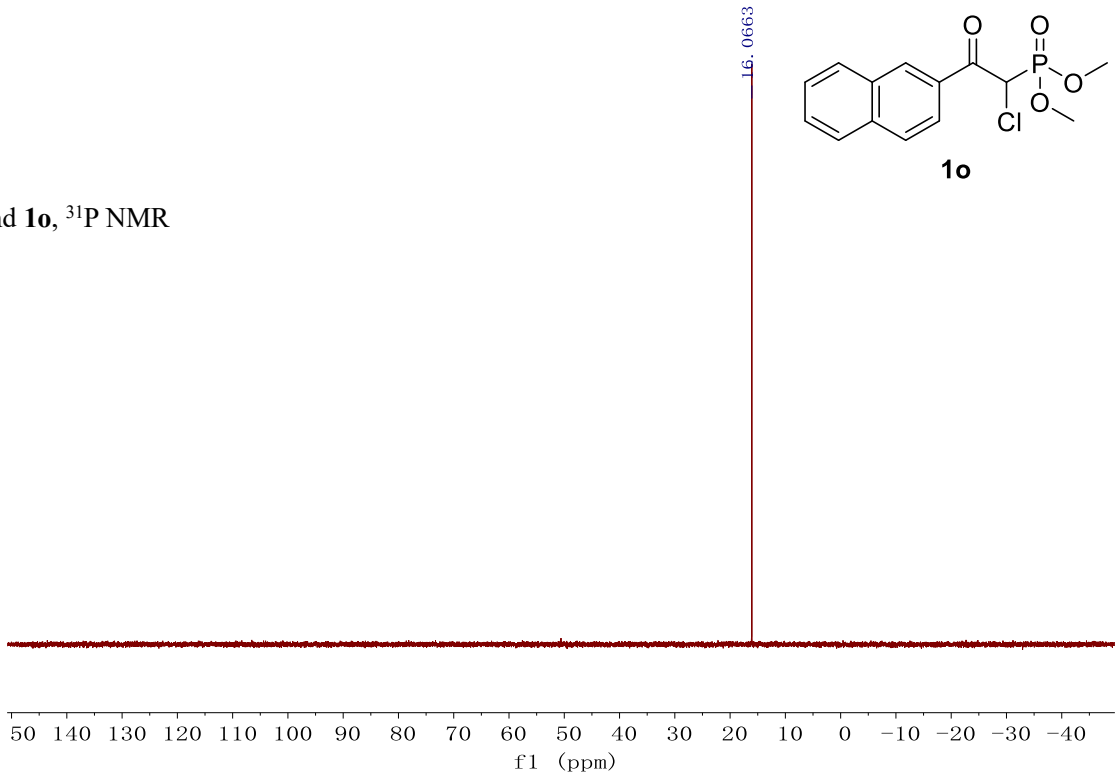


1o

Compound **1o**, ^{13}C NMR

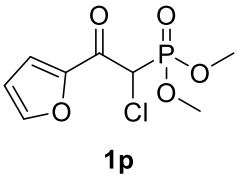


1o



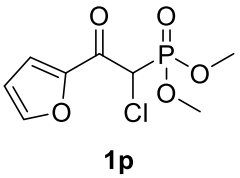
Compound **1o**, ^{31}P NMR

Compound **1p**, ^{1}H NMR



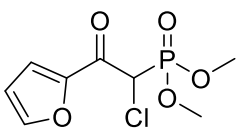
1p

Compound **1p**, ^{13}C NMR



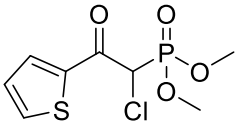
1p

Compound **1p**, ^{31}P NMR



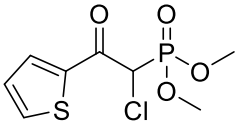
1p

Compound **1q**, ^{1}H NMR



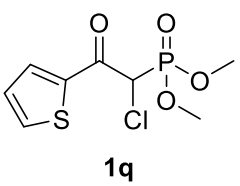
1q

Compound **1q**, ^{13}C NMR



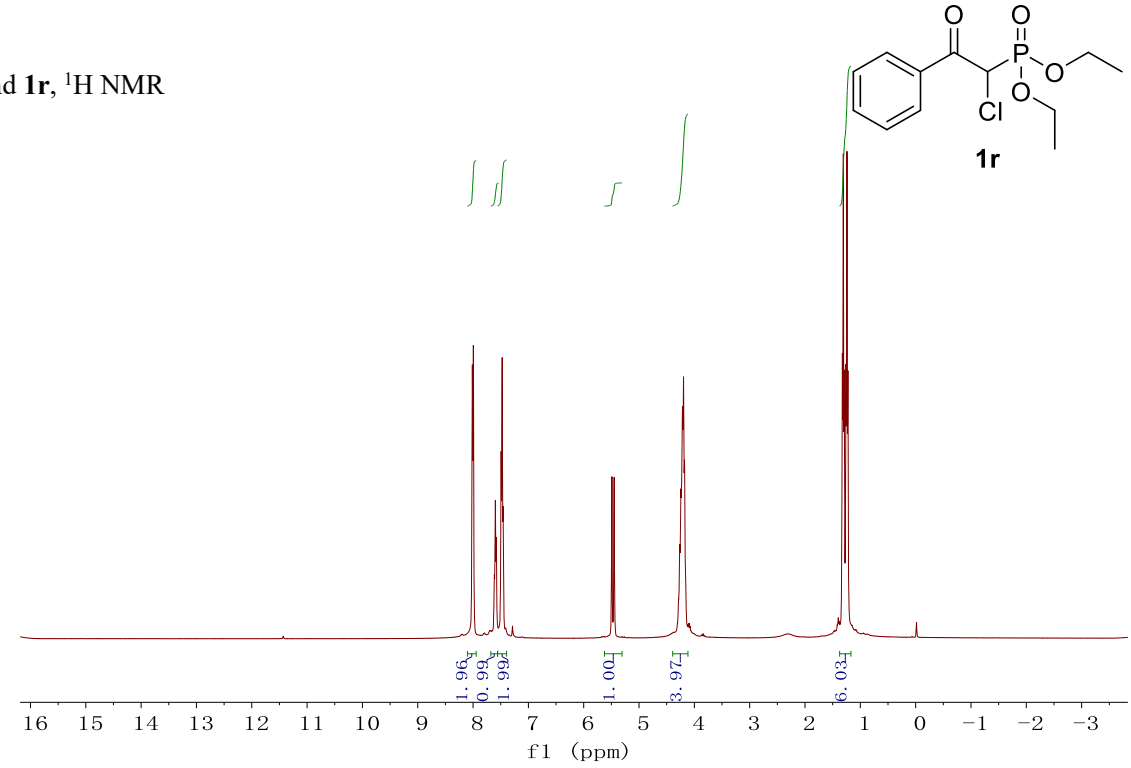
1q

Compound **1q**, ^{31}P NMR

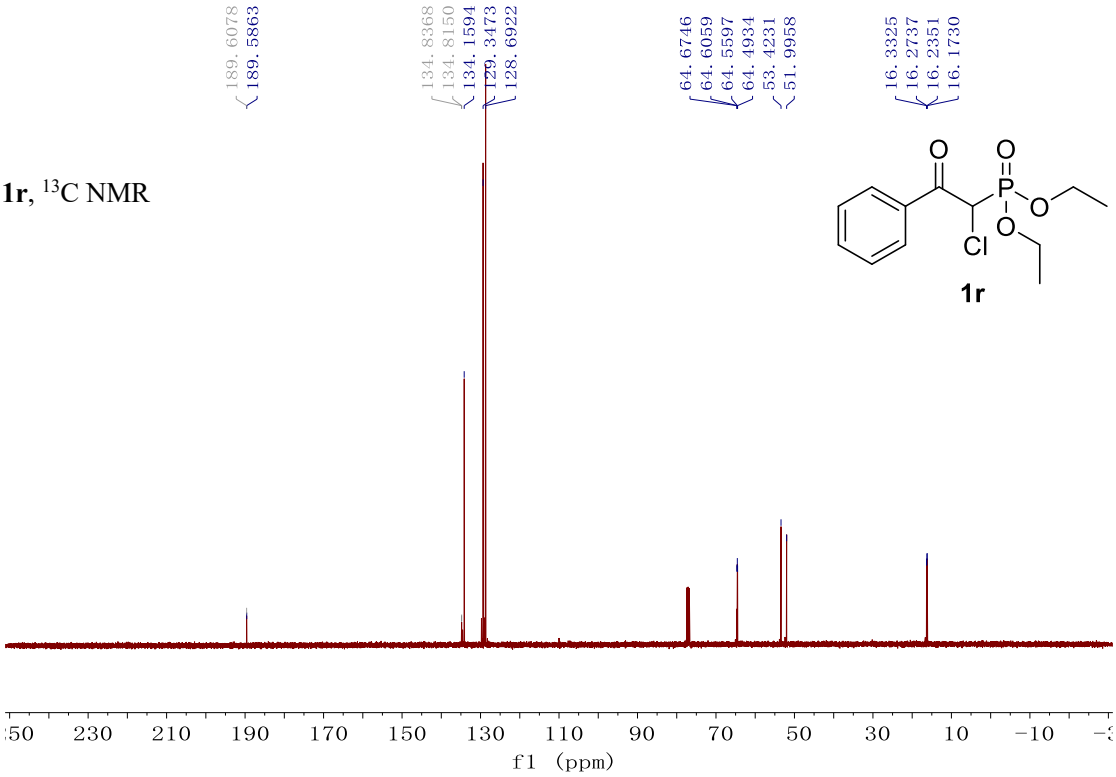


1q

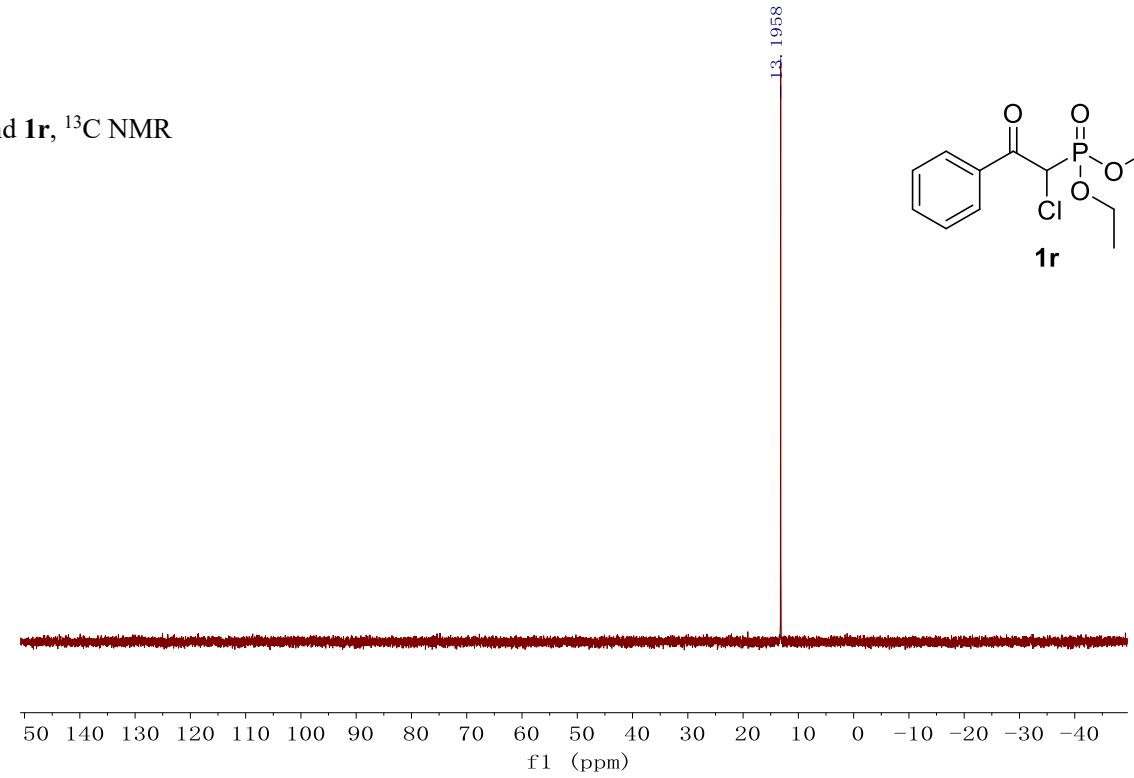
Compound **1r**, ^{1}H NMR



Compound **1r**, ^{13}C NMR

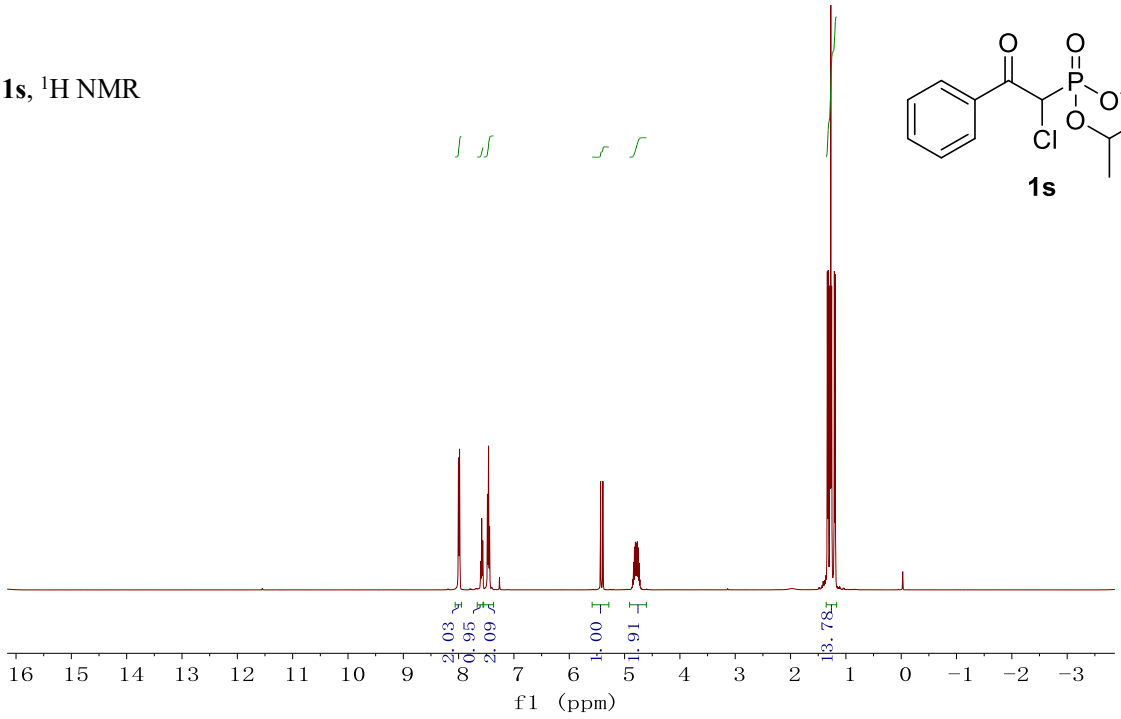


Compound **1r**, ^{13}C NMR



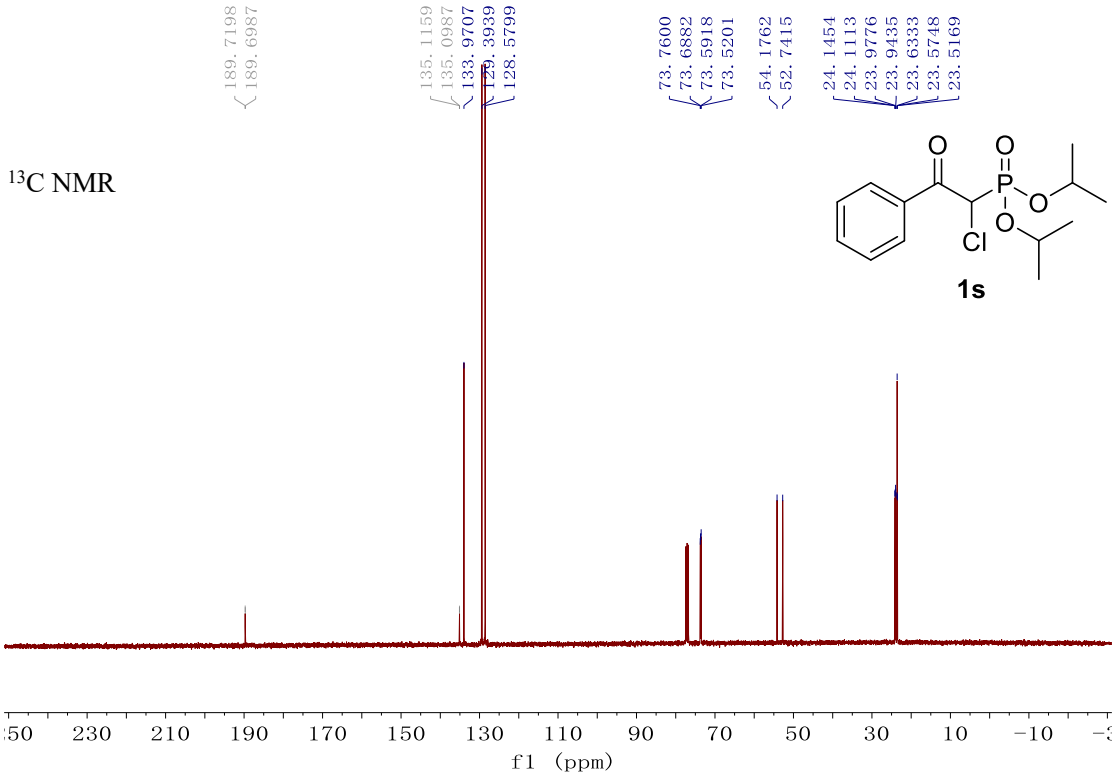
1r

Compound **1s**, ^{1}H NMR



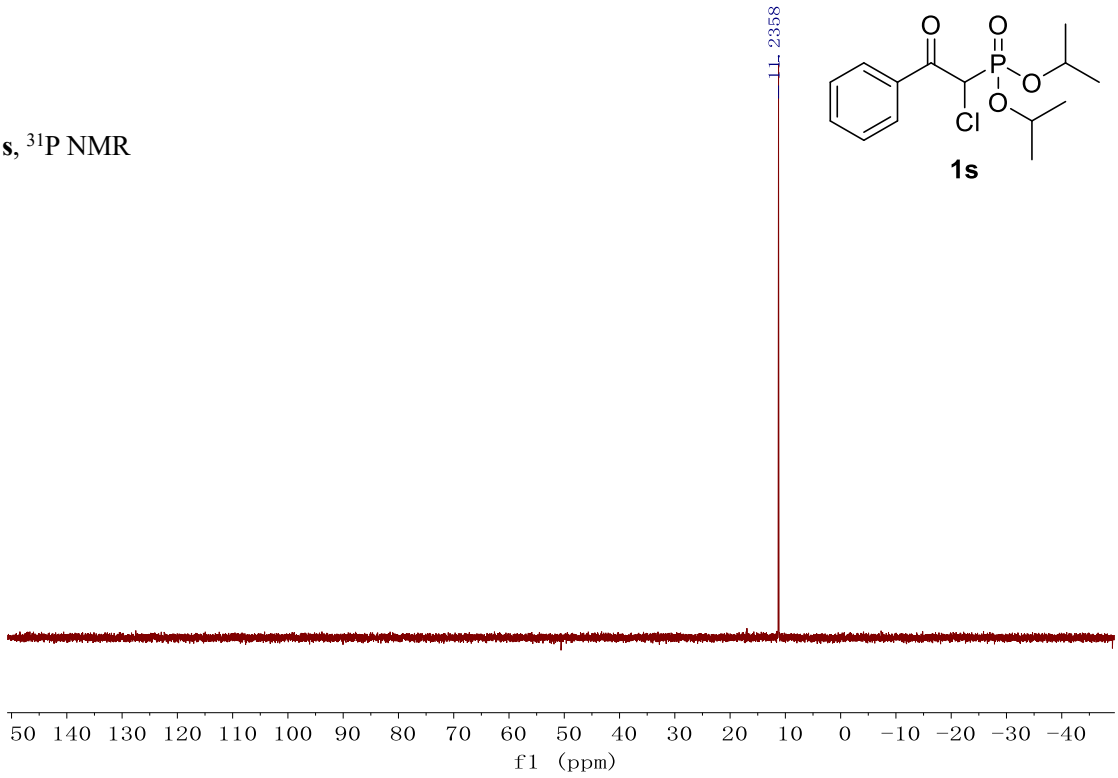
1s

Compound **1s**, ^{13}C NMR

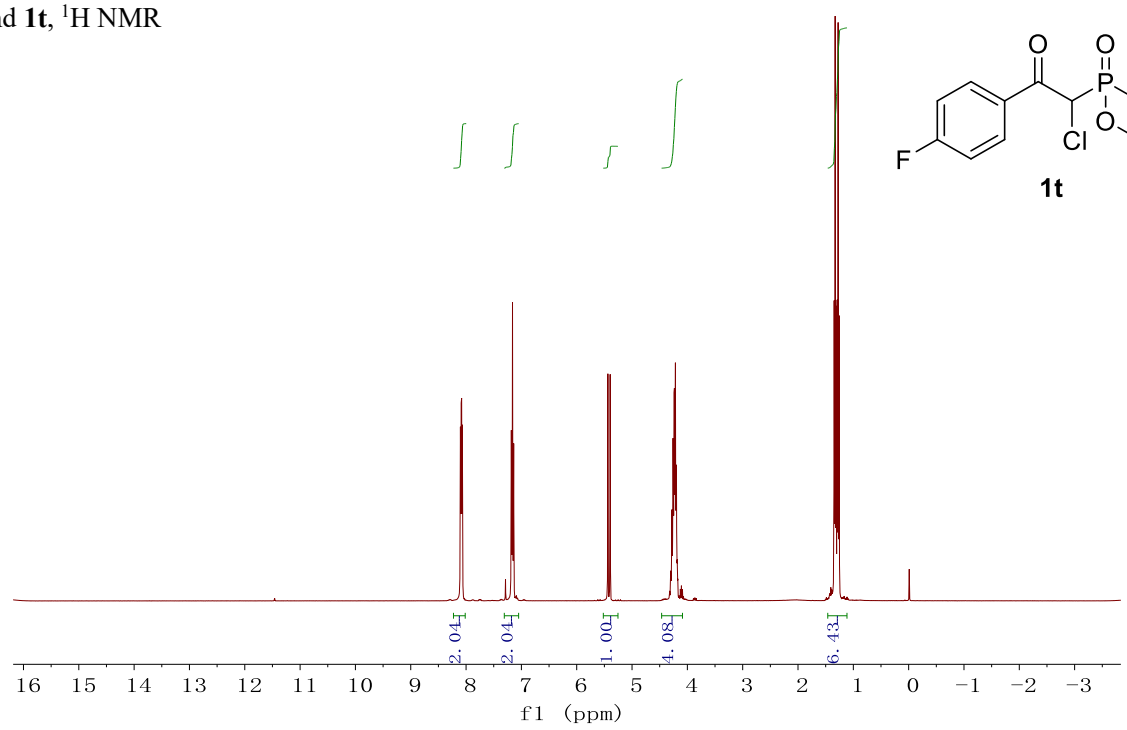


1s

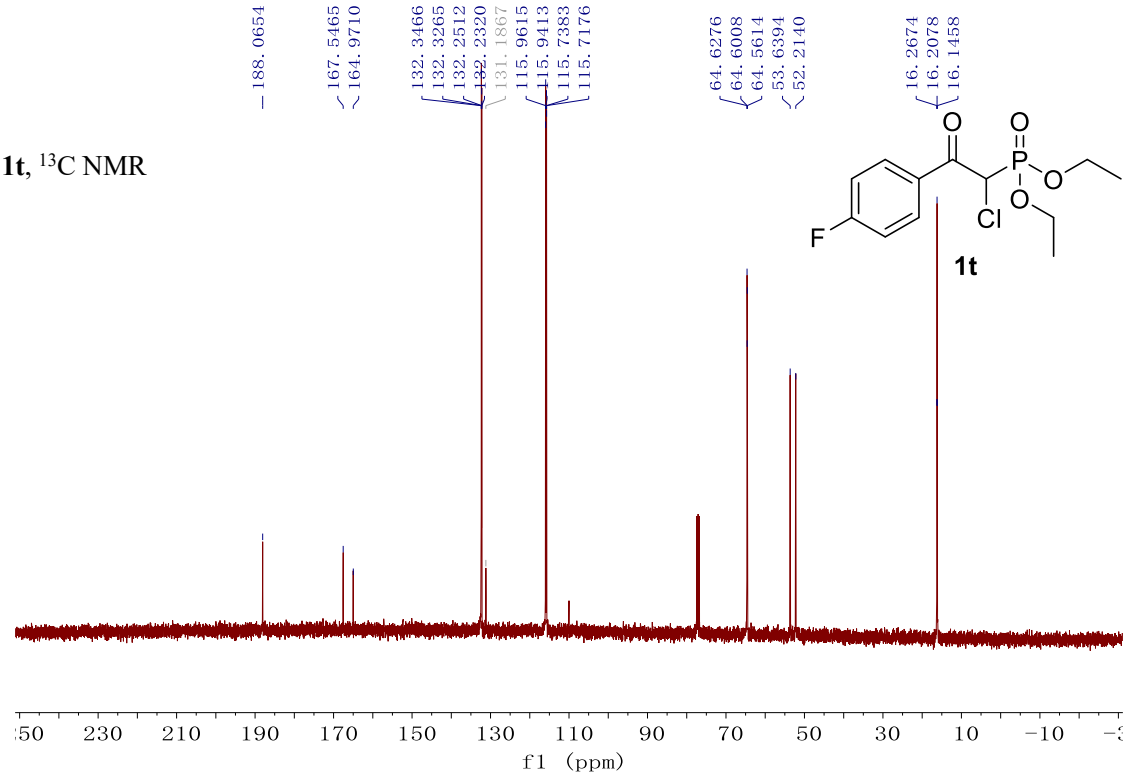
Compound **1s**, ^{31}P NMR



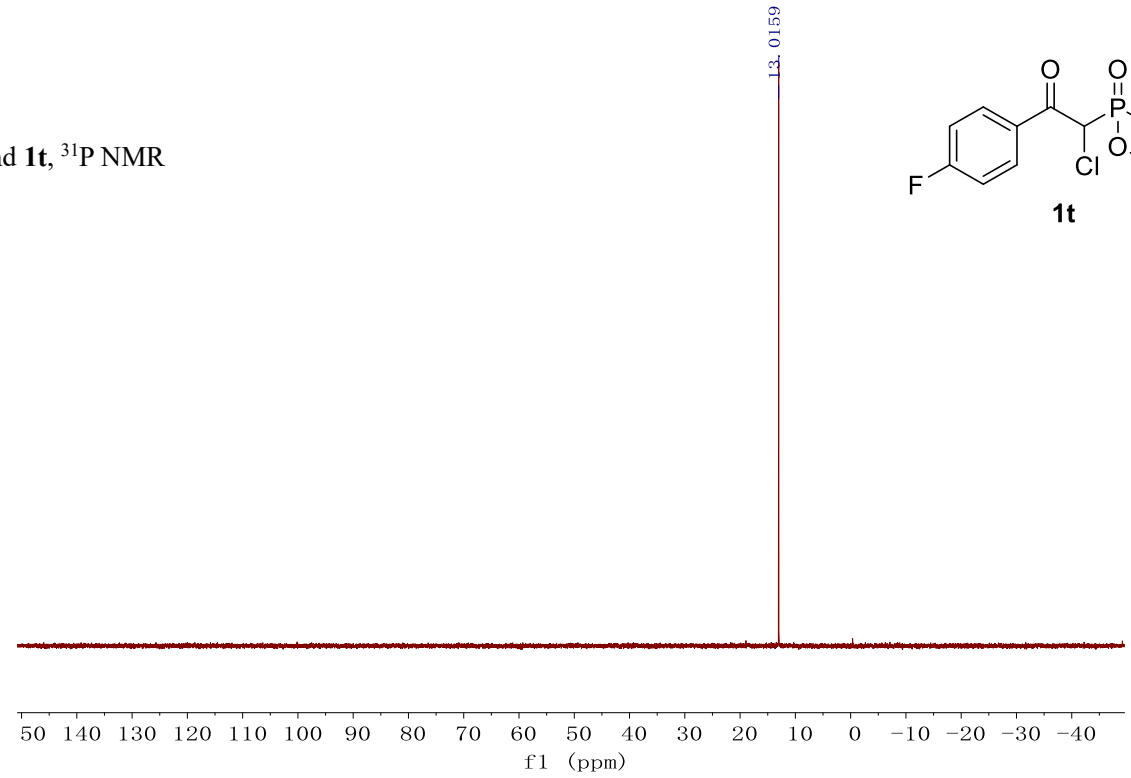
Compound **1t**, ^{1}H NMR



Compound **1t**, ^{13}C NMR

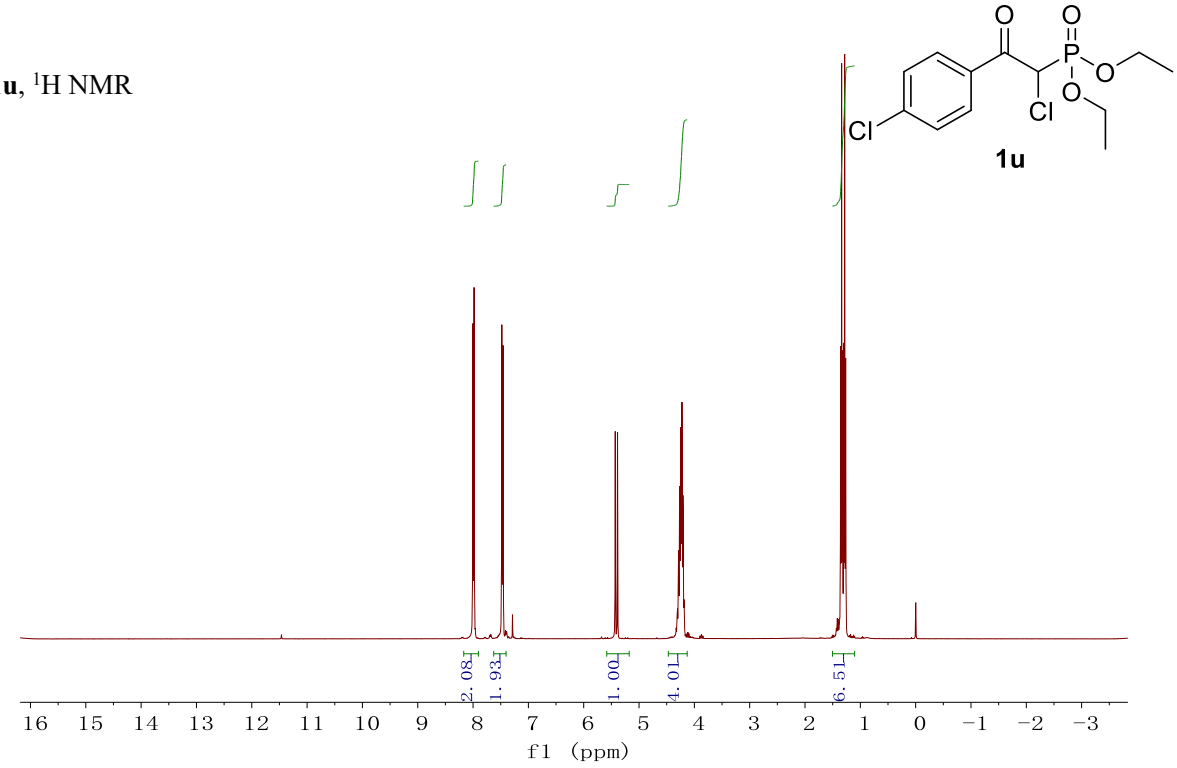


Compound **1t**, ^{31}P NMR

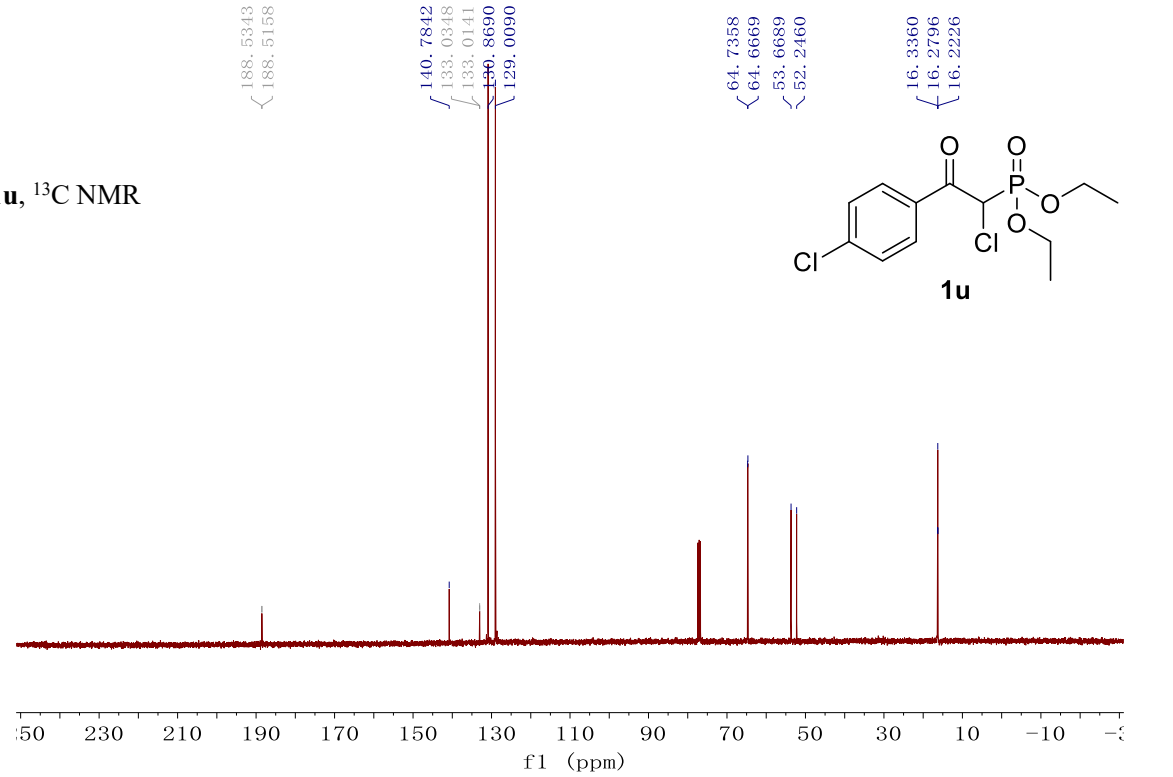


1t

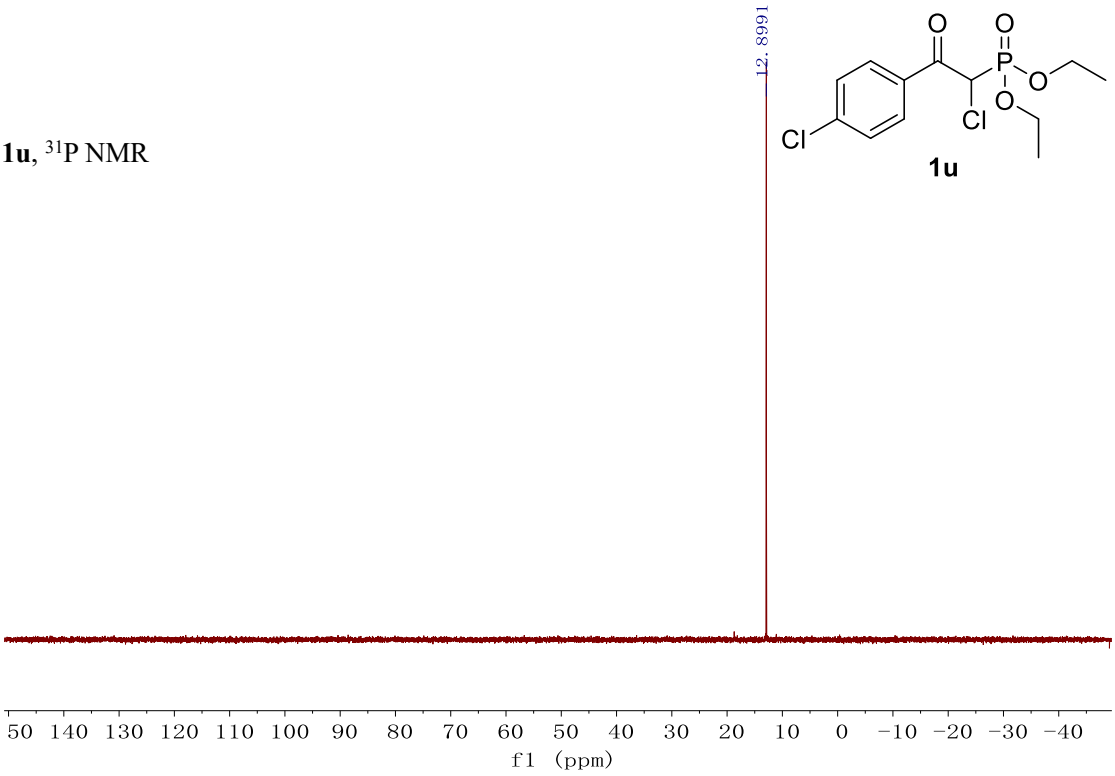
Compound **1u**, ^{1}H NMR



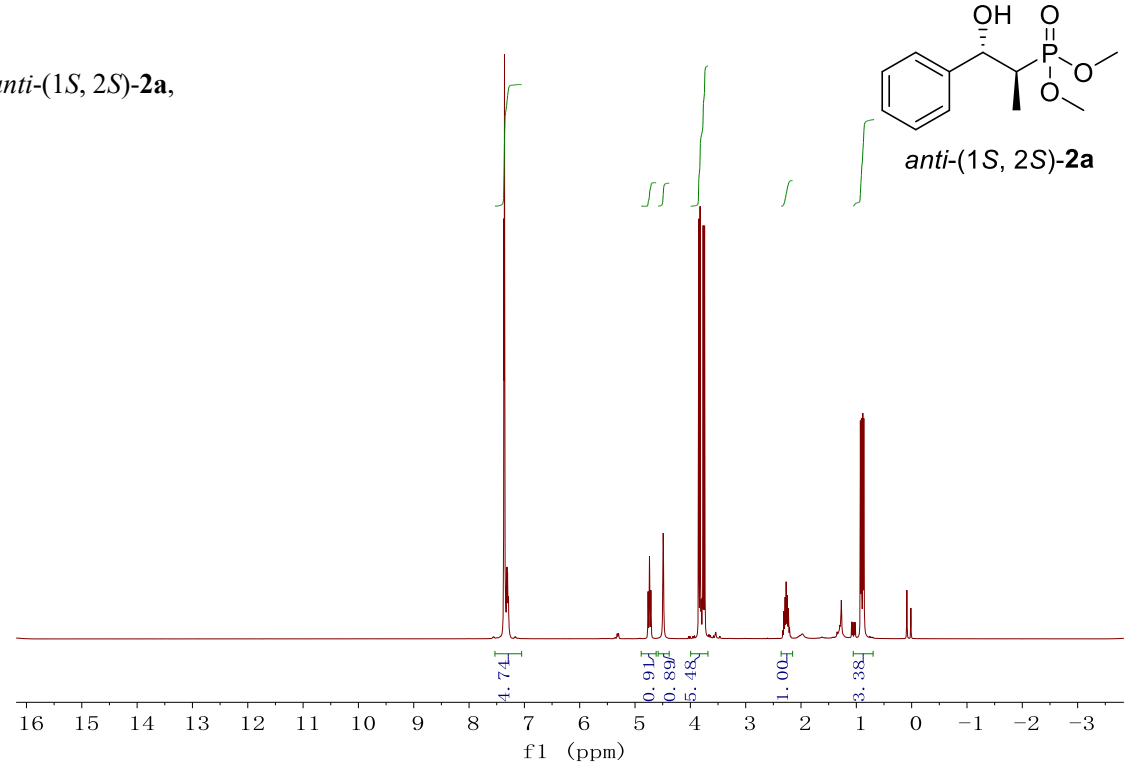
Compound **1u**, ^{13}C NMR



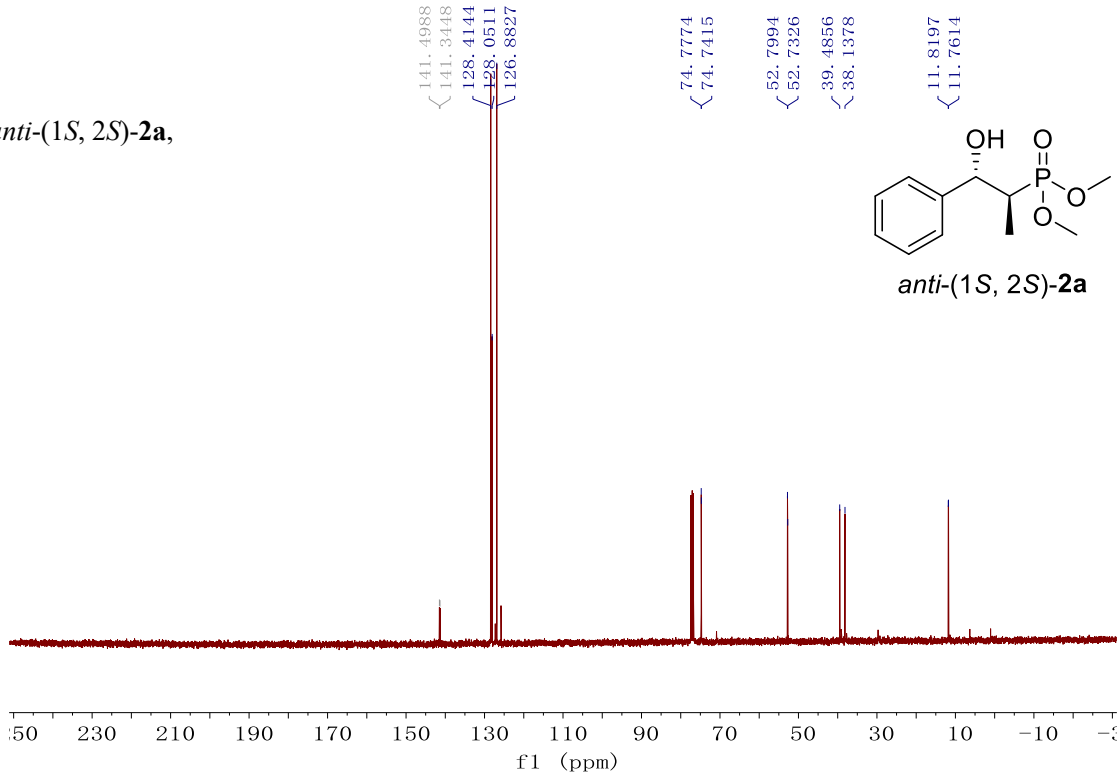
Compound **1u**, ^{31}P NMR



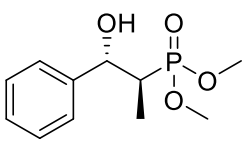
Compound *anti*-(1*S*, 2*S*)-**2a**,
^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2a**,
^{13}C NMR

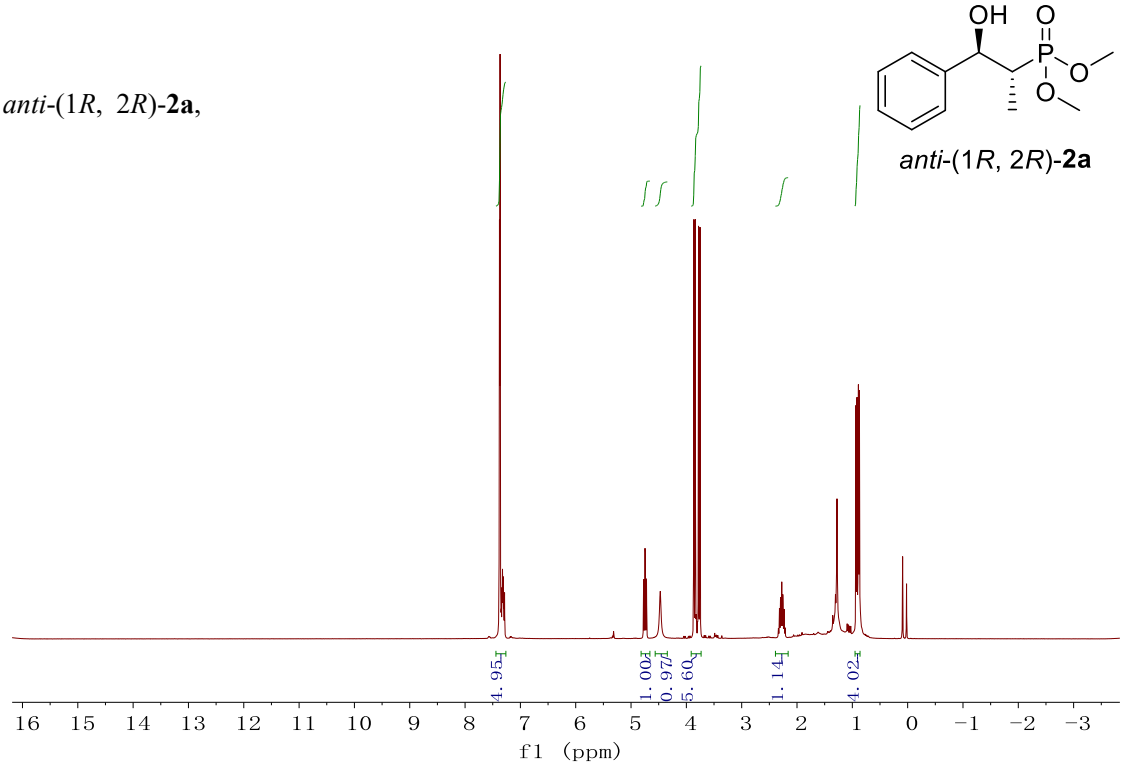


Compound *anti*-(1*S*, 2*S*)-**2a**,
^{31}P NMR

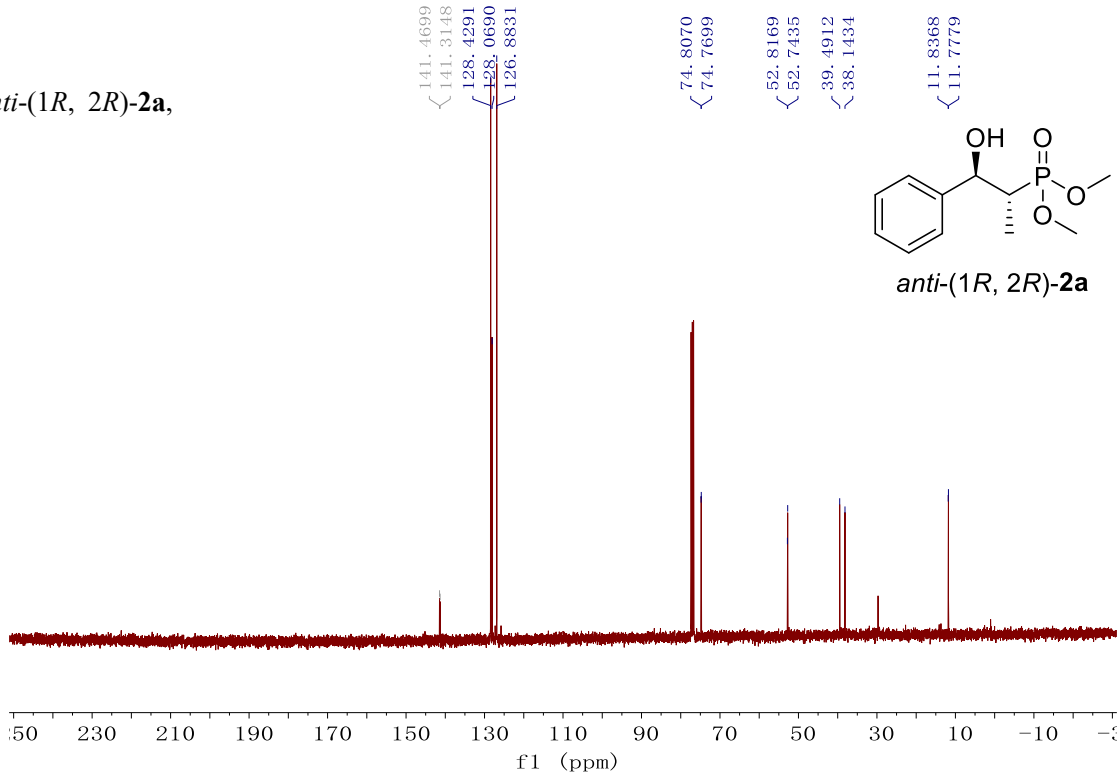


anti-(1*S*, 2*S*)-**2a**

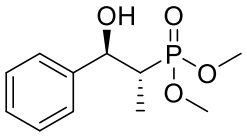
Compound *anti*-(1*R*, 2*R*)-**2a**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2a**,
^{13}C NMR

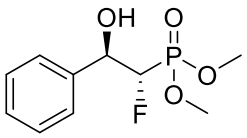


Compound *anti*-(1*R*, 2*R*)-**2a**,
^{31}P NMR

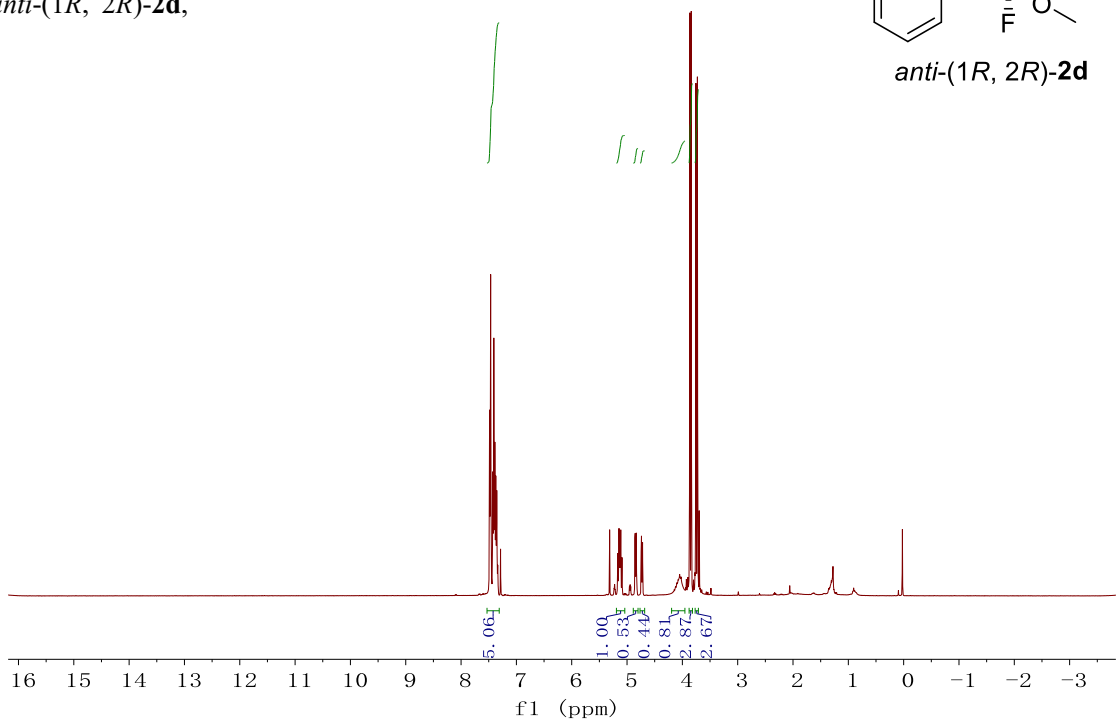


anti-(1*R*, 2*R*)-**2a**

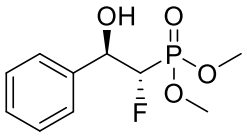
Compound *anti*-(1*R*, 2*R*)-**2d**,
^{1}H NMR



anti-(1*R*, 2*R*)-**2d**

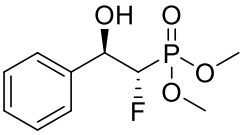


Compound *anti*-(1*R*, 2*R*)-**2d**,
^{13}C NMR



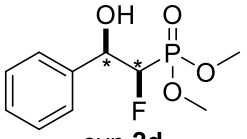
anti-(1*R*, 2*R*)-**2d**

Compound *anti*-(1*R*, 2*R*)-**2d**,
^{31}P NMR



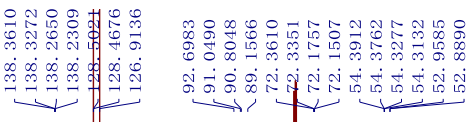
anti-(1*R*, 2*R*)-**2d**

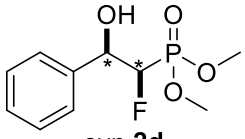
Compound *syn*-**2d** catalyzed by YDR368w, ^{1}H NMR



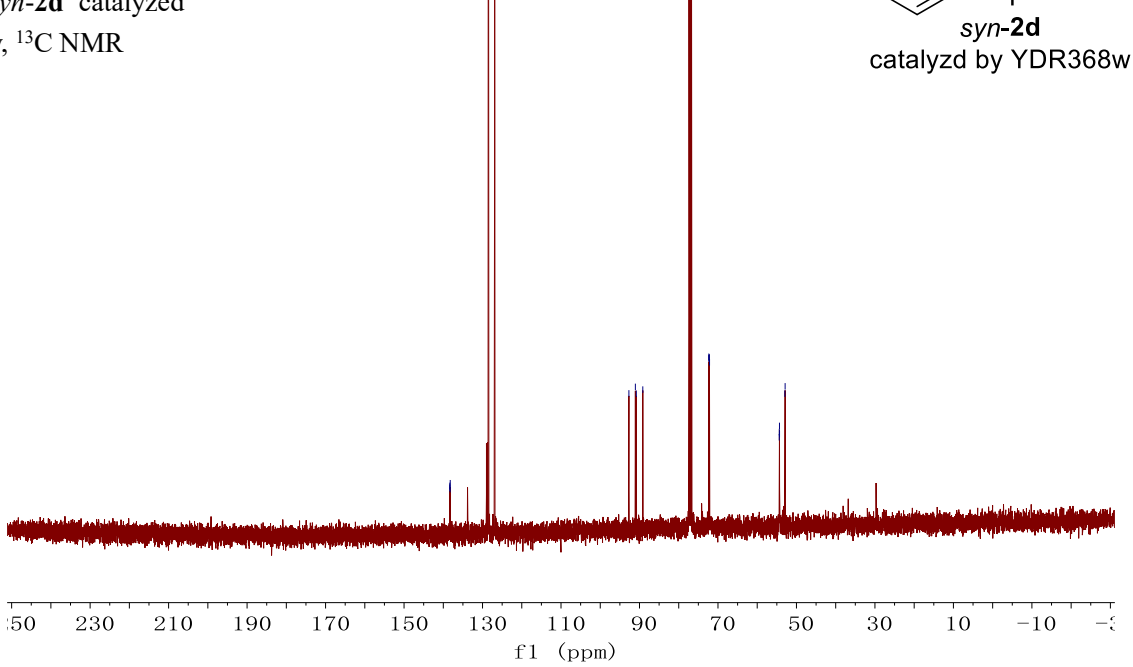
syn-**2d** catalyzd by YDR368w

Compound *syn*-**2d** catalyzed by YDR368w, ^{13}C NMR

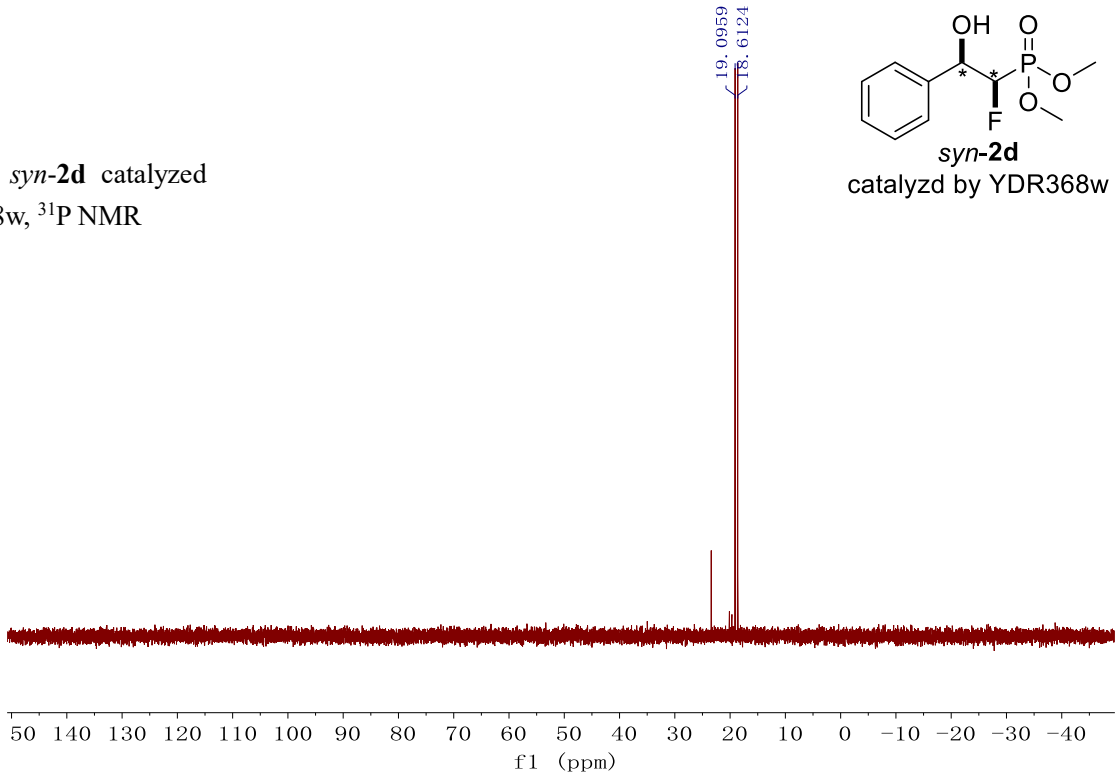




syn-**2d** catalyzd by YDR368w

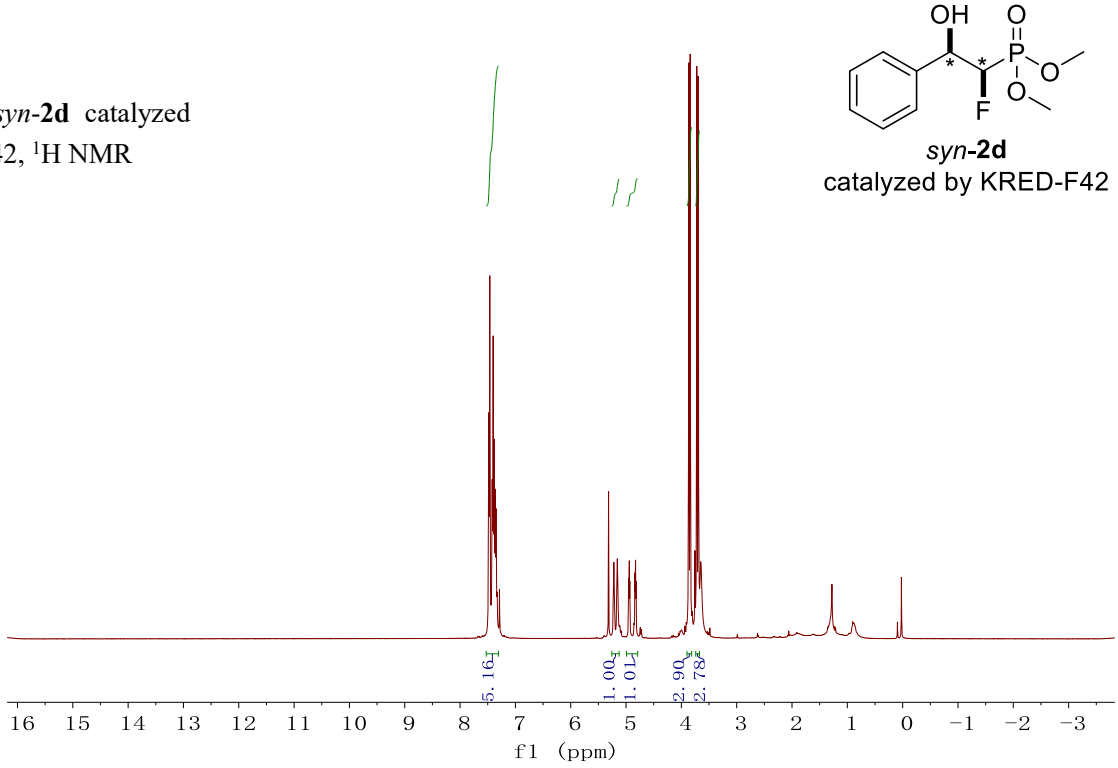


Compound *syn*-**2d** catalyzed by YDR368w, ^{31}P NMR

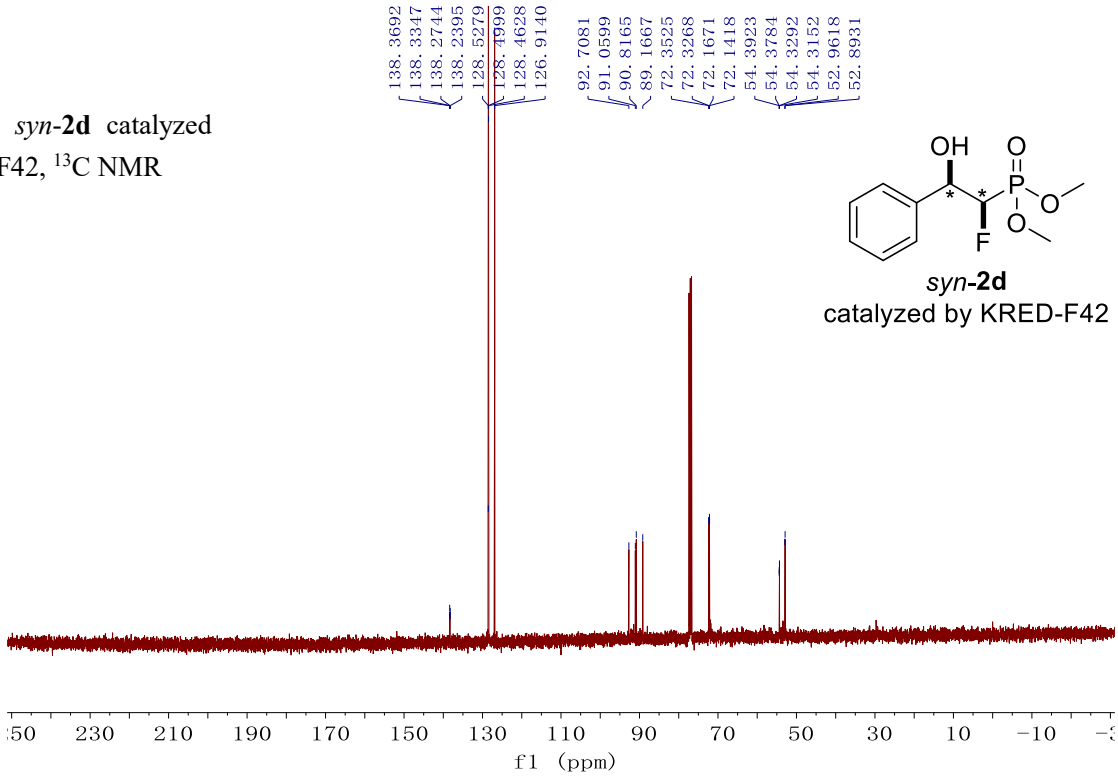


syn-**2d**
catalyzd by YDR368w

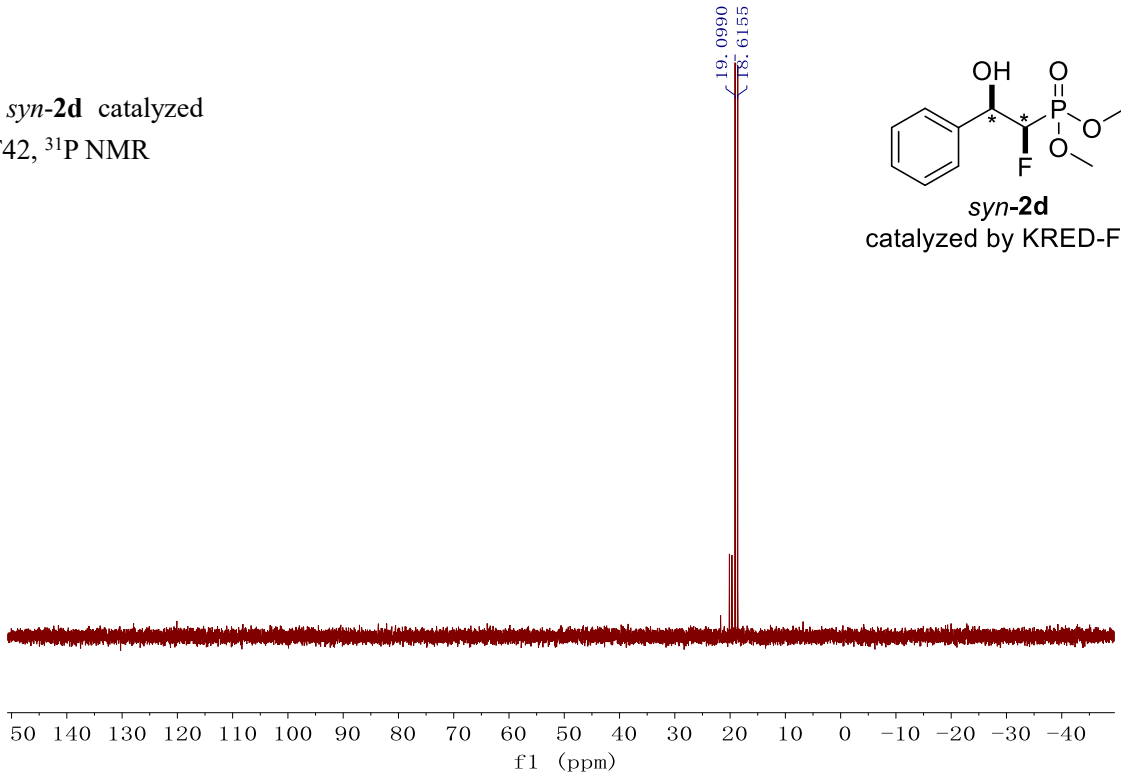
Compound *syn*-**2d** catalyzed by KRED-F42, ^{1}H NMR



Compound *syn*-**2d** catalyzed by KRED-F42, ^{13}C NMR

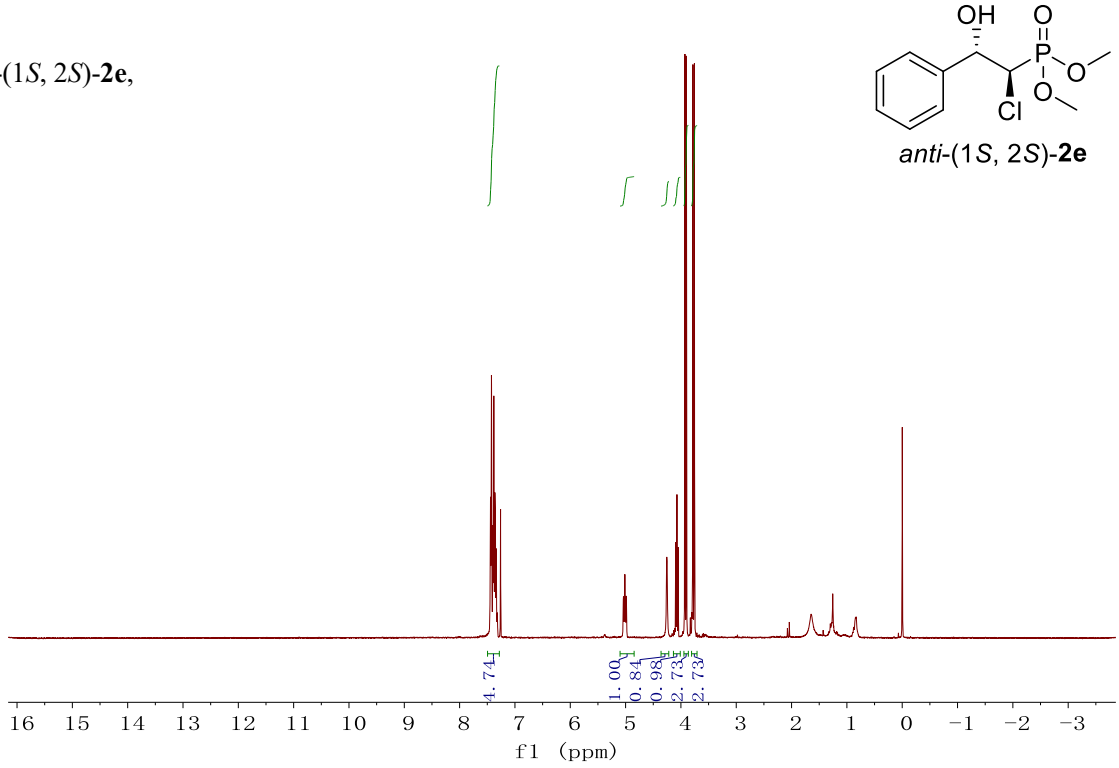


Compound *syn*-**2d** catalyzed by KRED-F42, ^{31}P NMR

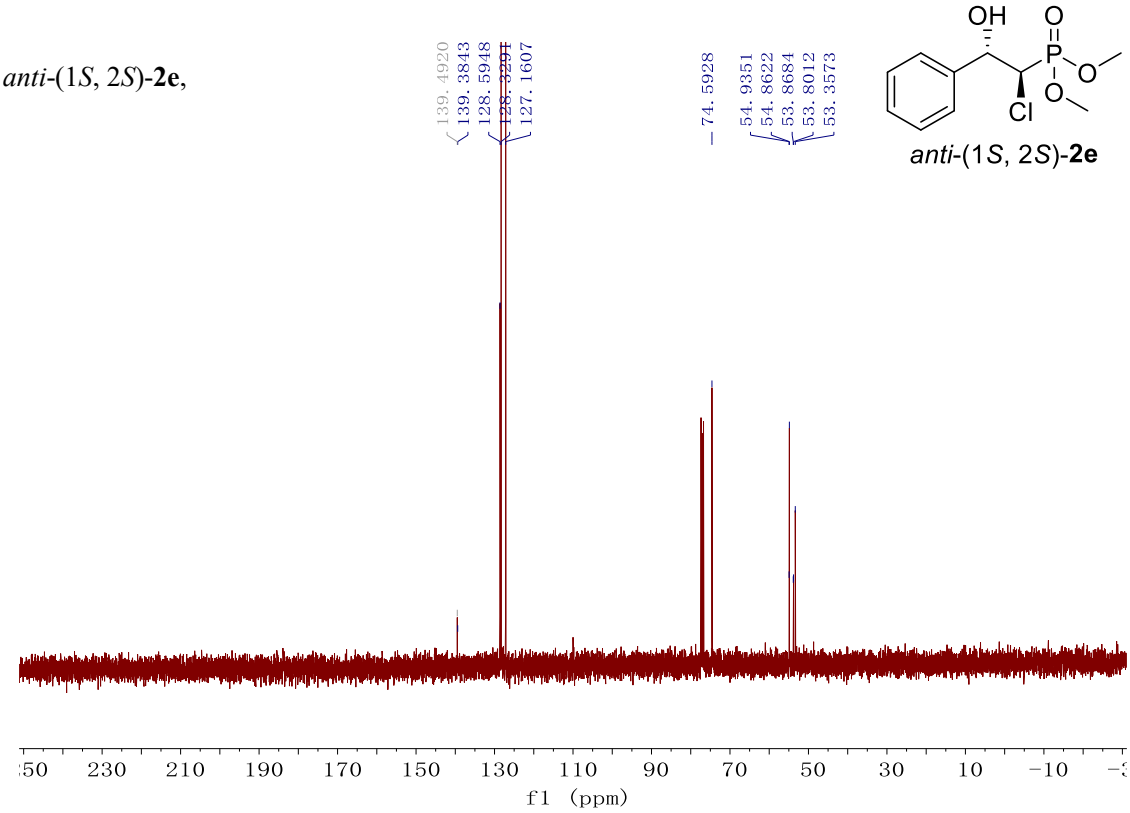


syn-**2d**
catalyzed by KRED-F42

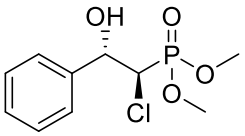
Compound *anti*-(1*S*, 2*S*)-**2e**,
^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2e**,
^{13}C NMR

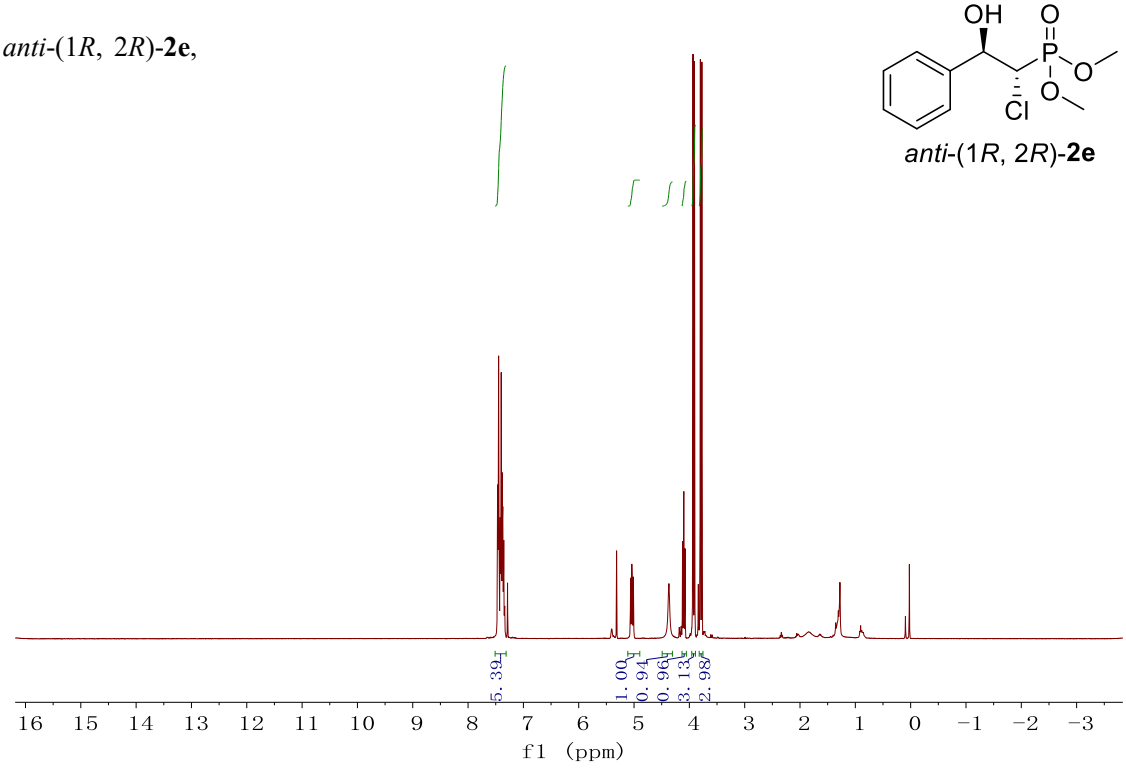


Compound *anti*-(1*S*, 2*S*)-**2e**,
^{31}P NMR

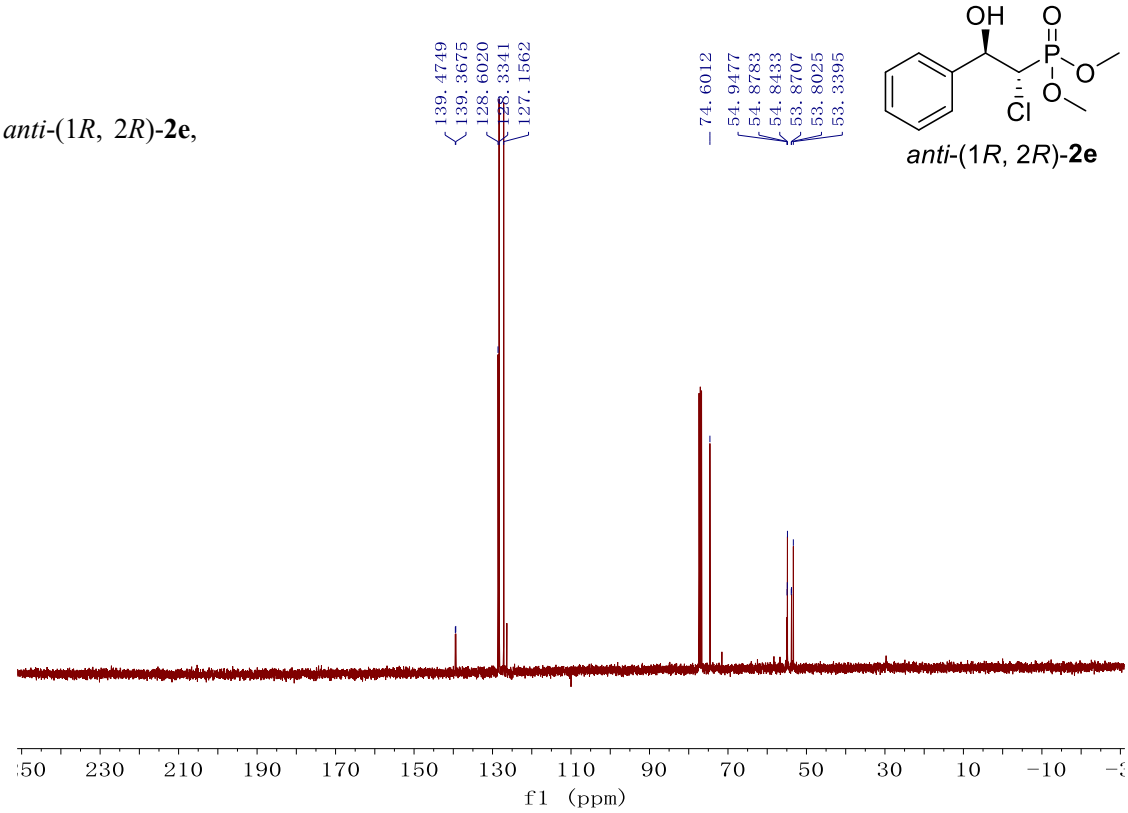


anti-(1*S*, 2*S*)-**2e**

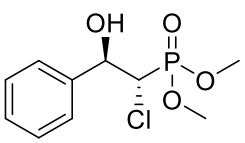
Compound *anti*-(1*R*, 2*R*)-**2e**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2e**,
^{13}C NMR

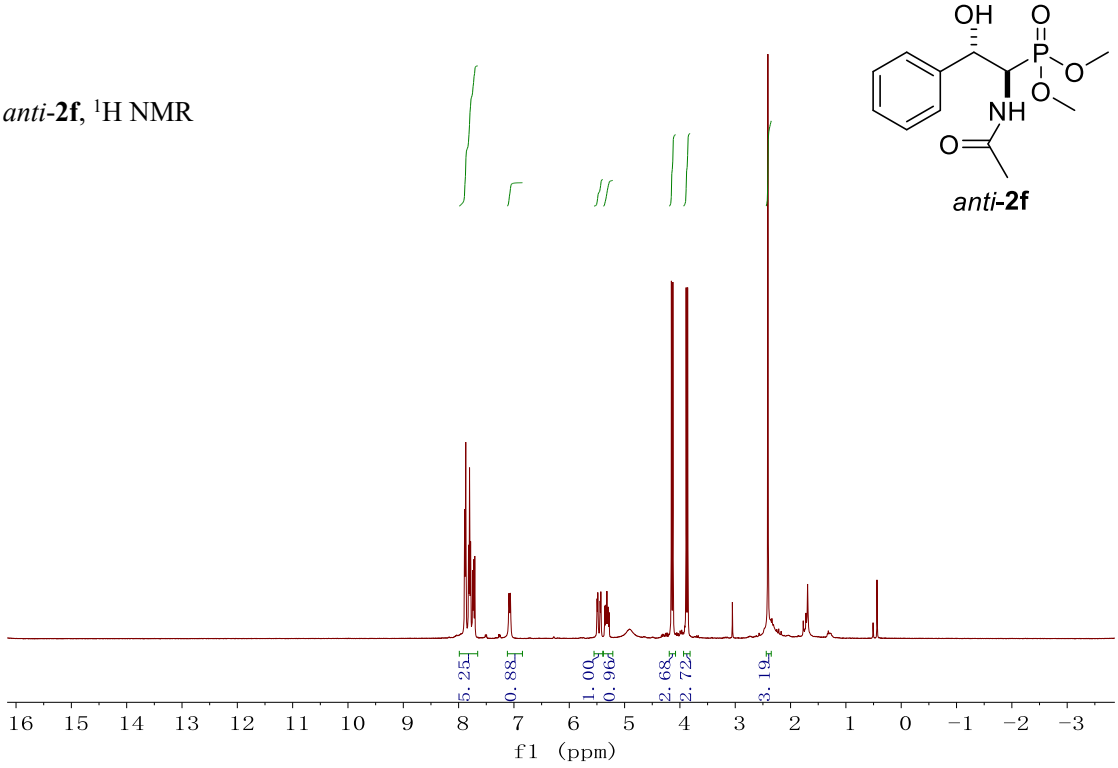


Compound *anti*-(1*R*, 2*R*)-**2e**,
^{31}P NMR

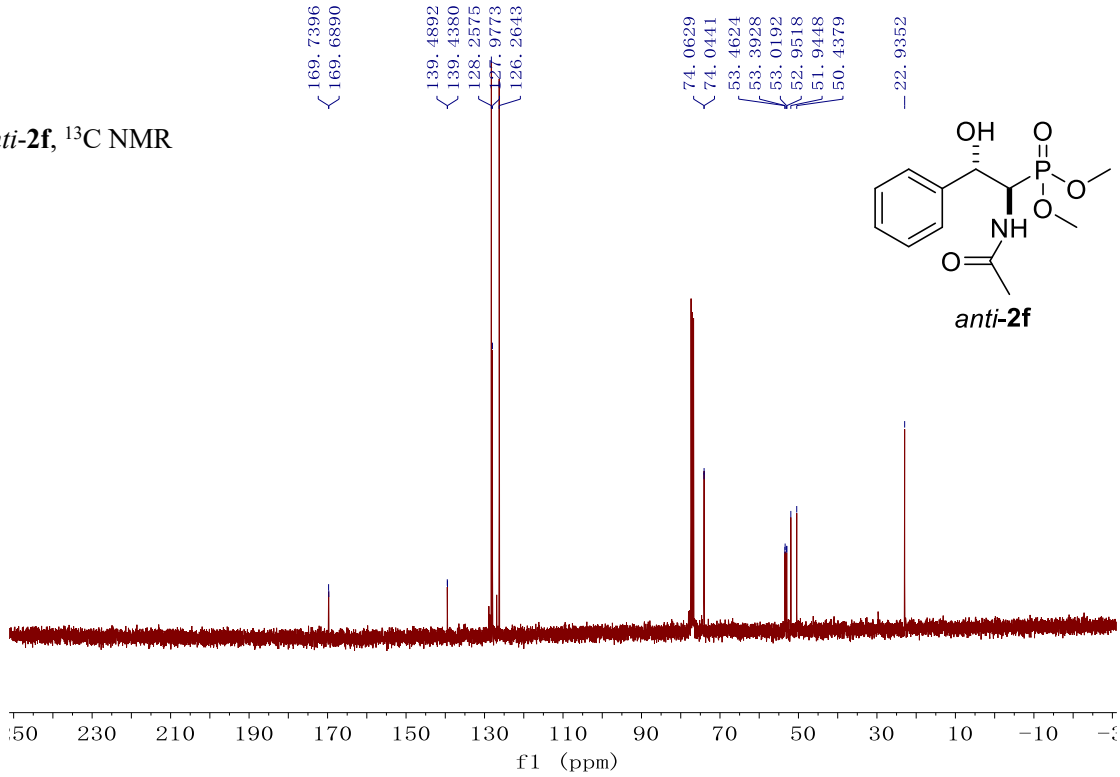


anti-(1*R*, 2*R*)-**2e**

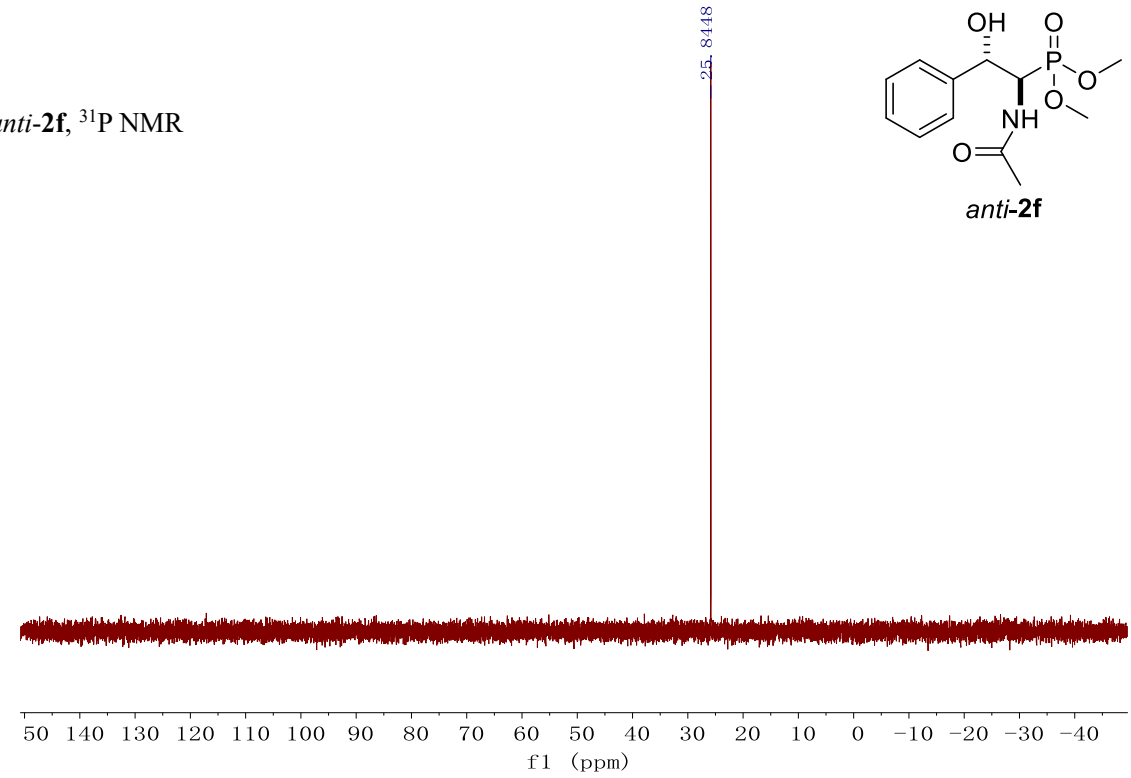
Compound *anti*-**2f**, ^{1}H NMR



Compound *anti*-**2f**, ^{13}C NMR

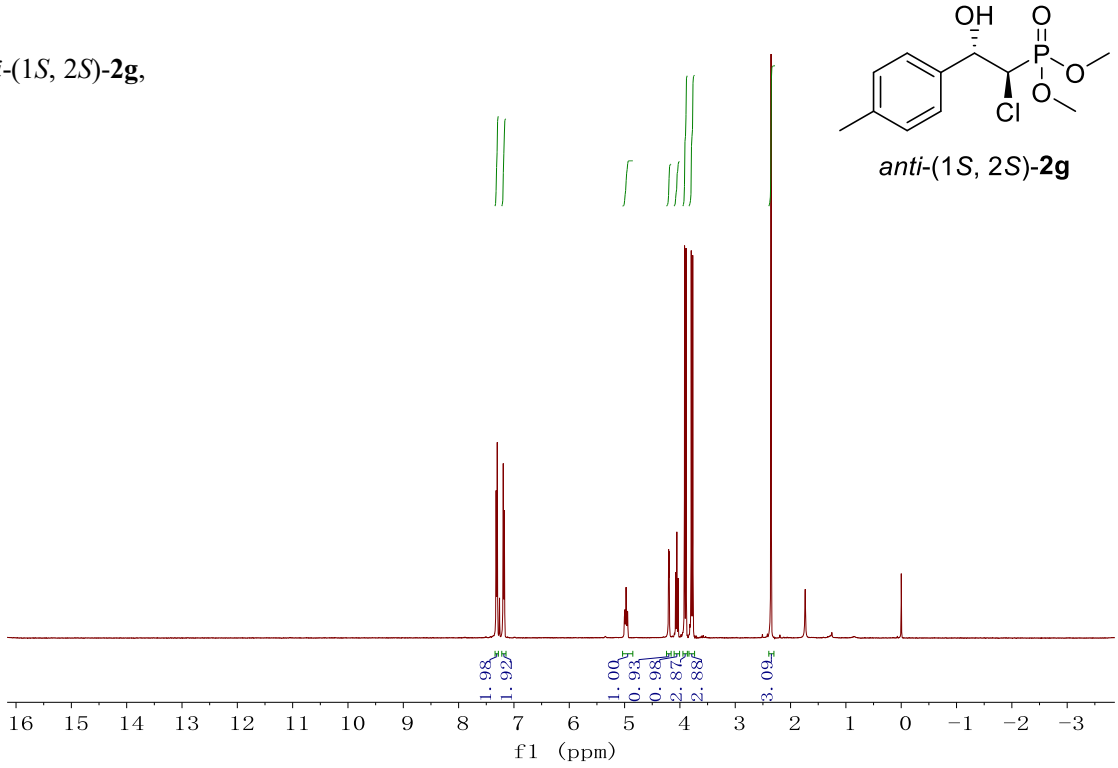


Compound *anti*-**2f**, ^{31}P NMR

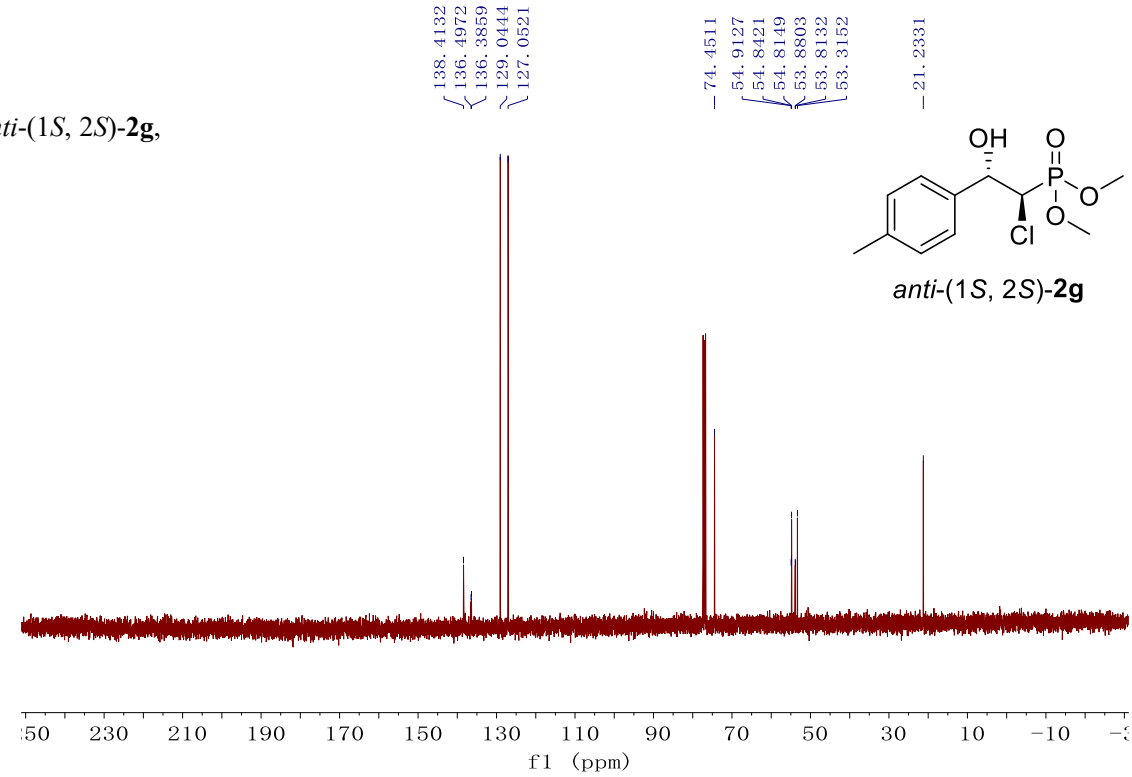


anti-**2f**

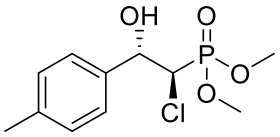
Compound *anti*-(1*S*, 2*S*)-**2g**,
^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2g**,
^{13}C NMR

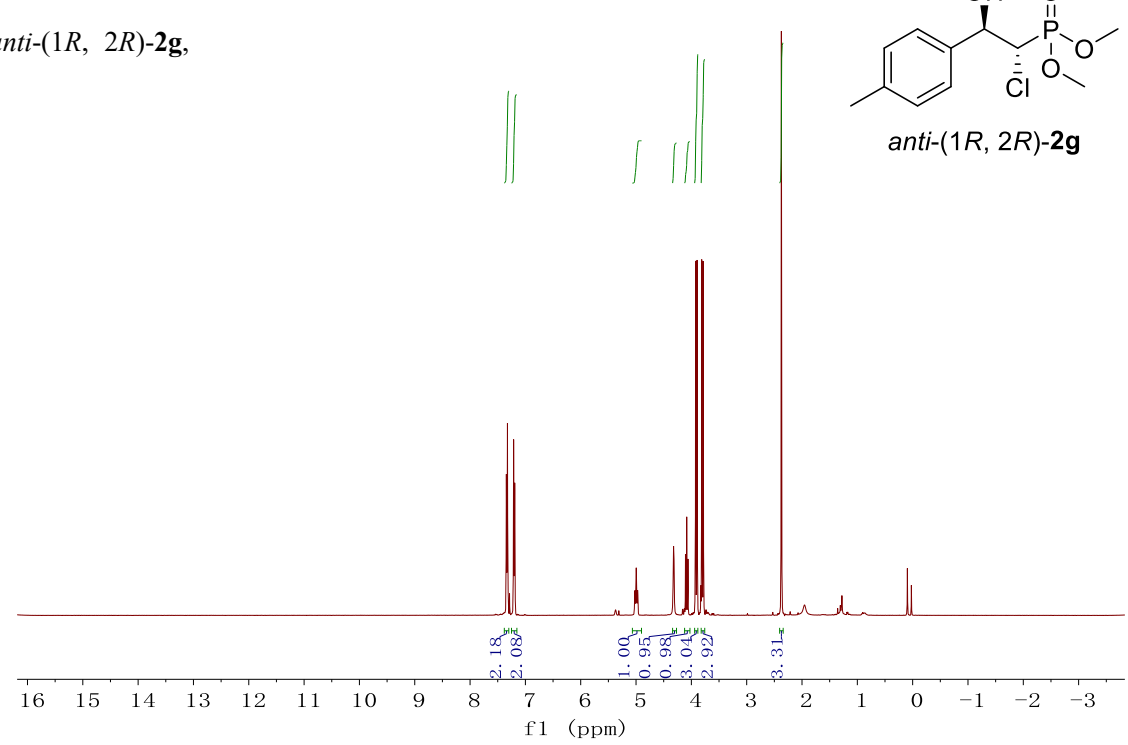


Compound *anti*-(1*S*, 2*S*)-**2g**,
^{31}P NMR

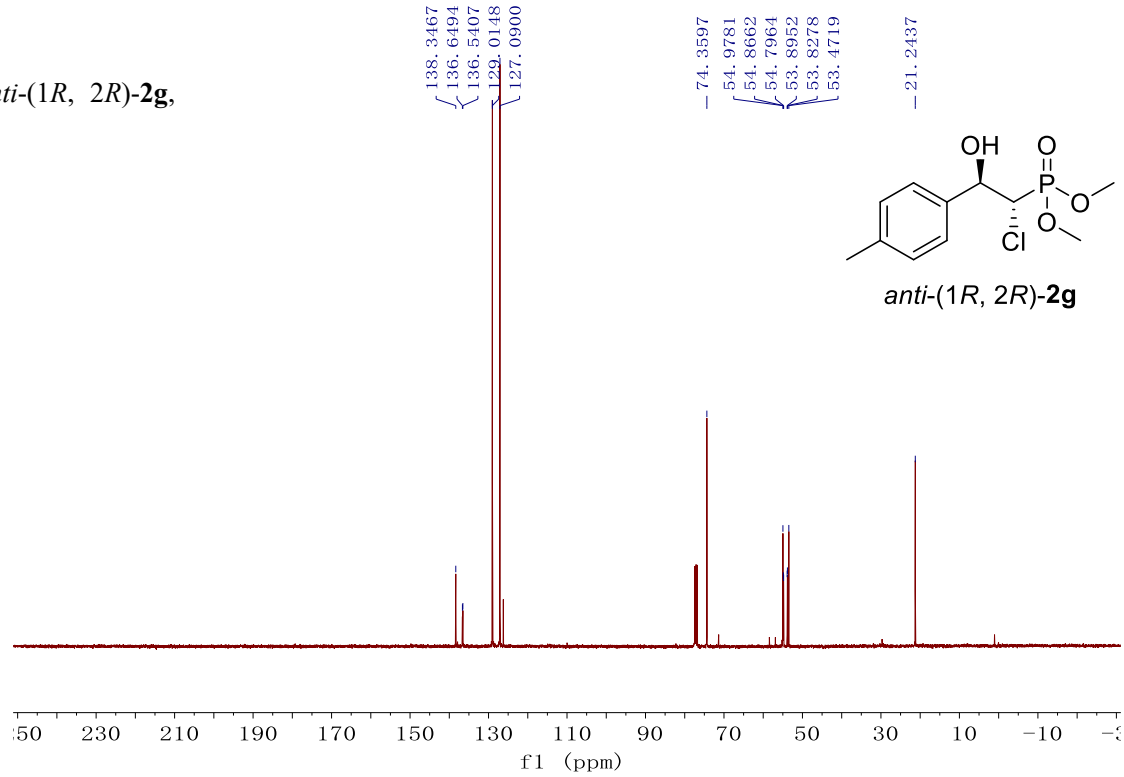


anti-(1*S*, 2*S*)-**2g**

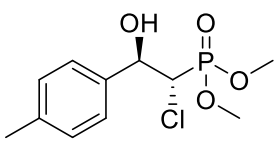
Compound *anti*-(1*R*, 2*R*)-**2g**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2g**,
^{13}C NMR

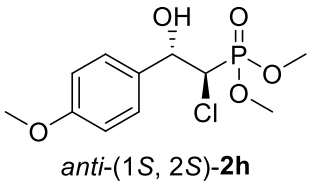


Compound *anti*-(1*R*, 2*R*)-**2g**,
^{31}P NMR



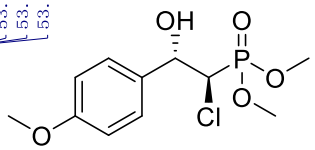
anti-(1*R*, 2*R*)-**2g**

Compound *anti*-(1*S*, 2*S*)-**2h**, ^{1}H NMR



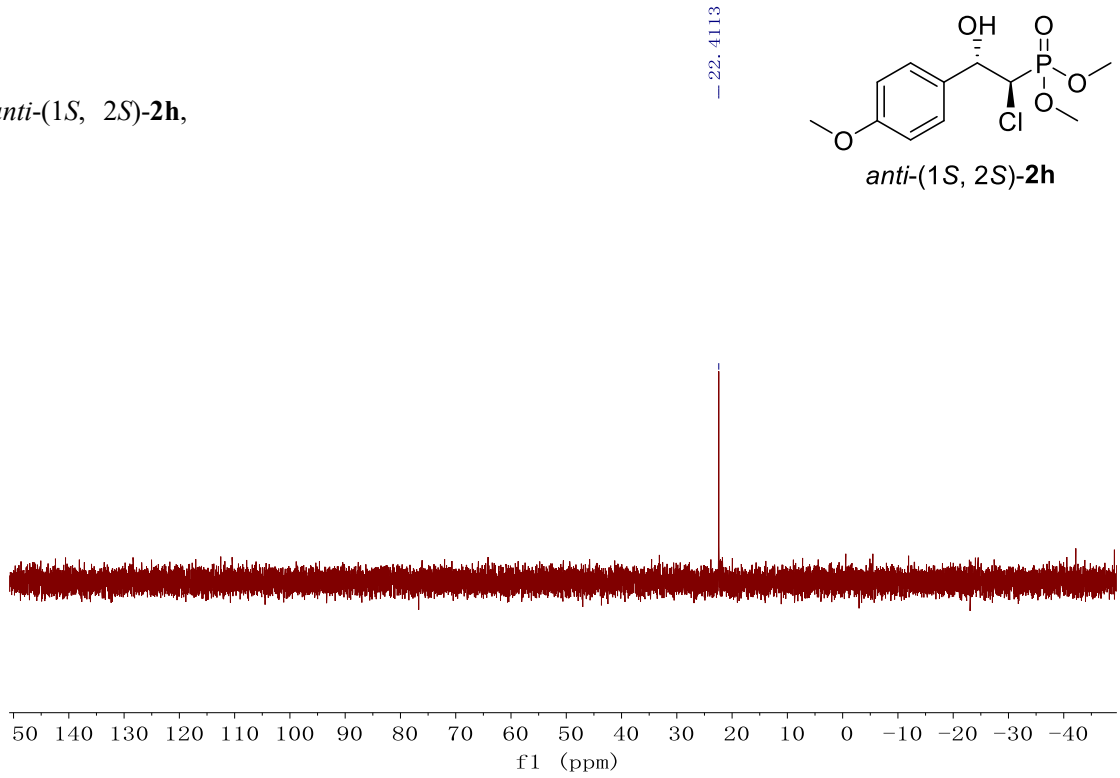
anti-(1*S*, 2*S*)-**2h**

Compound *anti*-(1*S*, 2*S*)-**2h**, ^{13}C NMR



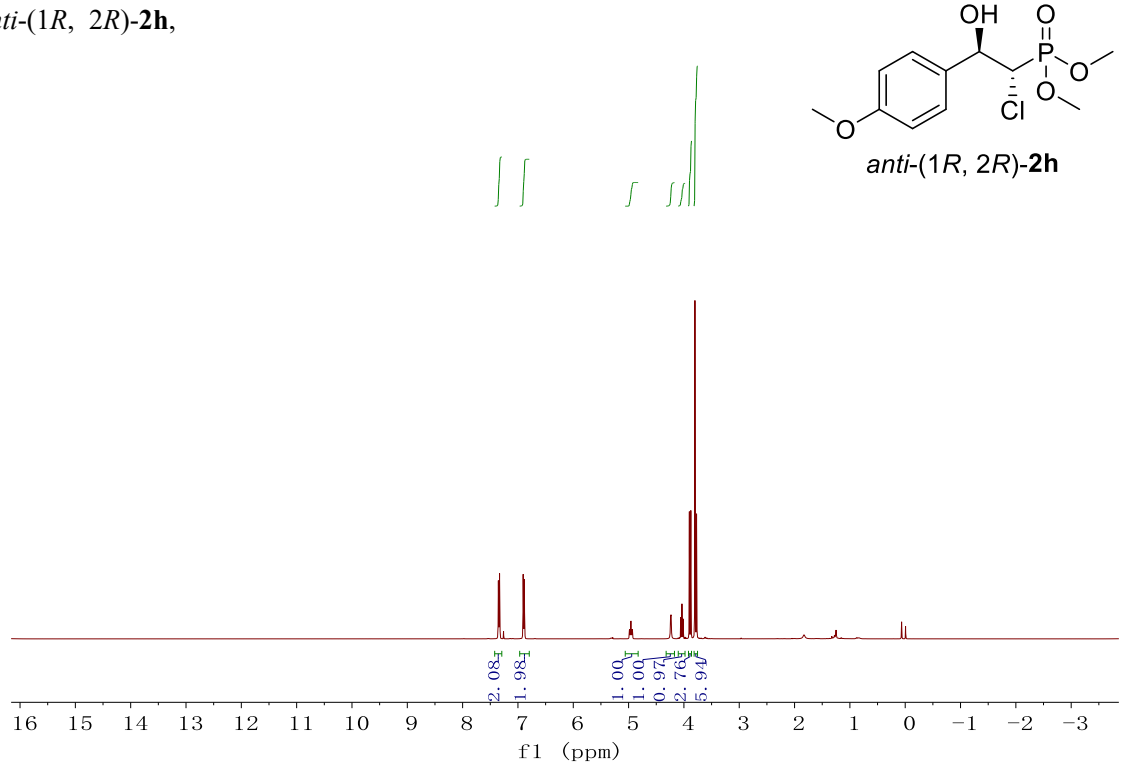
anti-(1*S*, 2*S*)-**2h**

Compound *anti*-(1*S*, 2*S*)-**2h**, ^{31}P NMR

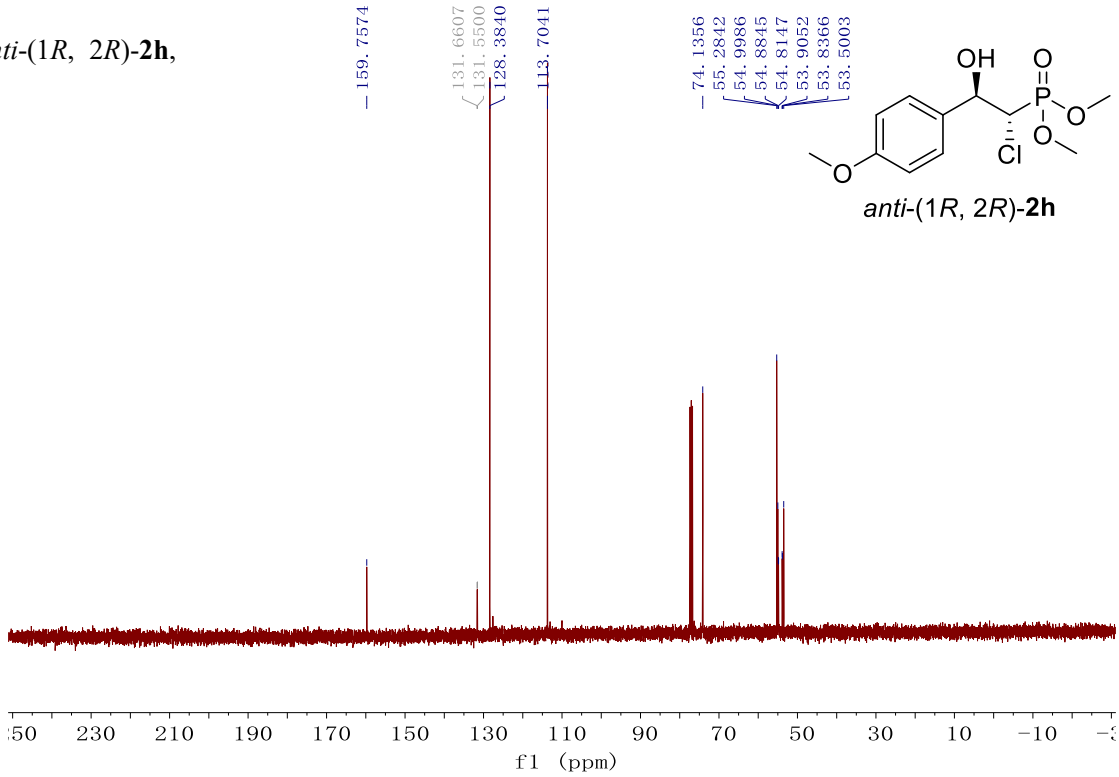


anti-(1*S*, 2*S*)-**2h**

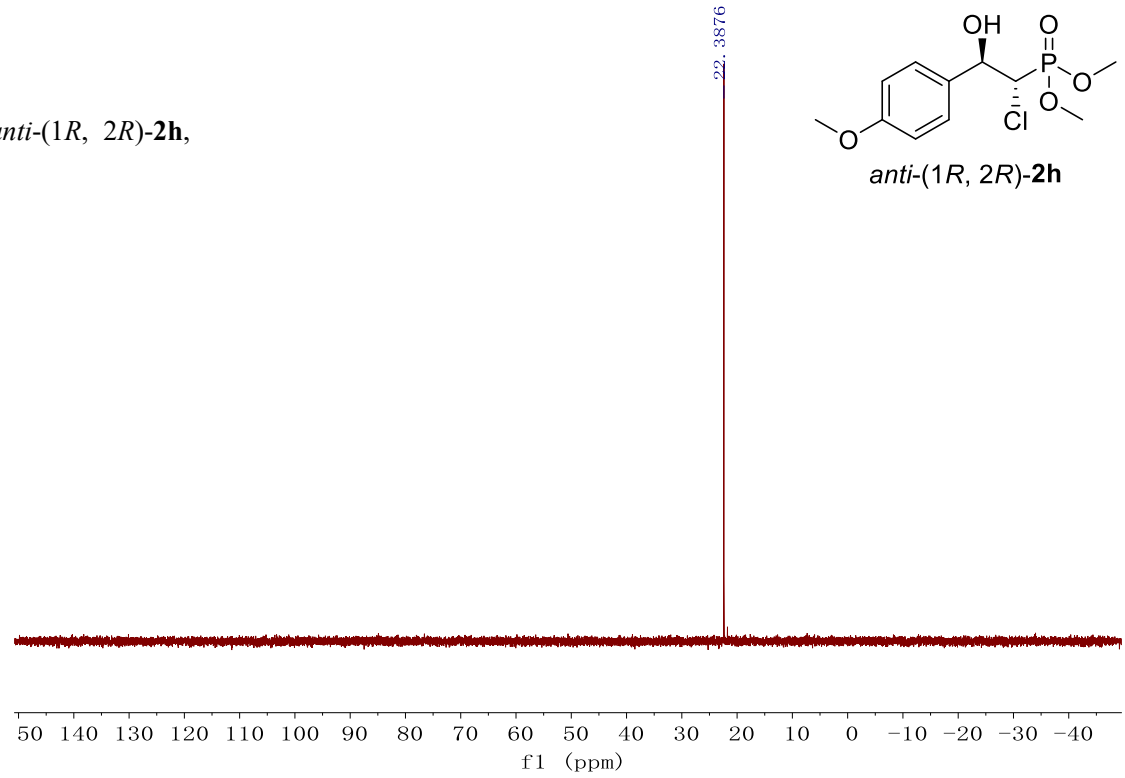
Compound *anti*-(1*R*, 2*R*)-**2h**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2h**,
^{13}C NMR

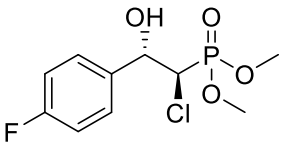


Compound *anti*-(1*R*, 2*R*)-**2h**,
^{31}P NMR

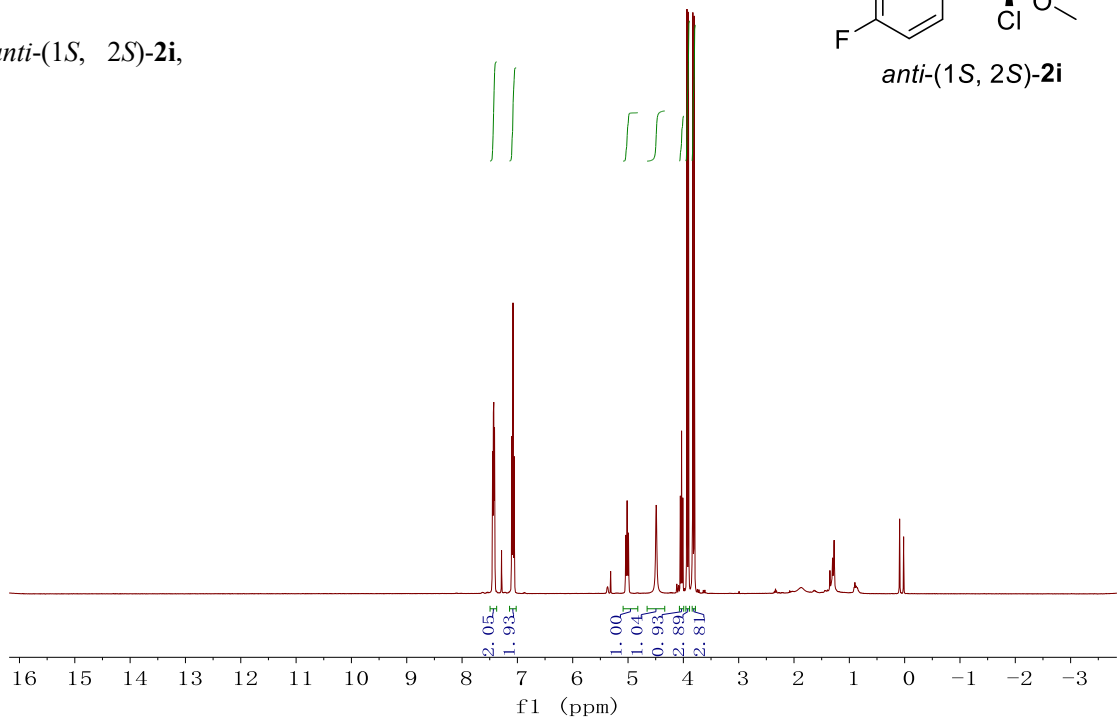


anti-(1*R*, 2*R*)-**2h**

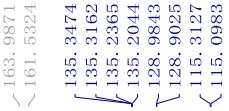
Compound *anti*-(1*S*, 2*S*)-**2i**, ^{1}H NMR

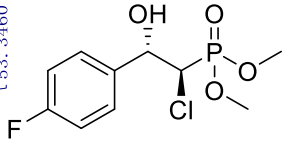


anti-(1*S*, 2*S*)-**2i**

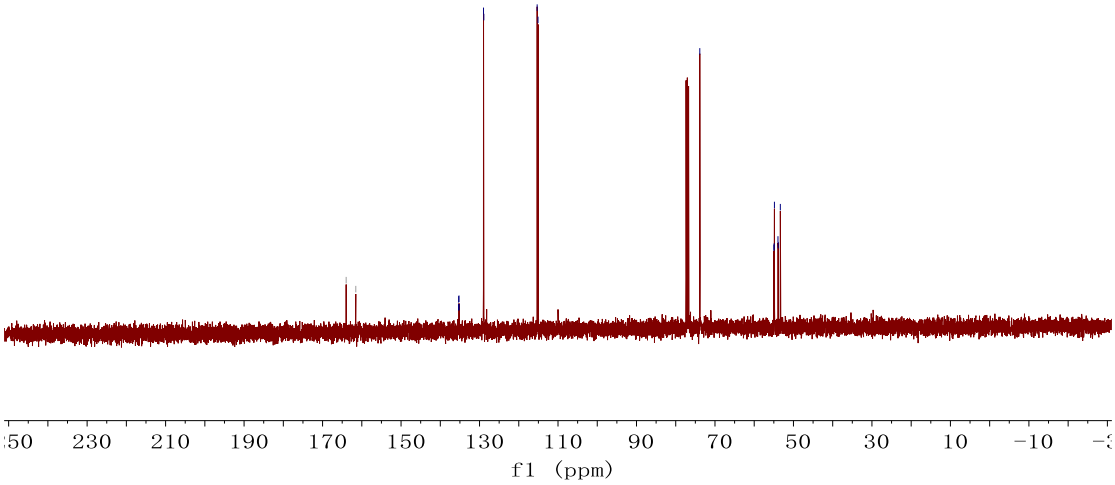


Compound *anti*-(1*S*, 2*S*)-**2i**, ^{13}C NMR

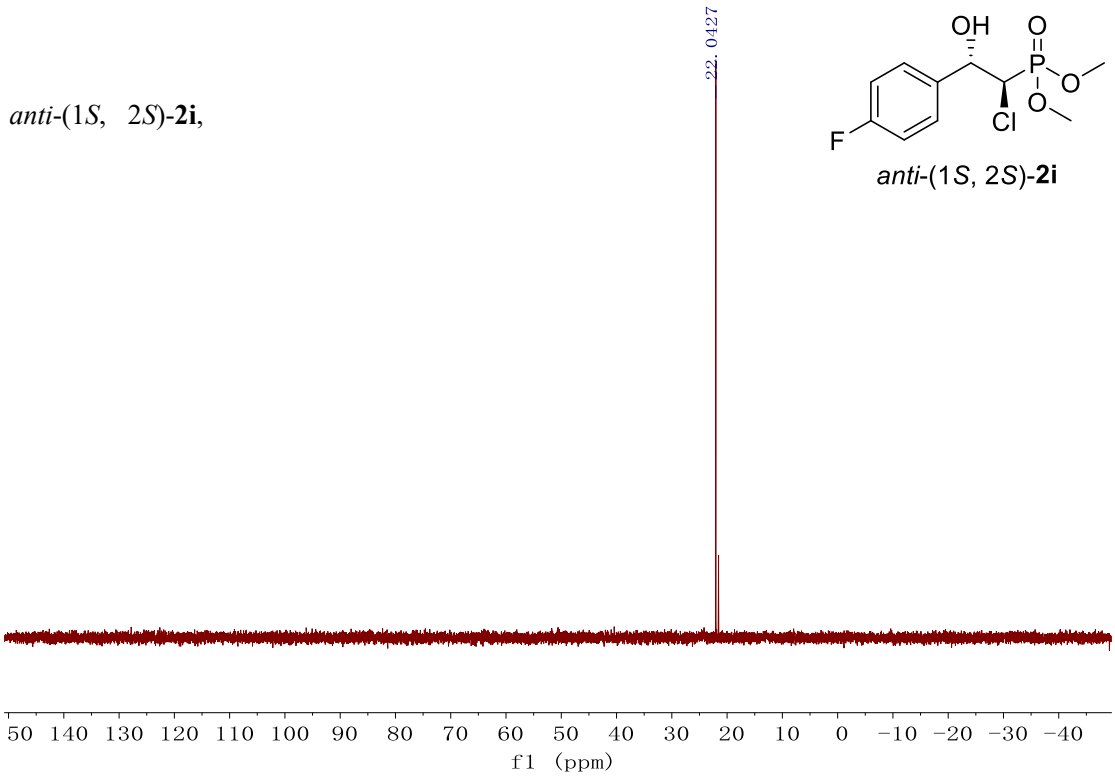




anti-(1*S*, 2*S*)-**2i**

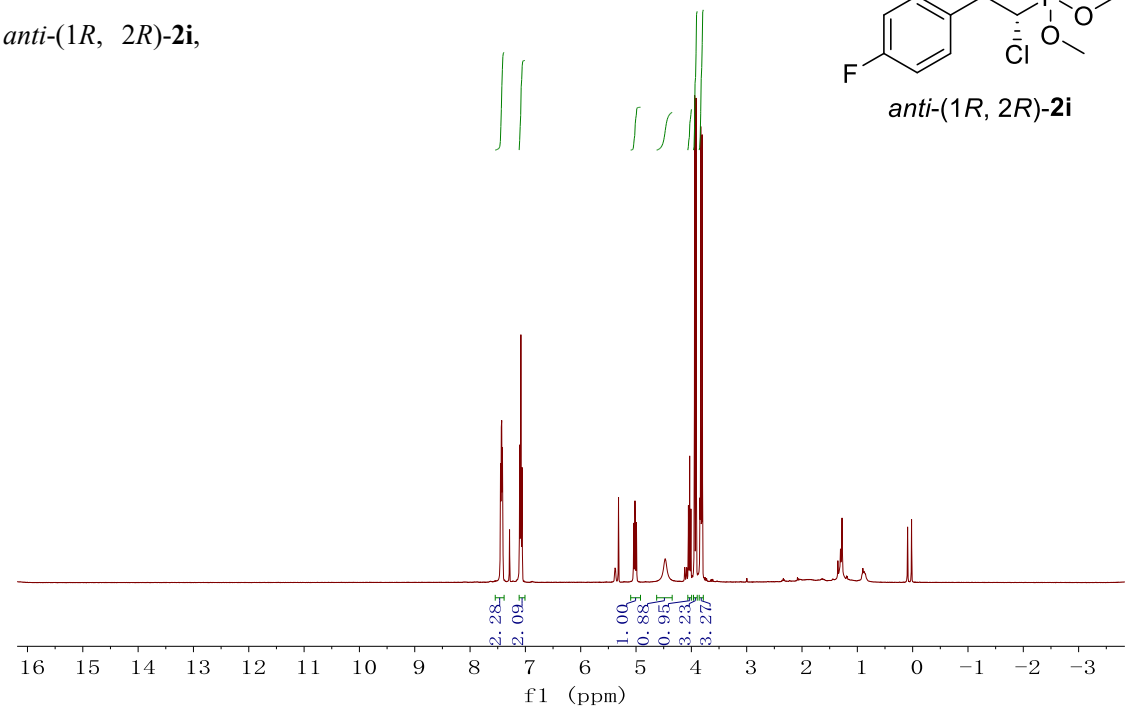


Compound *anti*-(1*S*, 2*S*)-**2i**, ^{31}P NMR

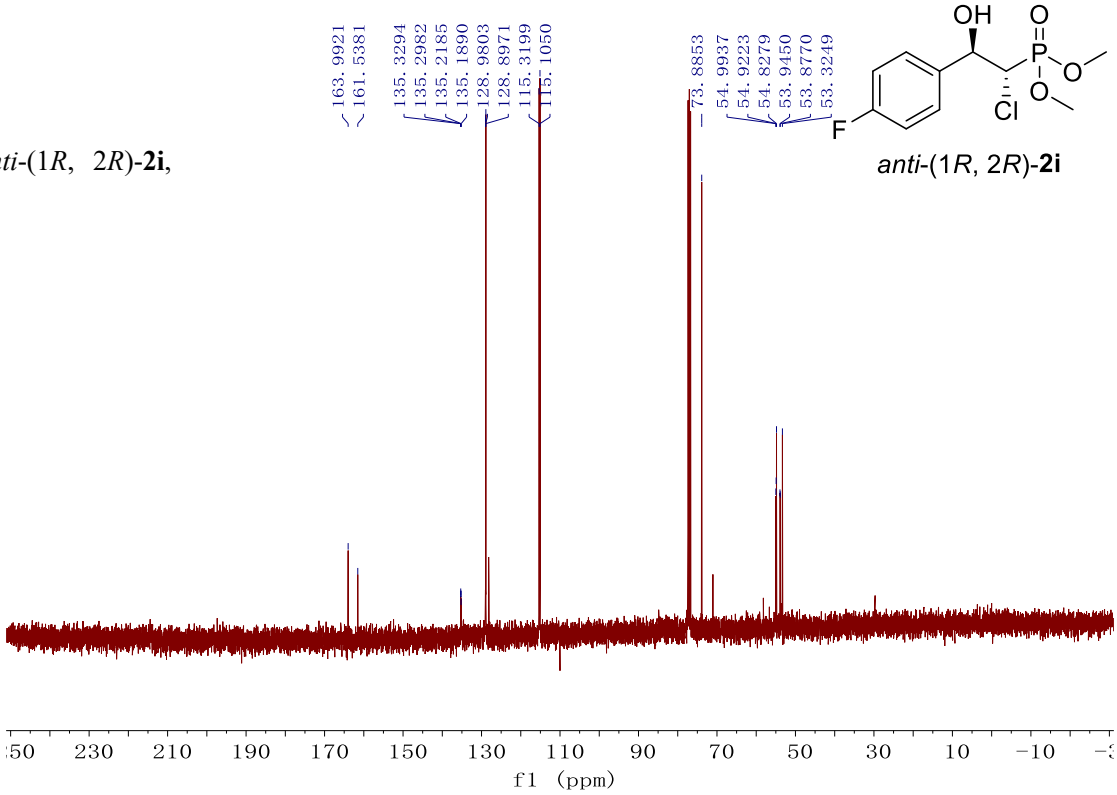


anti-(1*S*, 2*S*)-**2i**

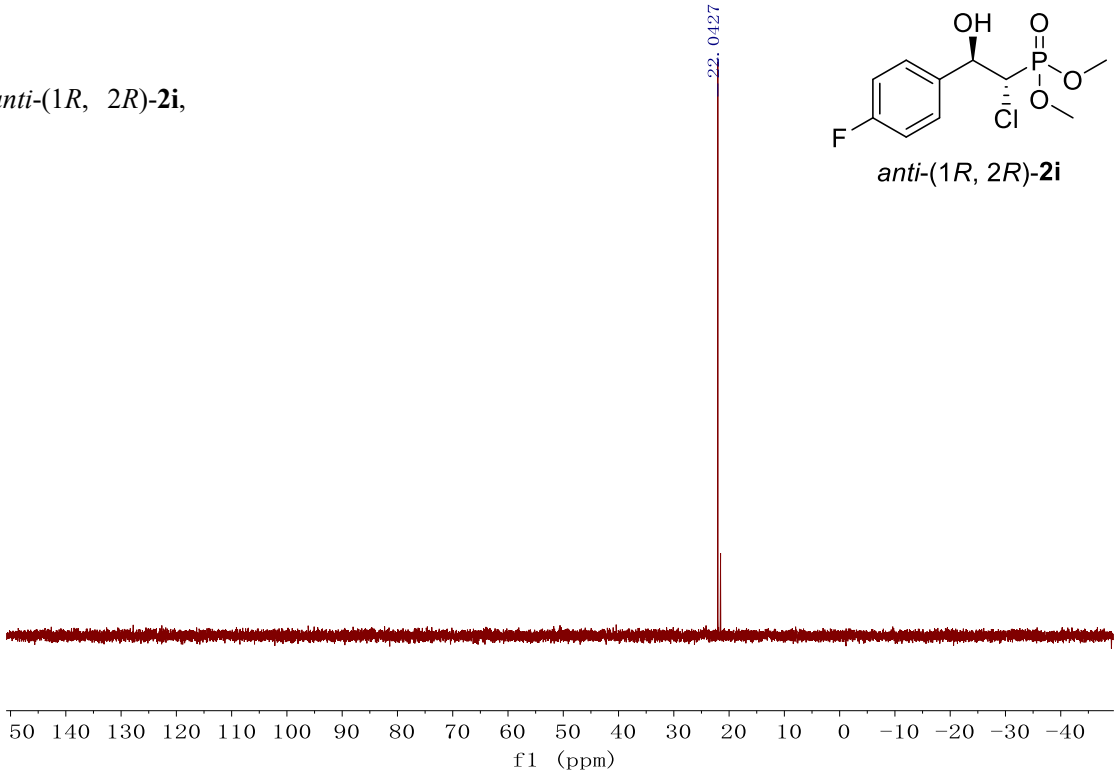
Compound *anti*-(1*R*, 2*R*)-**2i**, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2i**, ^{13}C NMR

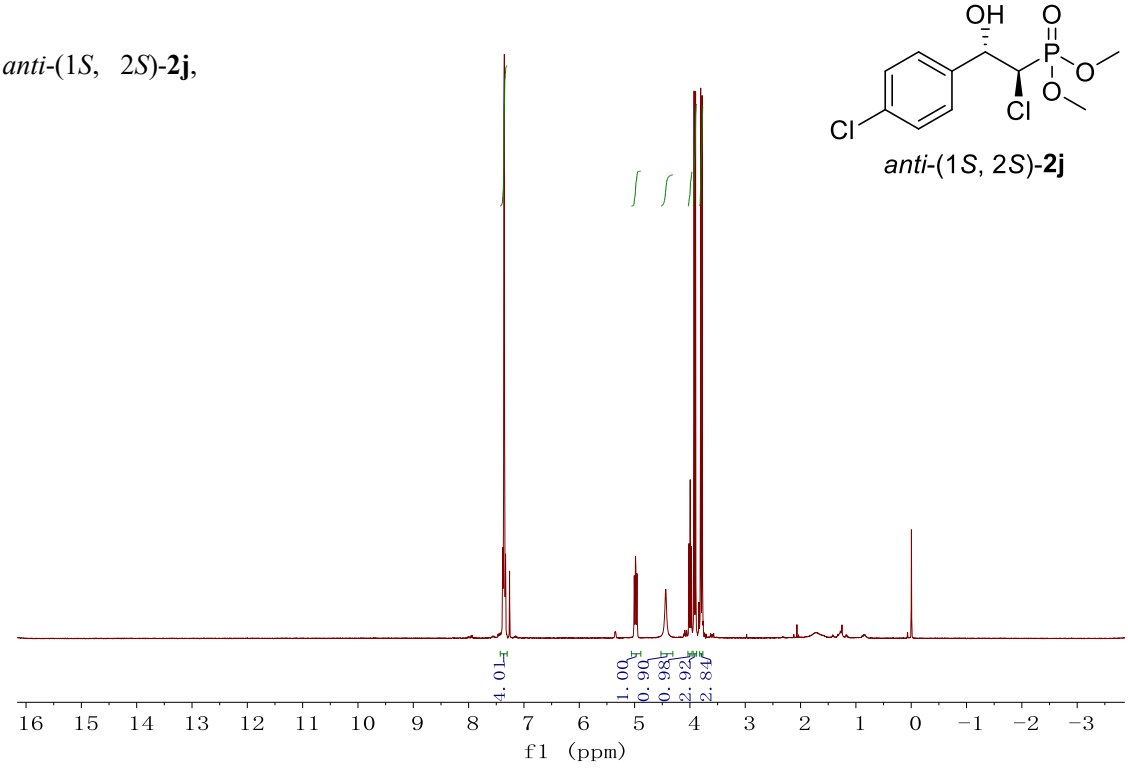


Compound *anti*-(1*R*, 2*R*)-**2i**, ^{31}P NMR

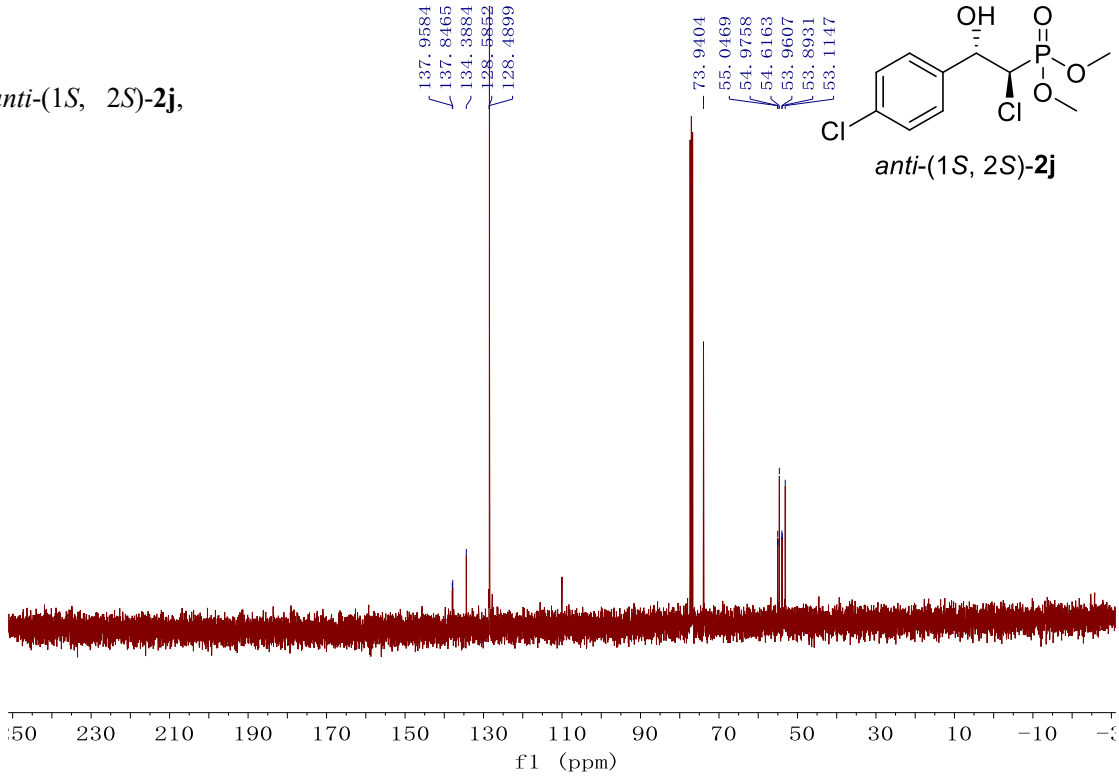


anti-(1*R*, 2*R*)-**2i**

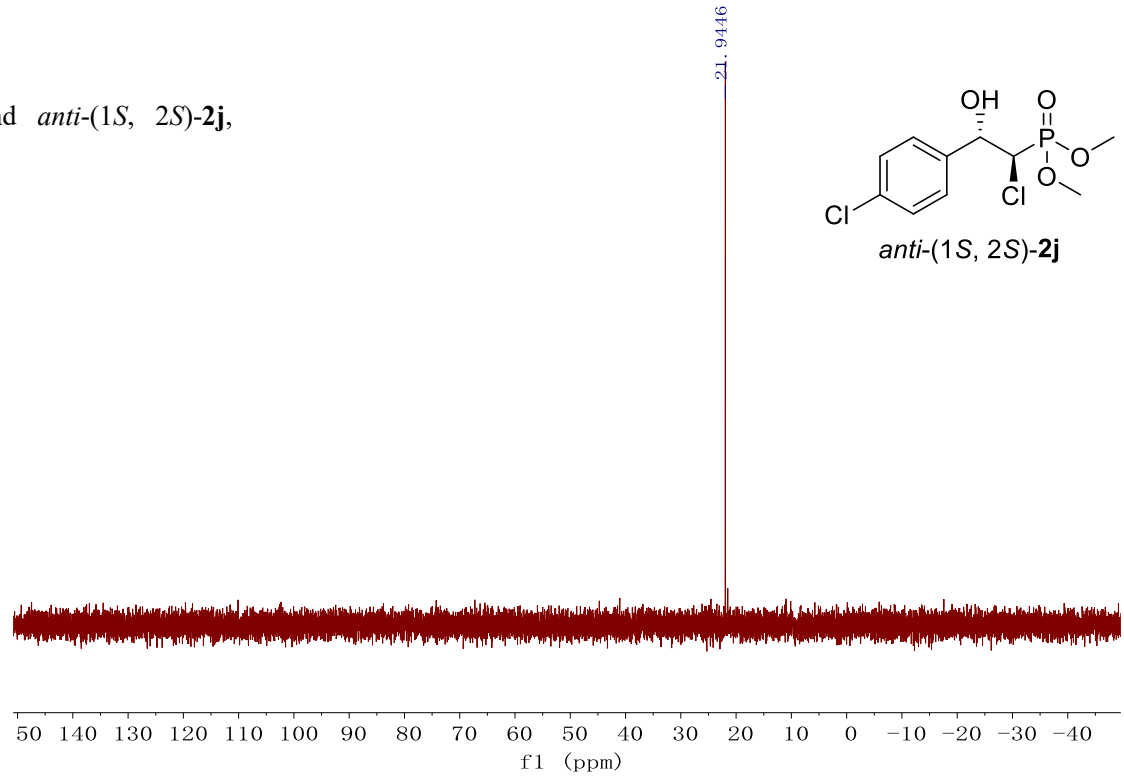
Compound *anti*-(1*S*, 2*S*)-**2j**, ^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2j**, ^{13}C NMR

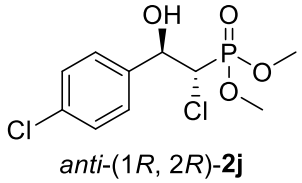


Compound *anti*-(1*S*, 2*S*)-**2j**, ^{31}P NMR



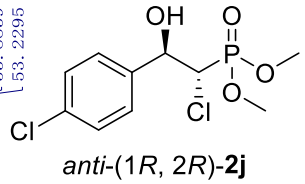
anti-(1*S*, 2*S*)-**2j**

Compound *anti*-(1*R*, 2*R*)-**2j**,
^{1}H NMR



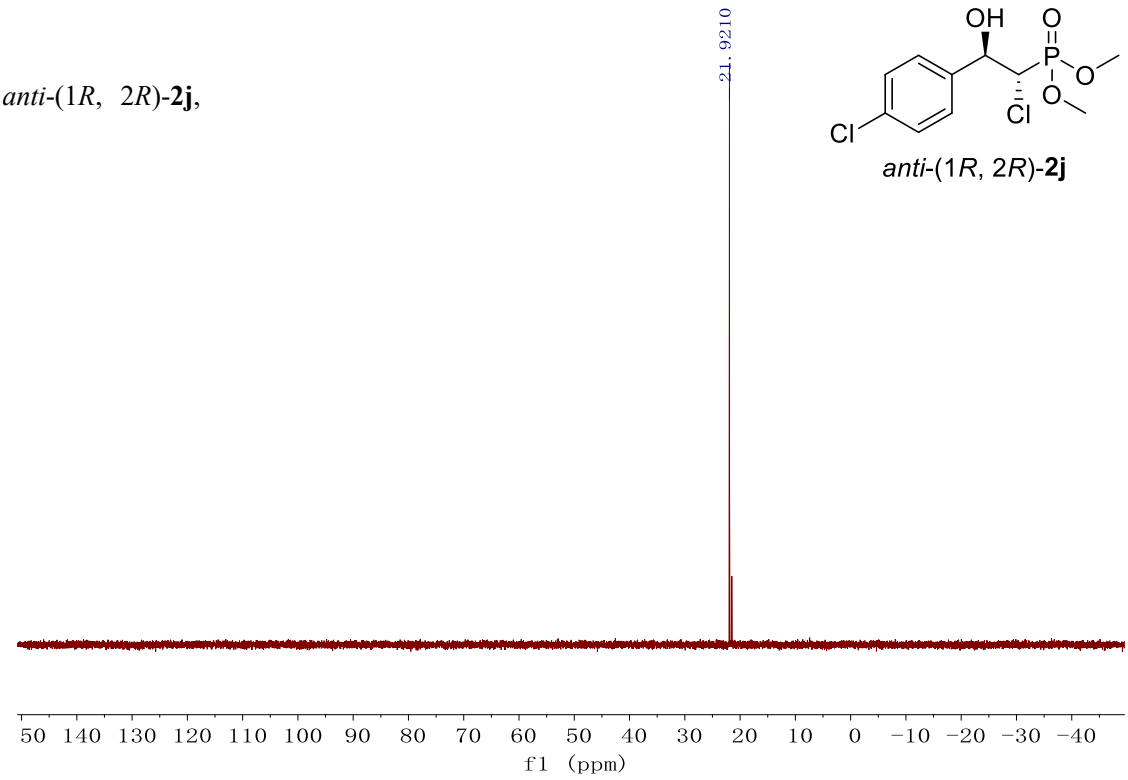
anti-(1*R*, 2*R*)-**2j**

Compound *anti*-(1*R*, 2*R*)-**2j**,
^{13}C NMR



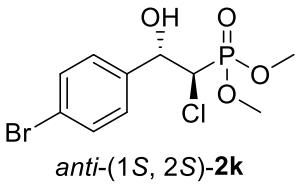
anti-(1*R*, 2*R*)-**2j**

Compound *anti*-(1*R*, 2*R*)-**2j**, ^{31}P NMR

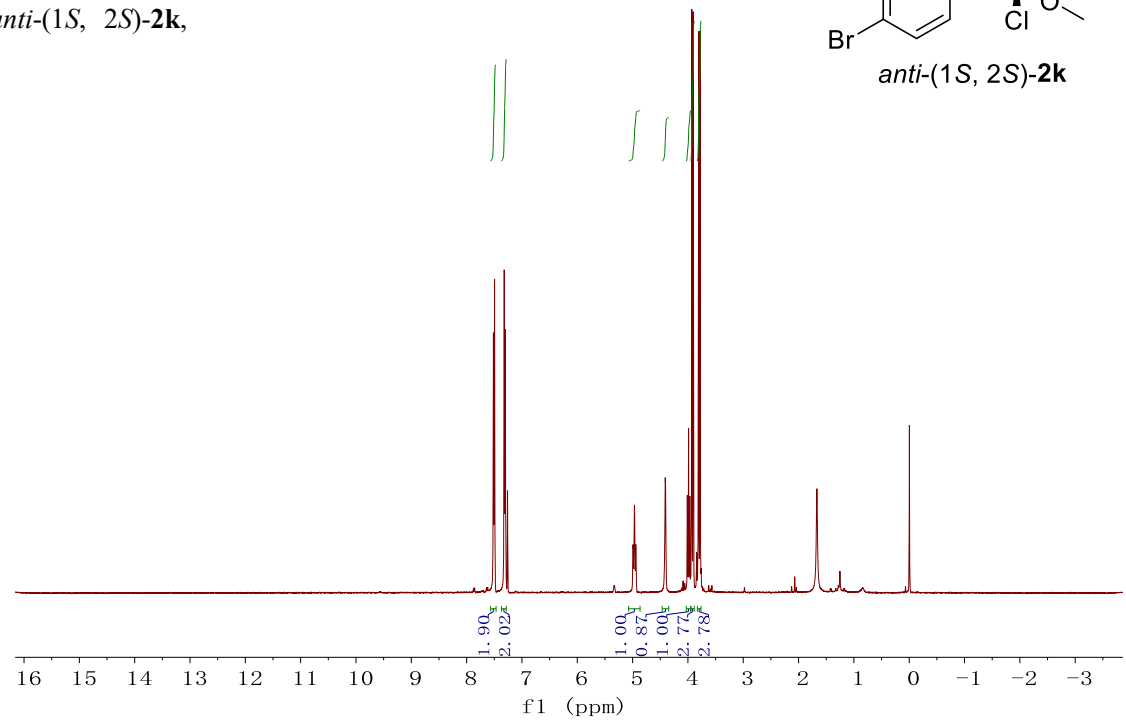


anti-(1*R*, 2*R*)-**2j**

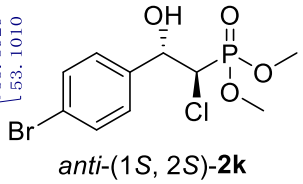
Compound *anti*-(1*S*, 2*S*)-**2k**,
^{1}H NMR



anti-(1*S*, 2*S*)-**2k**

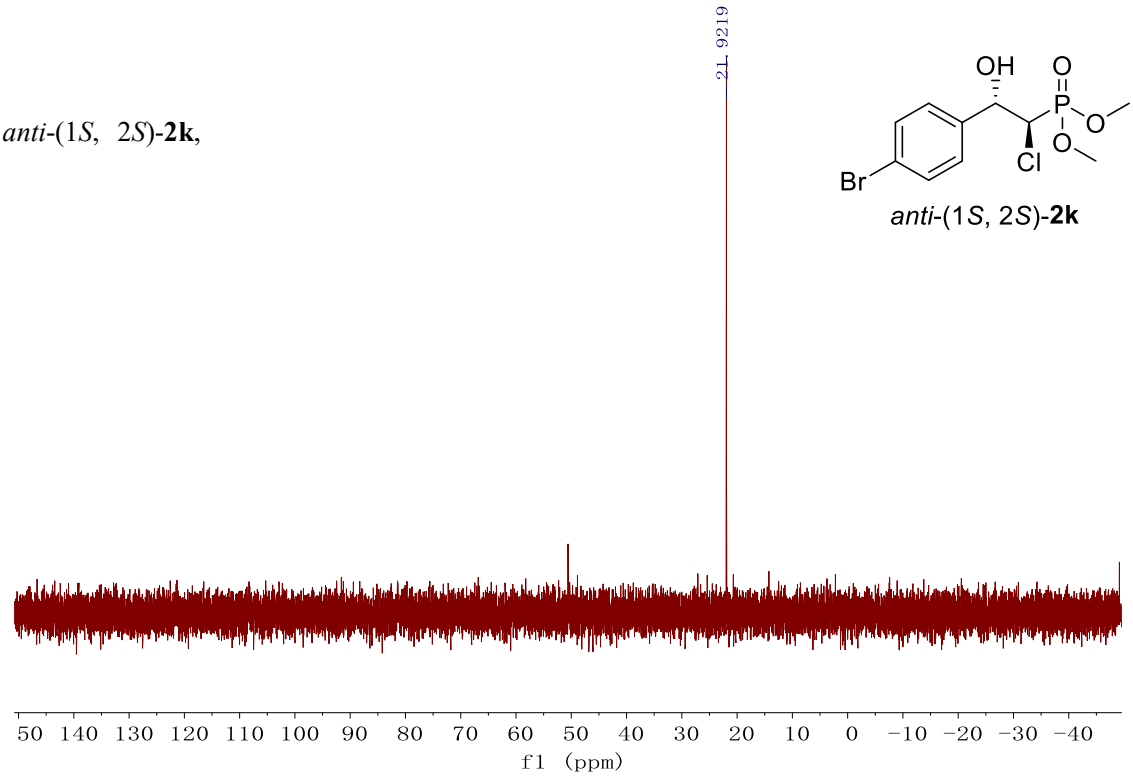


Compound *anti*-(1*S*, 2*S*)-**2k**,
^{13}C NMR



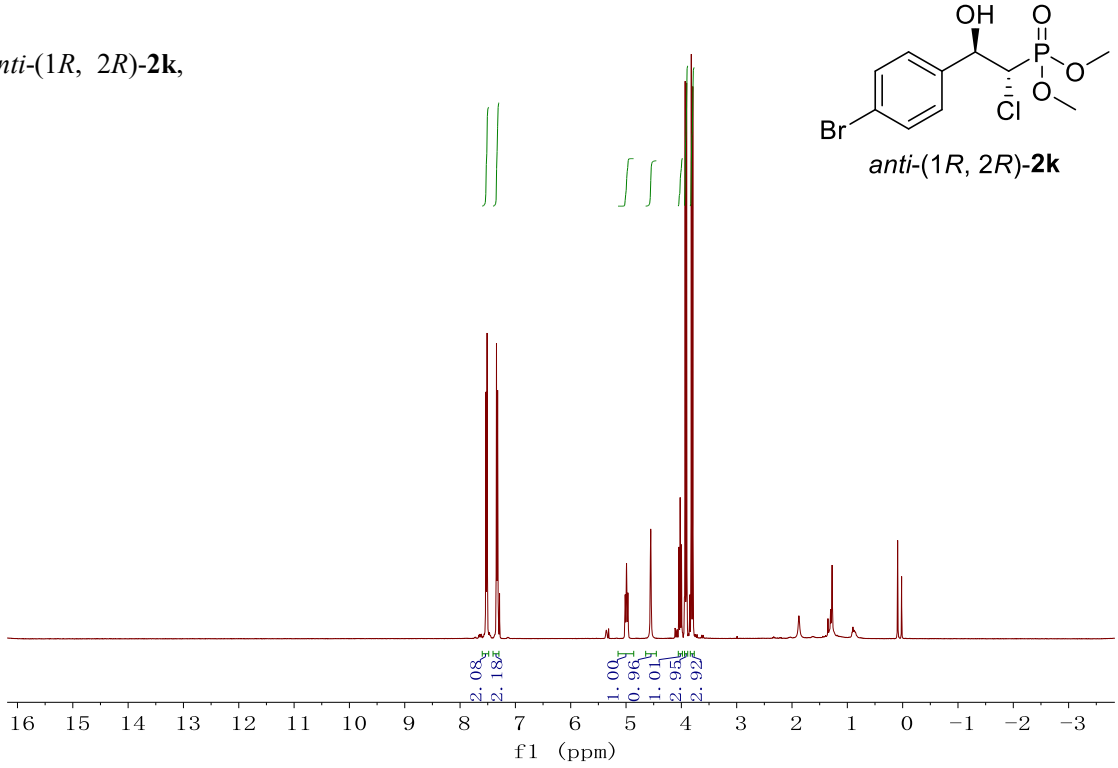
anti-(1*S*, 2*S*)-**2k**

Compound *anti*-(1*S*, 2*S*)-**2k**, ^{31}P NMR

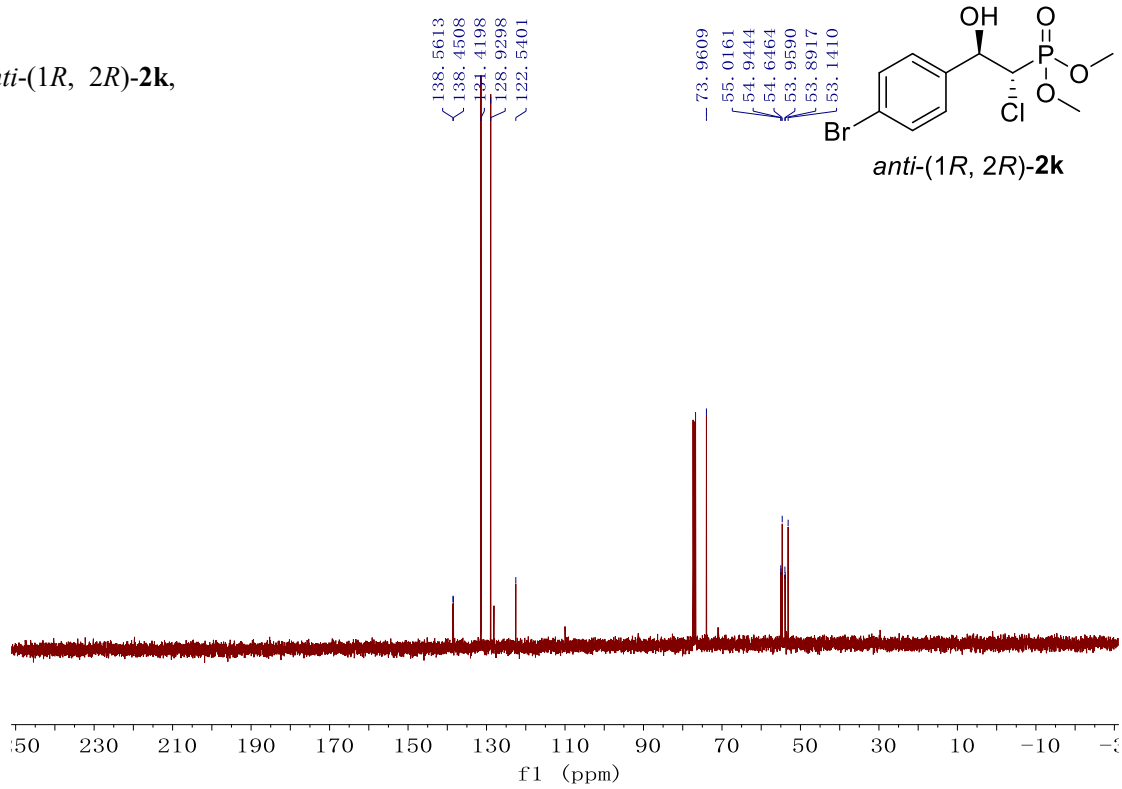


anti-(1*S*, 2*S*)-**2k**

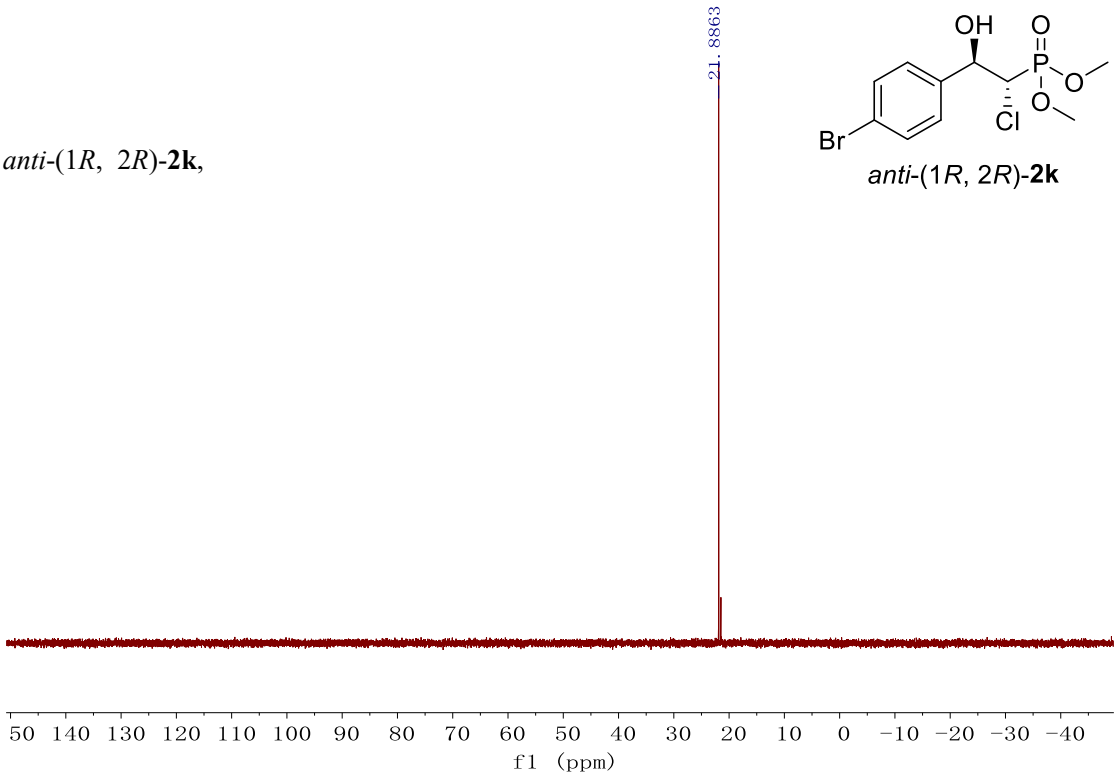
Compound *anti*-(1*R*, 2*R*)-**2k**,
^{1}H NMR



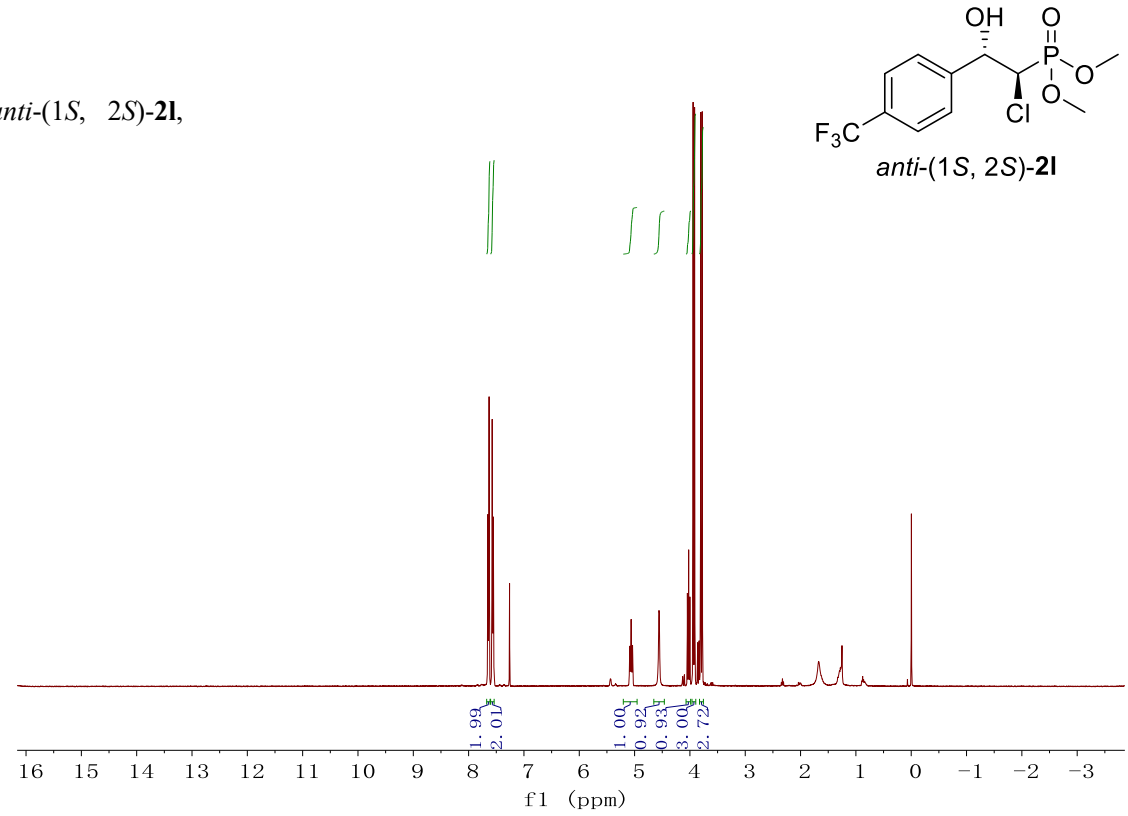
Compound *anti*-(1*R*, 2*R*)-**2k**,
^{13}C NMR



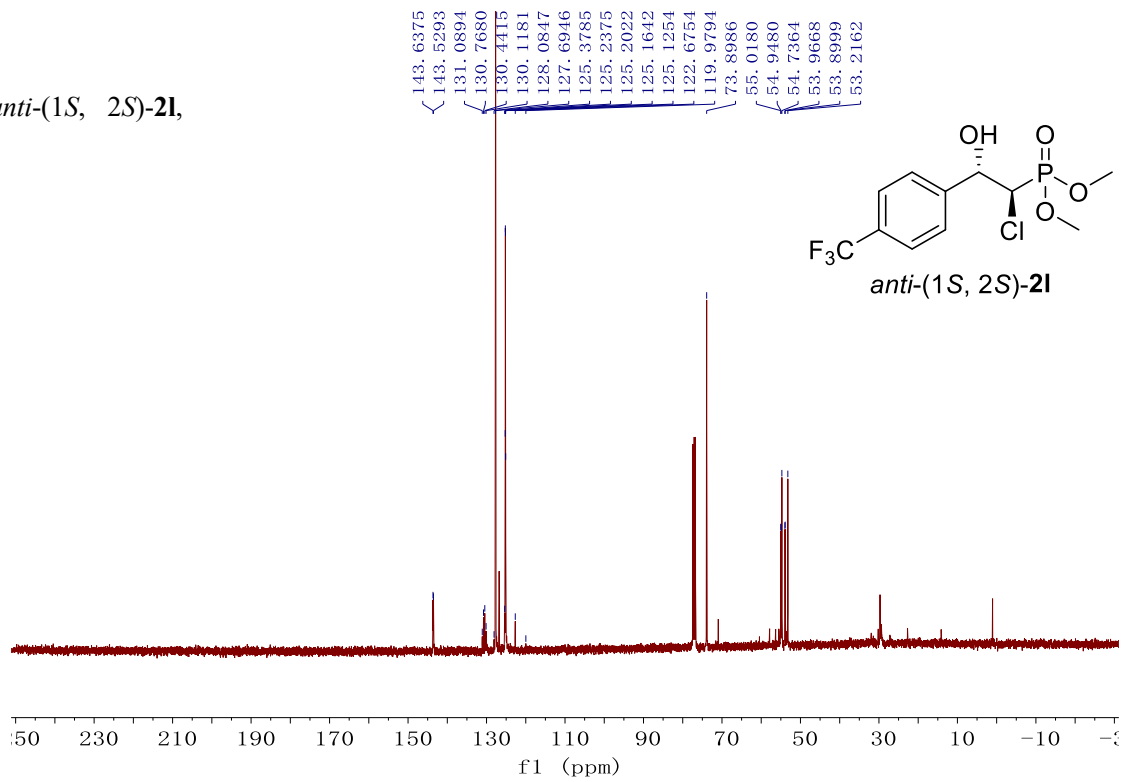
Compound *anti*-(1*R*, 2*R*)-**2k**,
^{31}P NMR



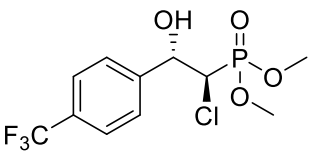
Compound *anti*-(1*S*, 2*S*)-**2l**, ^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2l**, ^{13}C NMR

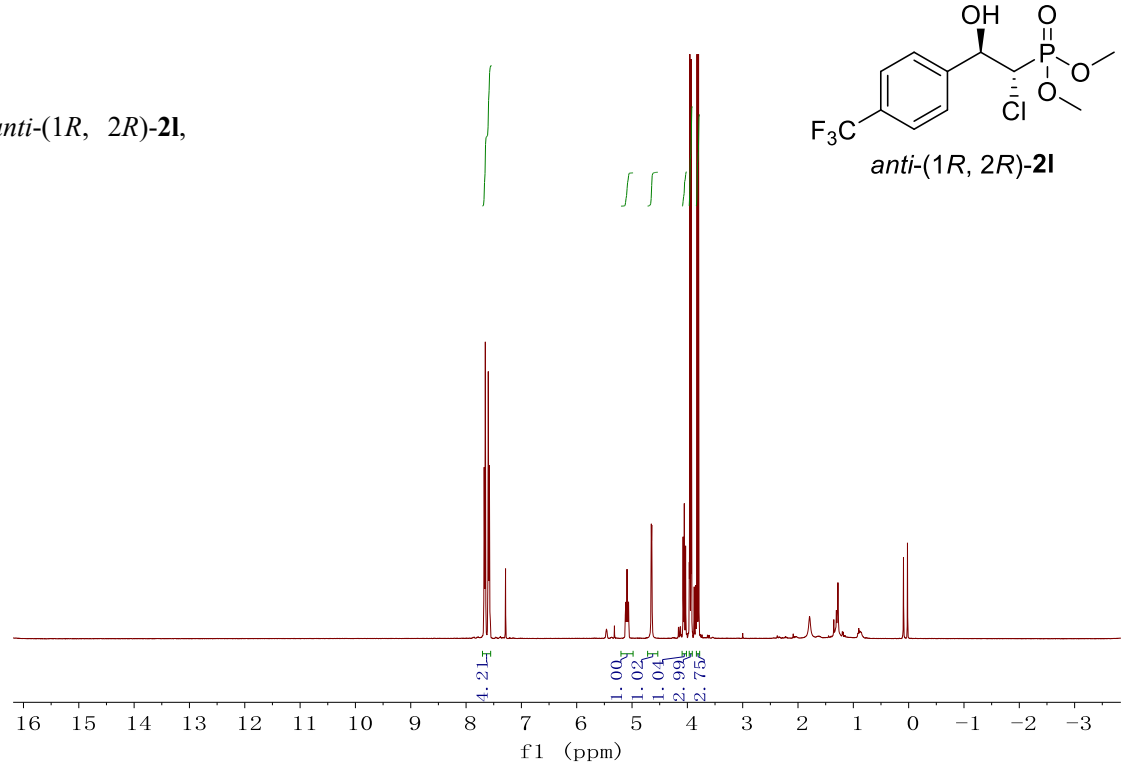


Compound *anti*-(1*S*, 2*S*)-**2l**, ^{31}P NMR



anti-(1*S*, 2*S*)-**2l**

Compound *anti*-(1*R*, 2*R*)-**2l**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2l**,
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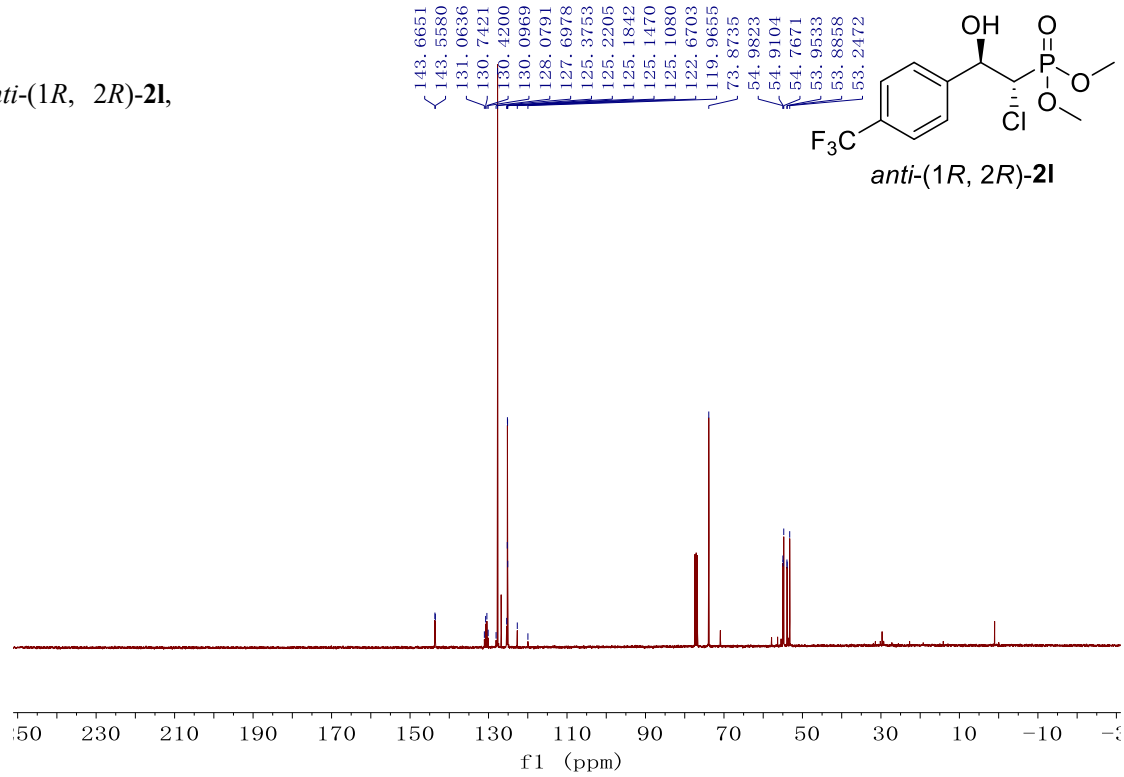
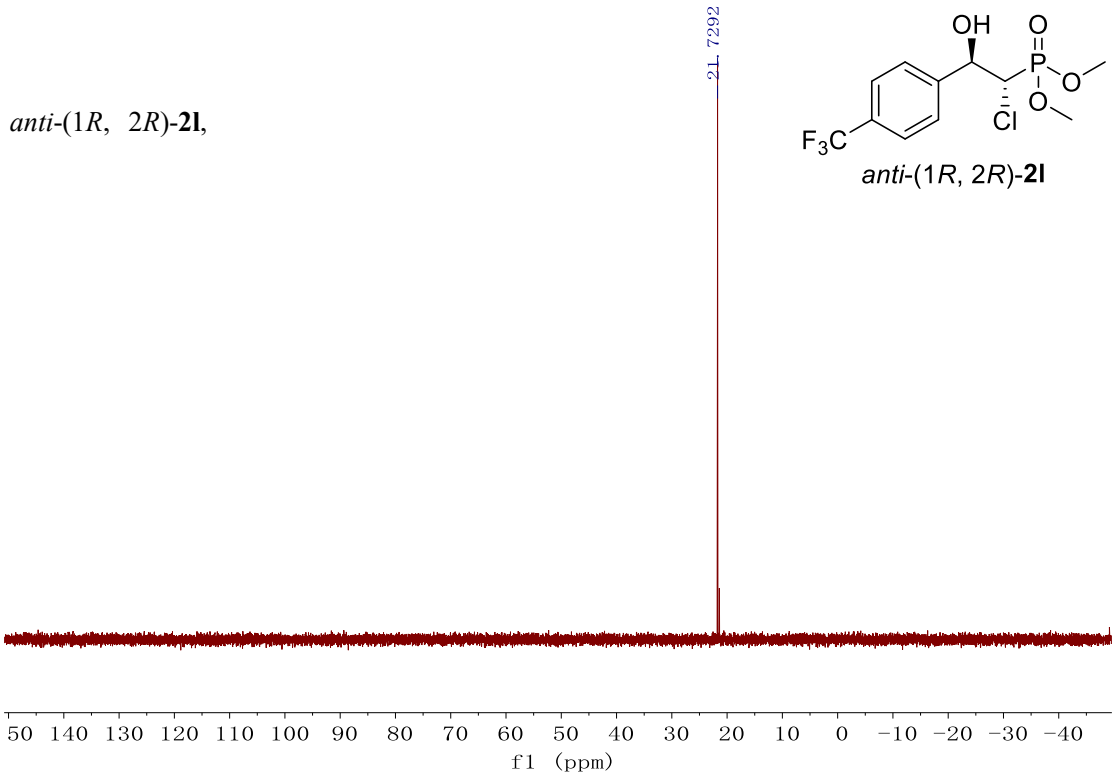
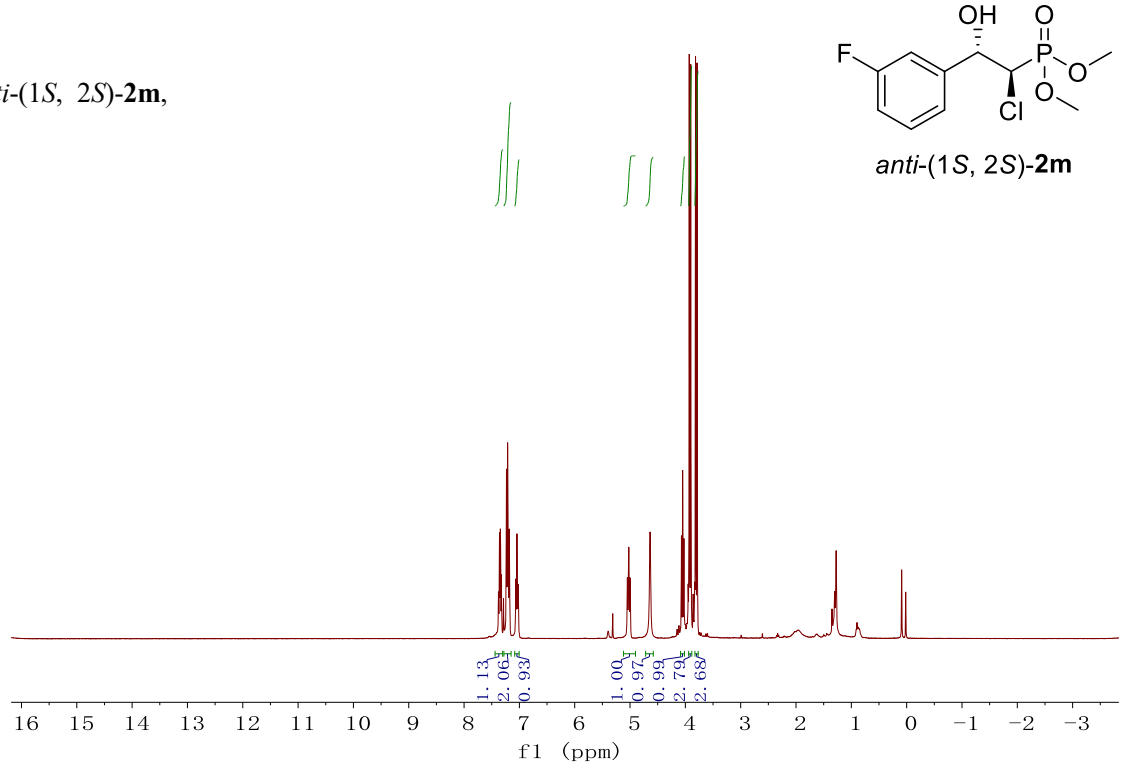


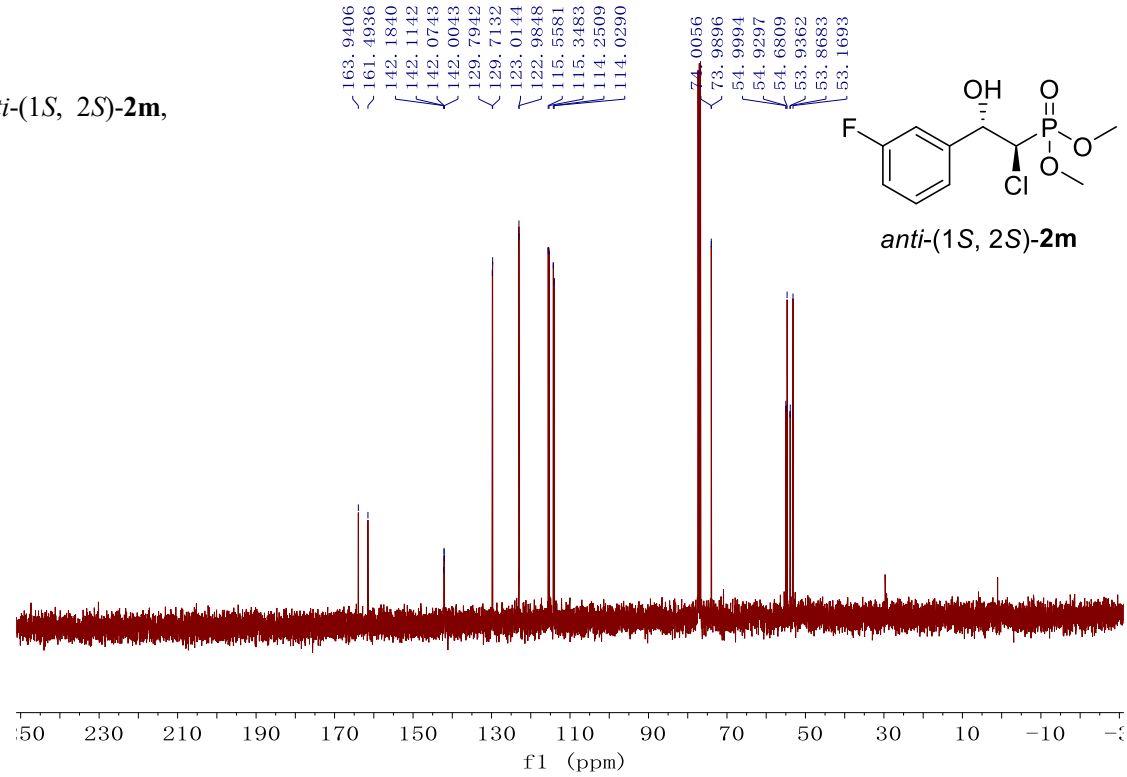
Compound *anti*-(1*R*, 2*R*)-**2l**,
^{31}P NMR



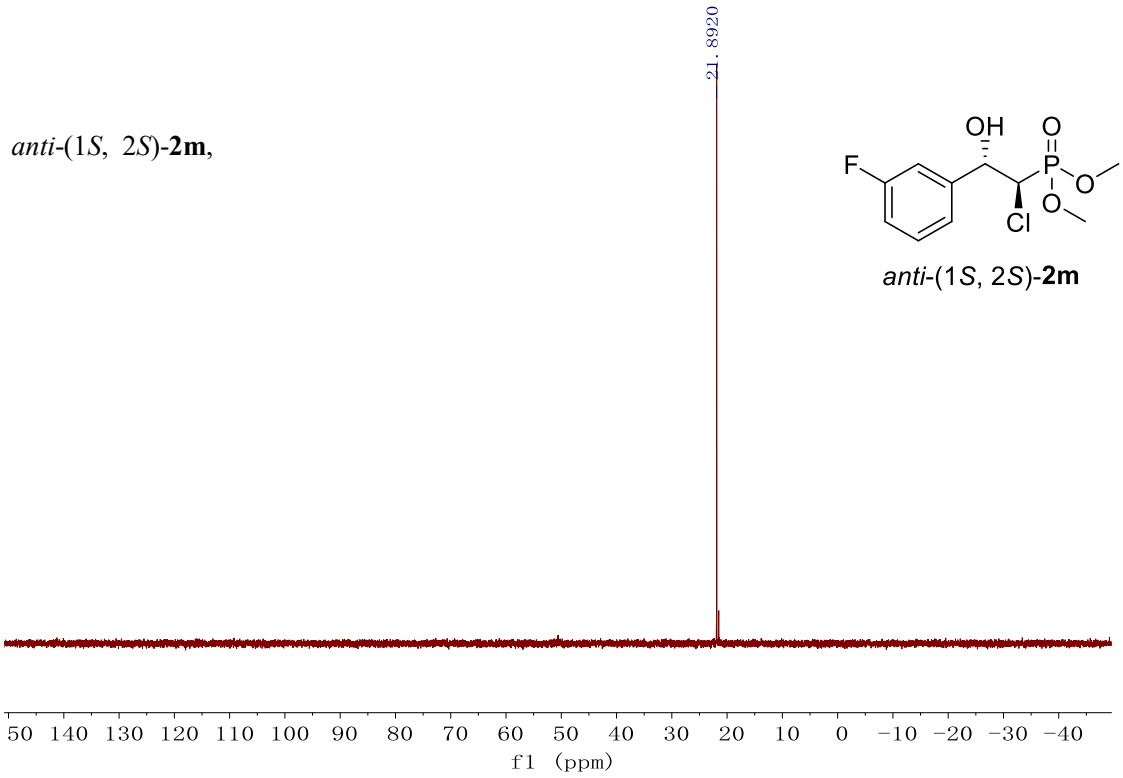
Compound *anti*-(1*S*, 2*S*)-**2m**, ^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2m**, ^{13}C NMR

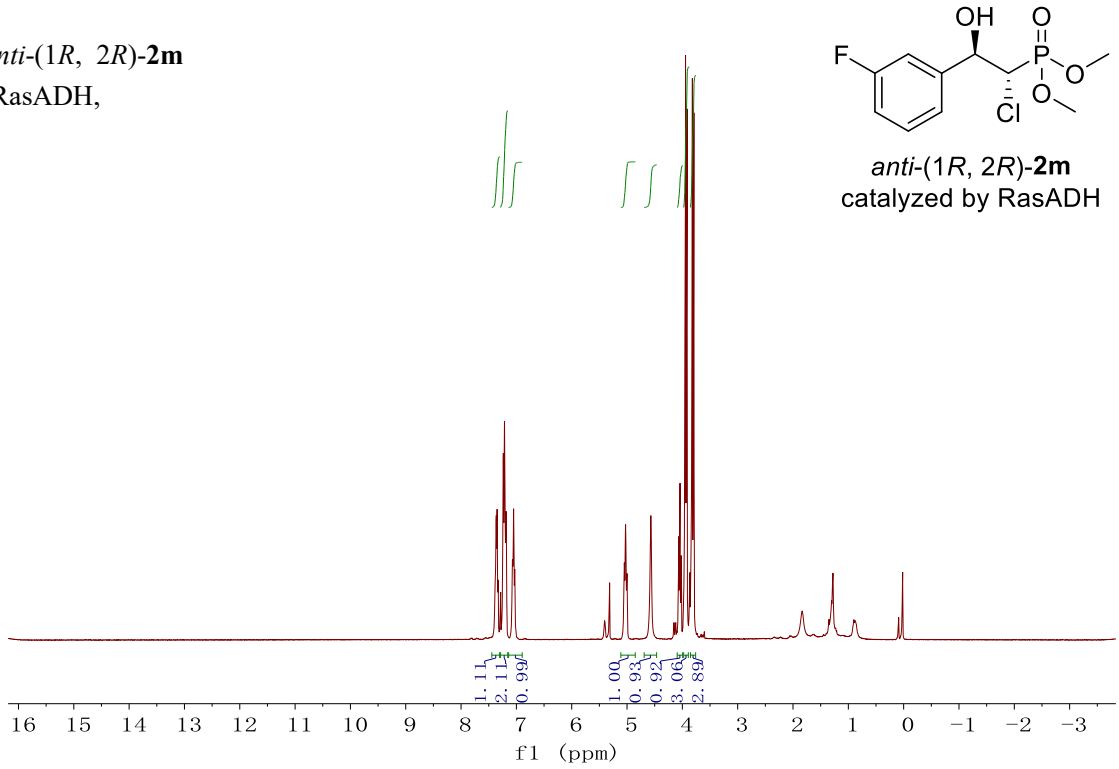


Compound *anti*-(1*S*, 2*S*)-**2m**,
^{31}P NMR

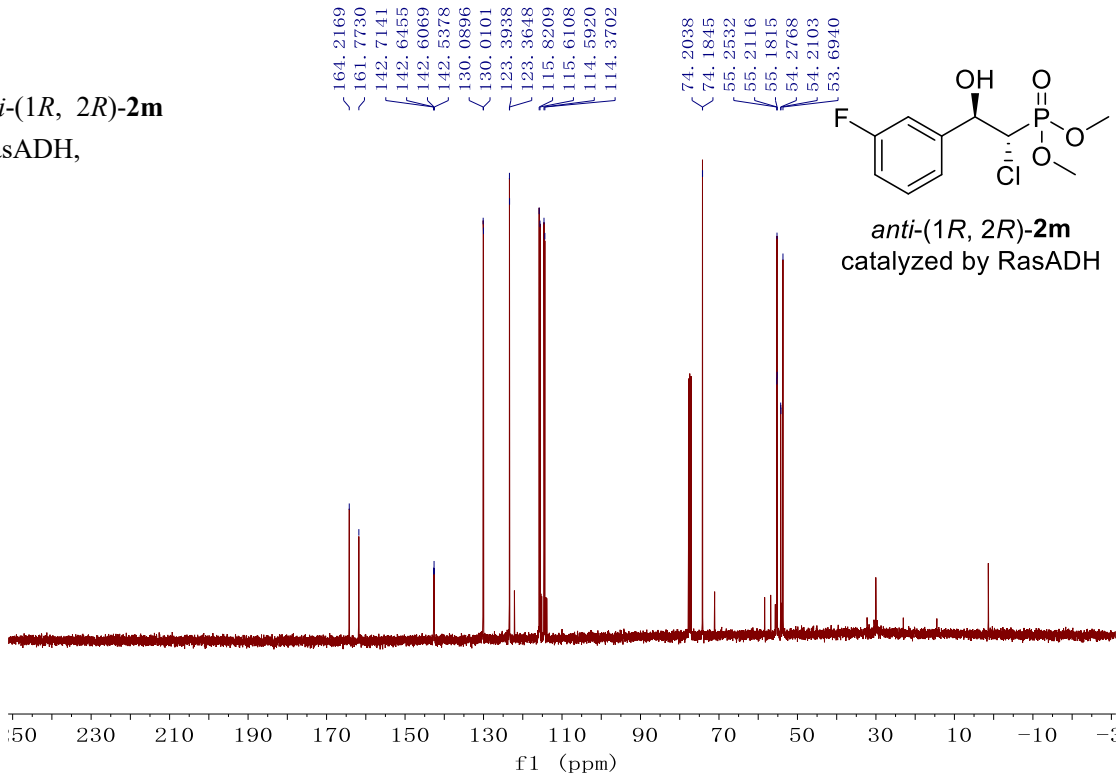


anti-(1*S*, 2*S*)-**2m**

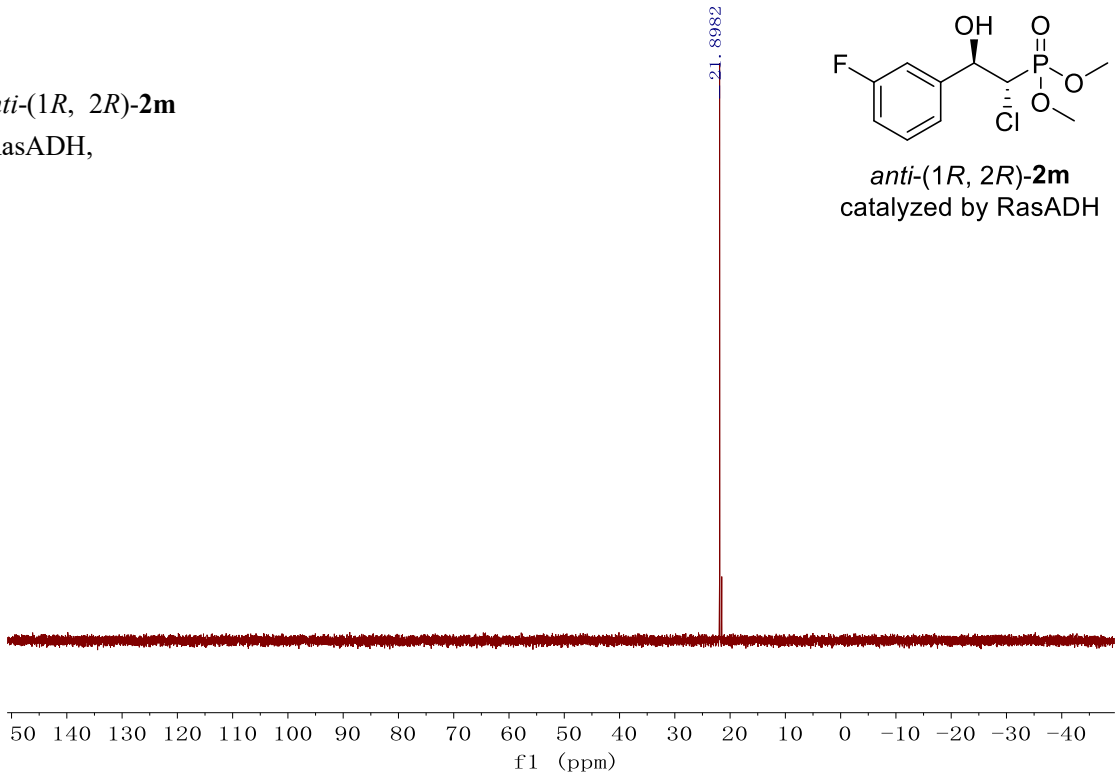
Compound *anti*-(1*R*, 2*R*)-**2m** catalyzed by RasADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2m** catalyzed by RasADH, ^{13}C NMR

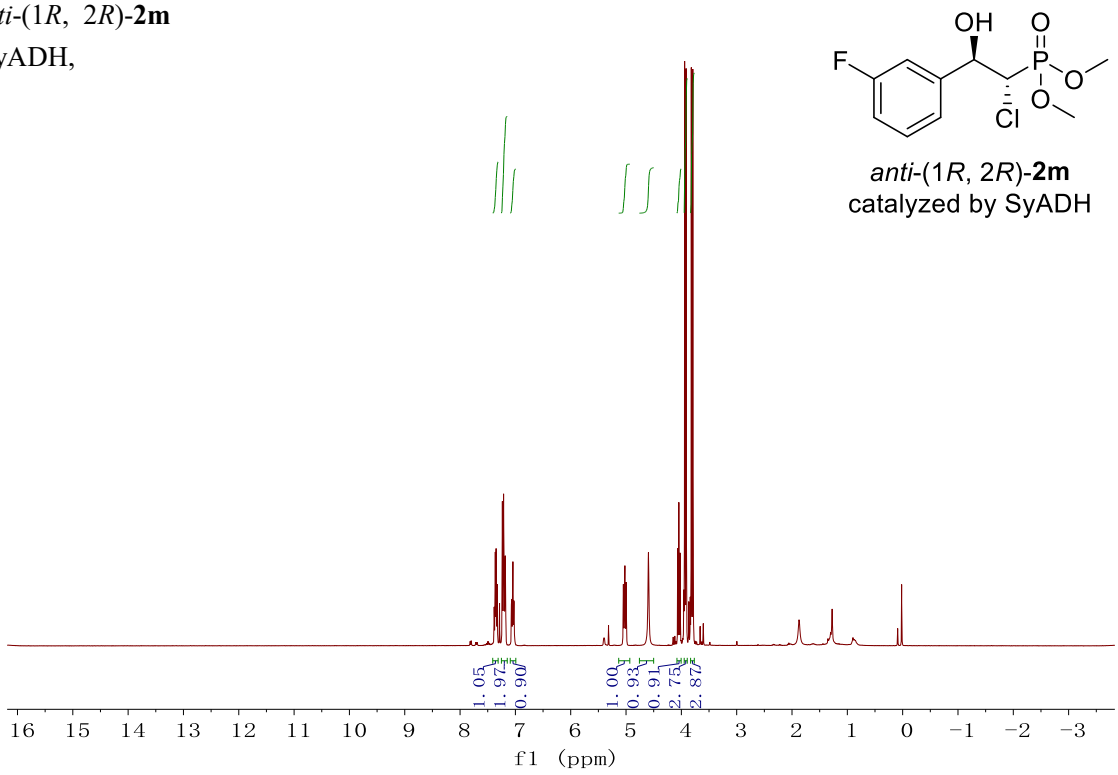


Compound *anti*-(1*R*, 2*R*)-**2m** catalyzed by RasADH, ^{31}P NMR

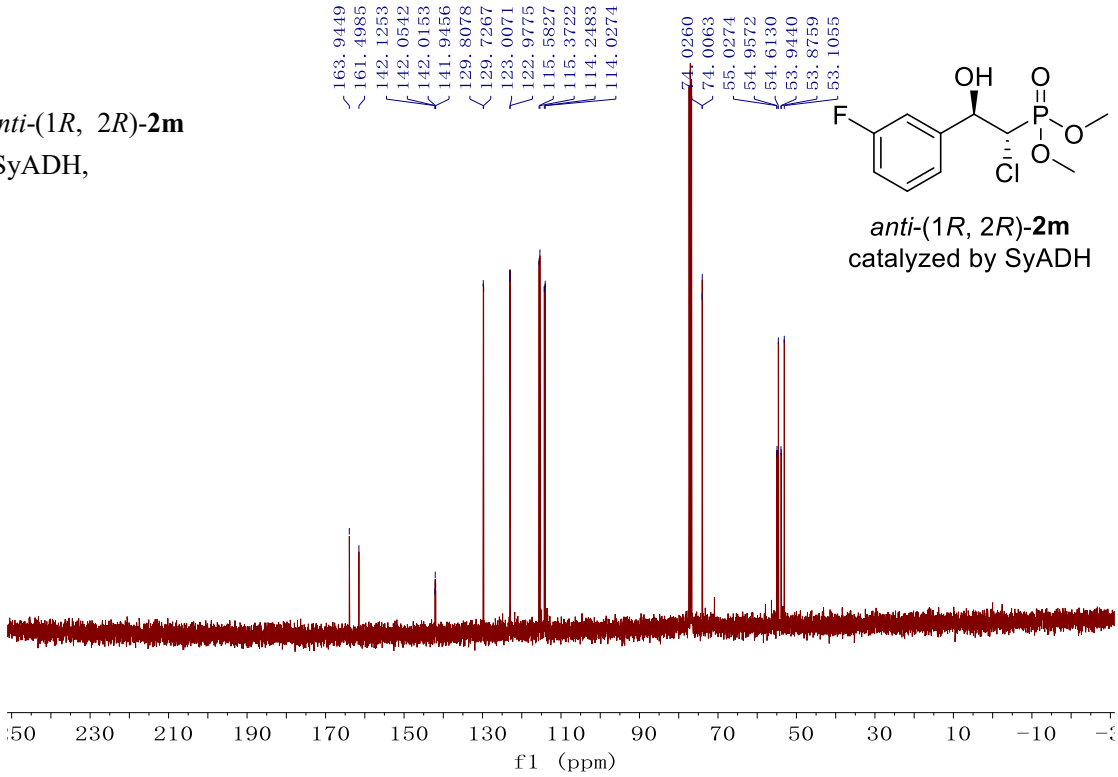


anti-(1*R*, 2*R*)-**2m** catalyzed by RasADH

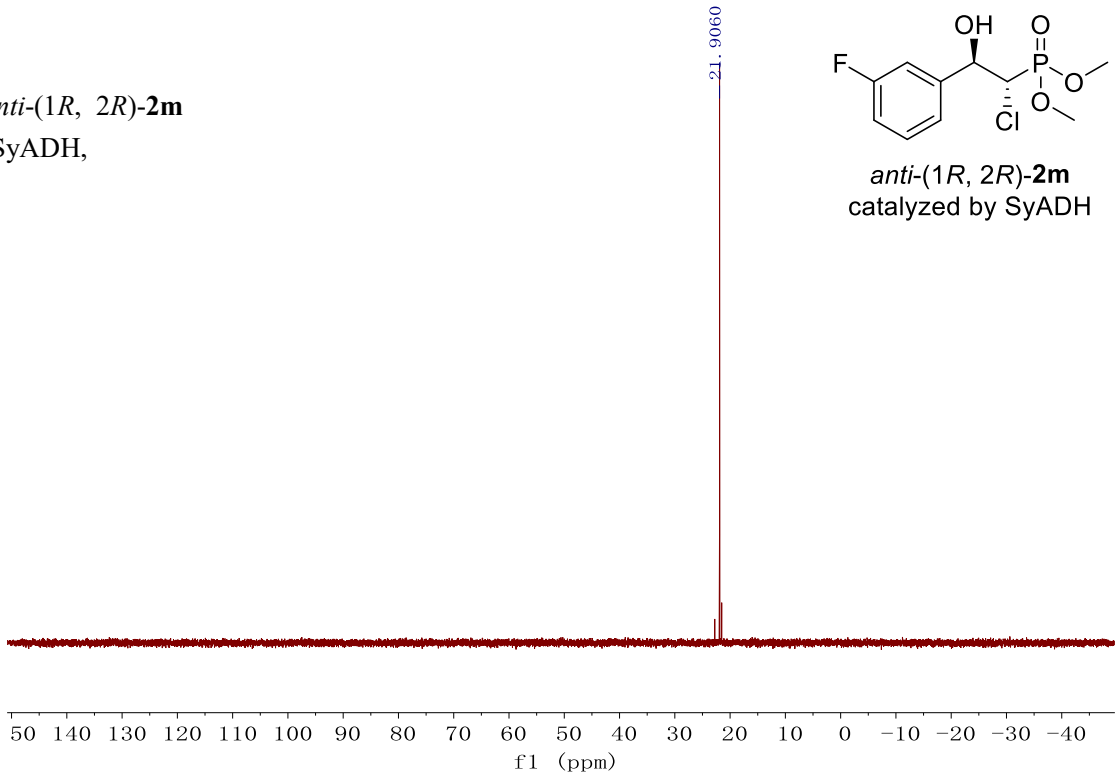
Compound *anti*-(1*R*, 2*R*)-**2m** catalyzed by SyADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2m** catalyzed by SyADH, ^{13}C NMR

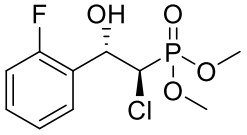


Compound *anti*-(1*R*, 2*R*)-**2m** catalyzed by SyADH, ^{31}P NMR



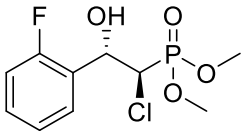
anti-(1*R*, 2*R*)-**2m** catalyzed by SyADH

Compound *anti*-(1*S*, 2*S*)-**2n**,
^{1}H NMR

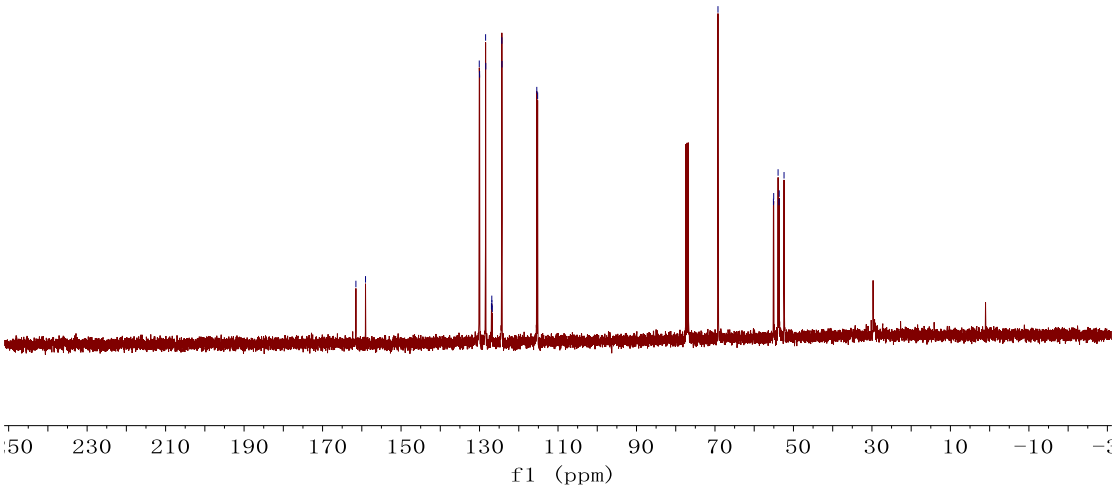


anti-(1*S*, 2*S*)-**2n**

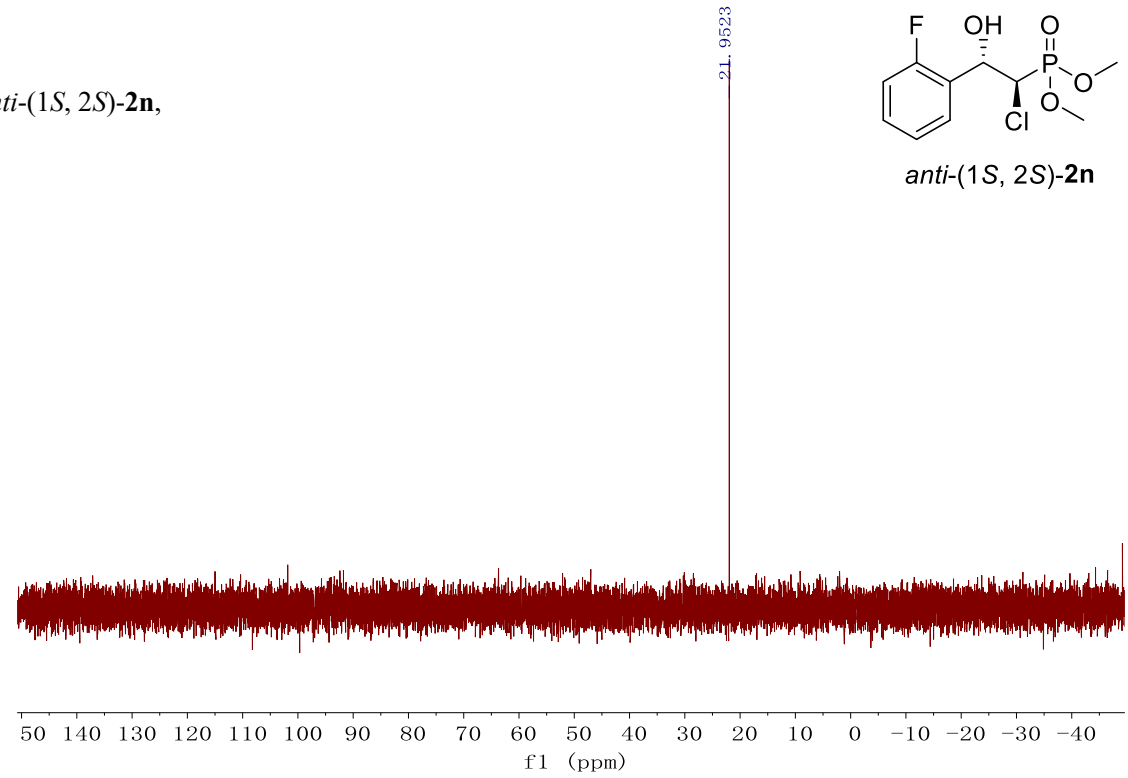
Compound *anti*-(1*S*, 2*S*)-**2n**,
^{13}C NMR



anti-(1*S*, 2*S*)-**2n**

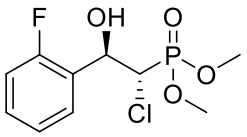


Compound *anti*-(1*S*, 2*S*)-**2n**,
^{31}P NMR

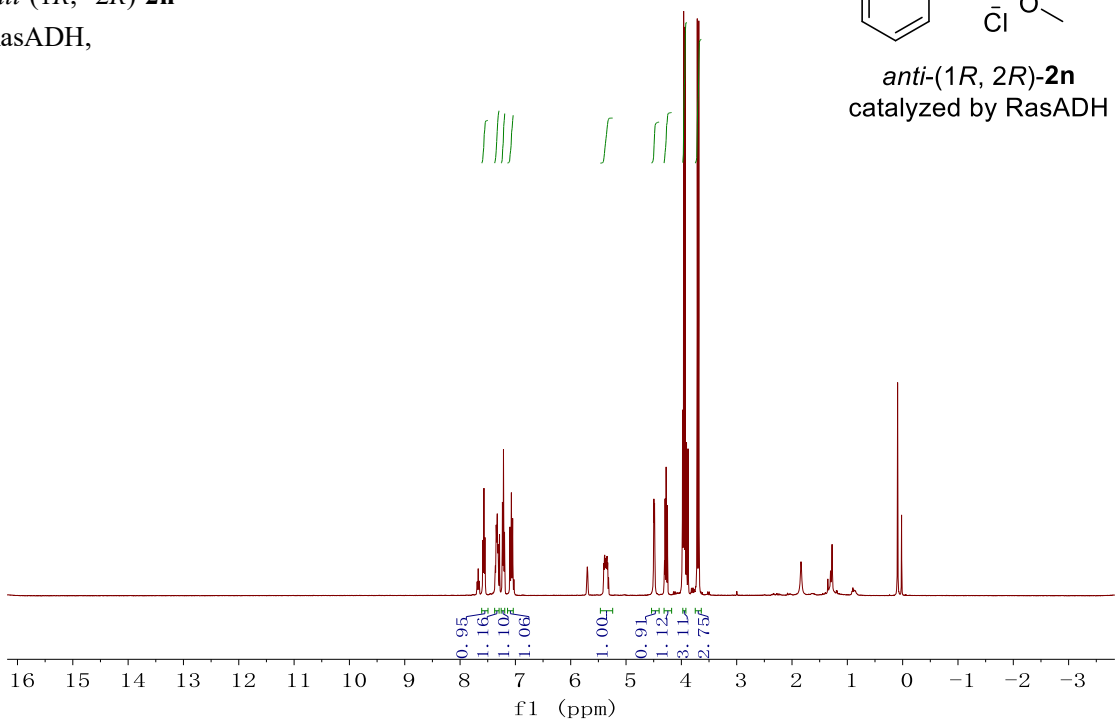


anti-(1*S*, 2*S*)-**2n**

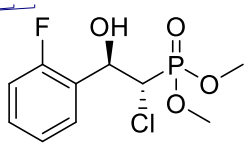
Compound *anti*-(1*R*, 2*R*)-**2n** catalyzed by RasADH, ^{1}H NMR



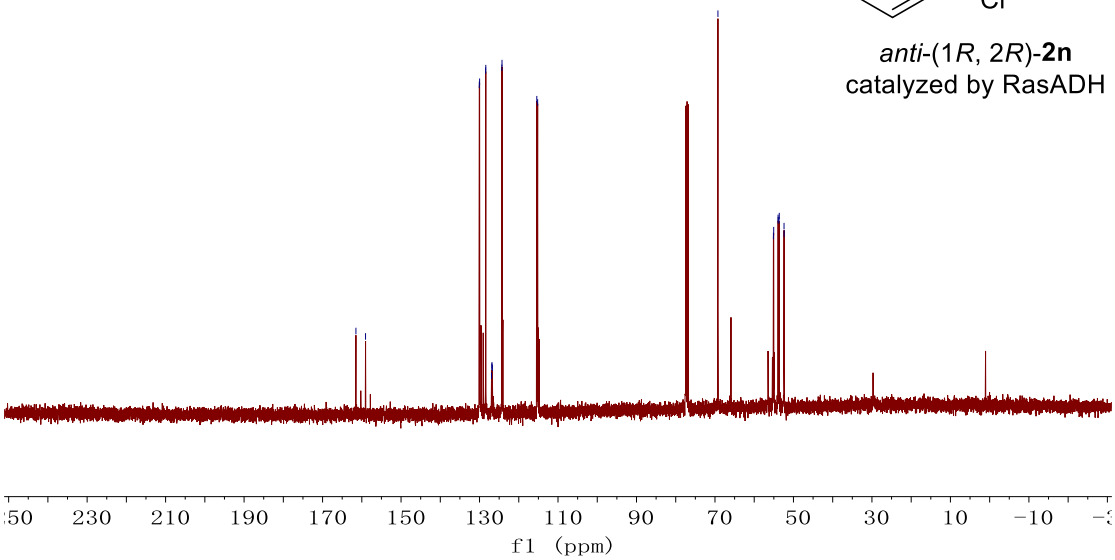
anti-(1*R*, 2*R*)-**2n** catalyzed by RasADH



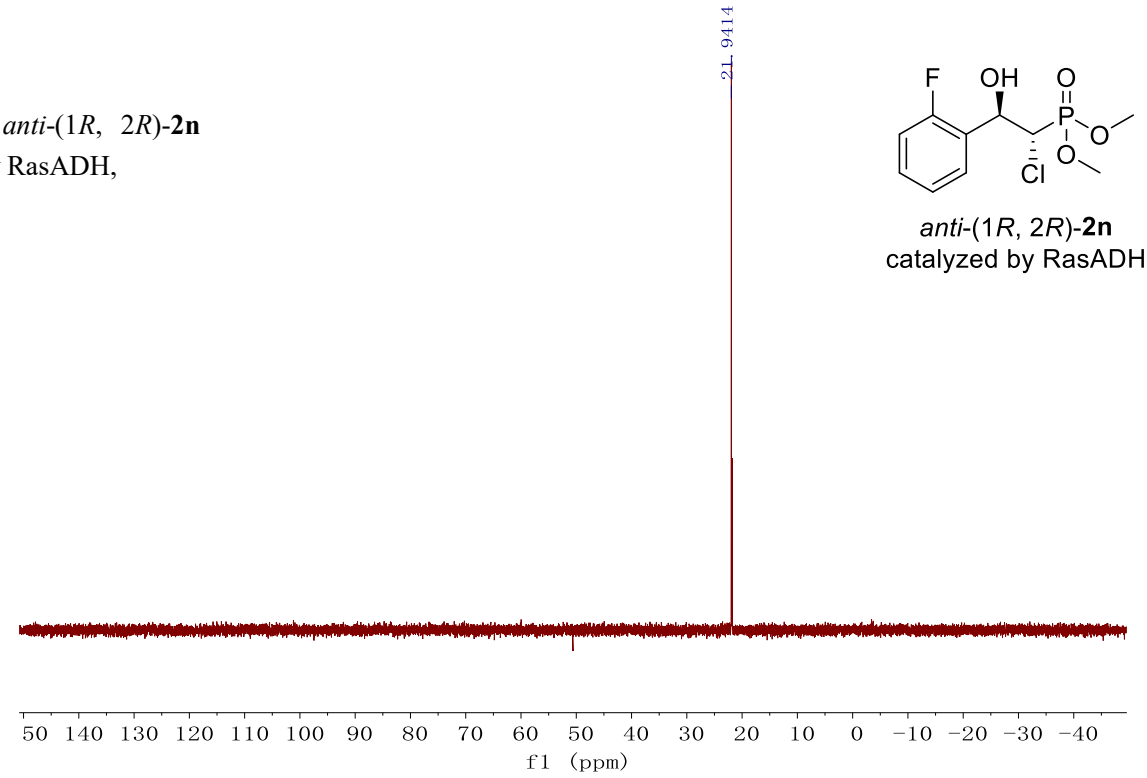
Compound *anti*-(1*R*, 2*R*)-**2n** catalyzed by RasADH, ^{13}C NMR



anti-(1*R*, 2*R*)-**2n** catalyzed by RasADH

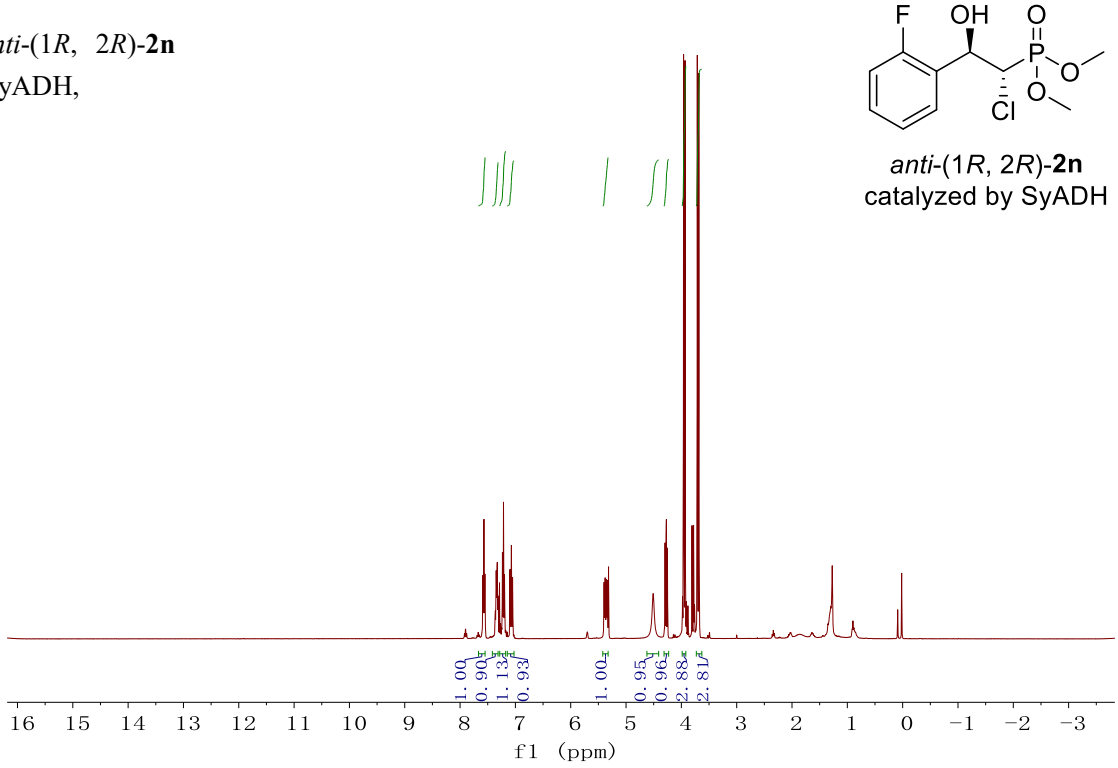


Compound *anti*-(1*R*, 2*R*)-**2n** catalyzed by RasADH, ^{31}P NMR

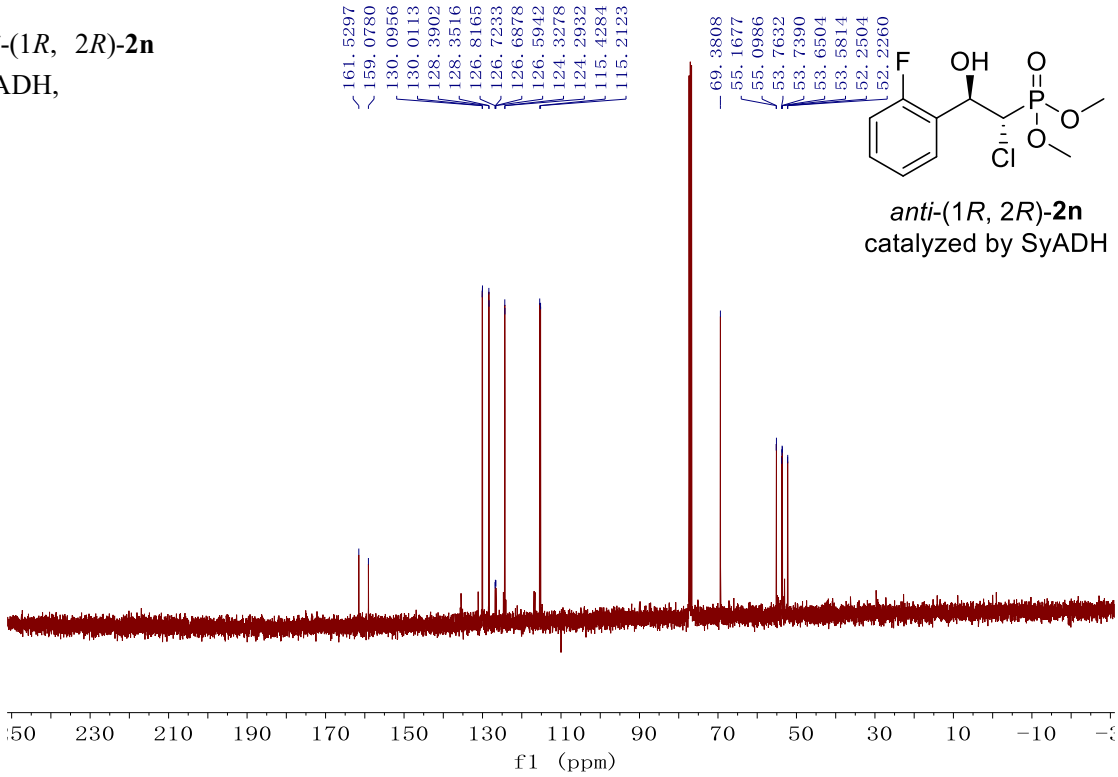


anti-(1*R*, 2*R*)-**2n** catalyzed by RasADH

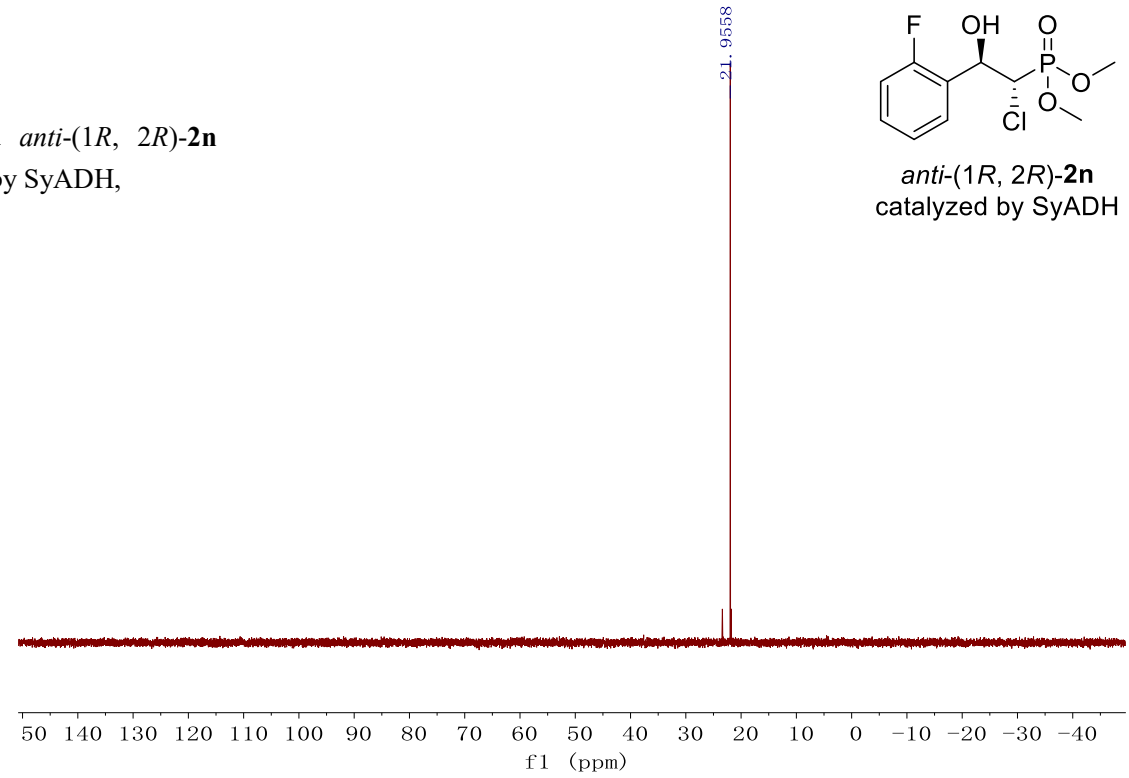
Compound *anti*-(1*R*, 2*R*)-**2n** catalyzed by SyADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2n** catalyzed by SyADH, ^{13}C NMR

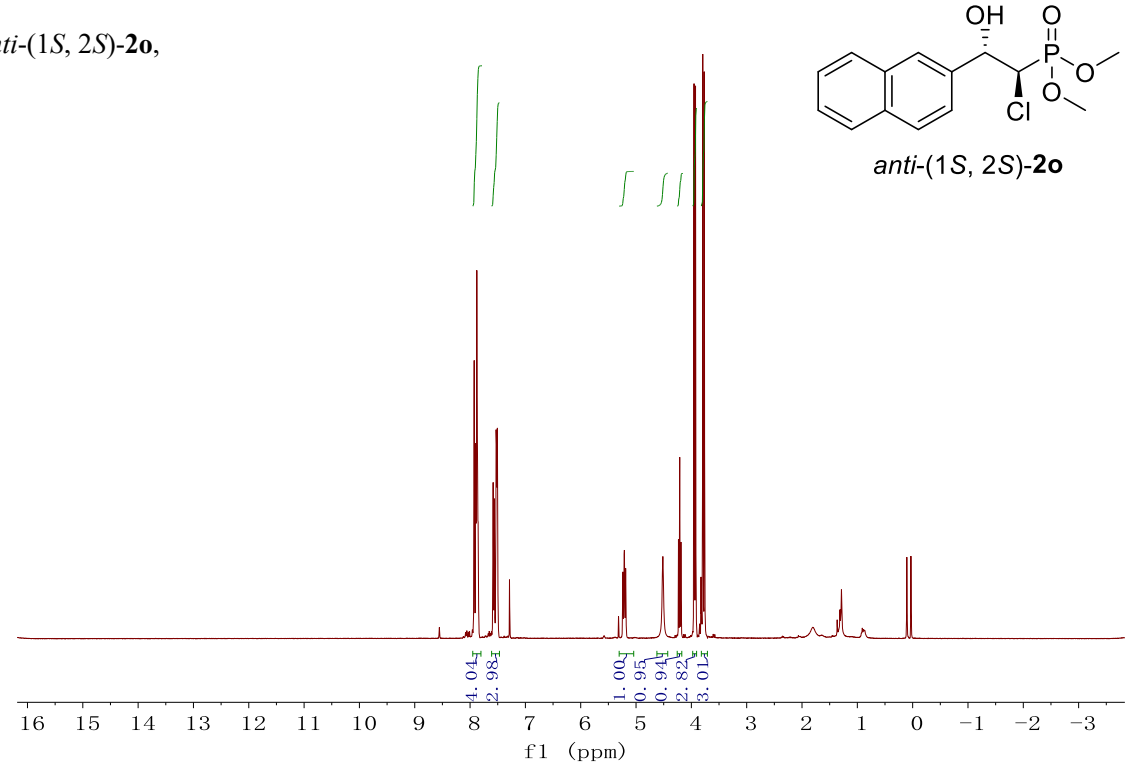


Compound *anti*-(1*R*, 2*R*)-**2n** catalyzed by SyADH, ^{31}P NMR

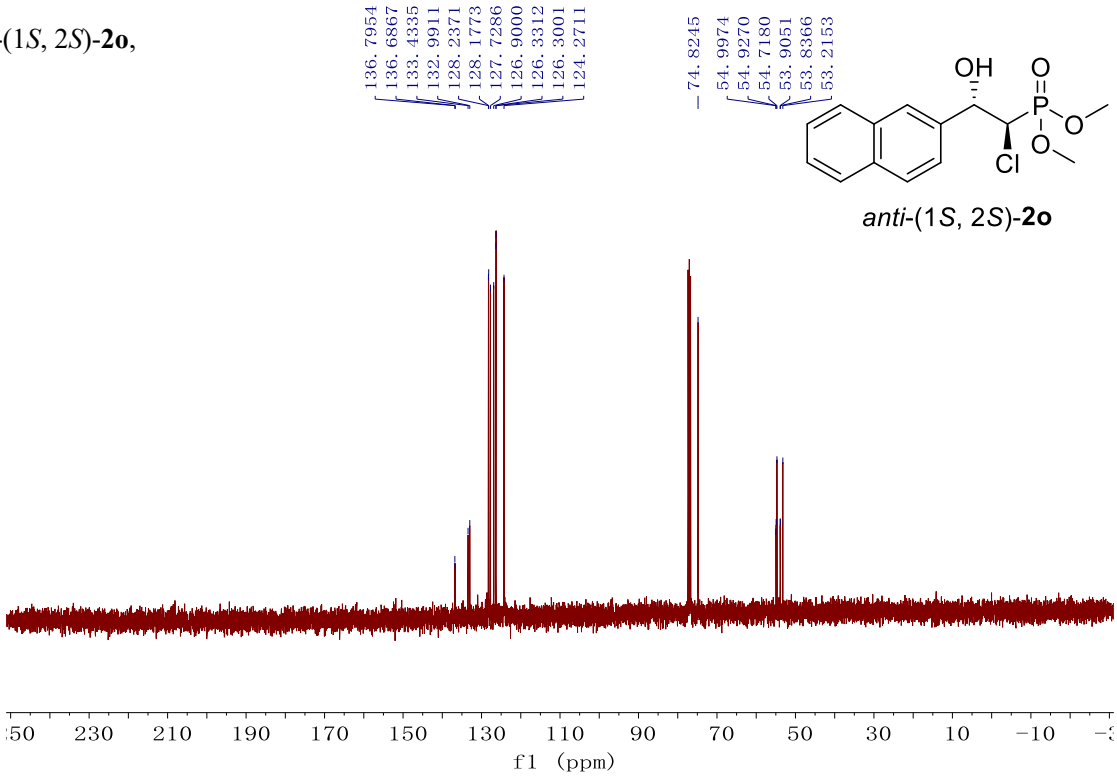


anti-(1*R*, 2*R*)-**2n** catalyzed by SyADH

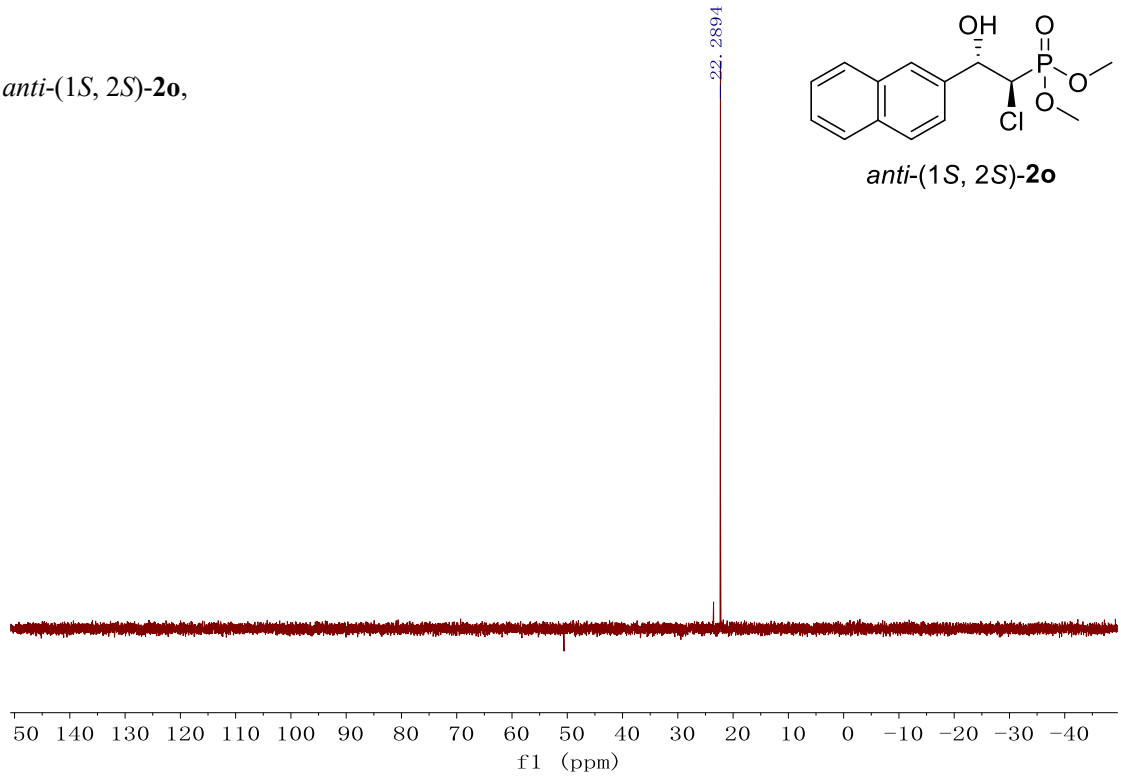
Compound *anti*-(1*S*, 2*S*)-**2o**,
^{1}H NMR



Compound *anti*-(1*S*, 2*S*)-**2o**,
^{13}C NMR

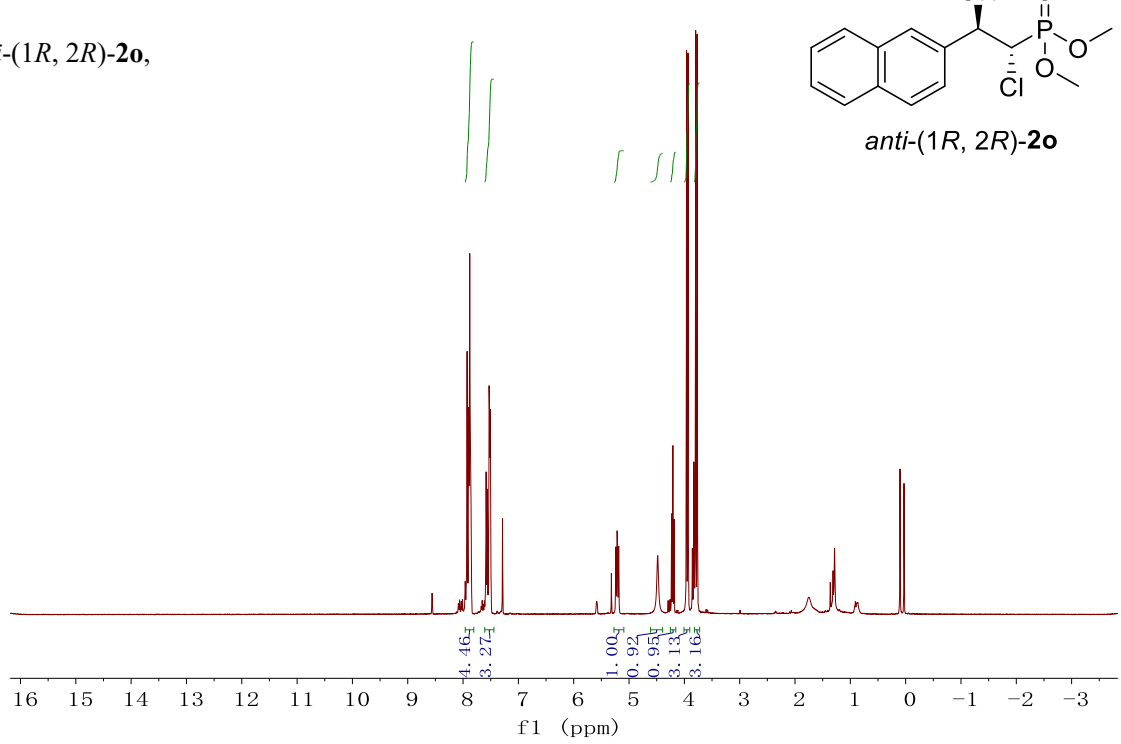


Compound *anti*-(1*S*, 2*S*)-**2o**,
^{31}P NMR

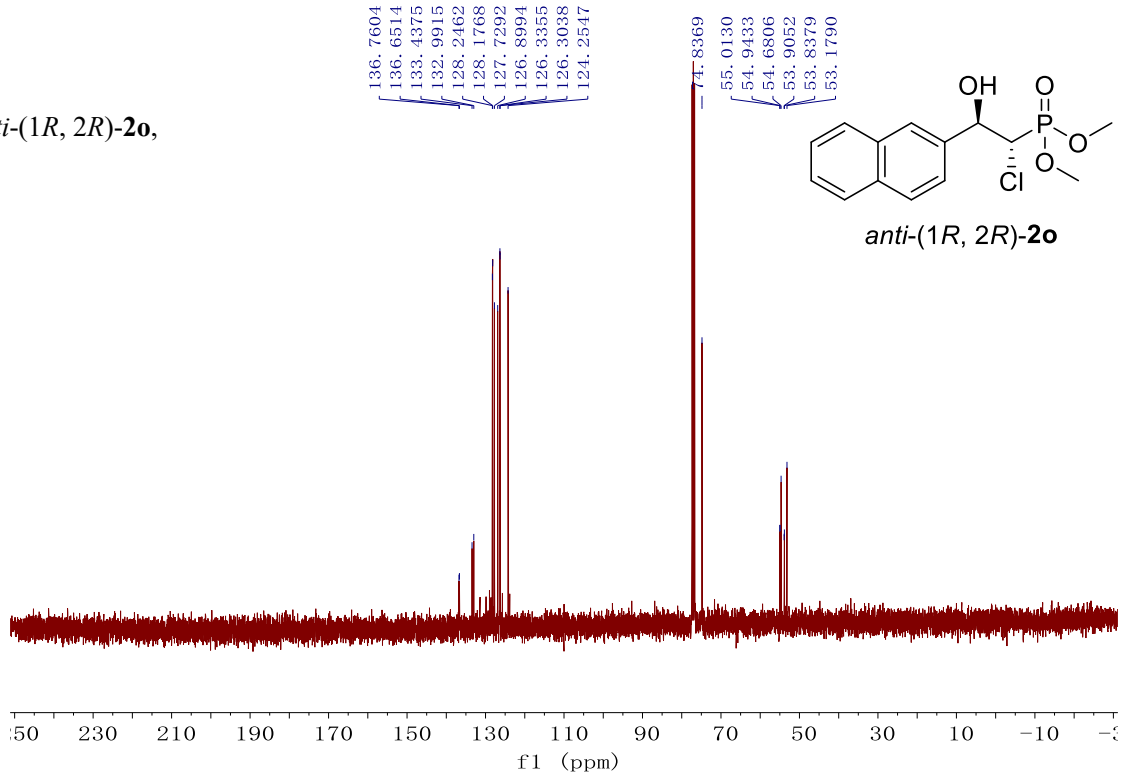


anti-(1*S*, 2*S*)-**2o**

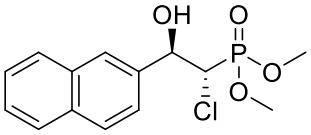
Compound *anti*-(1*R*, 2*R*)-**2o**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2o**,
^{13}C NMR

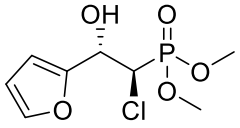


Compound *anti*-(1*R*, 2*R*)-**2o**,
^{31}P NMR

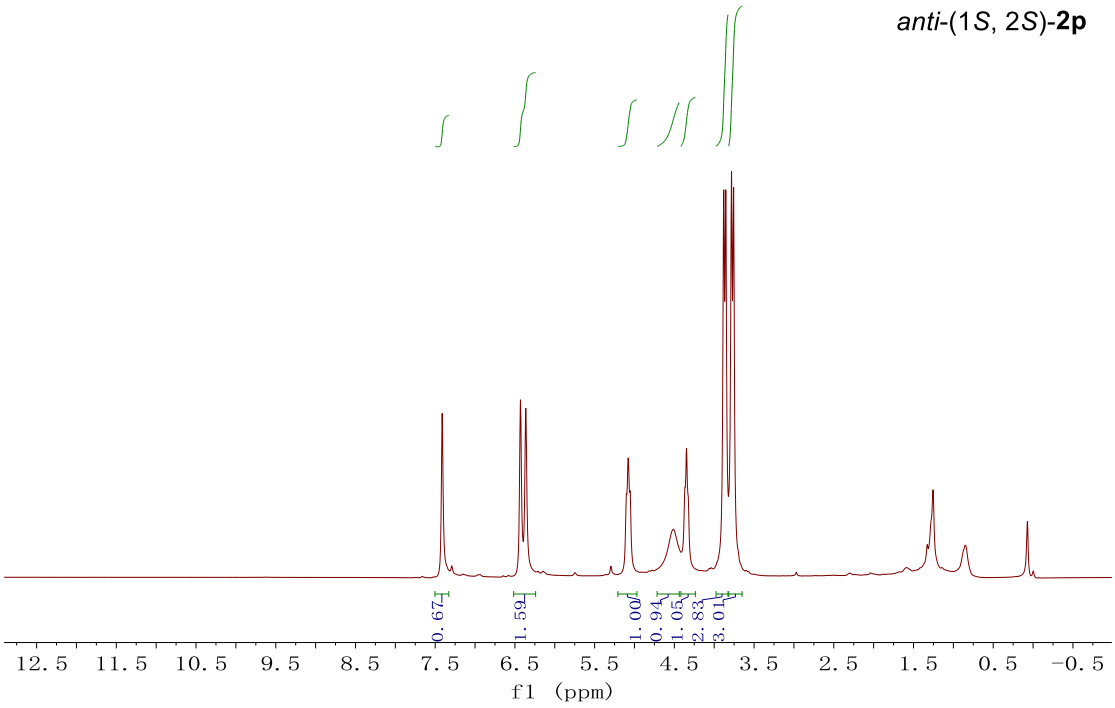


anti-(1*R*, 2*R*)-**2o**

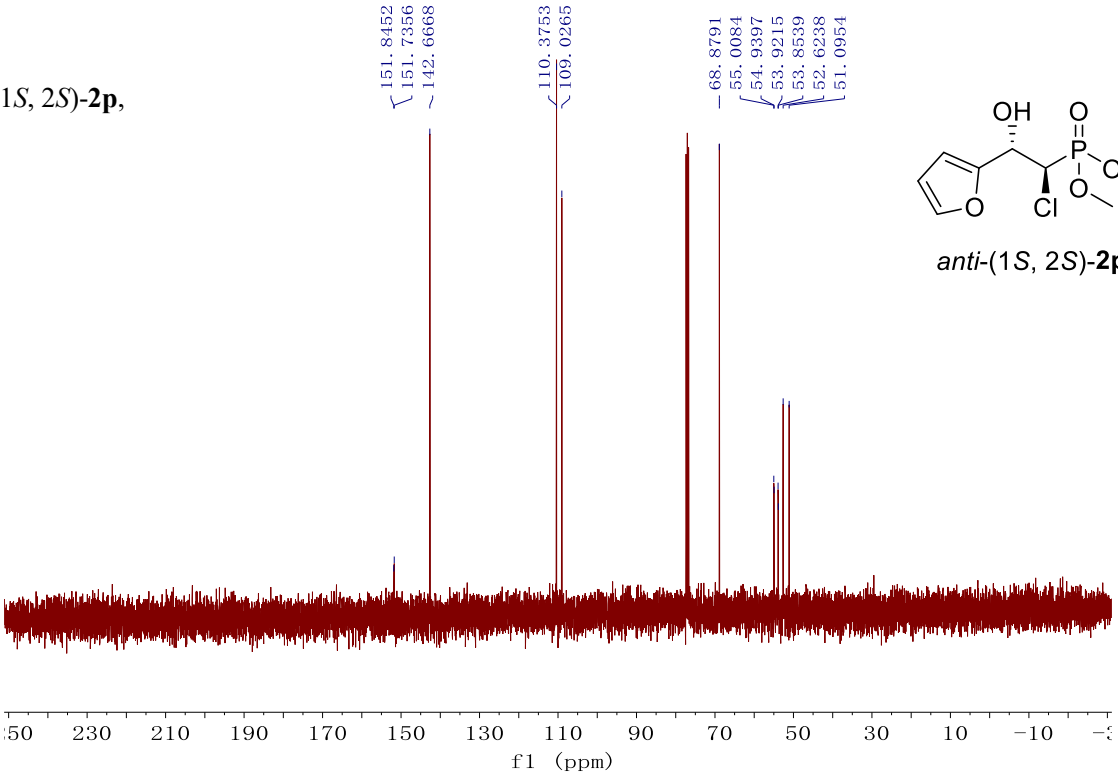
Compound *anti*-(1*S*, 2*S*)-**2p**,
^{1}H NMR



anti-(1*S*, 2*S*)-**2p**

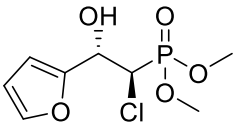


Compound *anti*-(1*S*, 2*S*)-**2p**,
^{13}C NMR

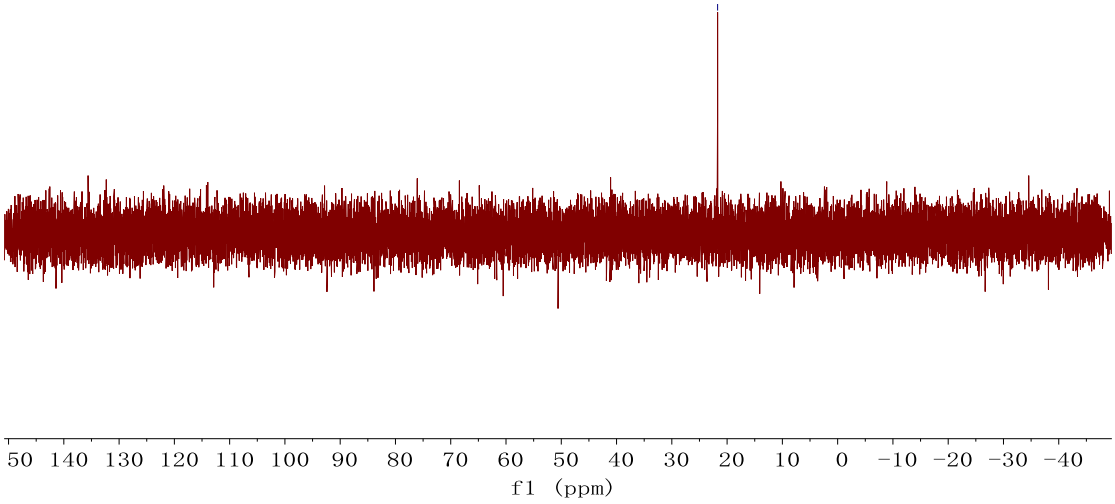


anti-(1*S*, 2*S*)-**2p**

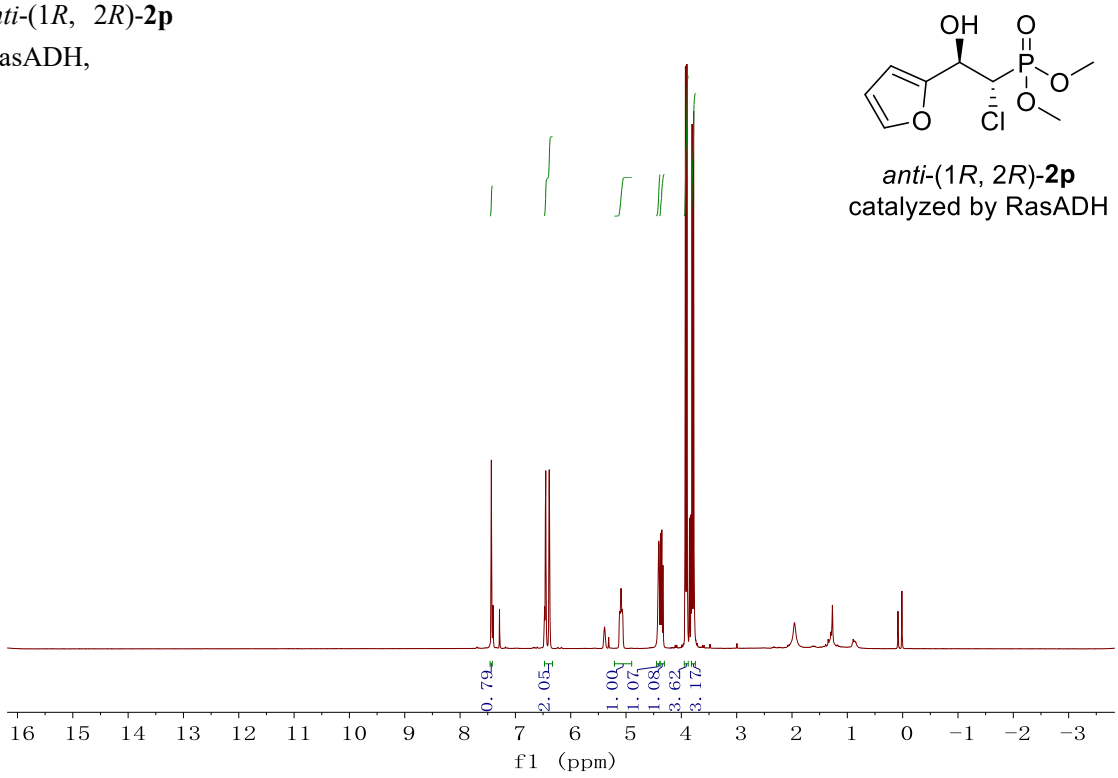
Compound *anti*-(1*S*, 2*S*)-**2p**,
^{31}P NMR



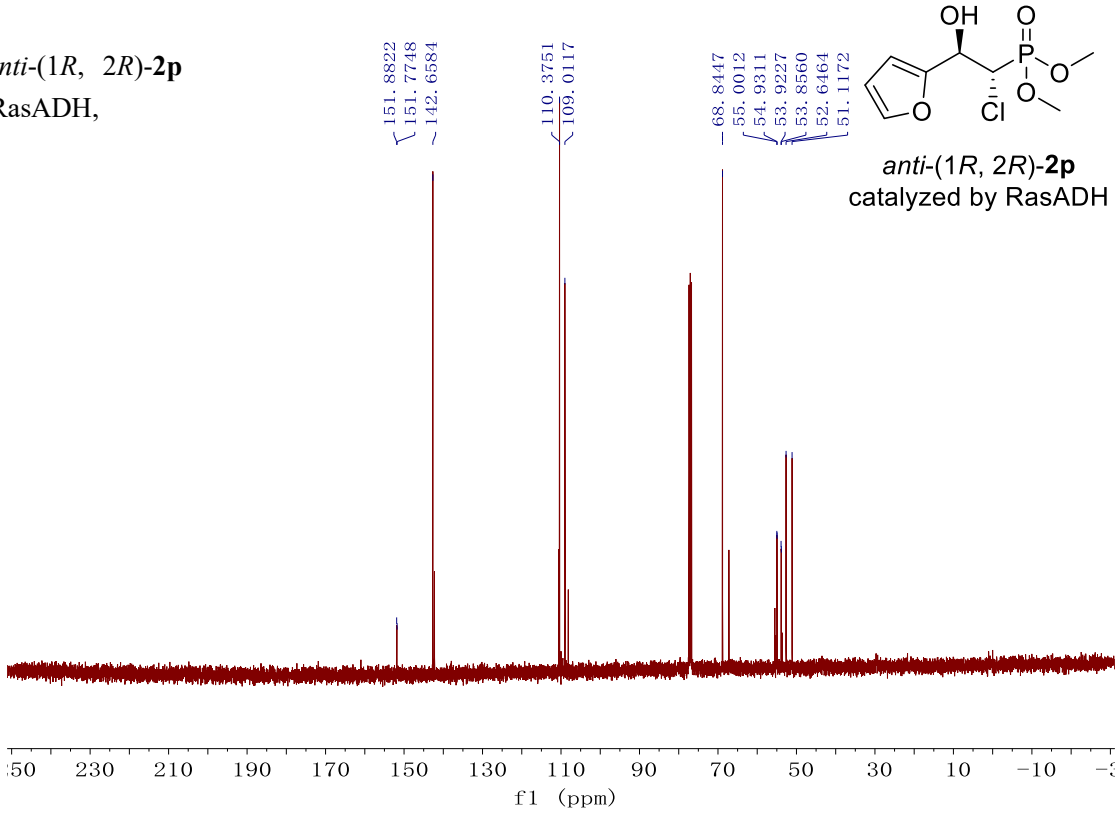
anti-(1*S*, 2*S*)-**2p**



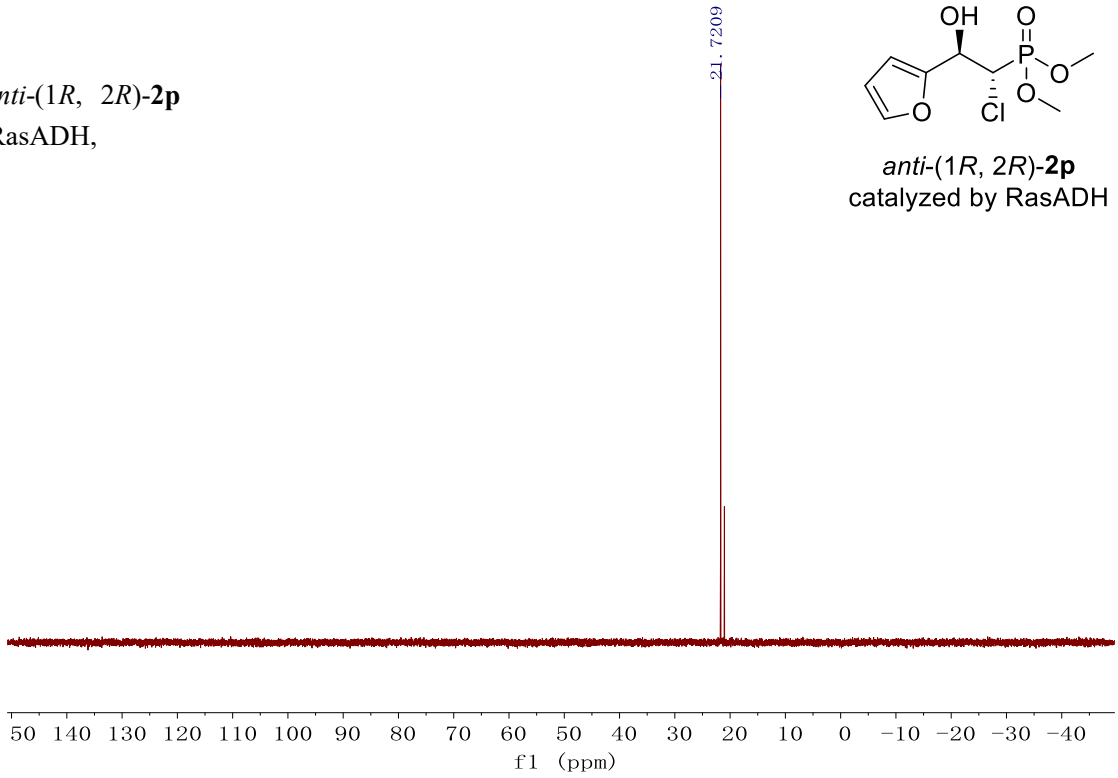
Compound *anti*-(1*R*, 2*R*)-**2p** catalyzed by RasADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2p** catalyzed by RasADH, ^{13}C NMR

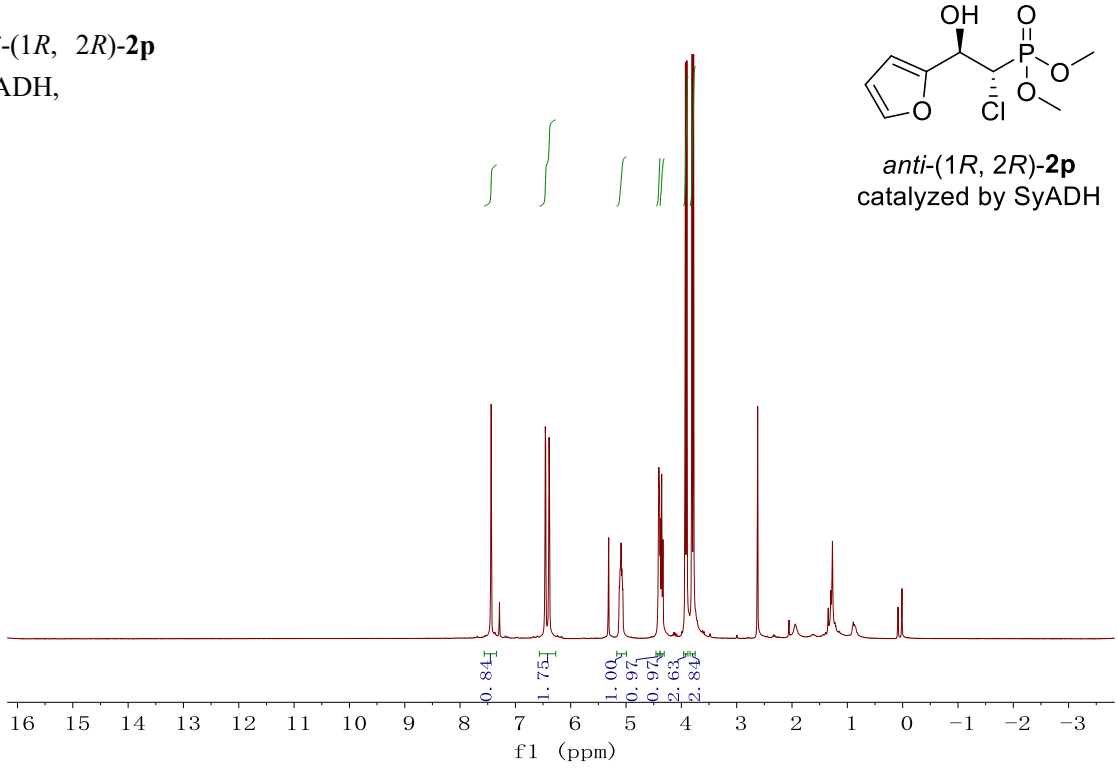


Compound *anti*-(1*R*, 2*R*)-**2p** catalyzed by RasADH, ^{31}P NMR

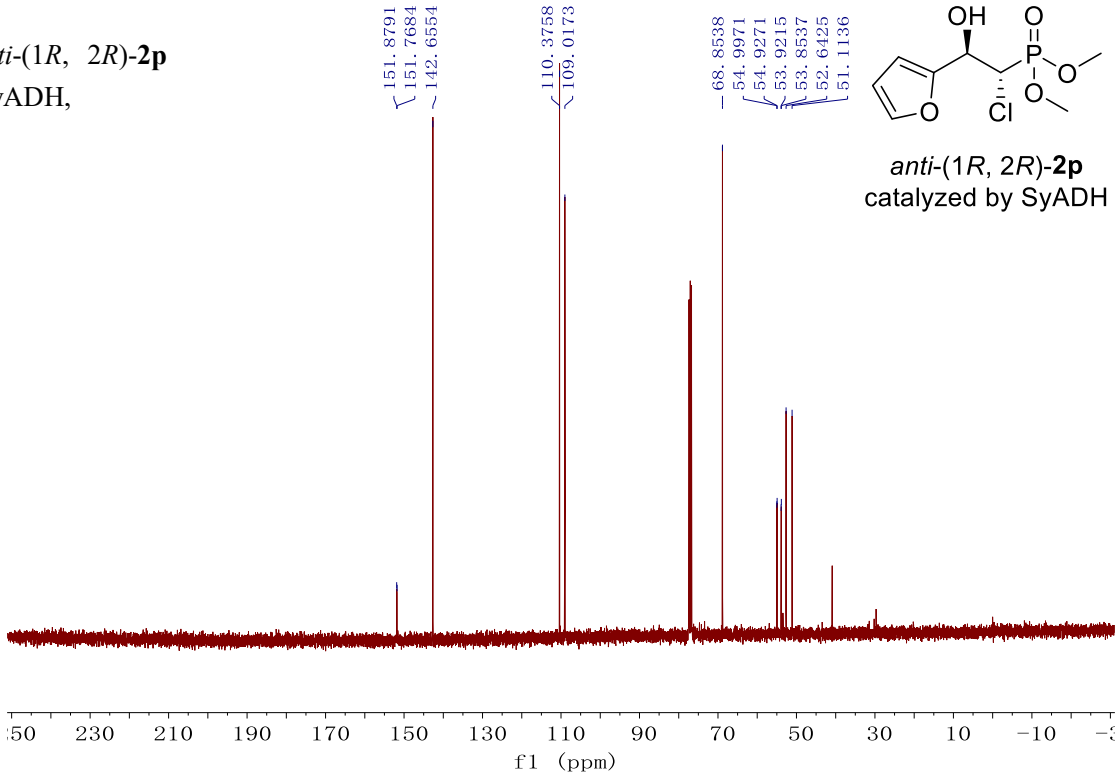


anti-(1*R*, 2*R*)-**2p** catalyzed by RasADH

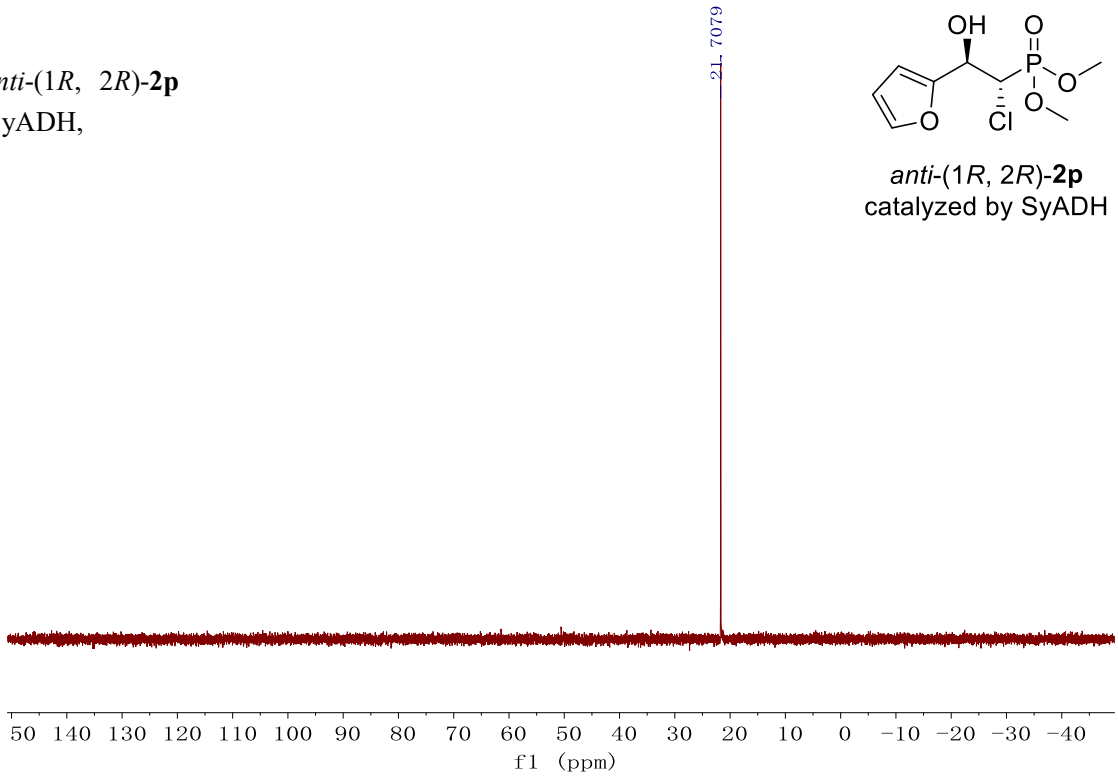
Compound *anti*-(1*R*, 2*R*)-**2p** catalyzed by SyADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2p** catalyzed by SyADH, ^{13}C NMR

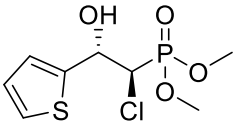


Compound *anti*-(1*R*, 2*R*)-**2p** catalyzed by SyADH, ^{31}P NMR



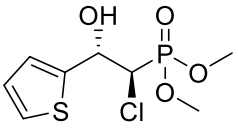
anti-(1*R*, 2*R*)-**2p**
catalyzed by SyADH

Compound *anti*-(1*S*, 2*S*)-**2q**,
^{1}H NMR



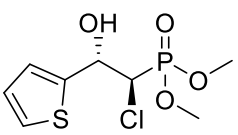
anti-(1*S*, 2*S*)-**2q**

Compound *anti*-(1*S*, 2*S*)-**2q**,
^{13}C NMR



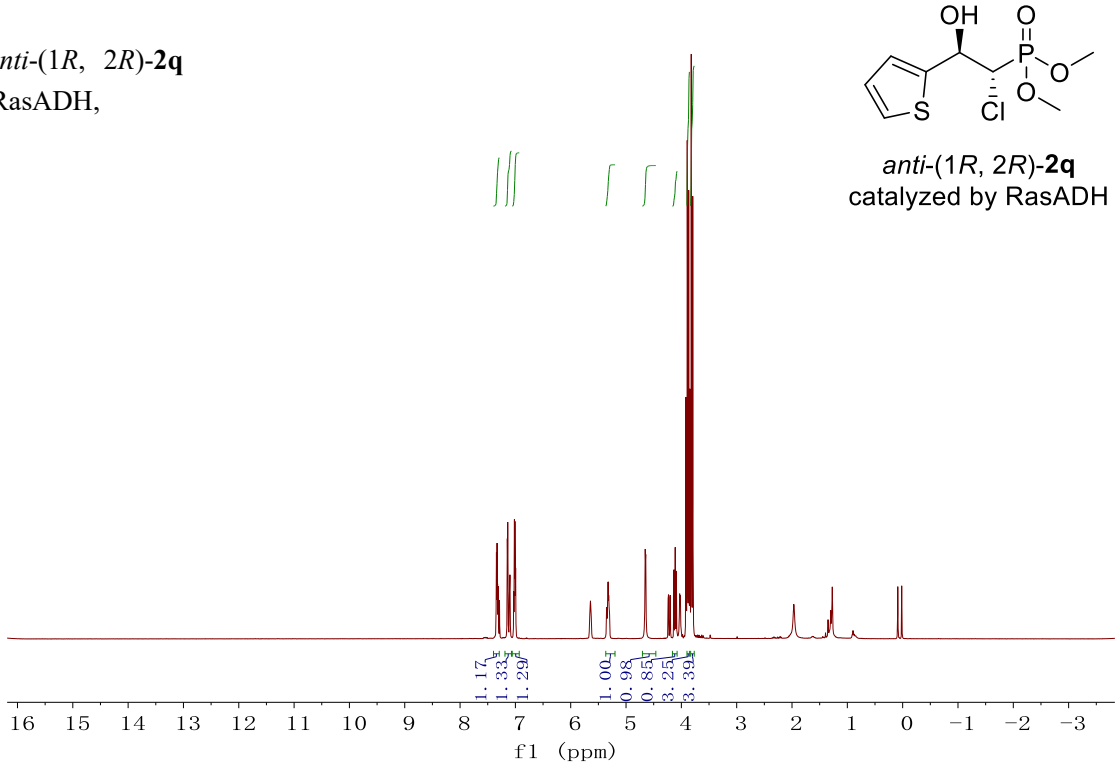
anti-(1*S*, 2*S*)-**2q**

Compound *anti*-(1*S*, 2*S*)-**2q**,
^{31}P NMR

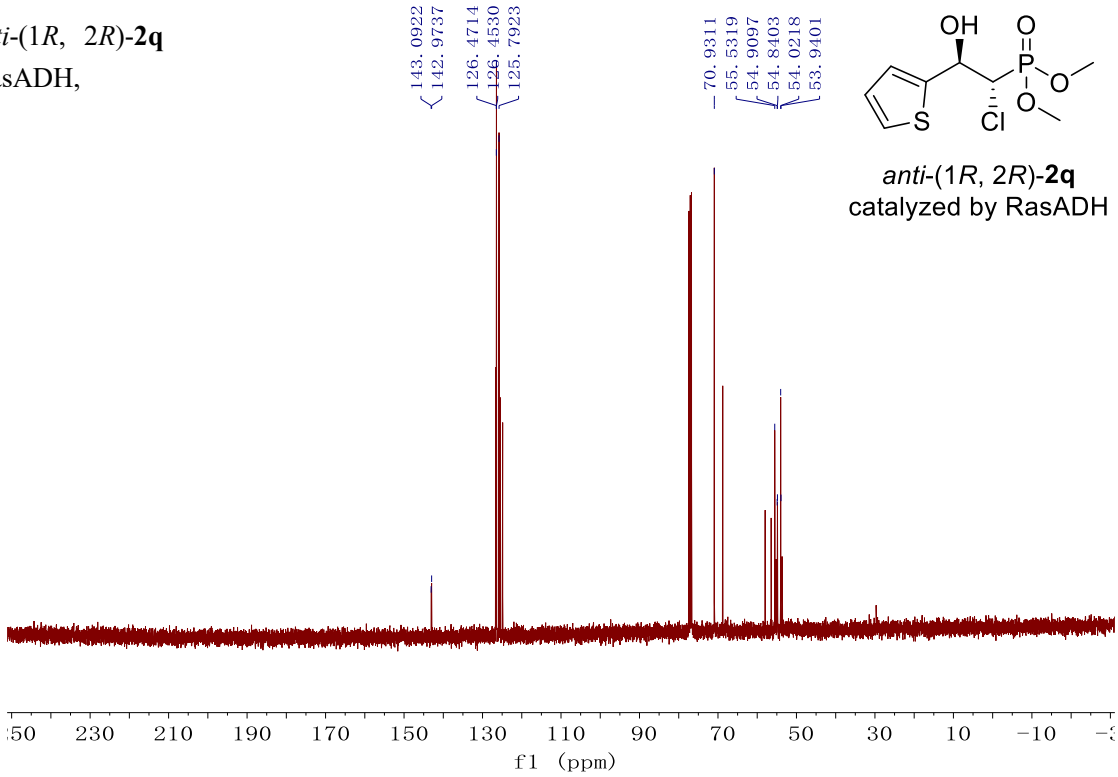


anti-(1*S*, 2*S*)-**2q**

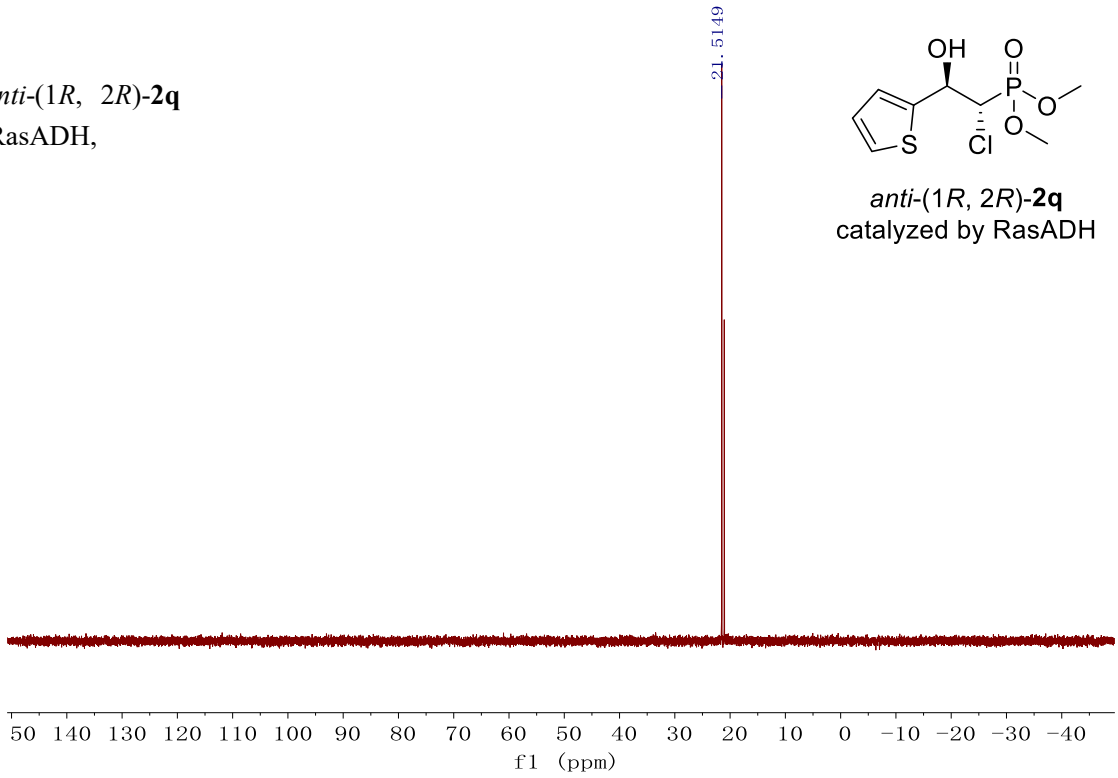
Compound *anti*-(1*R*, 2*R*)-**2q** catalyzed by RasADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2q** catalyzed by RasADH, ^{13}C NMR

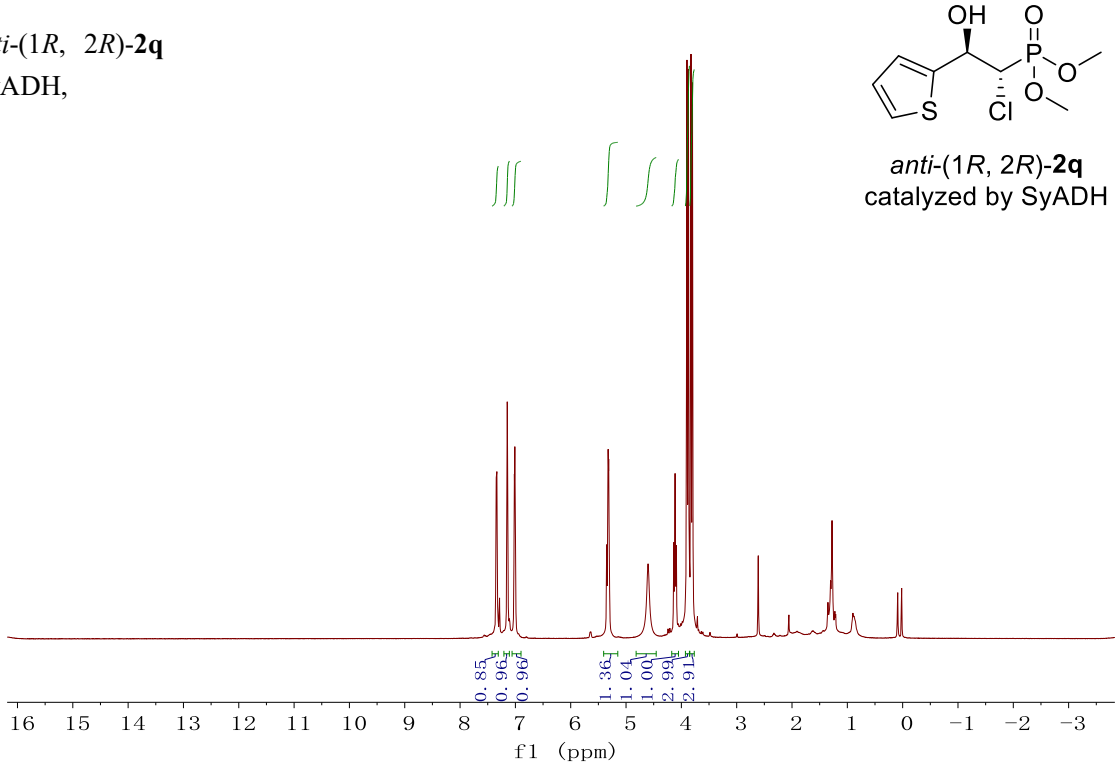


Compound *anti*-(1*R*, 2*R*)-**2q** catalyzed by RasADH, ^{31}P NMR

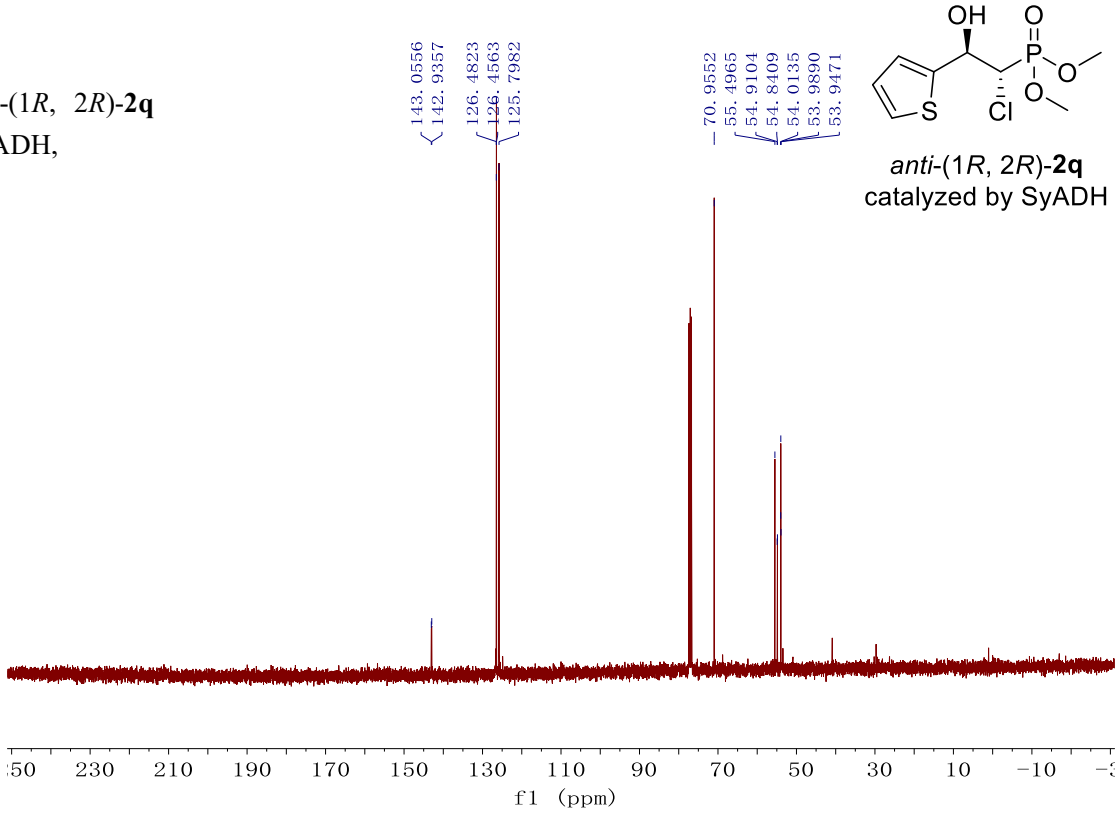


anti-(1*R*, 2*R*)-**2q**
catalyzed by RasADH

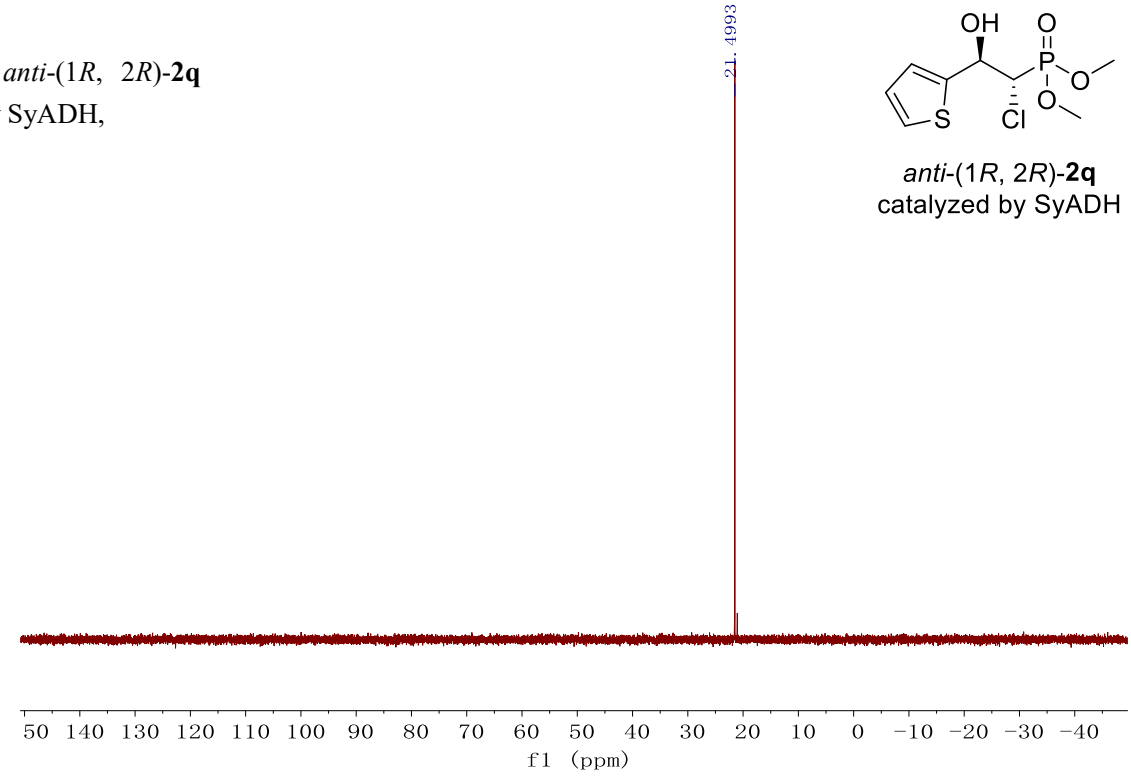
Compound *anti*-(1*R*, 2*R*)-**2q** catalyzed by SyADH, ^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2q** catalyzed by SyADH, ^{13}C NMR

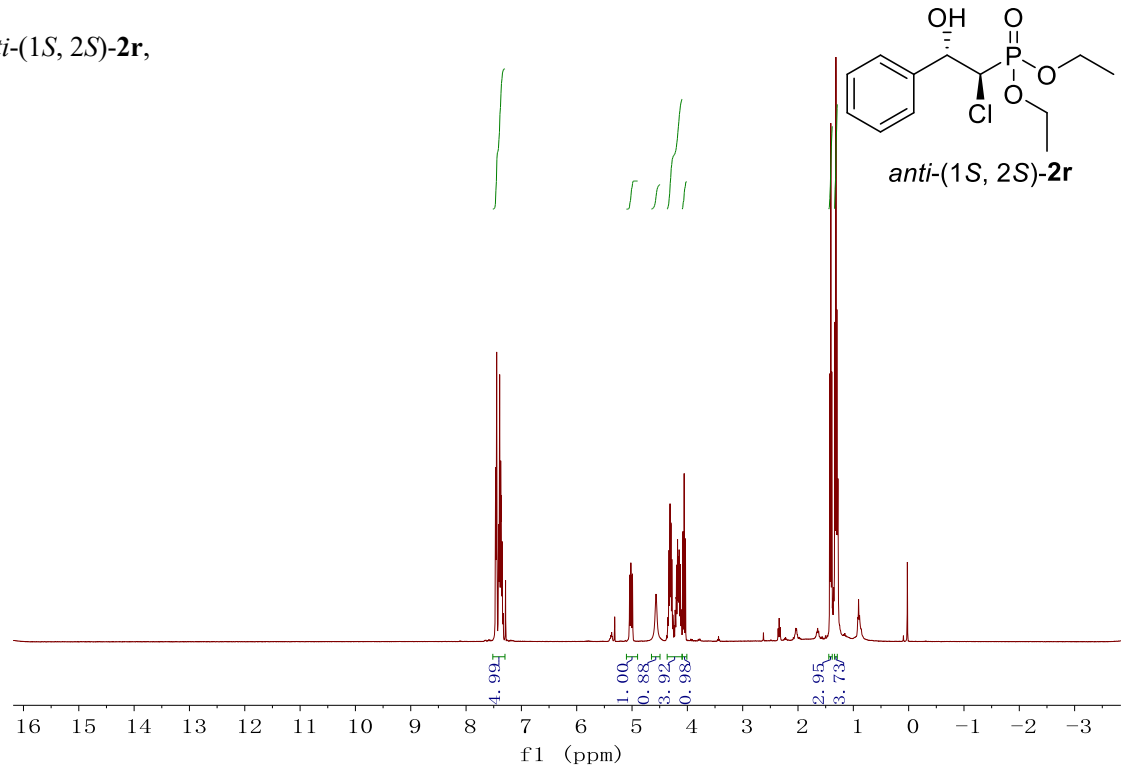


Compound *anti*-(1*R*, 2*R*)-**2q** catalyzed by SyADH, ^{31}P NMR

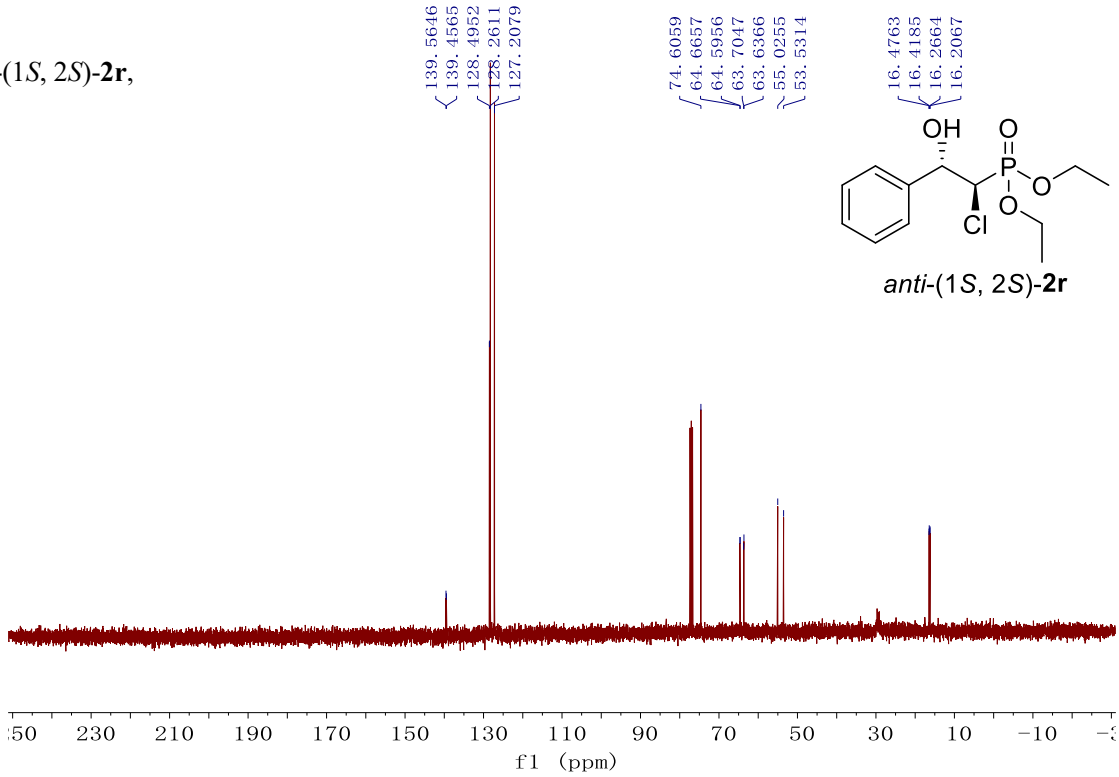


anti-(1*R*, 2*R*)-**2q** catalyzed by SyADH

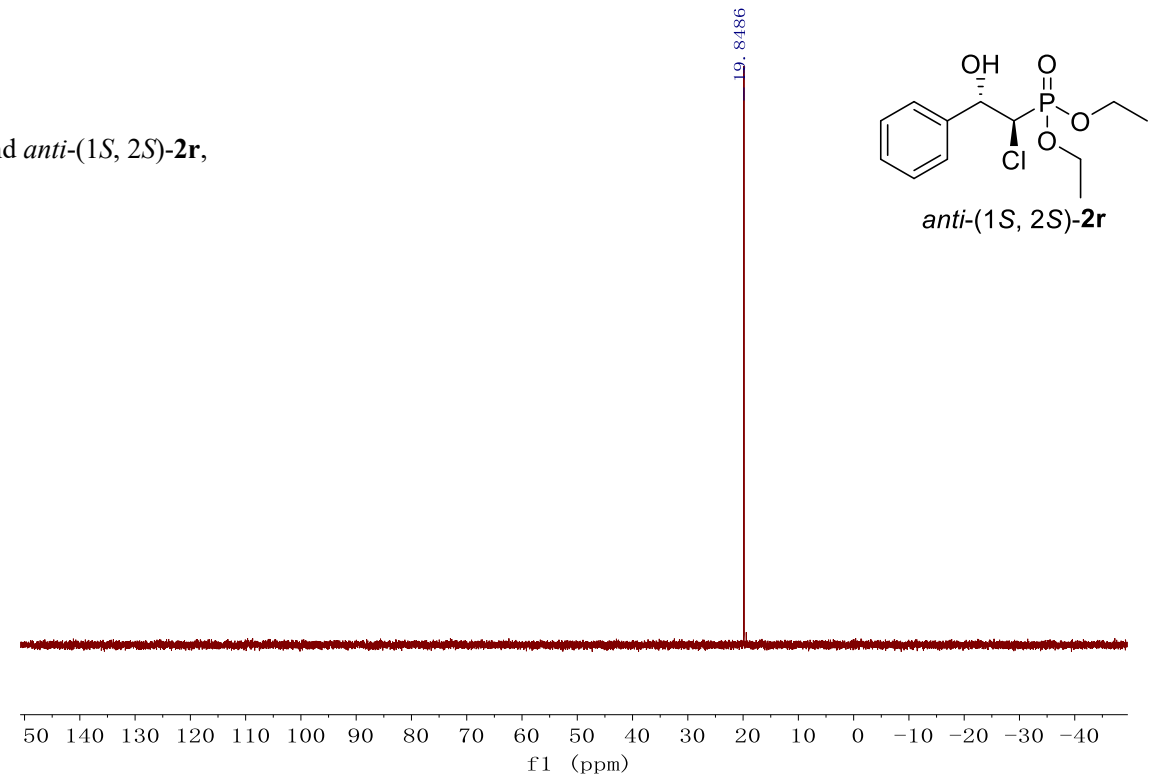
Compound *anti*-(1*S*, 2*S*)-**2r**,
^{1}H NMR



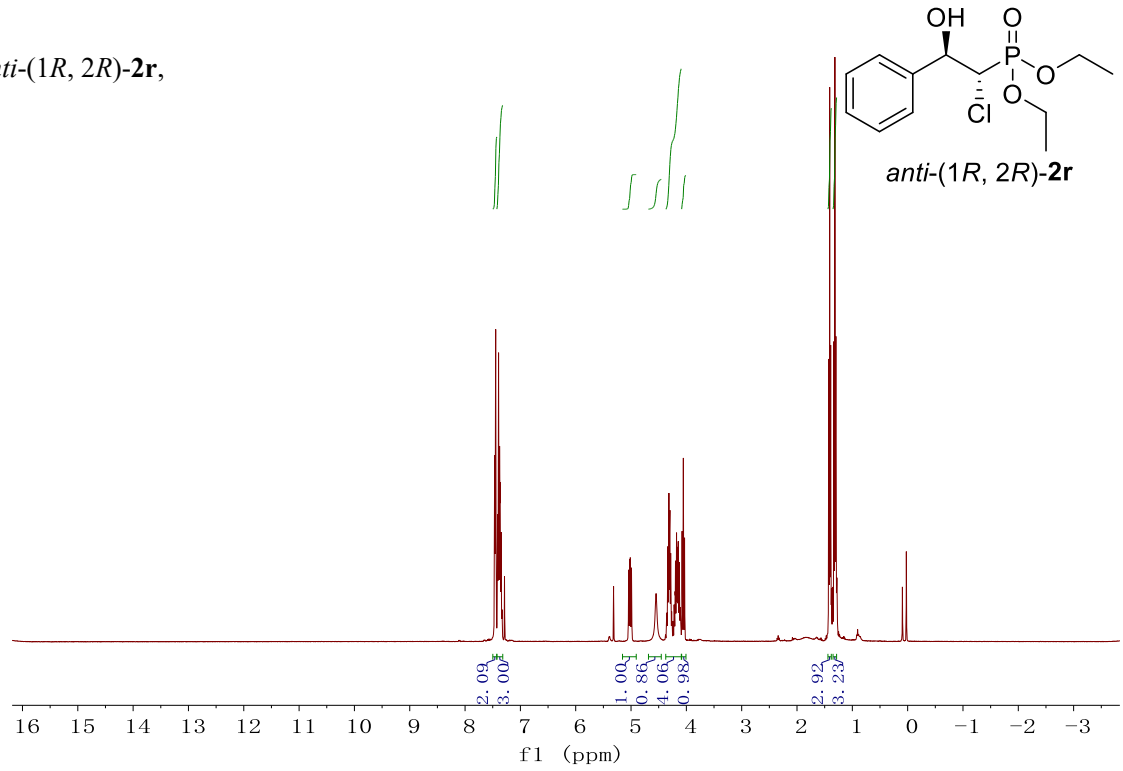
Compound *anti*-(1*S*, 2*S*)-**2r**,
^{13}C NMR



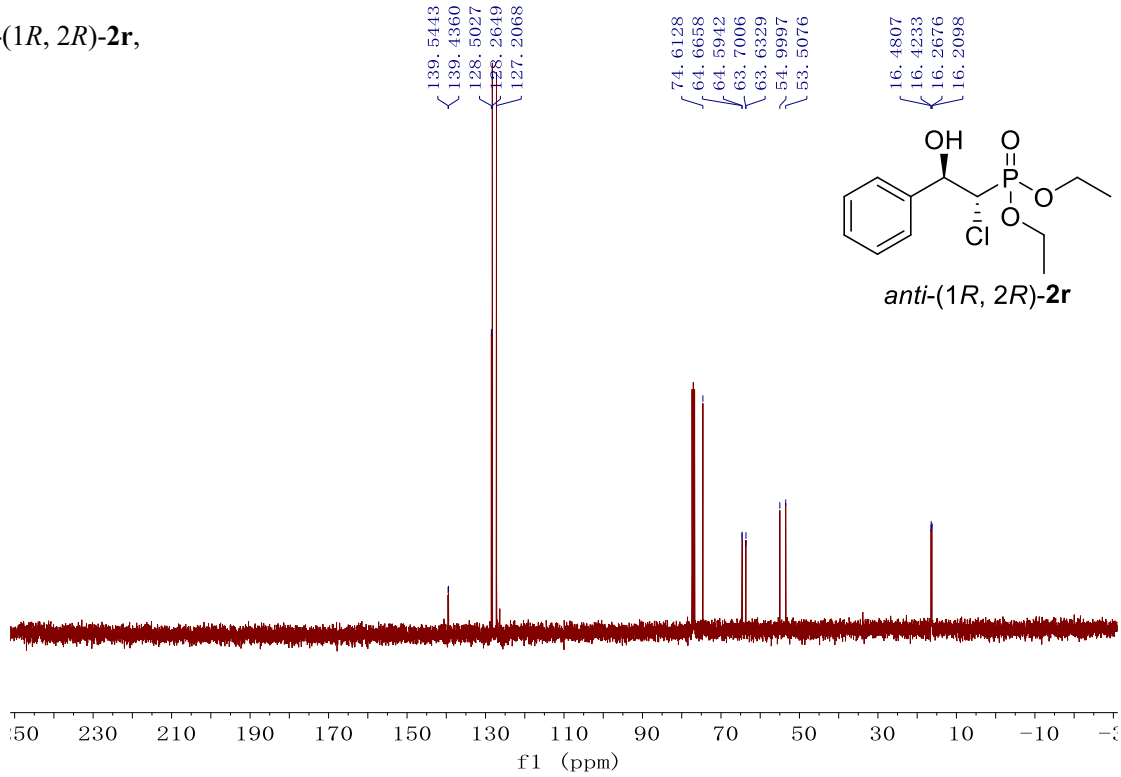
Compound *anti*-(1*S*, 2*S*)-**2r**,
^{31}P NMR



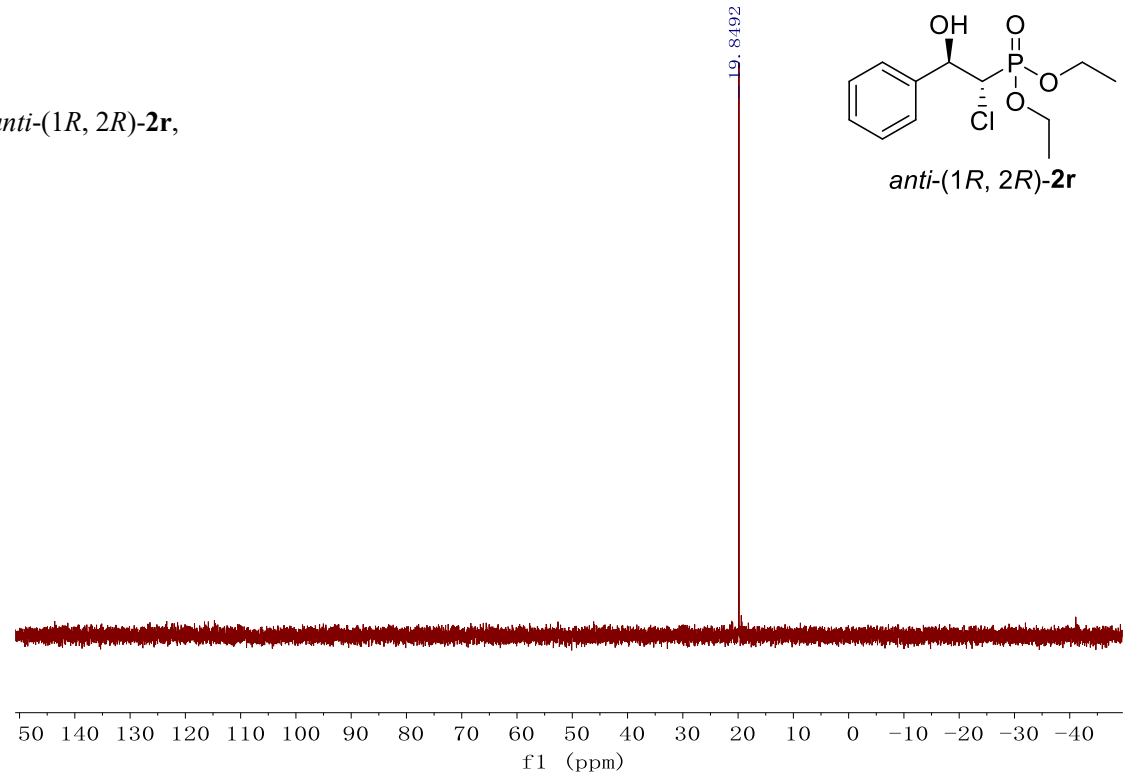
Compound *anti*-(1*R*, 2*R*)-**2r**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2r**,
^{13}C NMR

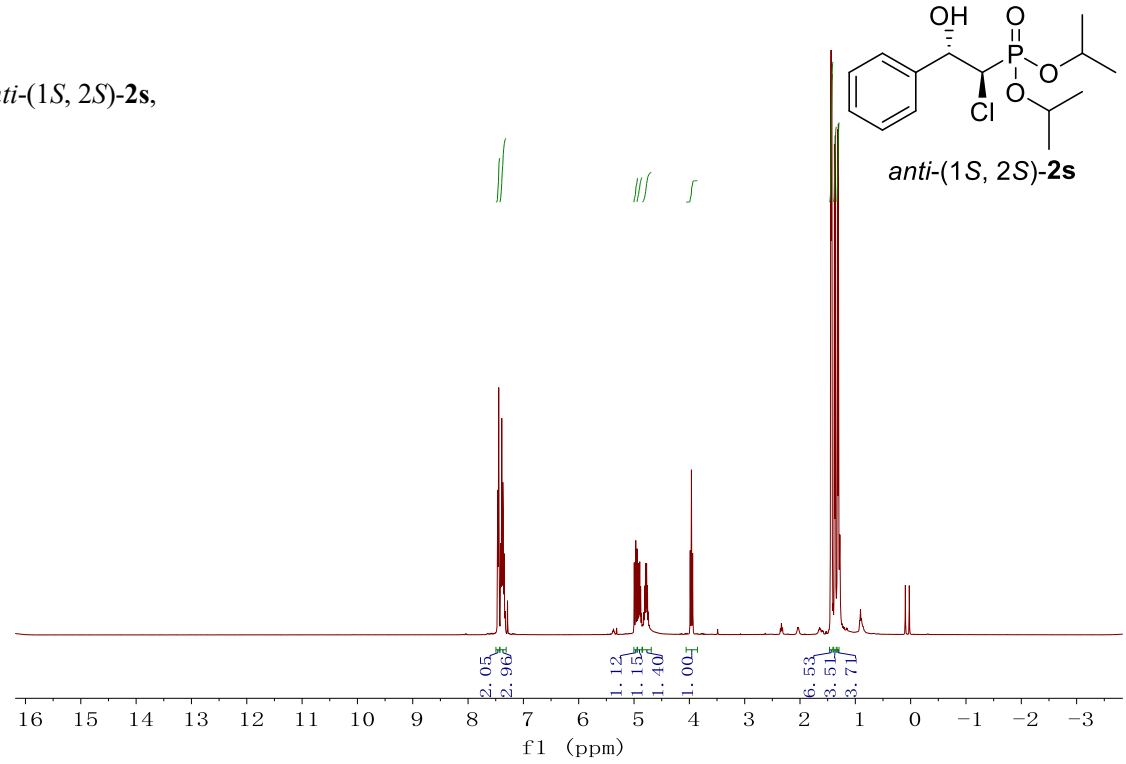


Compound *anti*-(1*R*, 2*R*)-**2r**,
^{31}P NMR

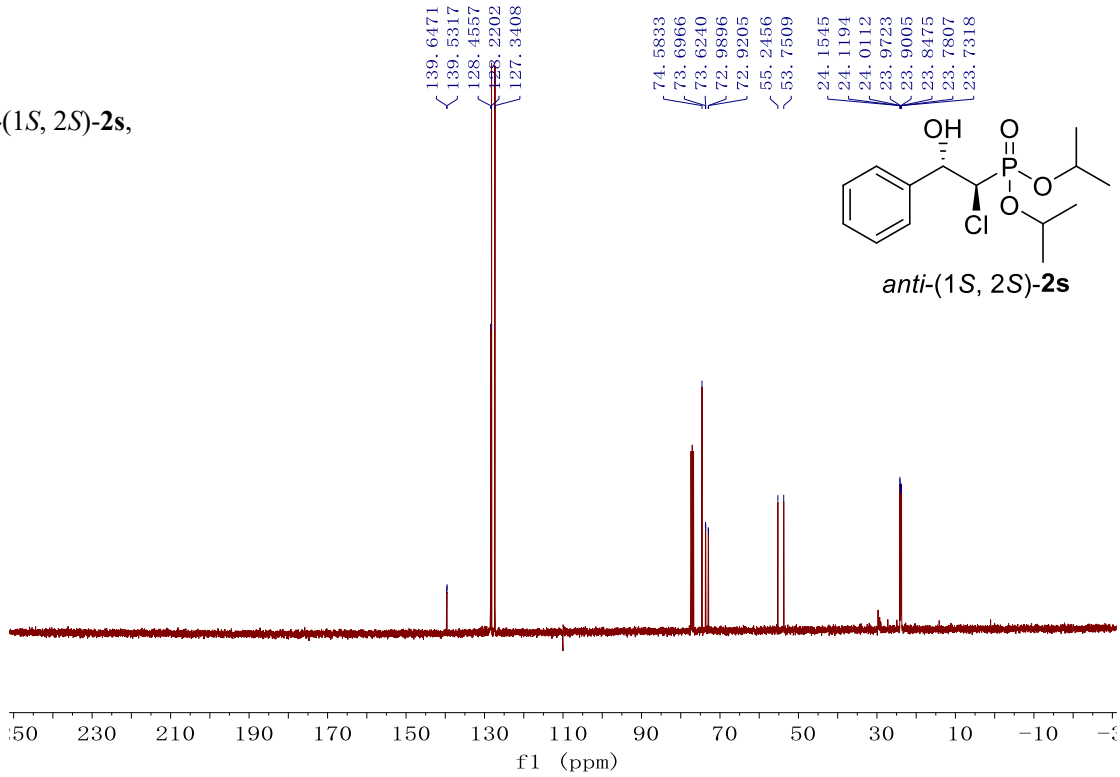


anti-(1*R*, 2*R*)-**2r**

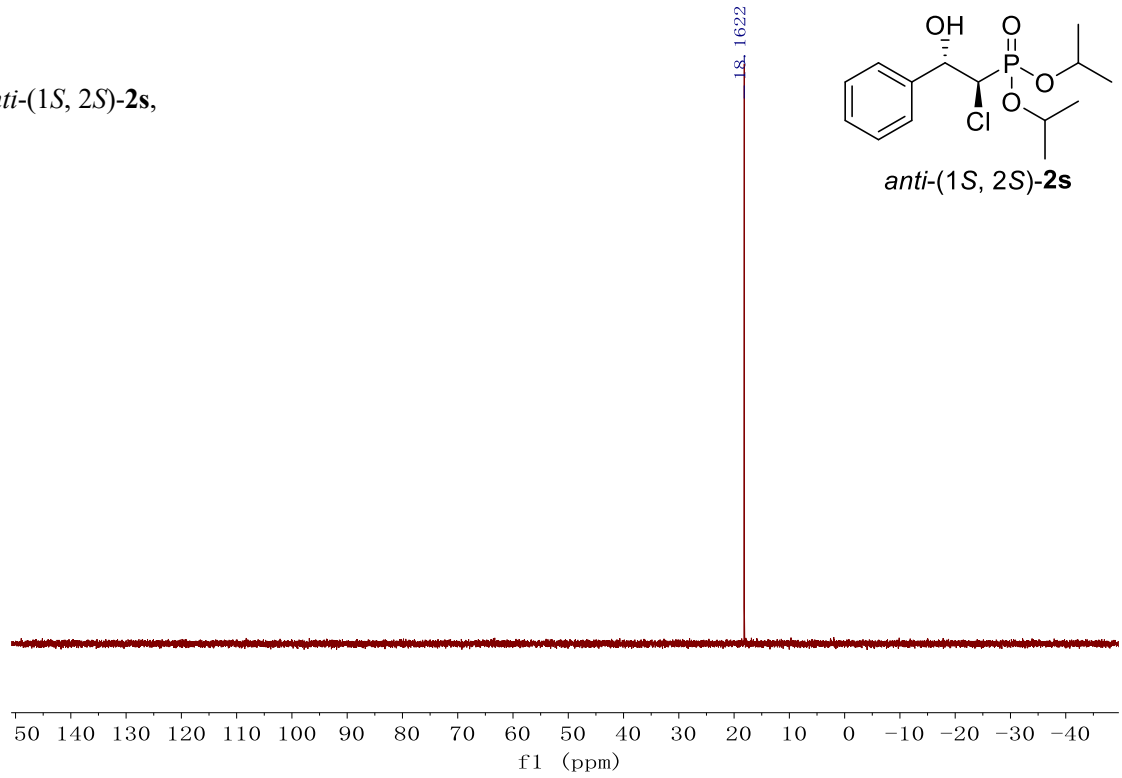
Compound *anti*-(1*S*, 2*S*)-**2s**,
^{1}H NMR



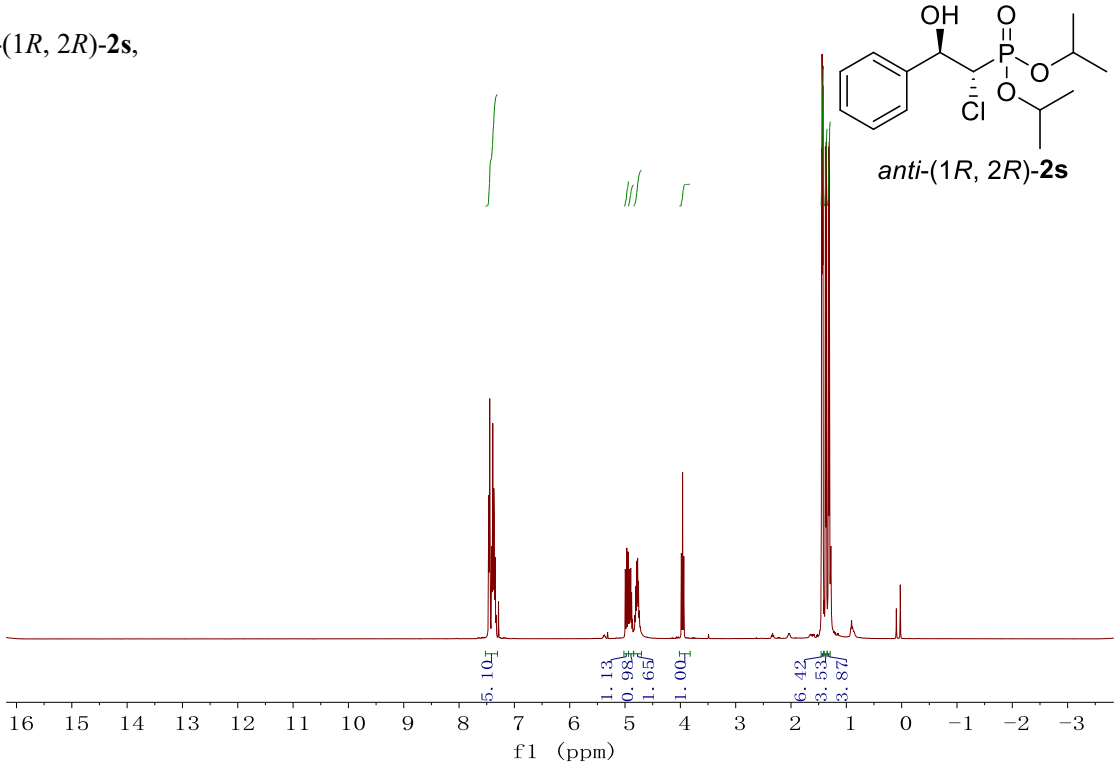
Compound *anti*-(1*S*, 2*S*)-**2s**,
^{13}C NMR



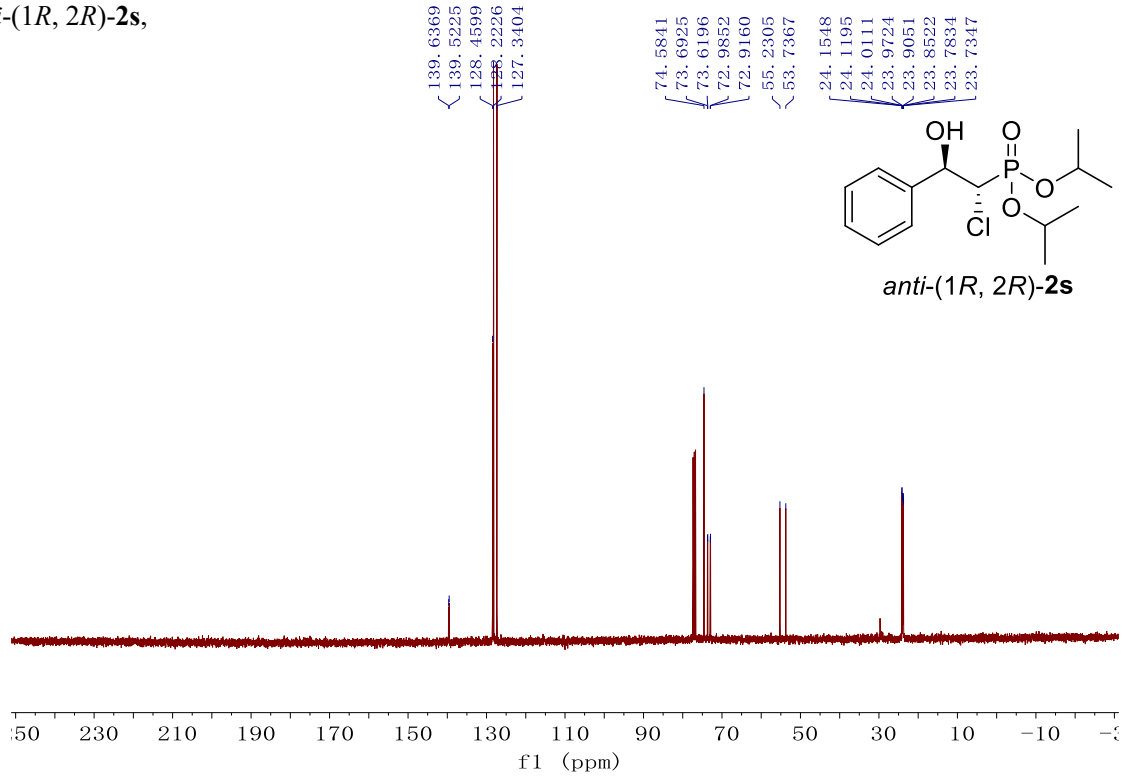
Compound *anti*-(1*S*, 2*S*)-**2s**,
^{31}P NMR



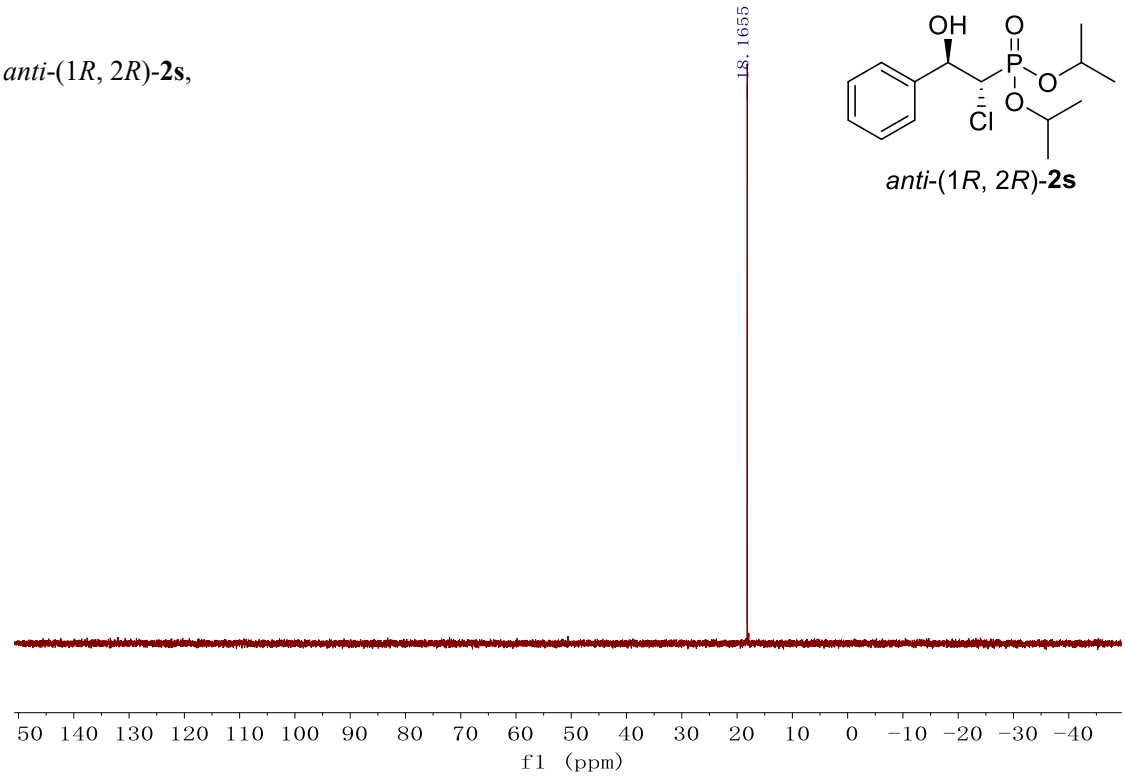
Compound *anti*-(1*R*, 2*R*)-**2s**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2s**,
^{13}C NMR

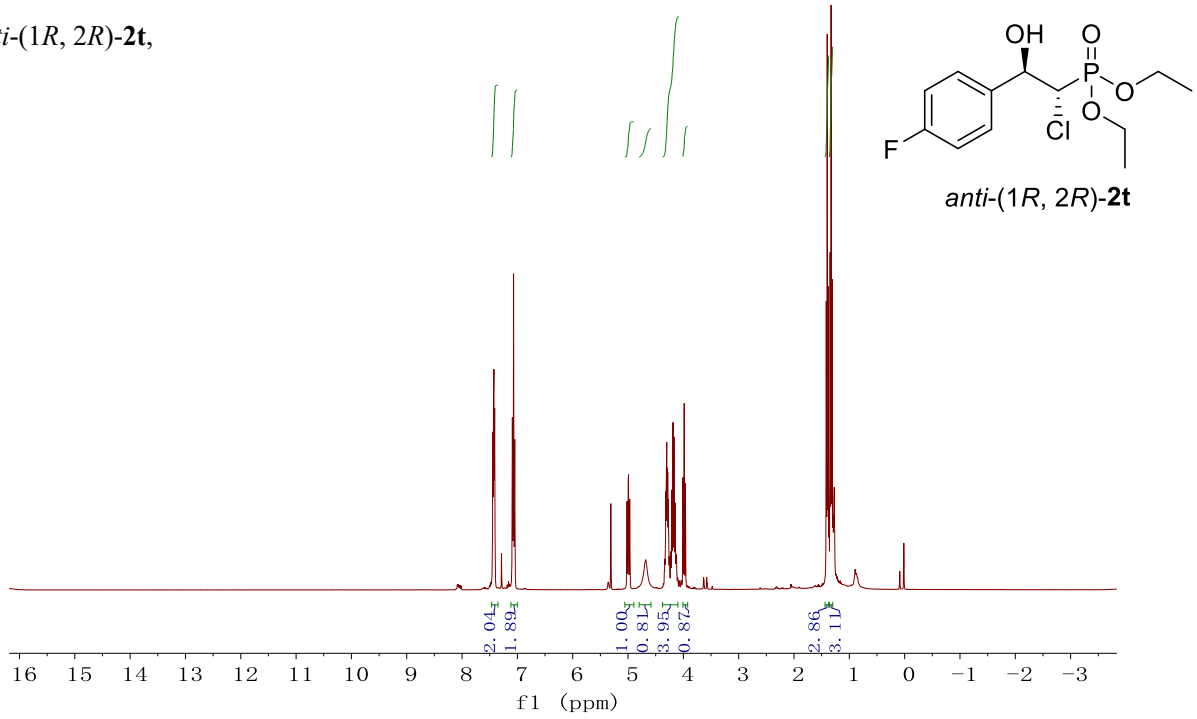


Compound *anti*-(1*R*, 2*R*)-**2s**,
^{31}P NMR

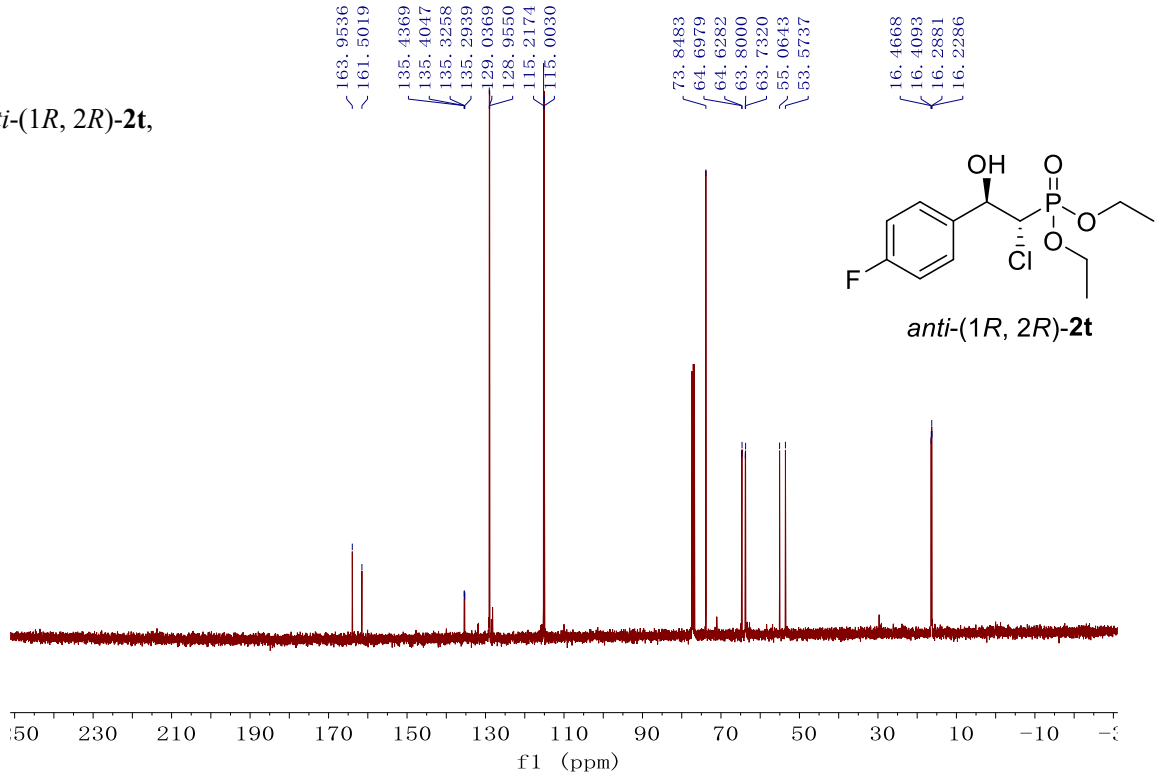


anti-(1*R*, 2*R*)-**2s**

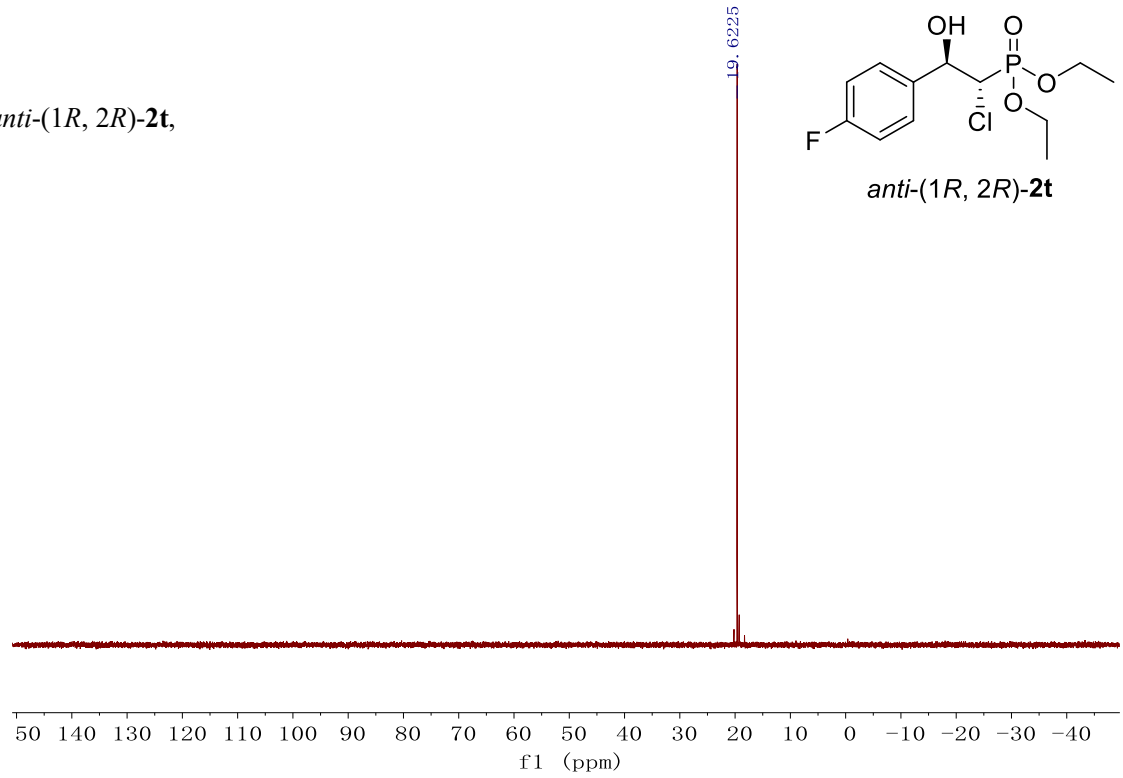
Compound *anti*-(1*R*, 2*R*)-**2t**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2t**,
^{13}C NMR

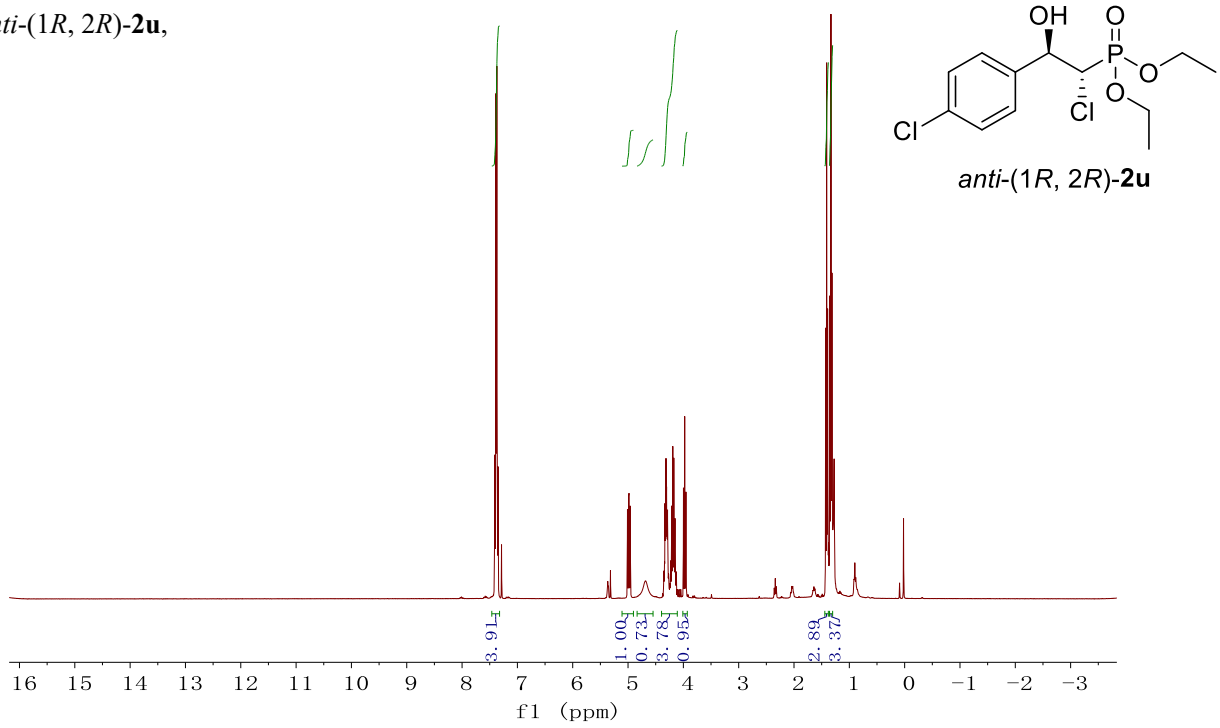


Compound *anti*-(1*R*, 2*R*)-**2t**,
^{31}P NMR

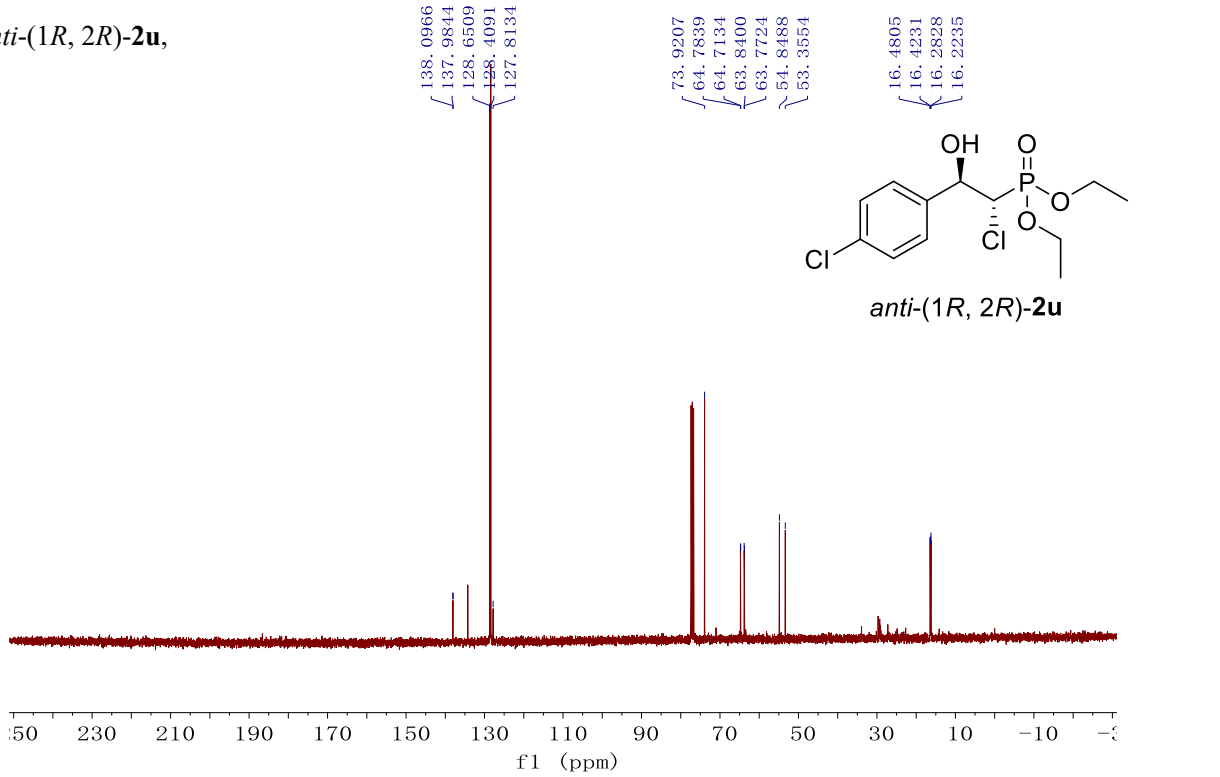


anti-(1*R*, 2*R*)-**2t**

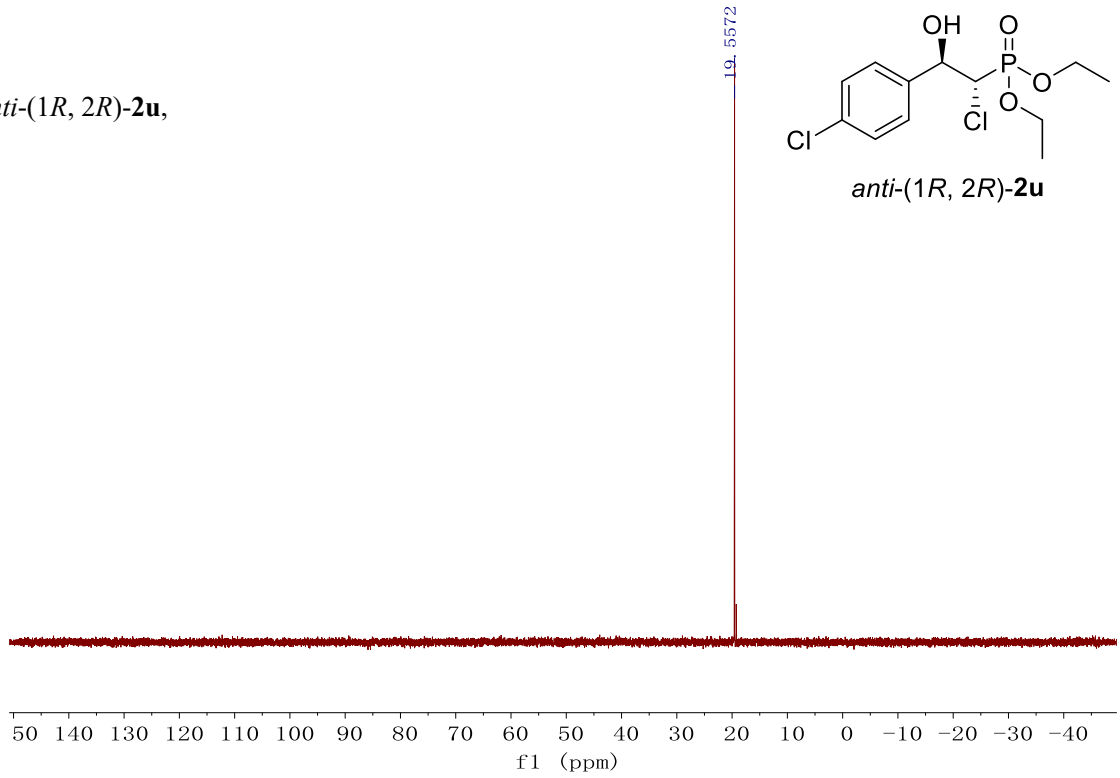
Compound *anti*-(1*R*, 2*R*)-**2u**,
^{1}H NMR



Compound *anti*-(1*R*, 2*R*)-**2u**,
^{13}C NMR

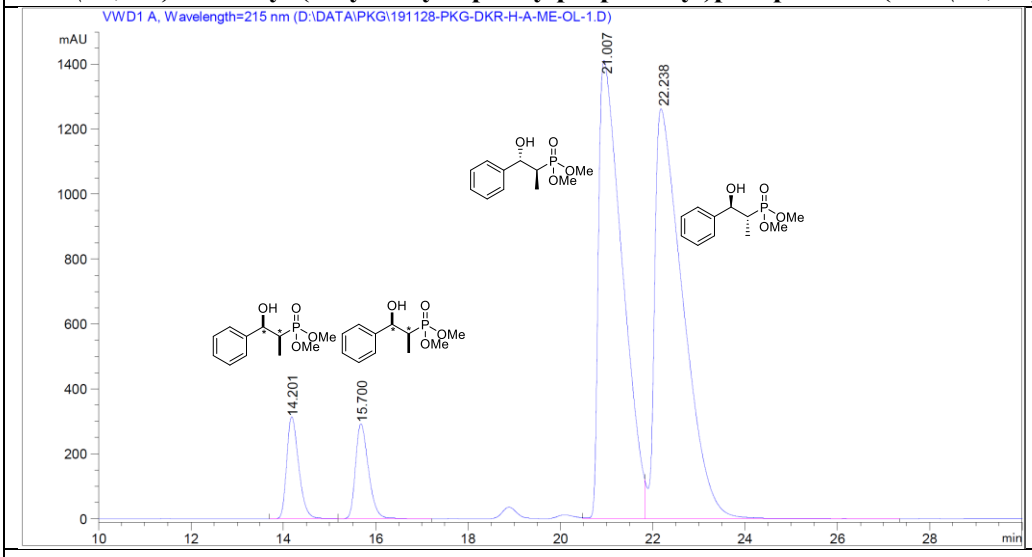


Compound *anti*-(1*R*, 2*R*)-**2u**,
^{31}P NMR



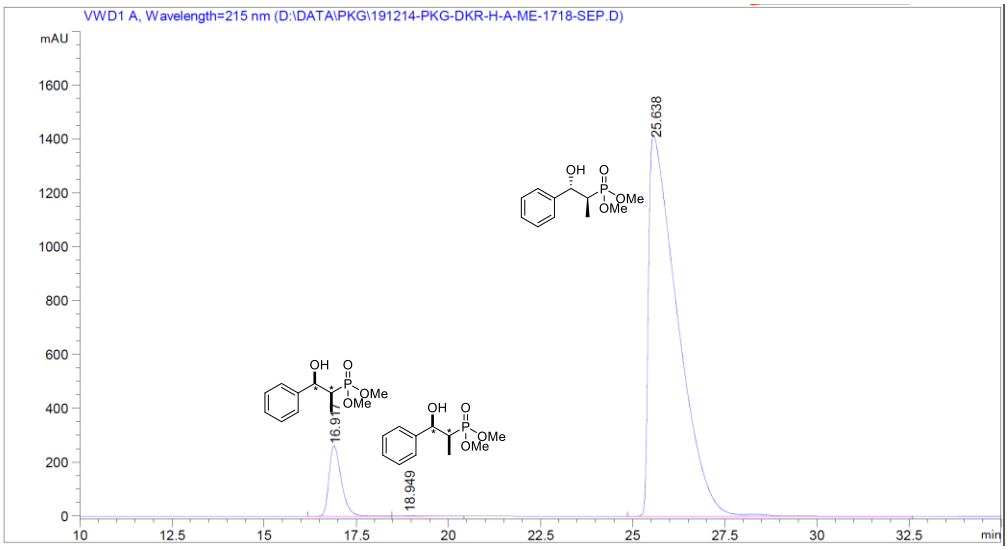
anti-(1*R*, 2*R*)-**2u**

***anti-(1S, 2S)*-dimethyl (1-hydroxy-1-phenylpropan-2-yl)phosphonate (*anti-(1S, 2S)*-2a)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.201	BV	0.3158	5741.83057	304.79572	4.9564
2	15.700	VB	0.3307	5764.03076	286.51297	4.9756

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	21.007	VV	0.5636	5.02864e4	1398.11316	43.4078
4	22.238	VB	0.6442	5.40543e4	1260.80212	46.6603

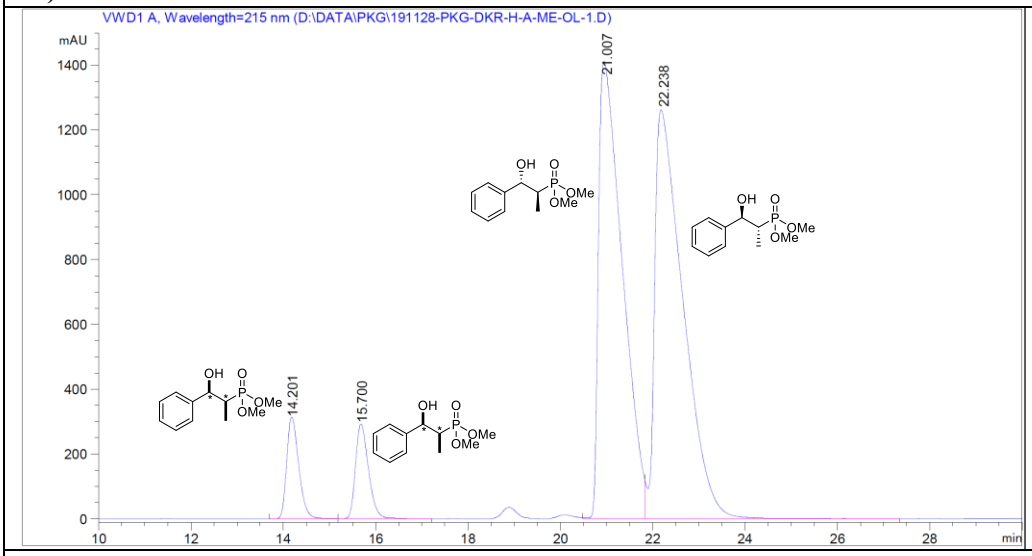


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	16.917	BV	0.3770	6119.06934	254.02634	7.3414
2	18.949	VB	0.5860	81.65181	2.00986	0.0980

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	25.638	BB	0.8225	7.71490e4	1392.12317	92.5606

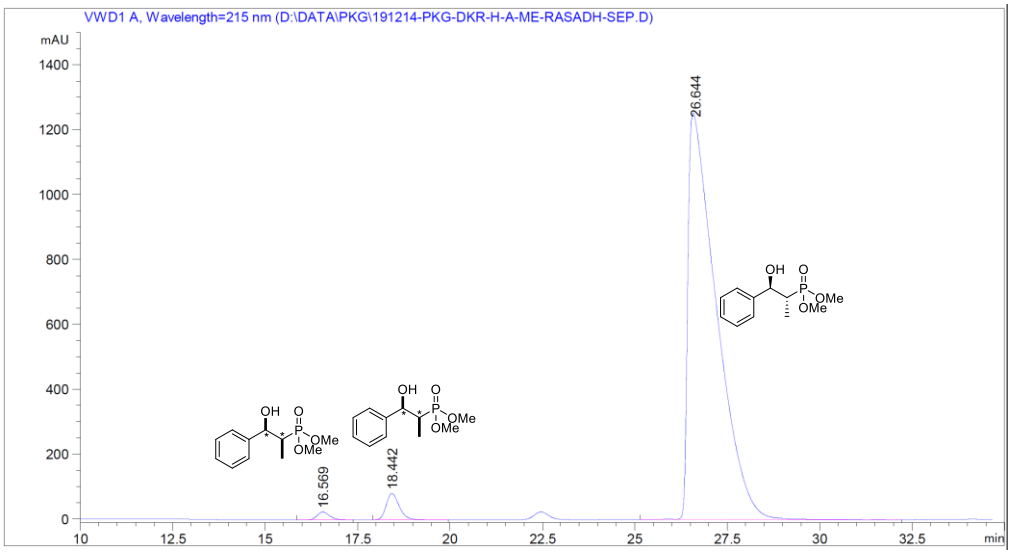
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-hydroxy-1-phenylpropan-2-yl)phosphonate (*anti-(1R, 2R)*-2a)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.201	BV	0.3158	5741.83057	304.79572	4.9564
2	15.700	VB	0.3307	5764.03076	286.51297	4.9756

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	21.007	VV	0.5636	5.02864e4	1398.11316	43.4078
4	22.238	VB	0.6442	5.40543e4	1260.80212	46.6603

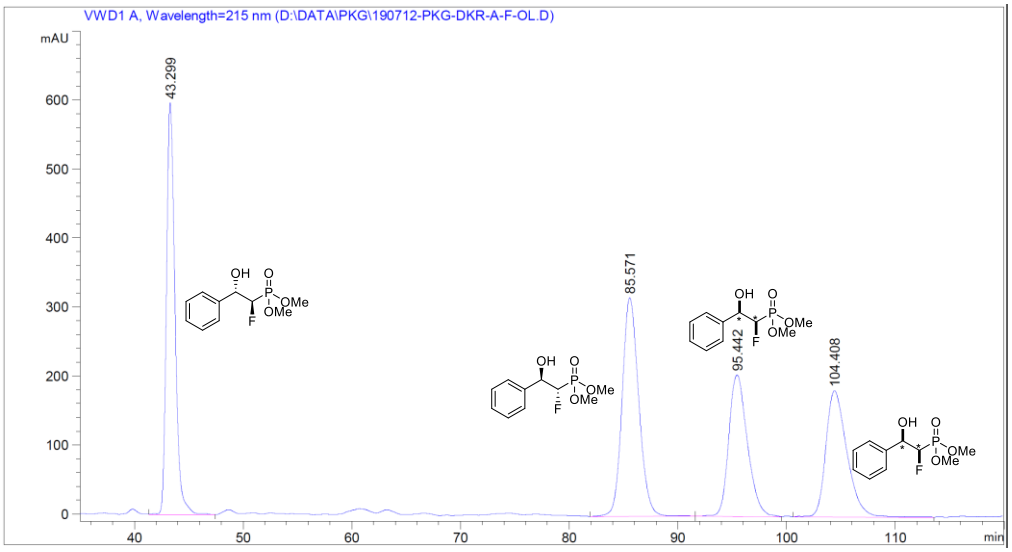


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	16.569	BB	0.3827	560.29468	24.14350	0.8078
2	18.442	BB	0.3967	1977.19043	81.02451	2.8506

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	26.644	BB	0.8098	6.68237e4	1230.10120	96.3416

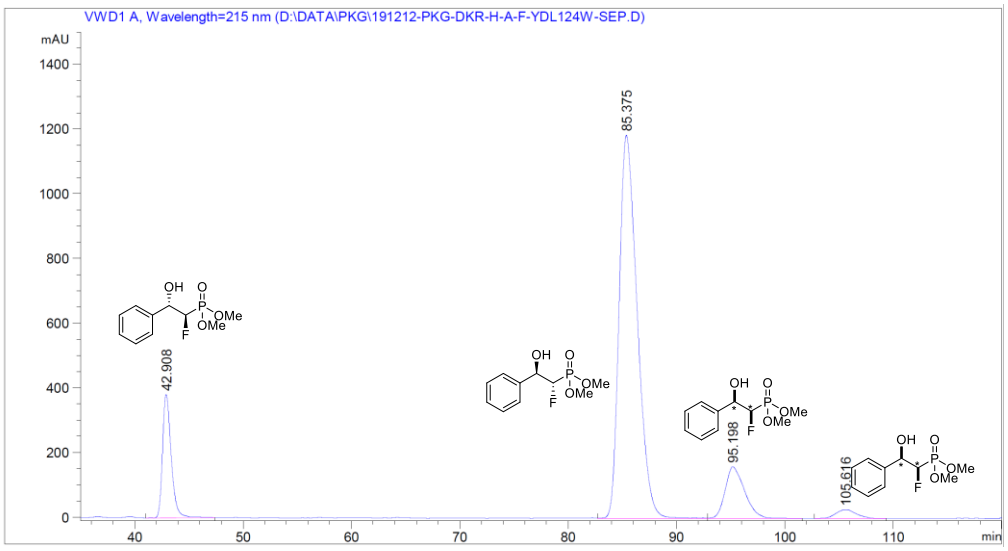
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S,2R)*-dimethyl (1-fluoro-2-hydroxy-2-phenylethyl)phosphonate (*anti-(1S,2R)*-2d)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	43.299	VB	0.8573	3.23694e4	596.31140	28.1050
2	85.571	BB	1.6566	3.36586e4	316.51431	29.2243

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	95.442	BV	1.7914	2.44343e4	204.87068	21.2152
4	104.408	BV	2.0716	2.47110e4	182.97267	21.4555

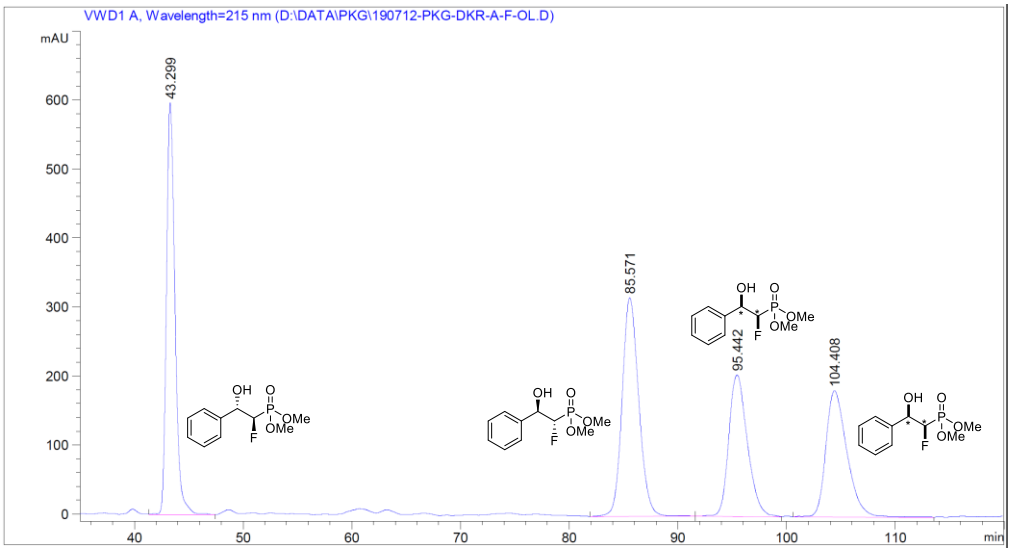


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	42.908	BB	0.8587	2.12646e4	381.29099	11.6992
2	85.375	VV	1.8437	1.36799e5	1184.27429	75.2630

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	95.442	BV	1.7914	2.44343e4	204.87068	21.2152
4	104.408	BV	2.0716	2.47110e4	182.97267	21.4555

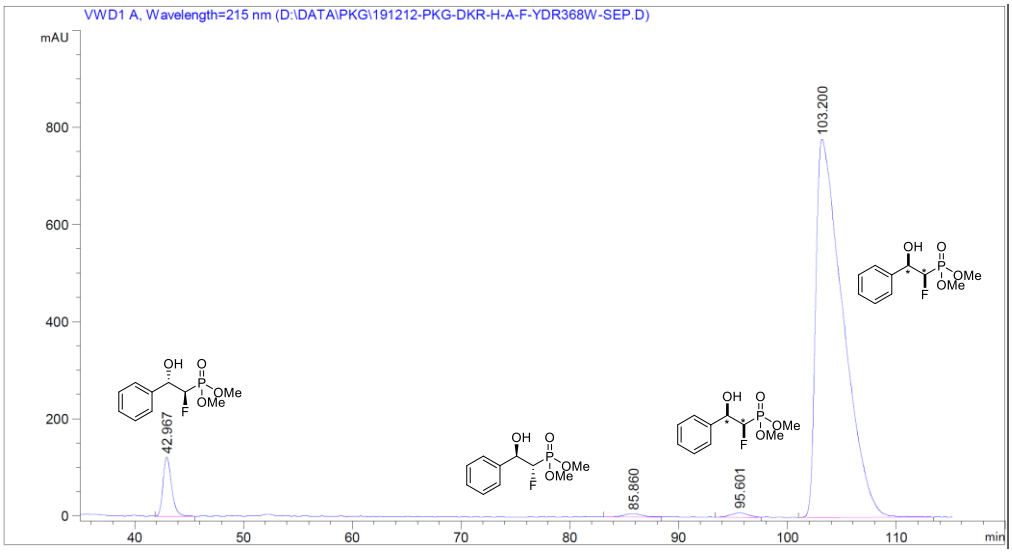
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of YDL124w-catalyzed biotransformation.

syn-dimethyl (1-fluoro-2-hydroxy-2-phenylethyl)phosphonate (_syn_-2d)



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	43.299	VB	0.8573	3.23694e4	596.31140	28.1050
2	85.571	BB	1.6566	3.36586e4	316.51431	29.2243

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	95.442	BV	1.7914	2.44343e4	204.87068	21.2152
4	104.408	BV	2.0716	2.47110e4	182.97267	21.4555

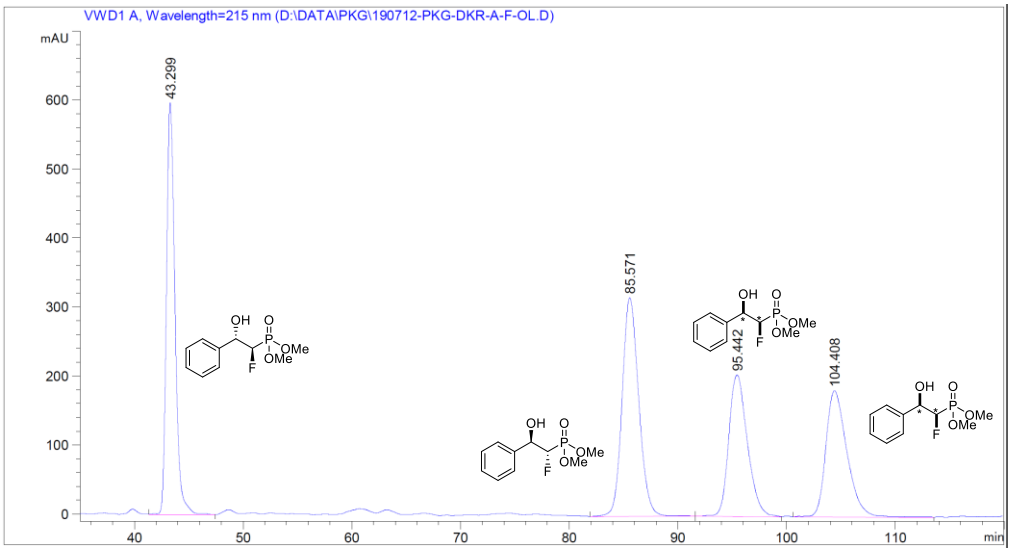


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	42.967	BB	0.8443	6633.40039	121.62947	4.6297
2	85.860	BV	1.7305	830.31140	6.94646	0.5795

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	95.601	VV	1.6786	1097.19885	9.64950	0.7658
4	103.200	BB	2.4983	1.34717e5	778.74066	94.0250

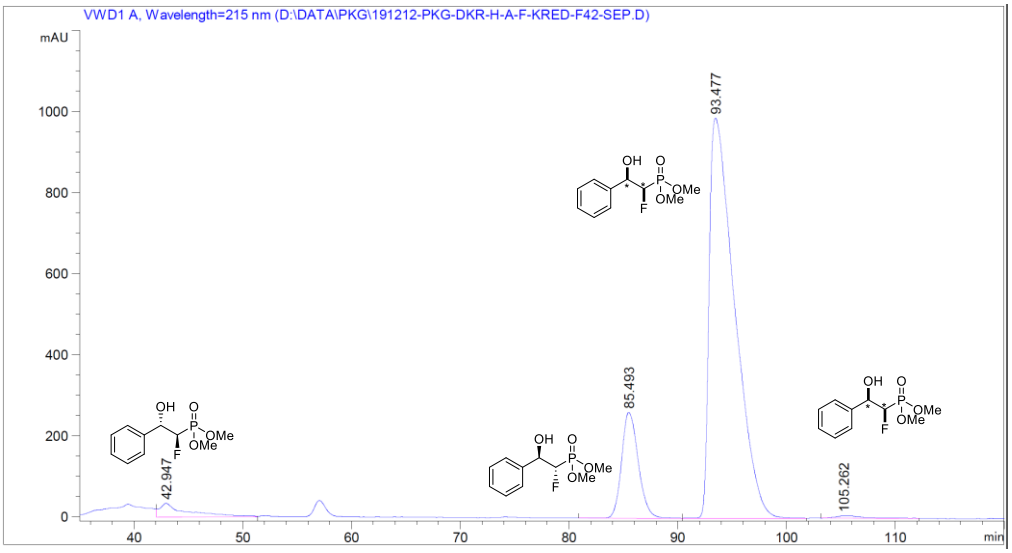
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of YDR368w-catalyzed biotransformation.

syn-dimethyl (1-fluoro-2-hydroxy-2-phenylethyl)phosphonate (_syn_-2d)



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	43.299	VB	0.8573	3.23694e4	596.31140	28.1050
2	85.571	BB	1.6566	3.36586e4	316.51431	29.2243

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	95.442	BV	1.7914	2.44343e4	204.87068	21.2152
4	104.408	BV	2.0716	2.47110e4	182.97267	21.4555

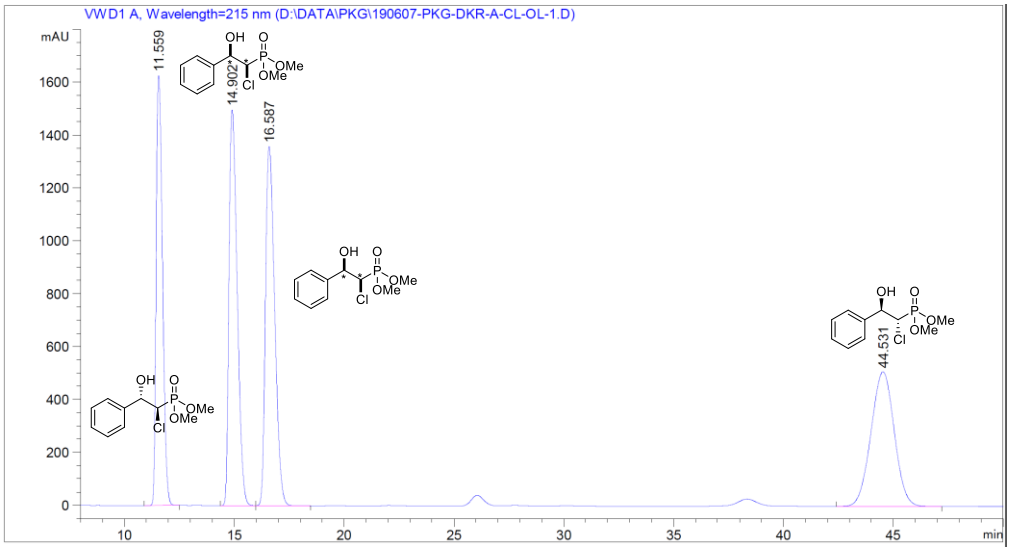


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	42.947	VV	2.3527	6189.50537	33.92259	3.1776
2	85.493	BB	1.6492	2.79463e4	260.99802	14.3470

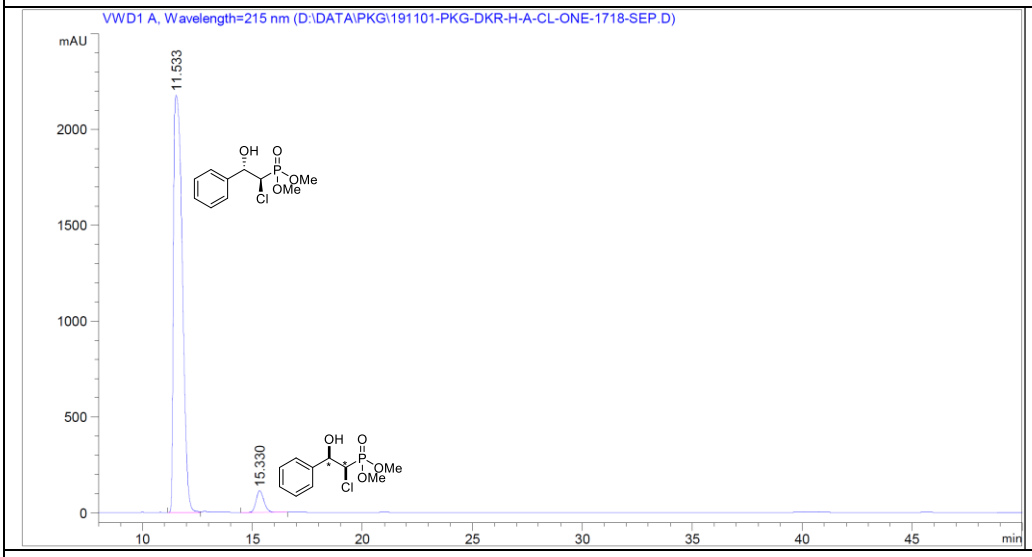
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	93.477	BB	2.2681	1.59391e5	986.96826	81.8280
4	105.262	BV	2.4936	1261.12183	6.39255	0.6474

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KRED-F42-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti-(1S, 2S)*-2e)**



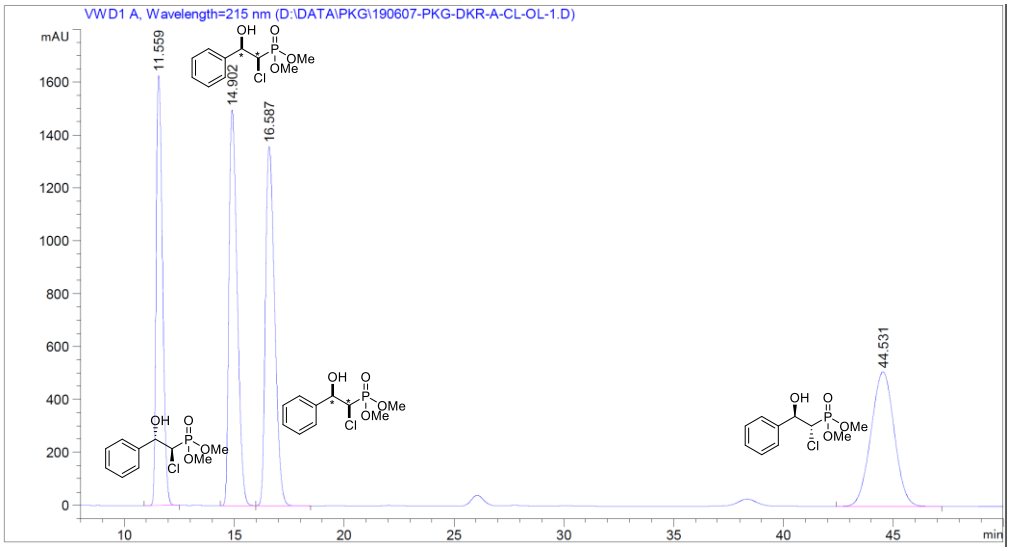
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	11.559	BB	0.3195	3.26734e4	1625.67102	21.9798
2	14.902	BB	0.4099	3.88587e4	1496.90173	26.1407
3	16.587	BB	0.4584	3.96189e4	1357.84070	26.6521
4	44.531	BB	1.1493	3.75010e4	509.14444	25.2274



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	11.533	BV	0.4518	6.04114e4	2176.96240	95.5495
2	15.330	BB	0.3831	2813.81055	113.53531	4.4505

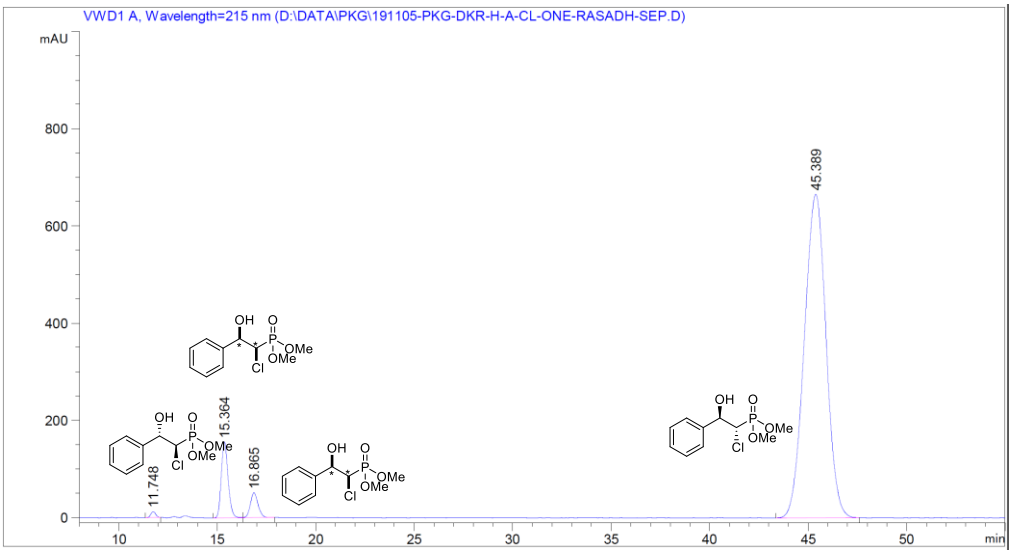
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti-(1R, 2R)*-2e)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	11.559	BB	0.3195	3.26734e4	1625.67102	21.9798
2	14.902	BB	0.4099	3.88587e4	1496.90173	26.1407

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	16.587	BB	0.4584	3.96189e4	1357.84070	26.6521
4	44.531	BB	1.1493	3.75010e4	509.14444	25.2274

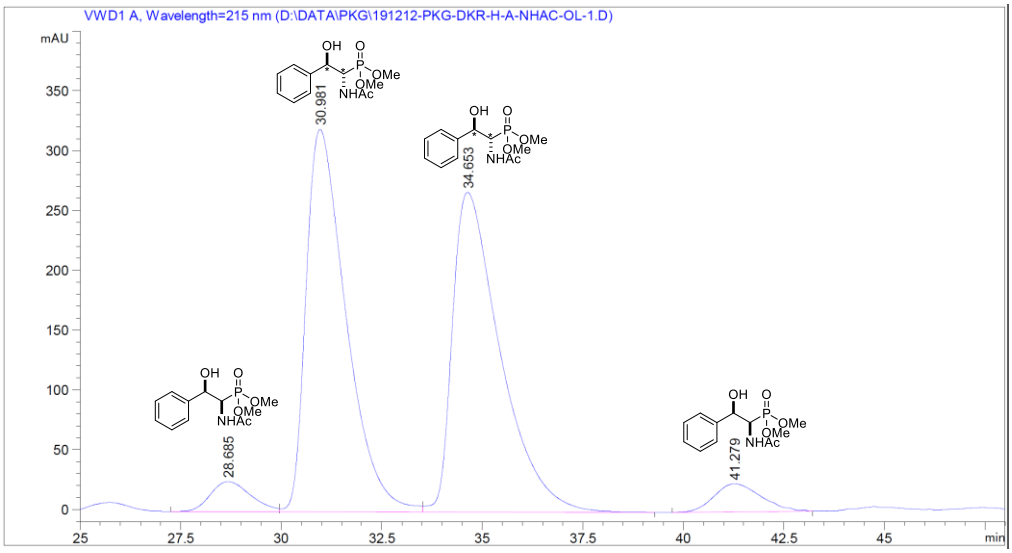


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	11.748	BB	0.2724	221.05966	12.55906	0.3922
2	15.364	BV	0.3719	3769.54004	156.00165	6.6883

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	16.865	VB	0.4192	1387.61426	51.03429	2.4621
4	45.389	BB	1.1941	5.09819e4	665.27301	90.4574

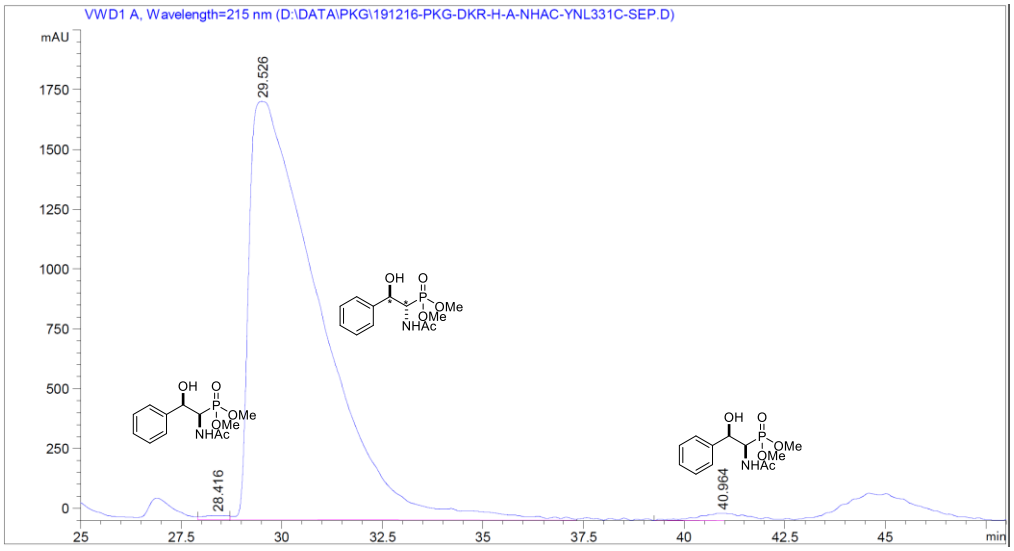
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

anti-dimethyl (1-acetamido-2-hydroxy-2-phenylethyl)phosphonate (_anti_-2f)



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	28.685	BV	1.0887	1755.71460	25.08101	3.6686
2	30.981	VV	1.0612	2.20650e4	319.68799	46.1049

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	34.653	VB	1.2380	2.21177e4	267.12277	46.2151
4	41.279	BB	1.2724	1919.76208	23.51599	4.0114

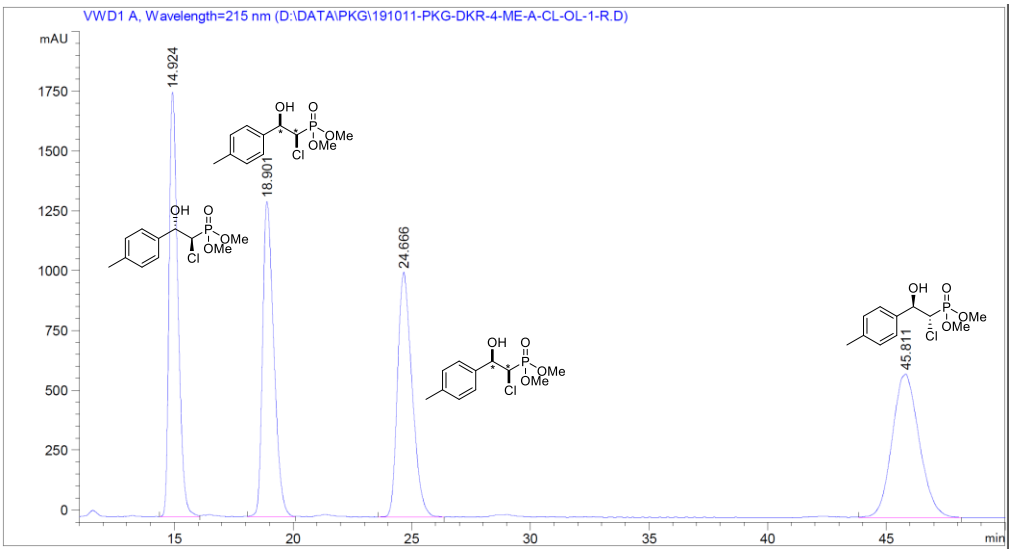


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	28.416	VV	0.6661	719.06219	16.57487	0.3334
2	29.526	VV	1.6084	2.12074e5	1746.83020	98.3175

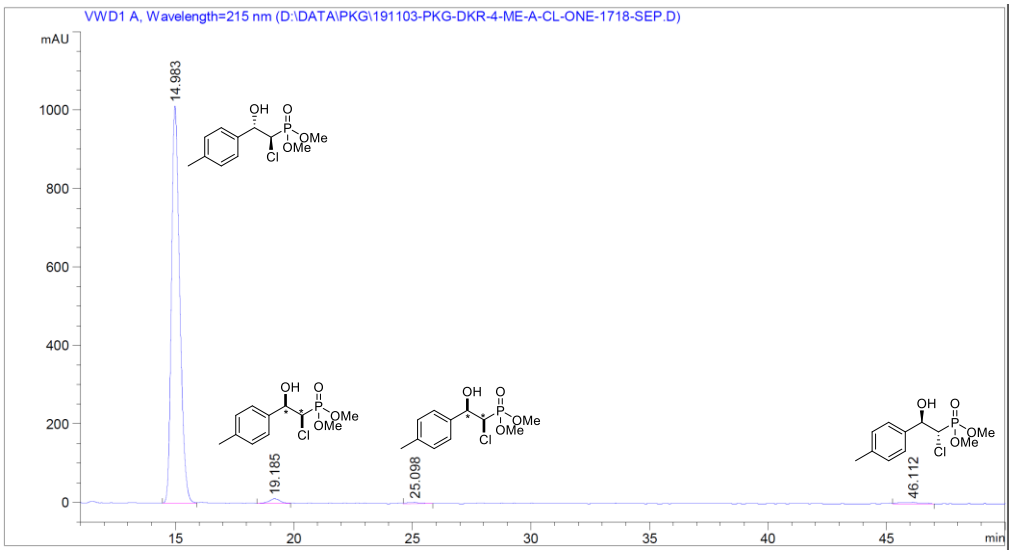
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	40.964	BV	1.2664	2910.24170	30.68746	1.3492

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of YNL331c-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-hydroxy-2-(p-tolyl)ethyl)phosphonate (*anti-(1S, 2S)*-2g)**



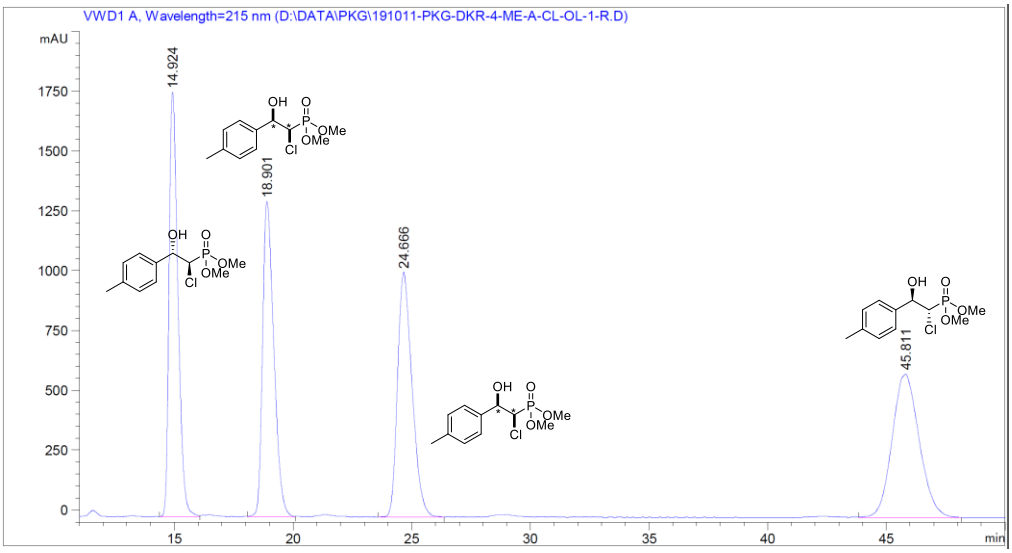
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.924	VV	0.4011	4.60959e4	1774.04028	25.5503
2	18.901	VV	0.5058	4.33233e4	1316.88977	24.0135
3	24.666	VV	0.6563	4.34982e4	1022.57587	24.1105
4	45.811	VV	1.0403	4.74948e4	599.48639	26.3257



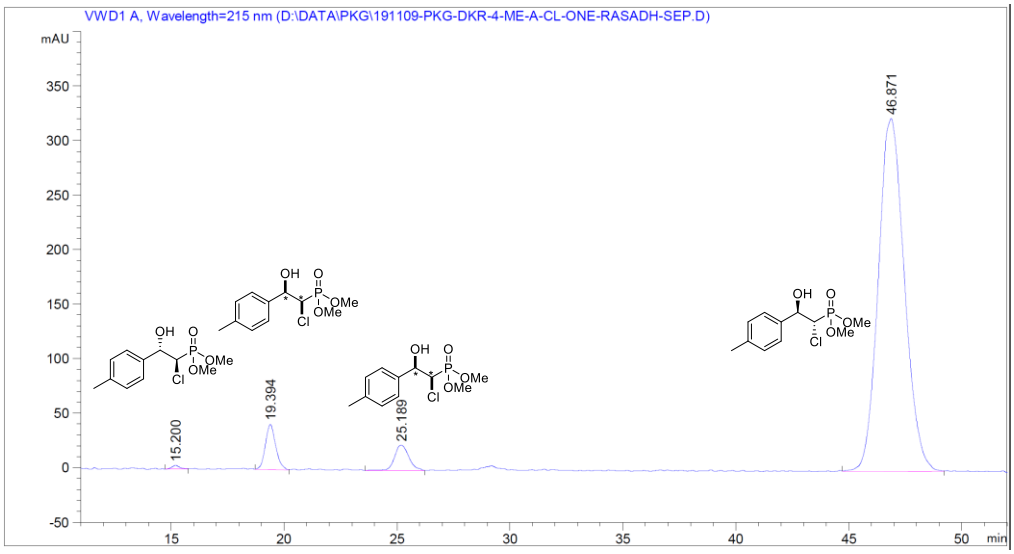
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.983	BV	0.3753	2.47585e4	1012.52197	97.0334
2	19.185	BV	0.5056	388.63916	11.63802	1.5232
3	25.098	VV	0.5017	129.26193	3.28052	0.5066
4	46.112	VB	0.8039	239.03447	3.64131	0.9368

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-hydroxy-2-(p-tolyl)ethyl)phosphonate (*anti-(1R, 2R)*-2g)**



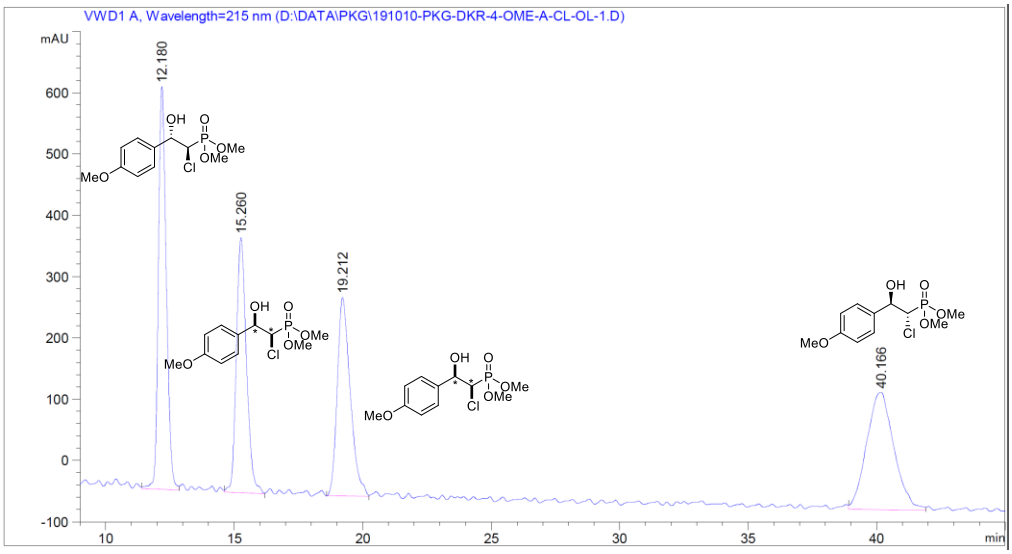
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.924	VV	0.4011	4.60959e4	1774.04028	25.5503
2	18.901	VV	0.5058	4.33233e4	1316.88977	24.0135
3	24.666	VV	0.6563	4.34982e4	1022.57587	24.1105
4	45.811	VV	1.0403	4.74948e4	599.48639	26.3257



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	15.200	VV	0.3564	92.96348	3.68435	0.3260
2	19.394	VV	0.4856	1325.56067	41.61621	4.6483
3	25.189	BB	0.6754	1022.26935	23.22959	3.5847
4	46.871	VV	1.0780	2.60764e4	323.65955	91.4410

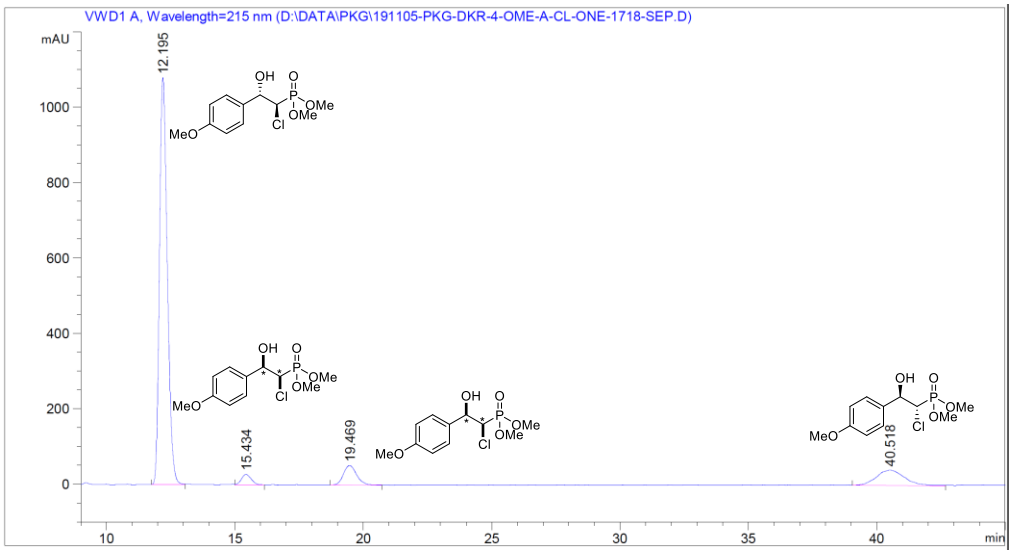
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-(dimethyl (1-chloro-2-hydroxy-2-(4-methoxyphenyl)ethyl)phosphonate (*anti-(1S, 2S)*-2h)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.180	VV	0.3276	1.39964e4	656.85632	27.4855
2	15.260	VV	0.4161	1.13785e4	416.06210	22.3444

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.212	BV	0.5403	1.14045e4	324.25589	22.3956
4	40.166	VV	1.0243	1.41437e4	191.12733	27.7746

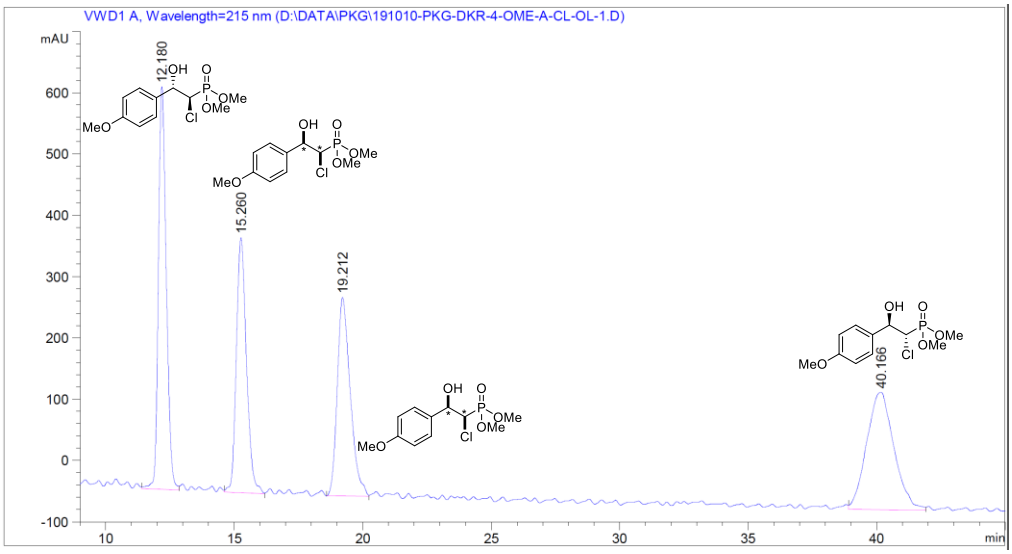


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.195	BV	0.3279	2.28306e4	1078.91541	79.8641
2	15.434	VV	0.4145	756.02185	27.78378	2.6446

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.469	BV	0.5670	1885.56787	52.37257	6.5959
4	40.518	VV	1.0656	3114.65063	40.61920	10.8954

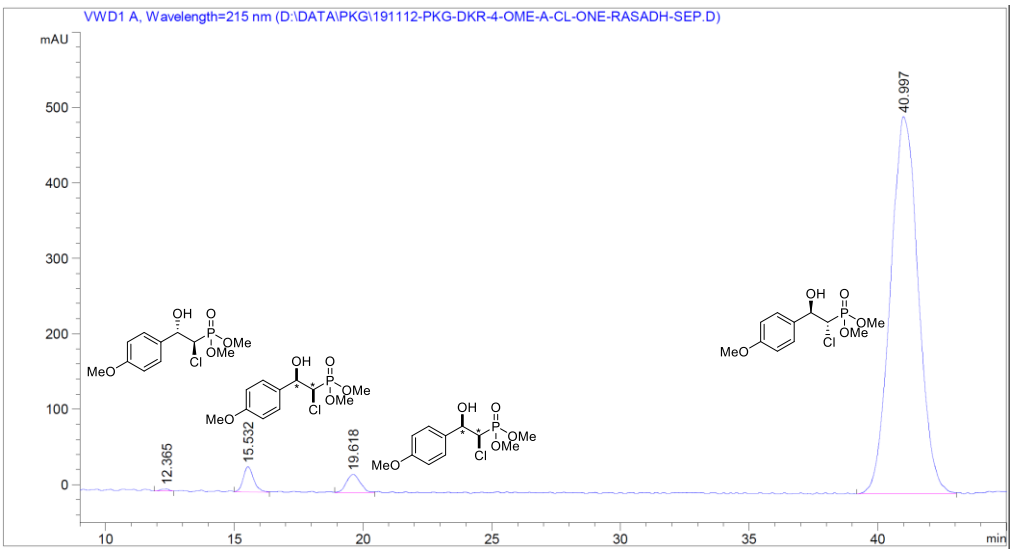
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-(dimethyl (1-chloro-2-hydroxy-2-(4-methoxyphenyl)ethyl)phosphonate (*anti-(1R, 2R)*-2h)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.180	VV	0.3276	1.39964e4	656.85632	27.4855
2	15.260	VV	0.4161	1.13785e4	416.06210	22.3444

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.212	BV	0.5403	1.14045e4	324.25589	22.3956
4	40.166	VV	1.0243	1.41437e4	191.12733	27.7746

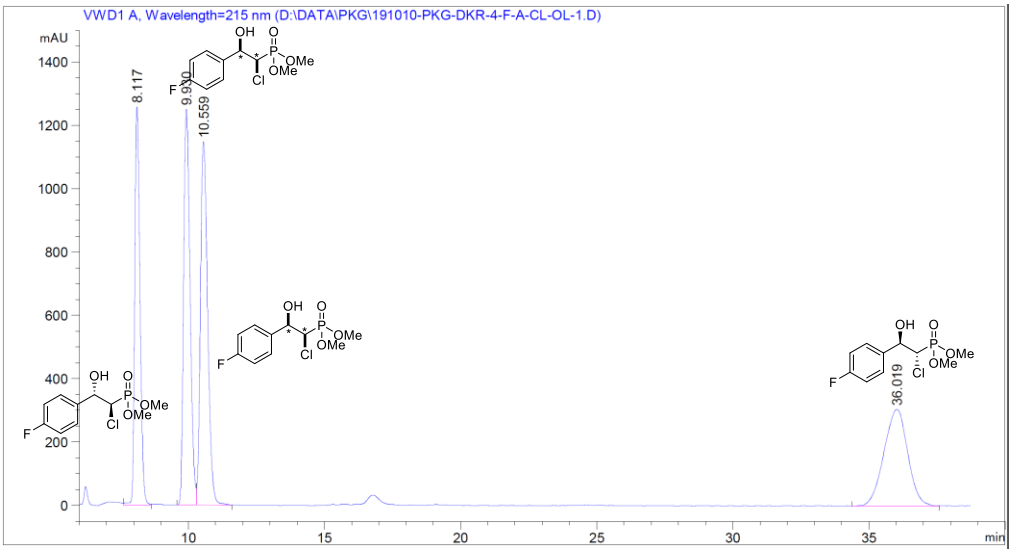


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.365	BB	0.2934	54.87552	2.54621	0.1386
2	15.532	VV	0.4359	947.24622	33.39599	2.3933

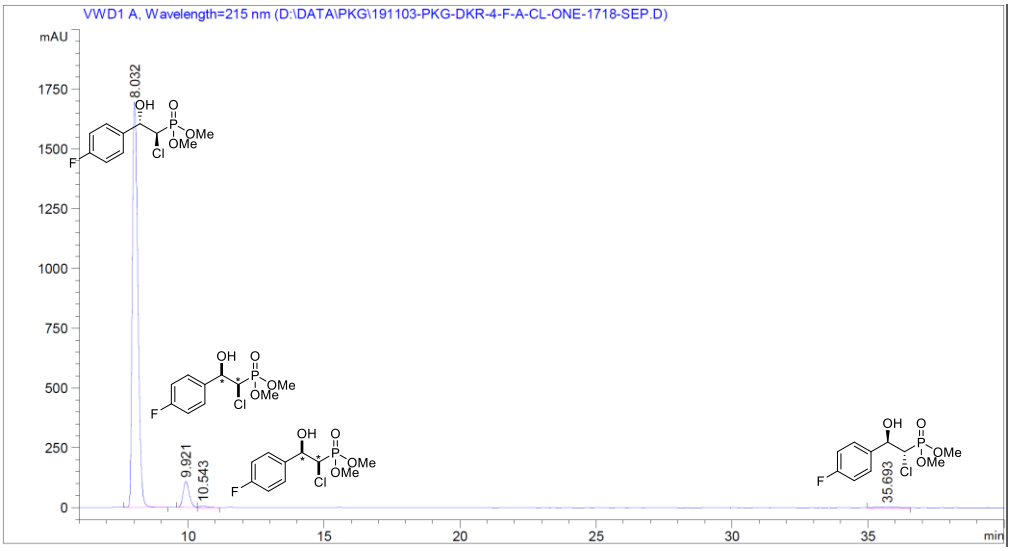
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.618	VV	0.5964	910.39362	24.17415	2.3002
4	40.997	VV	1.0549	3.76665e4	500.01859	95.1679

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-(4-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1S, 2S)*-2i)**



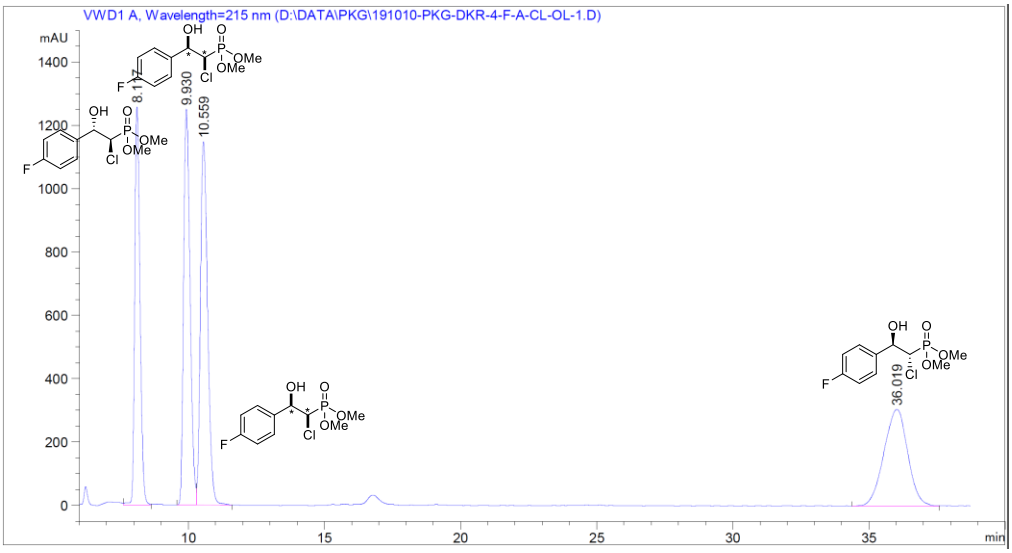
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	8.117	VV	0.2095	1.68812e4	1258.73694	21.8743
2	9.930	BV	0.2582	2.04905e4	1250.05750	26.5512
3	10.559	VV	0.2884	2.11978e4	1147.98193	27.4677
4	36.019	BV	0.9364	1.86041e4	305.54092	24.1068



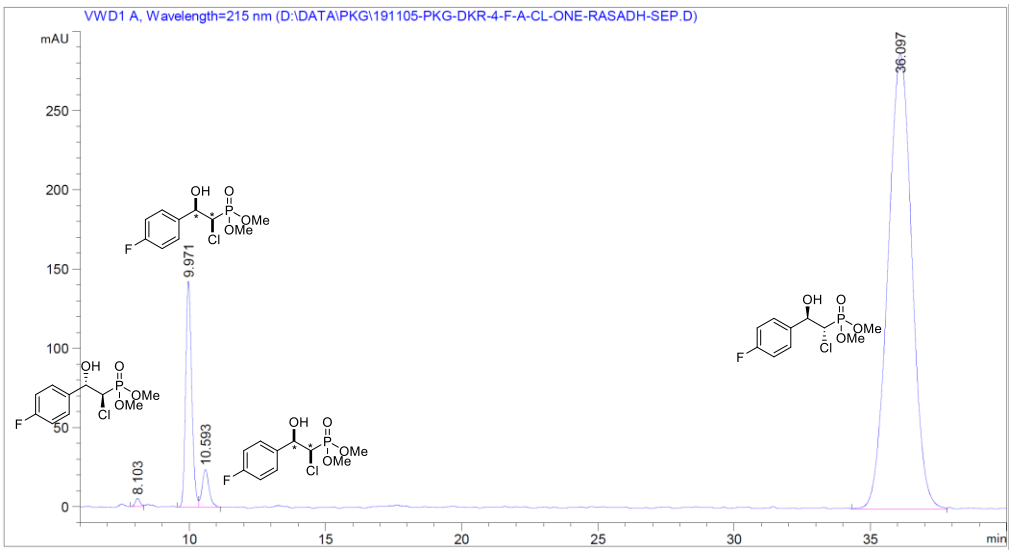
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	8.032	VB	0.2275	2.41852e4	1694.92383	92.1929
2	9.921	VV	0.2383	1685.10938	109.06840	6.4236
3	10.543	VB	0.2955	121.02383	6.31790	0.4613
4	35.693	VV	0.7850	241.92778	4.07891	0.9222

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(4-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2i)**



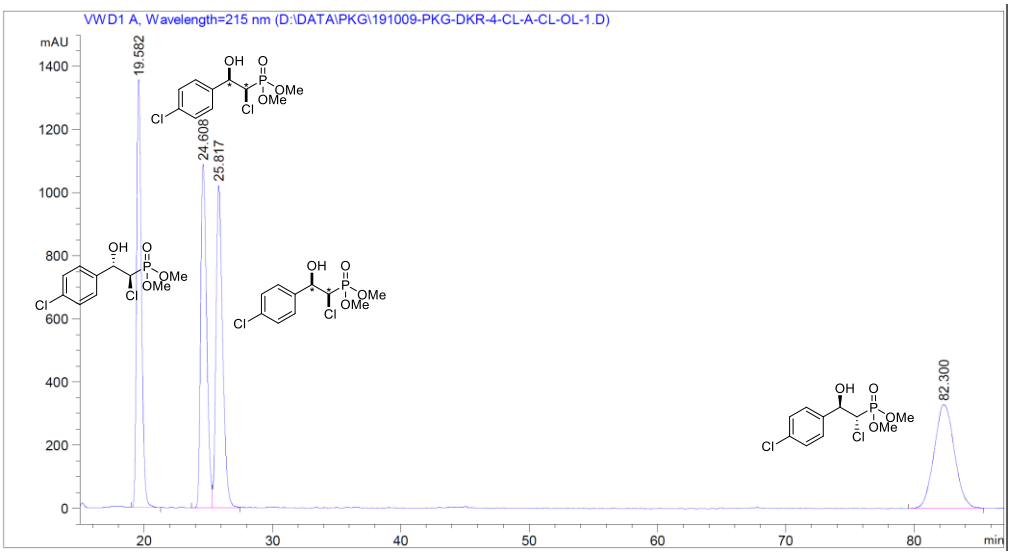
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	8.117	VV	0.2095	1.68812e4	1258.73694	21.8743
2	9.930	BV	0.2582	2.04905e4	1250.05750	26.5512
3	10.559	VV	0.2884	2.11978e4	1147.98193	27.4677
4	36.019	BV	0.9364	1.86041e4	305.54092	24.1068



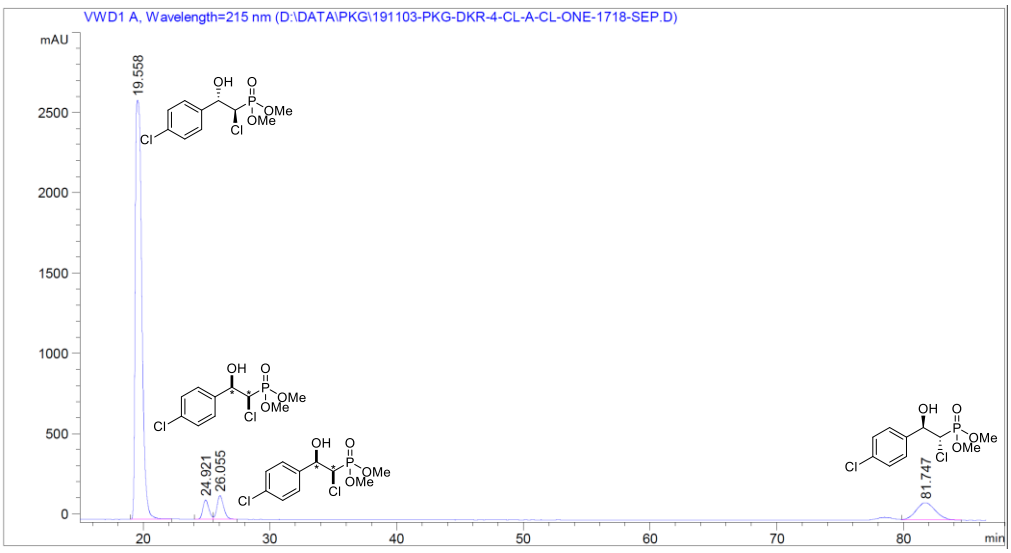
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	8.103	BV	0.1931	66.48842	5.23614	0.3289
2	9.971	BV	0.2383	2203.62280	142.59404	10.9011
3	10.593	VB	0.2682	421.58371	23.85245	2.0855
4	36.097	BV	0.9626	1.75229e4	286.90414	86.6844

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-(4-chlorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1S, 2S)*-2j)**



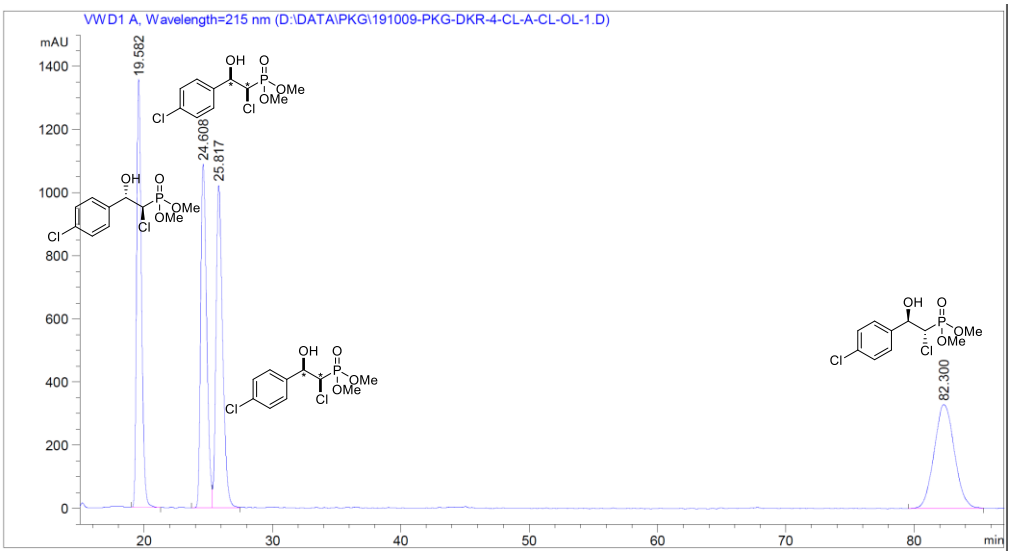
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	19.582	BB	0.3997	3.52178e4	1357.14600	24.4860
2	24.608	BV	0.5122	3.56829e4	1089.30286	24.8094
3	25.817	VV	0.5420	3.66154e4	1021.84106	25.4578
4	82.300	VV	1.5861	3.63120e4	329.39941	25.2468



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	19.558	BV	0.5635	9.40572e4	2609.70972	81.6100
2	24.921	BV	0.5144	3994.93335	120.32037	3.4663
3	26.055	VB	0.5513	5373.36914	148.44675	4.6623
4	81.747	VB	1.5766	1.18266e4	109.36617	10.2615

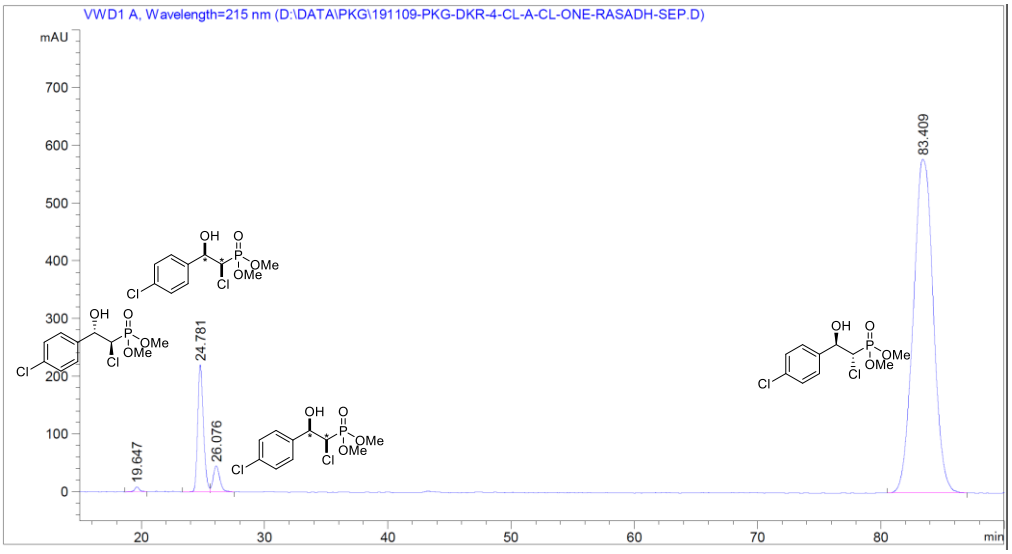
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(4-chlorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2j)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	19.582	BB	0.3997	3.52178e4	1357.14600	24.4860
2	24.608	BV	0.5122	3.56829e4	1089.30286	24.8094

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	25.817	VV	0.5420	3.66154e4	1021.84106	25.4578
4	82.300	VV	1.5861	3.63120e4	329.39941	25.2468

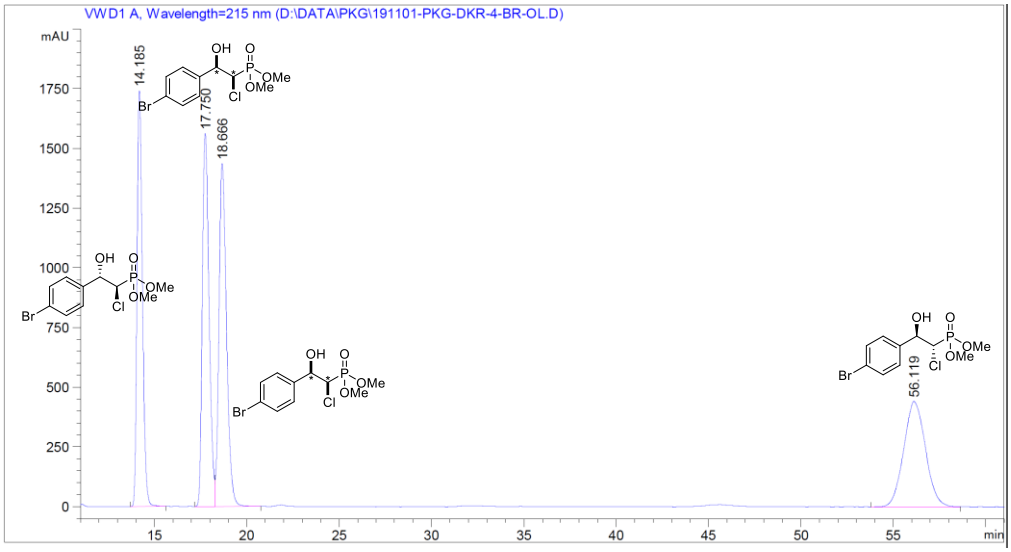


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	19.647	BB	0.4031	220.63596	8.22184	0.2967
2	24.781	BV	0.4981	7178.29199	220.32225	9.6533

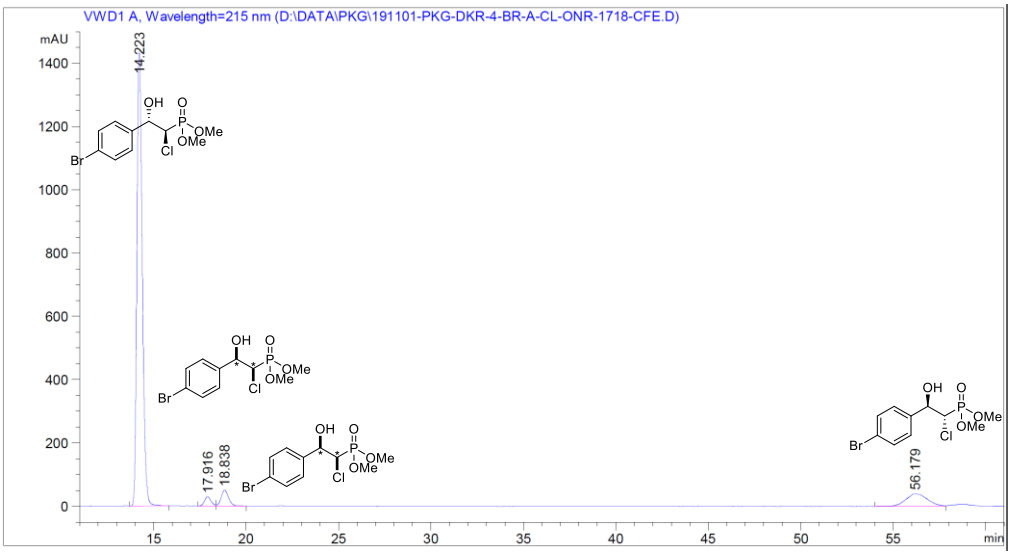
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	26.076	VB	0.5700	1693.93005	45.42685	2.2780
4	83.409	BB	1.6937	6.52684e4	577.86108	87.7720

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (2-(4-bromophenyl)-1-chloro-2-hydroxyethyl)phosphonate (*anti-(1S, 2S)*-2k)**



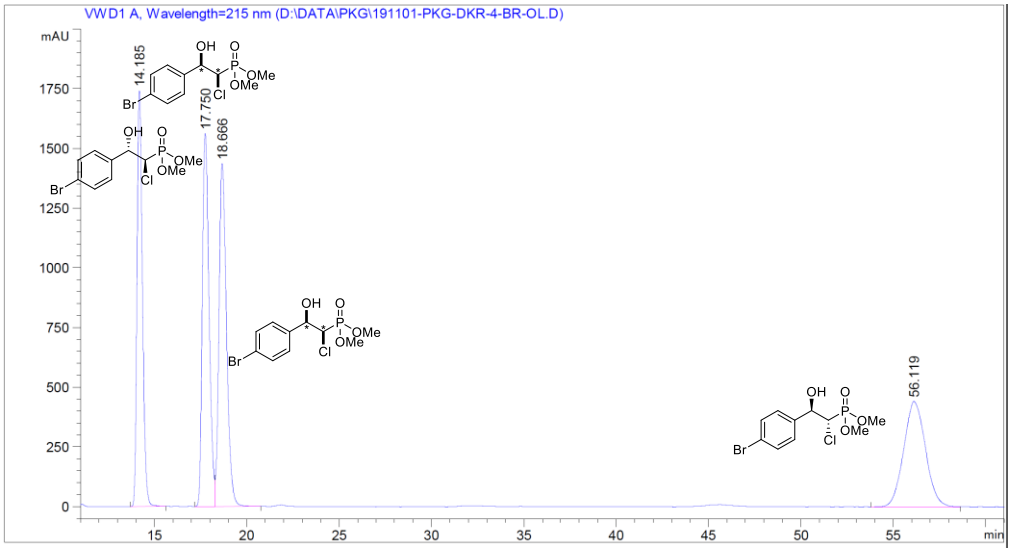
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.185	BB	0.3131	3.52325e4	1740.89026	23.2011
2	17.750	VV	0.3951	3.96230e4	1561.14478	26.0923
3	18.666	VB	0.4388	4.08356e4	1436.00781	26.8908
4	56.119	BV	1.2948	3.61658e4	441.90231	23.8157



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.223	VB	0.3143	2.90856e4	1436.31580	84.2236
2	17.916	VV	0.3834	737.38202	29.51937	2.1352
3	18.838	VB	0.4331	1420.41882	50.34698	4.1131
4	56.179	BV	1.0965	3290.38330	39.80007	9.5280

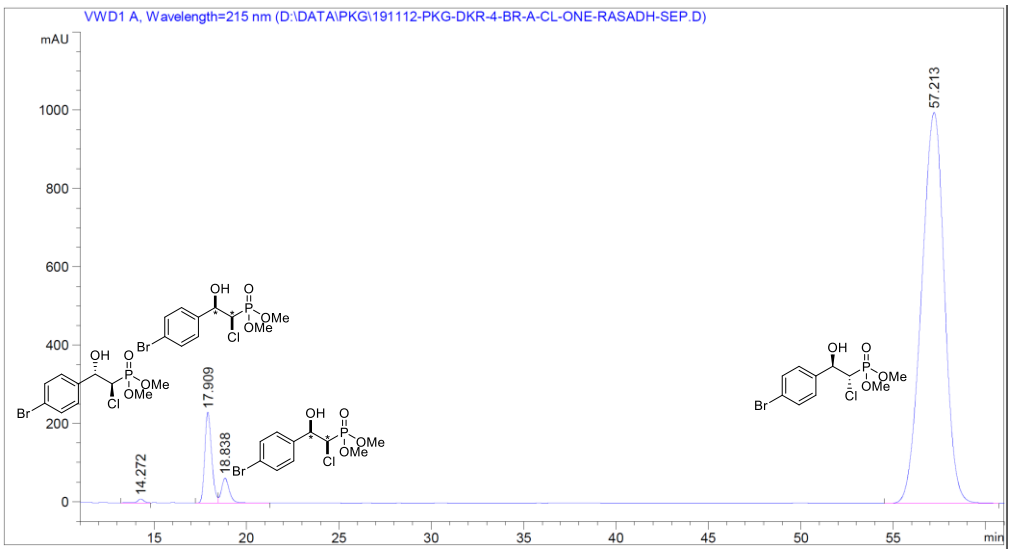
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (2-(4-bromophenyl)-1-chloro-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2k)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.185	BB	0.3131	3.52325e4	1740.89026	23.2011
2	17.750	VV	0.3951	3.96230e4	1561.14478	26.0923

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	18.666	VB	0.4388	4.08356e4	1436.00781	26.8908
4	56.119	BV	1.2948	3.61658e4	441.90231	23.8157

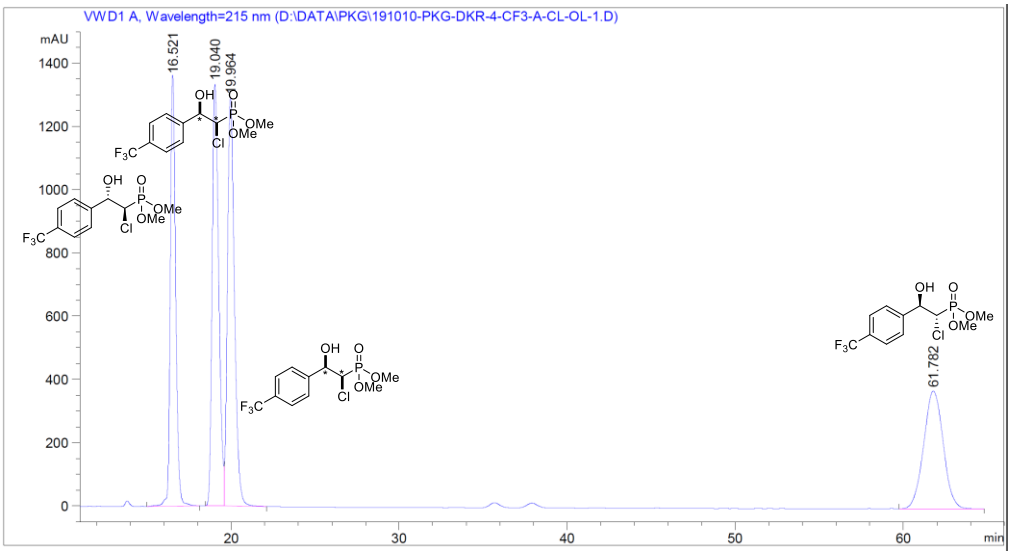


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	14.272	BB	0.3350	212.94818	9.63111	0.2269
2	17.909	BV	0.3989	5994.78955	231.65009	6.3867

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	18.838	VB	0.4487	1880.43201	63.46875	2.0034
4	57.213	BB	1.3365	8.57749e4	998.20728	91.3830

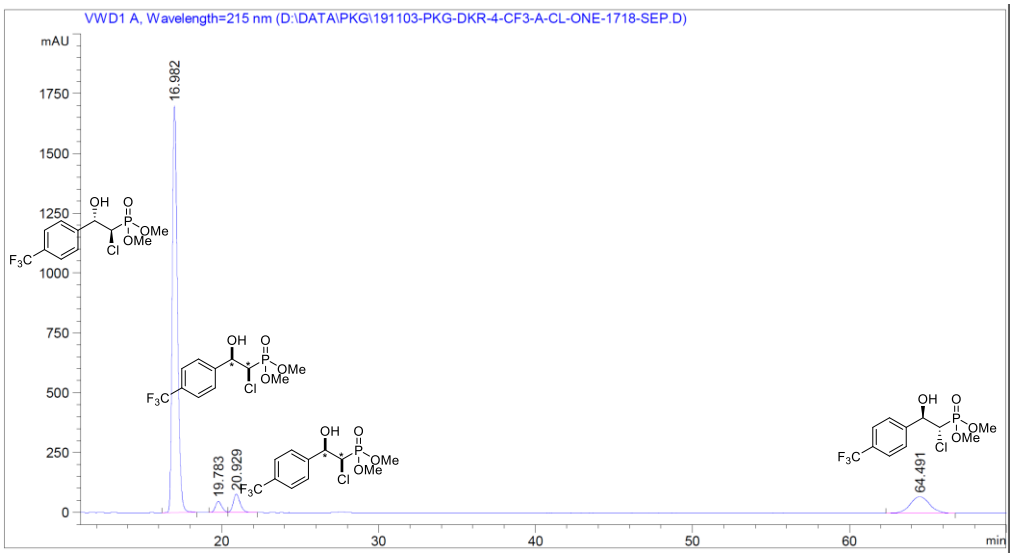
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-hydroxy-2-(4-(trifluoromethyl)phenyl)ethyl)phosphonate (*anti-(1S, 2S)*-2l)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	16.521	BB	0.3440	3.03986e4	1364.13782	22.6669
2	19.040	BV	0.4210	3.61290e4	1333.67297	26.9397

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.964	VB	0.4467	3.74846e4	1291.27686	27.9506
4	61.782	BBA	1.2922	3.00981e4	372.70035	22.4428

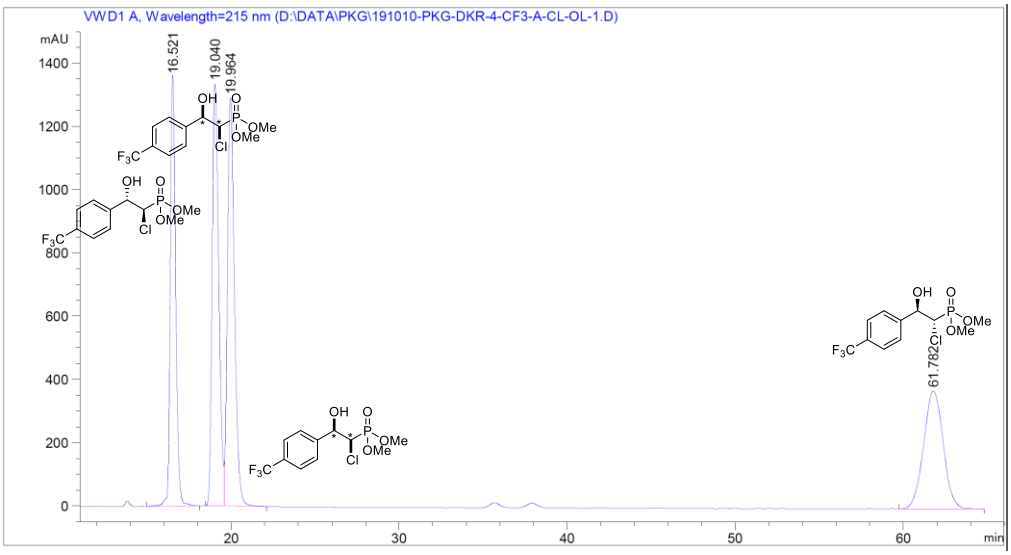


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	16.982	BB	0.3548	3.89975e4	1699.00293	80.2456
2	19.783	BV	0.4317	1324.23242	46.71447	2.7249

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	20.929	VB	0.4647	2343.70313	76.87665	4.8227
4	64.491	BB	1.3172	5932.25000	69.33497	12.2069

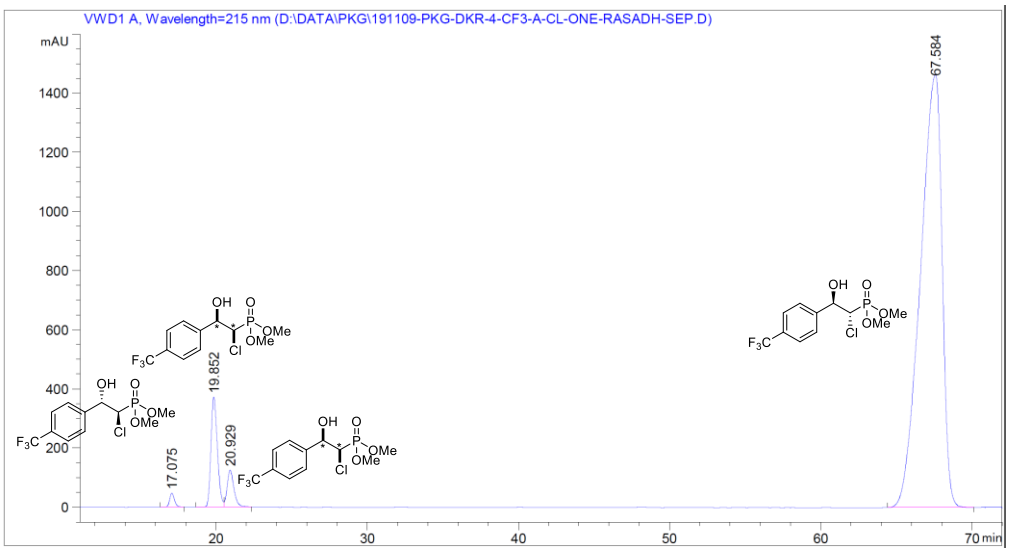
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-hydroxy-2-(4-(trifluoromethyl)phenyl)ethyl)phosphonate (*anti-(1R, 2R)*-2l)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	16.521	BB	0.3440	3.03986e4	1364.13782	22.6669
2	19.040	BV	0.4210	3.61290e4	1333.67297	26.9397

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.964	VB	0.4467	3.74846e4	1291.27686	27.9506
4	61.782	BBA	1.2922	3.00981e4	372.70035	22.4428

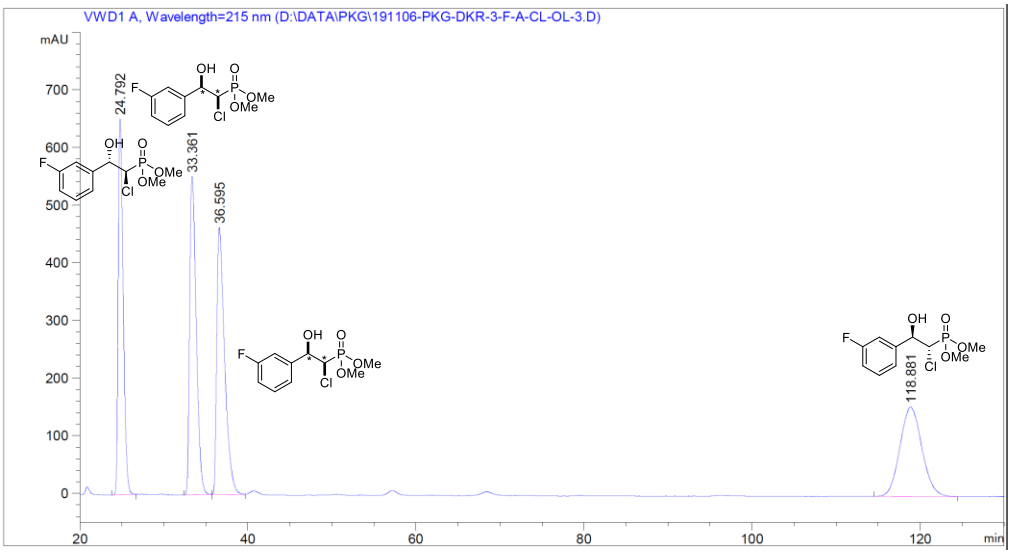


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	17.075	BB	0.3417	1041.57678	46.97521	0.6451
2	19.852	BV	0.4570	1.09979e4	371.92383	6.8113

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	20.929	VB	0.4735	3903.28027	124.59449	2.4174
4	67.584	BB	1.4397	1.45522e5	1465.18054	90.1262

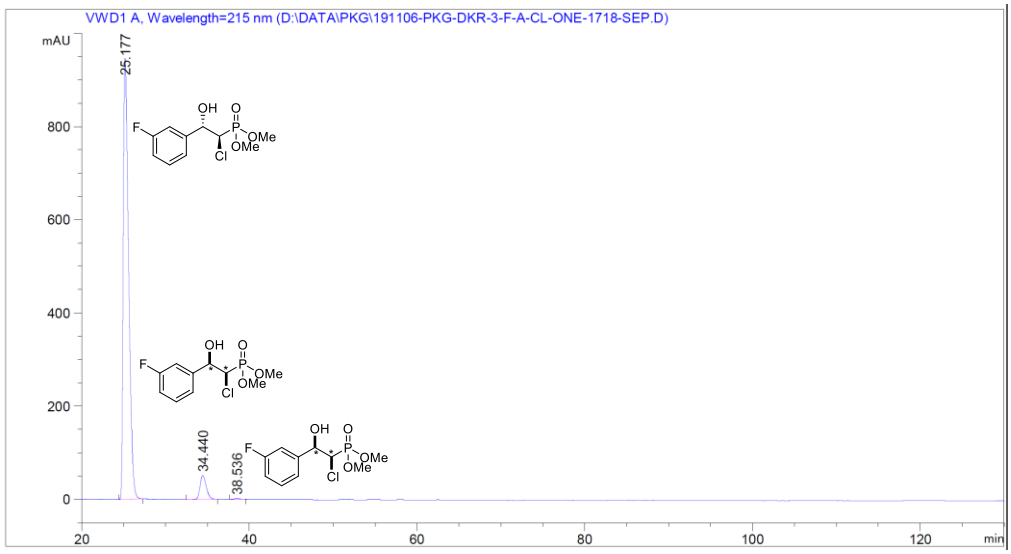
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-(3-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1S, 2S)*-2m)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	24.792	BB	0.6387	2.69900e4	652.38354	23.3914
2	33.361	VB	0.8388	3.00404e4	552.07574	26.0351

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	36.595	BV	0.9669	3.02811e4	463.05942	26.2436
4	118.881	BB	2.4791	2.80728e4	155.13995	24.3299

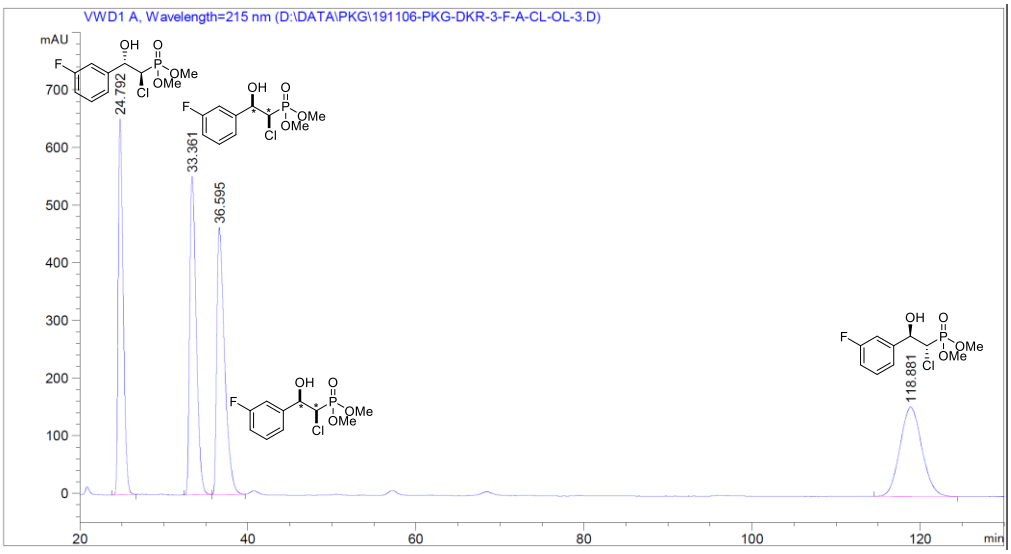


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	25.177	BB	0.6967	4.20028e4	946.56519	93.7669
2	34.440	BB	0.7929	2679.22510	51.50570	5.9811

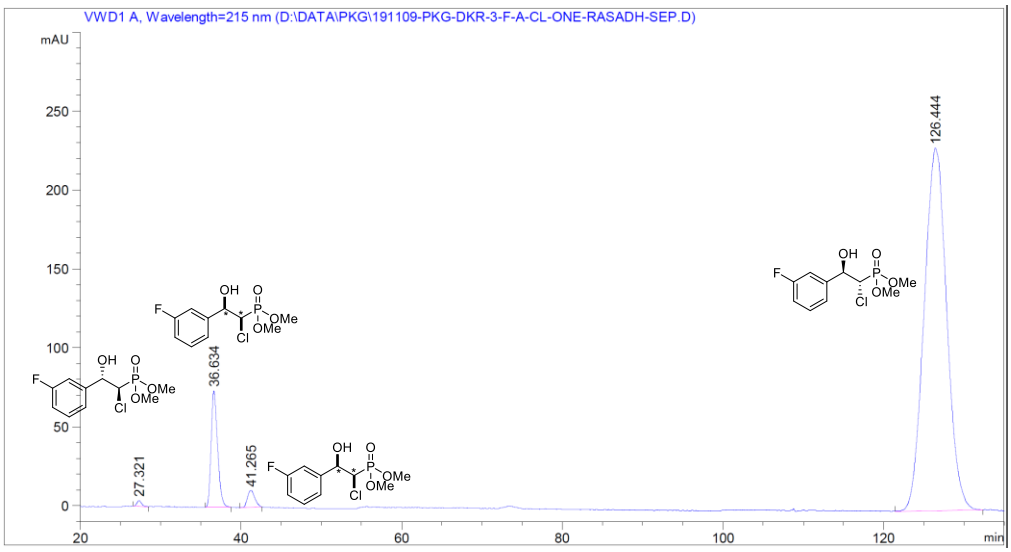
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	38.536	BB	0.7988	112.90112	2.09136	0.2520

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(3-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2m)**



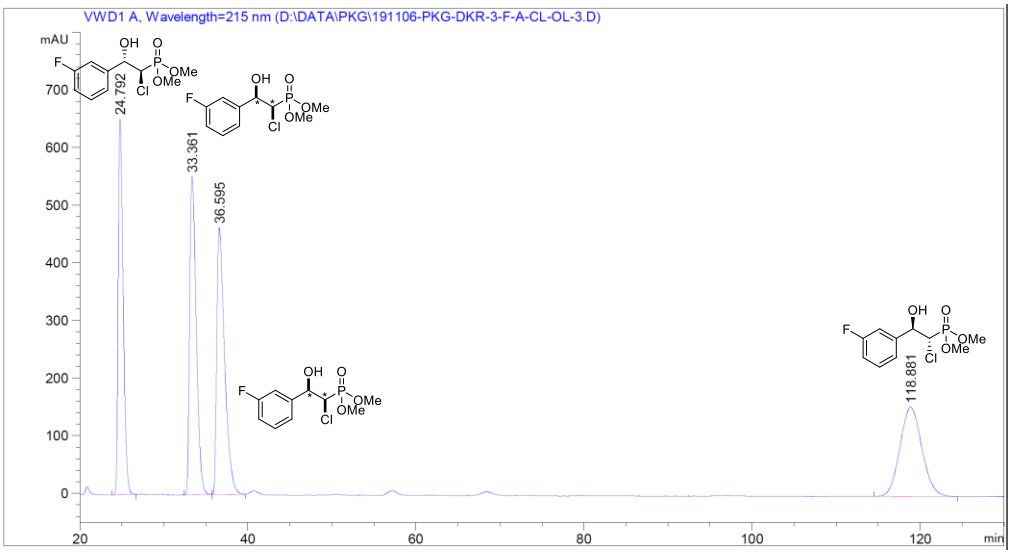
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	24.792	BB	0.6387	2.69900e4	652.38354	23.3914
2	33.361	VB	0.8388	3.00404e4	552.07574	26.0351
3	36.595	BV	0.9669	3.02811e4	463.05942	26.2436
4	118.881	BB	2.4791	2.80728e4	155.13995	24.3299



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	27.321	BB	0.5999	151.95610	3.73288	0.3043
2	36.634	BB	0.8617	4102.01514	73.76846	8.2147
3	41.265	BB	0.9558	677.47668	10.69854	1.3567
4	126.444	VV	2.4278	4.50035e4	229.89928	90.1242

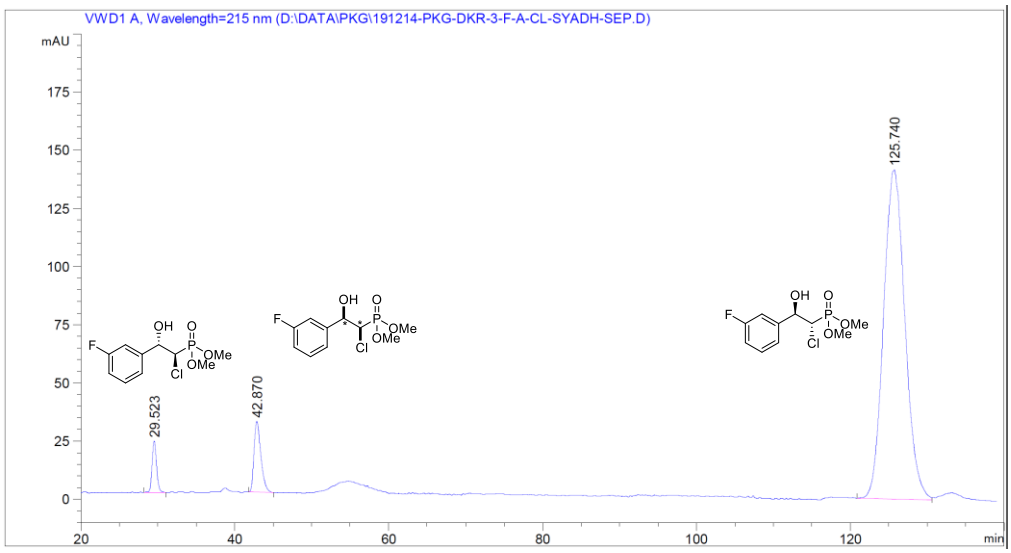
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(3-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2m)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	24.792	BB	0.6387	2.69900e4	652.38354	23.3914
2	33.361	VB	0.8388	3.00404e4	552.07574	26.0351

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	36.595	BV	0.9669	3.02811e4	463.05942	26.2436
4	118.881	BB	2.4791	2.80728e4	155.13995	24.3299

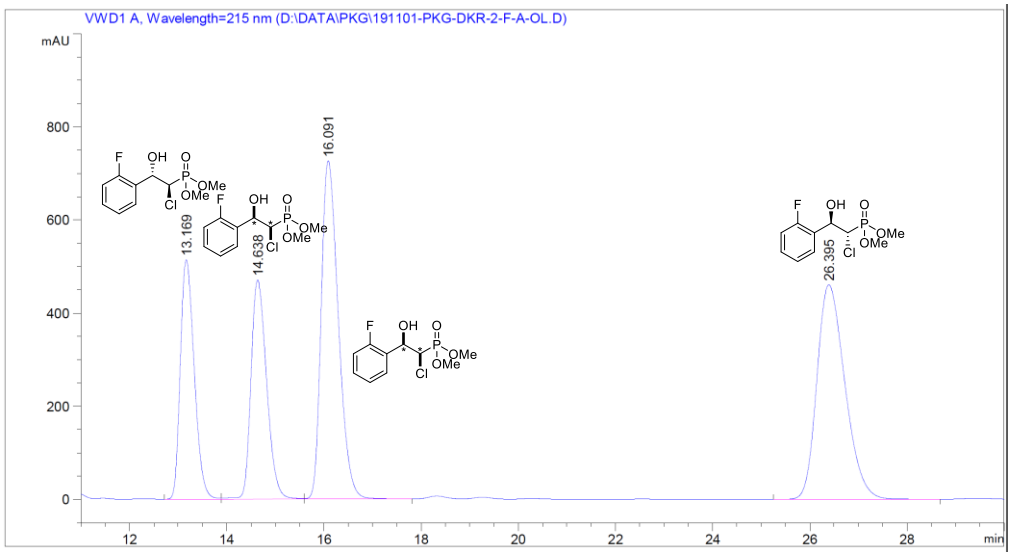


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	29.523	BB	0.6247	889.81079	21.96117	2.9576
2	42.870	BB	0.9589	1901.04858	30.42801	6.3188

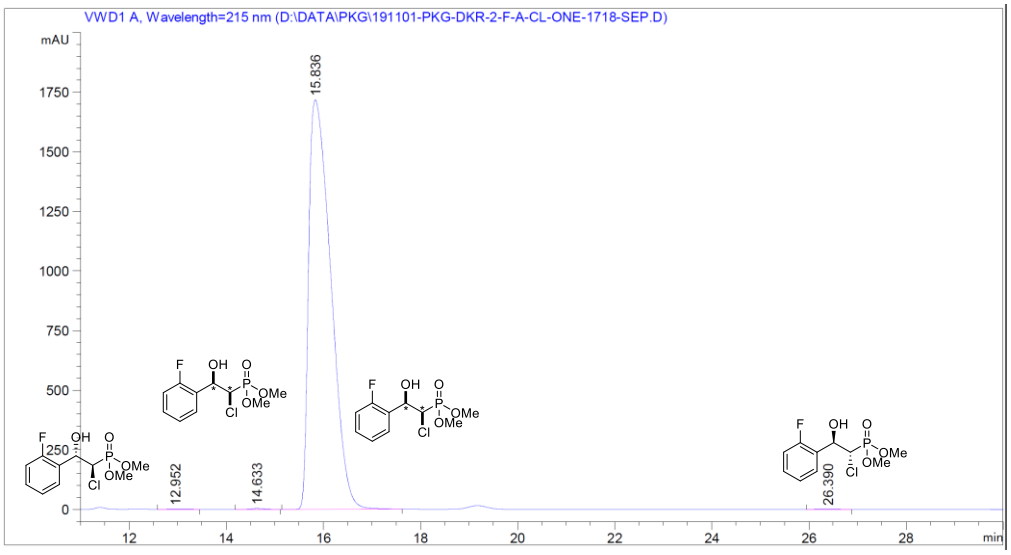
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	125.740	BV	2.3302	2.72946e4	141.51714	90.7236

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of SyADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-(2-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1S, 2S)*-2n)**



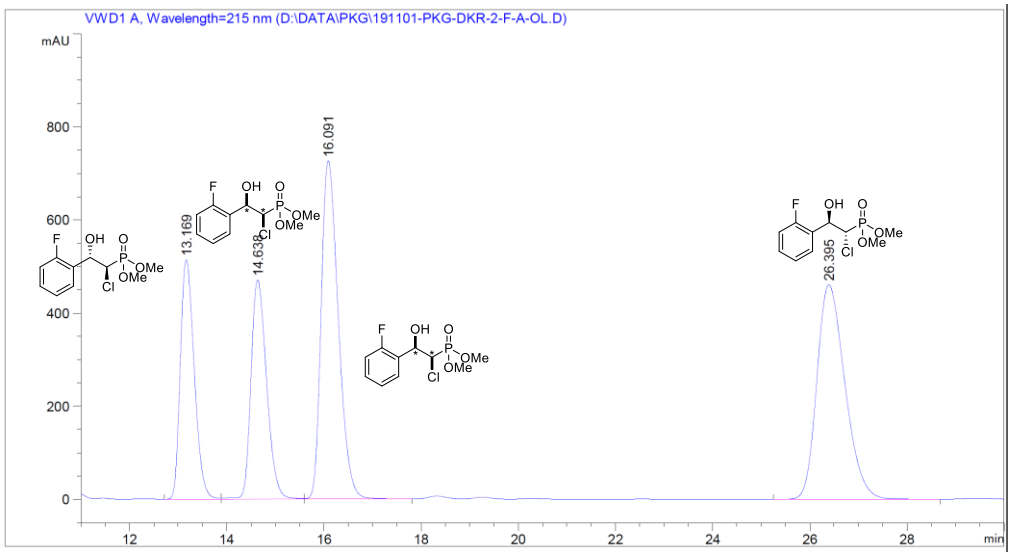
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.169	BV	0.3121	1.02178e4	513.54517	17.9312
2	14.638	VV	0.3509	1.05174e4	470.25378	18.4569
3	16.091	VB	0.3814	1.77610e4	726.16669	31.1687
4	26.395	BV	0.6241	1.84873e4	460.74255	32.4432



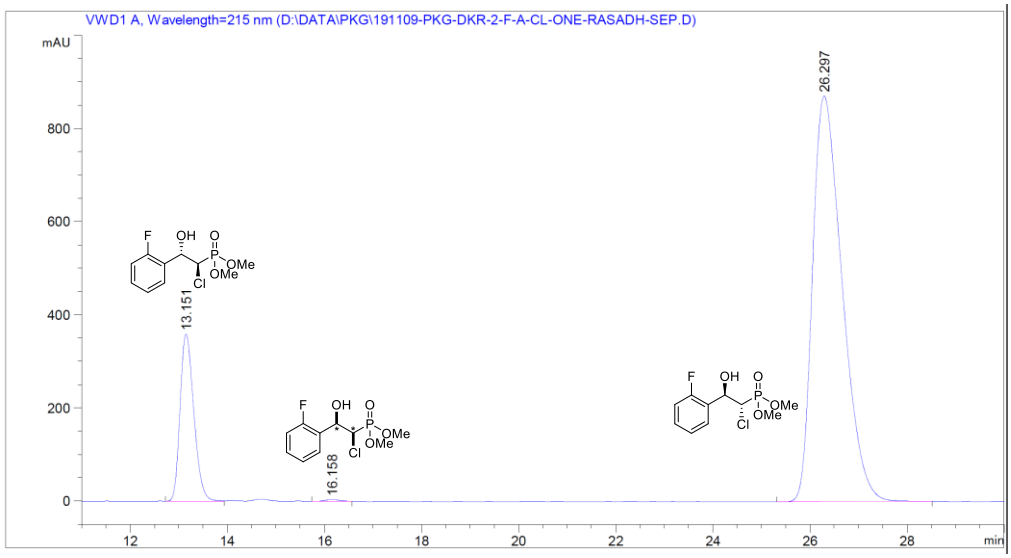
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.952	BV	0.3884	66.23597	2.34585	0.1218
2	14.633	BB	0.2885	85.35970	4.53597	0.1570
3	15.836	BB	0.5169	5.41210e4	1716.32214	99.5583
4	26.390	VV	0.6952	88.49899	2.07239	0.1628

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(2-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2n)**



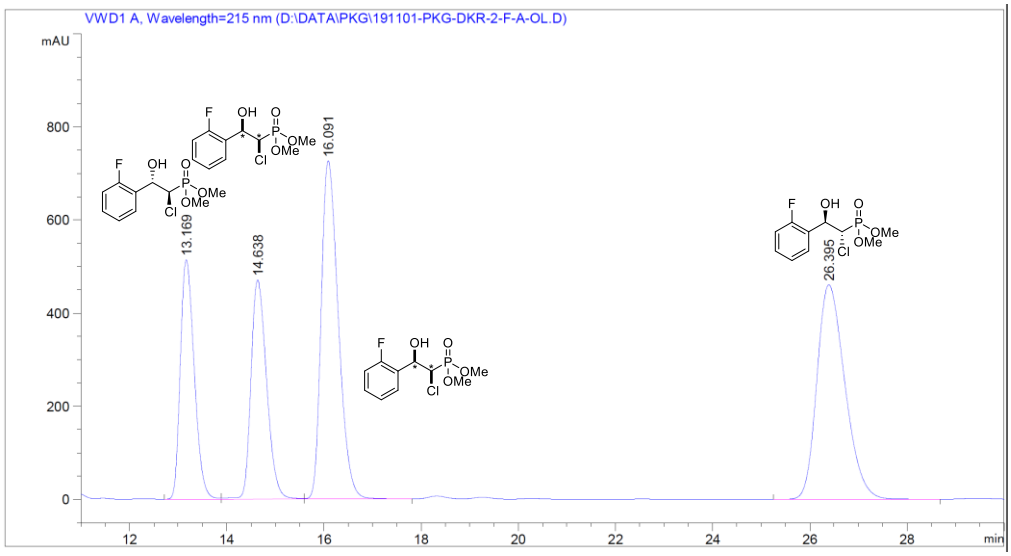
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.169	BV	0.3121	1.02178e4	513.54517	17.9312
2	14.638	VV	0.3509	1.05174e4	470.25378	18.4569
3	16.091	VB	0.3814	1.77610e4	726.16669	31.1687
4	26.395	BV	0.6241	1.84873e4	460.74255	32.4432



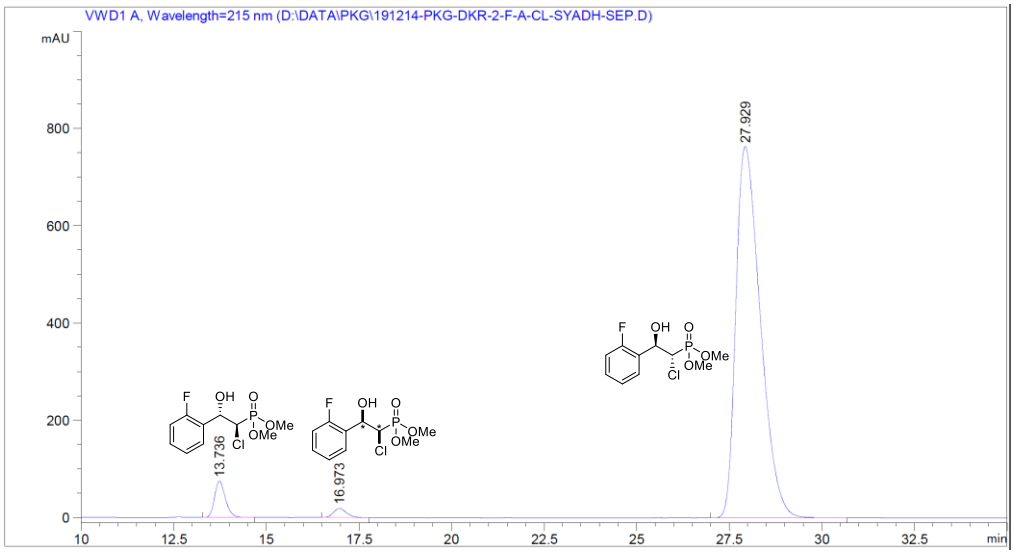
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.151	VV	0.3073	7085.43311	358.92447	16.0933
2	16.158	BB	0.3298	86.66315	4.13007	0.1968
3	26.297	BB	0.6686	3.68551e4	871.05725	83.7099

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(2-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2n)**



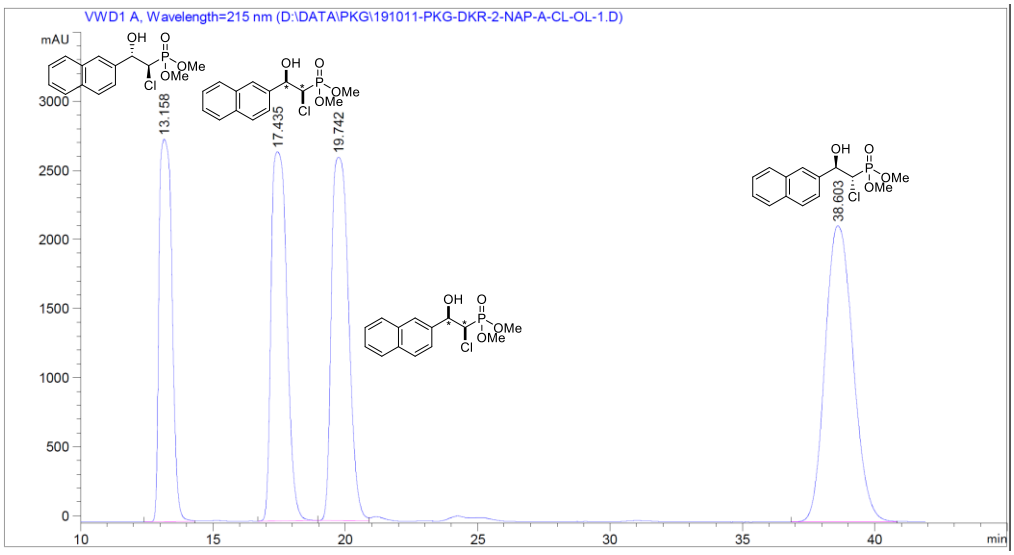
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.169	BV	0.3121	1.02178e4	513.54517	17.9312
2	14.638	VV	0.3509	1.05174e4	470.25378	18.4569
3	16.091	VB	0.3814	1.77610e4	726.16669	31.1687
4	26.395	BV	0.6241	1.84873e4	460.74255	32.4432



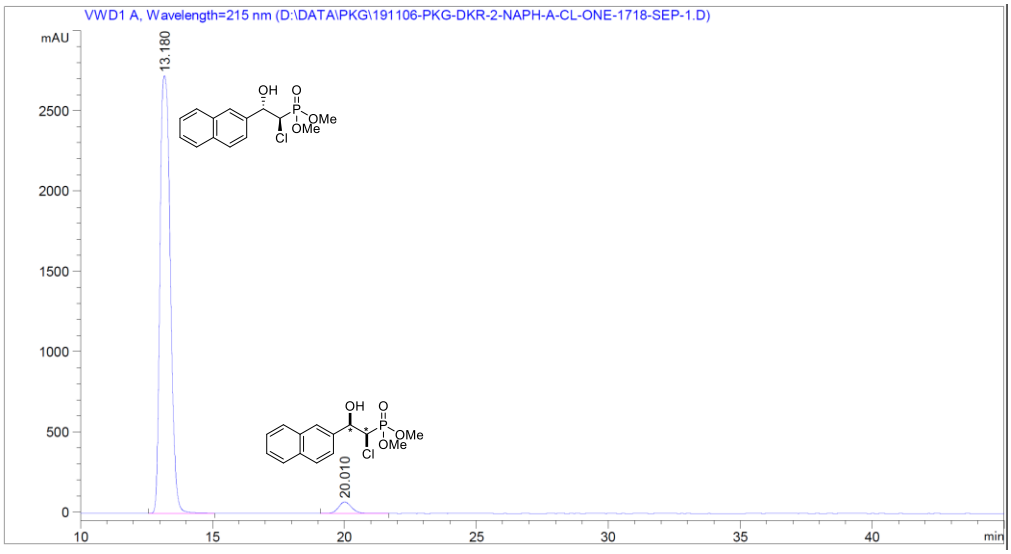
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.736	BB	0.3144	1516.90393	74.24758	4.1041
2	16.973	BB	0.3787	451.61914	18.37709	1.2219
3	27.929	BB	0.7111	3.49921e4	762.87622	94.6740

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of SyADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-hydroxy-2-(naphthalen-2-yl)ethyl)phosphonate (*anti-(1S, 2S)*-2o)**



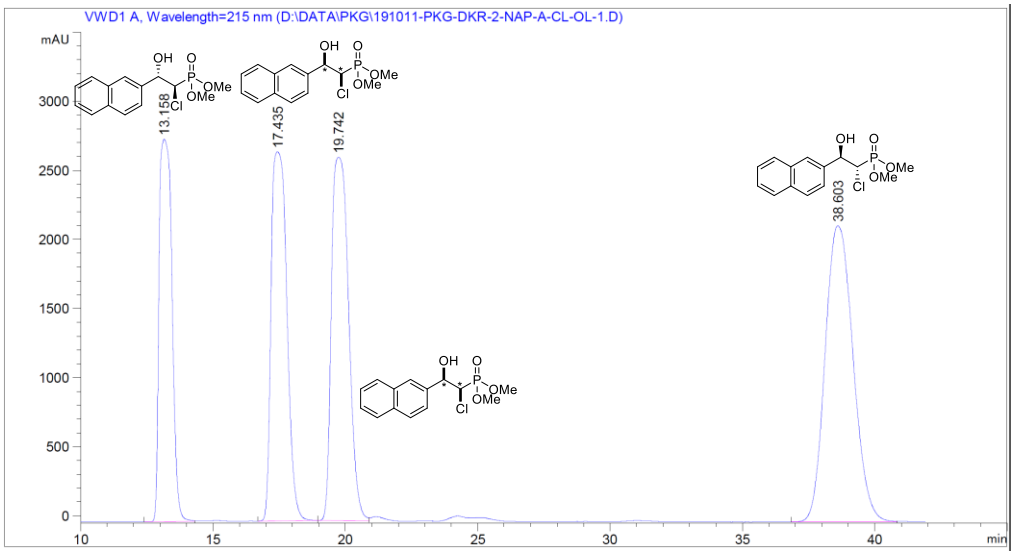
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.158	BV	0.5419	9.29028e4	2765.47070	19.4093
2	17.435	BB	0.6557	1.10309e5	2671.59888	23.0458
3	19.742	BV	0.7198	1.18532e5	2630.16138	24.7638
4	38.603	VV	1.1048	1.56907e5	2141.64404	32.7811



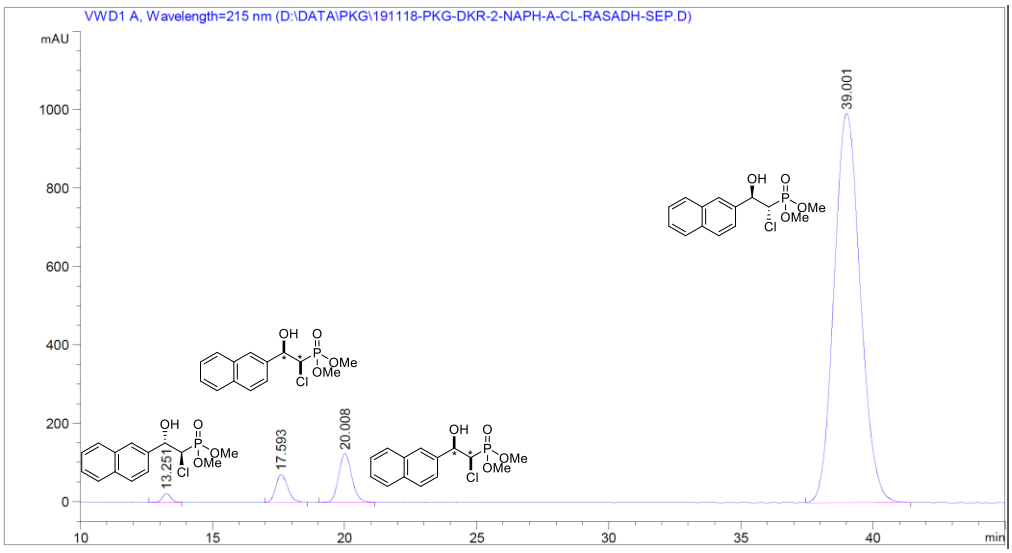
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.180	VV	0.4289	7.38188e4	2725.90405	96.6894
2	20.010	BV	0.5524	2527.56030	71.68517	3.3106

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-hydroxy-2-(naphthalen-2-yl)ethyl)phosphonate (*anti-(1R, 2R)*-2o)**



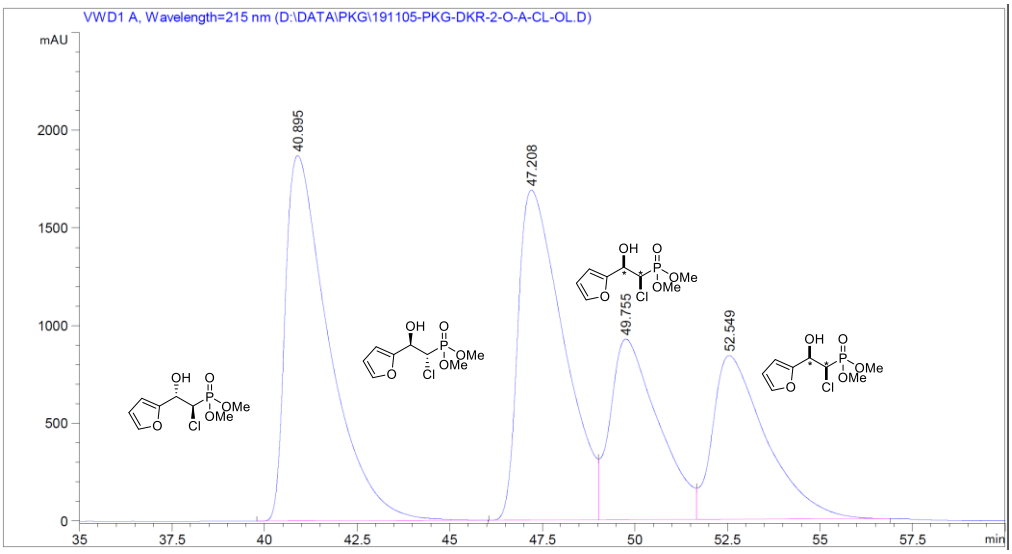
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.158	BV	0.5419	9.29028e4	2765.47070	19.4093
2	17.435	BB	0.6557	1.10309e5	2671.59888	23.0458
3	19.742	BV	0.7198	1.18532e5	2630.16138	24.7638
4	38.603	VV	1.1048	1.56907e5	2141.64404	32.7811



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.251	BV	0.3522	501.61084	22.32228	0.6613
2	17.593	VB	0.4915	2212.71997	70.62362	2.9173
3	20.008	BV	0.5334	4289.85840	124.67303	5.6558
4	39.001	VV	1.0202	6.88447e4	993.84595	90.7656

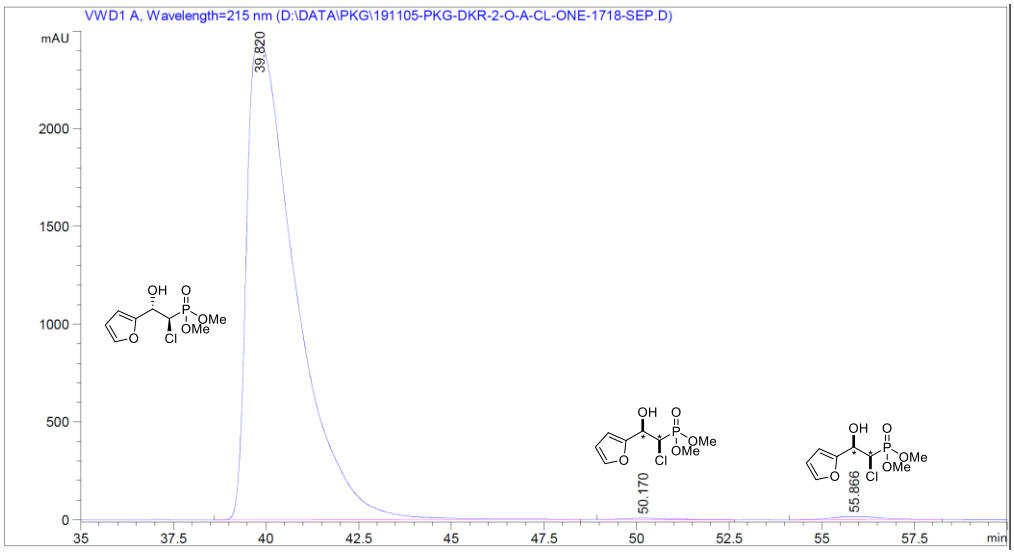
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-(furan-2-yl)-2-hydroxyethyl)phosphonate (*anti-(1S, 2S)*-2p)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	40.895	BB	1.1962	1.53310e5	1870.48474	32.9302
2	47.208	BV	1.2276	1.44143e5	1689.13782	30.9611

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	49.755	VV	1.3048	8.39538e4	925.04303	18.0329
4	52.549	VB	1.5066	8.41537e4	837.98767	18.0758

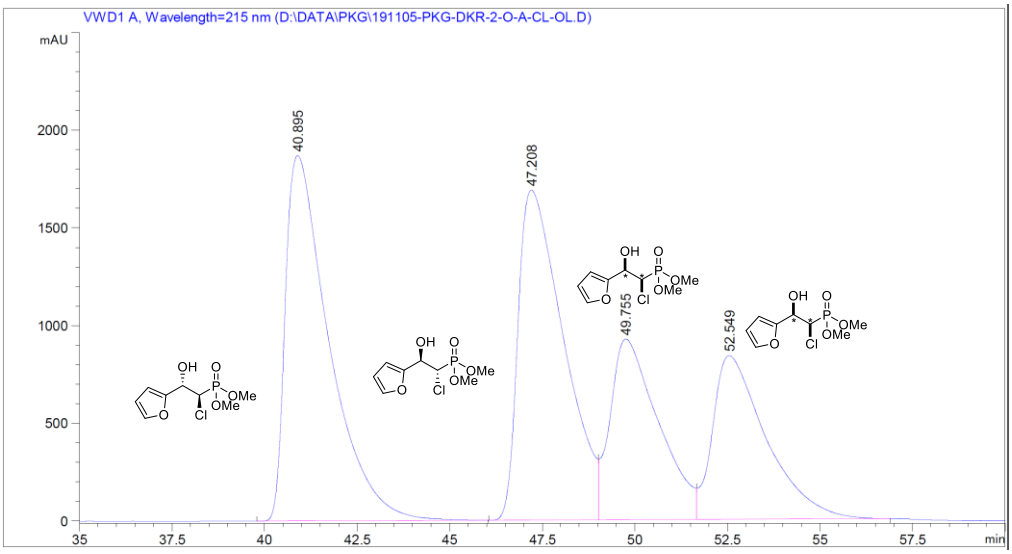


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	39.820	BB	1.3483	2.24168e5	2445.74438	99.0946
2	50.170	BB	1.2009	553.74738	6.73022	0.2448

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	55.866	BB	1.3298	1494.42712	15.37792	0.6606

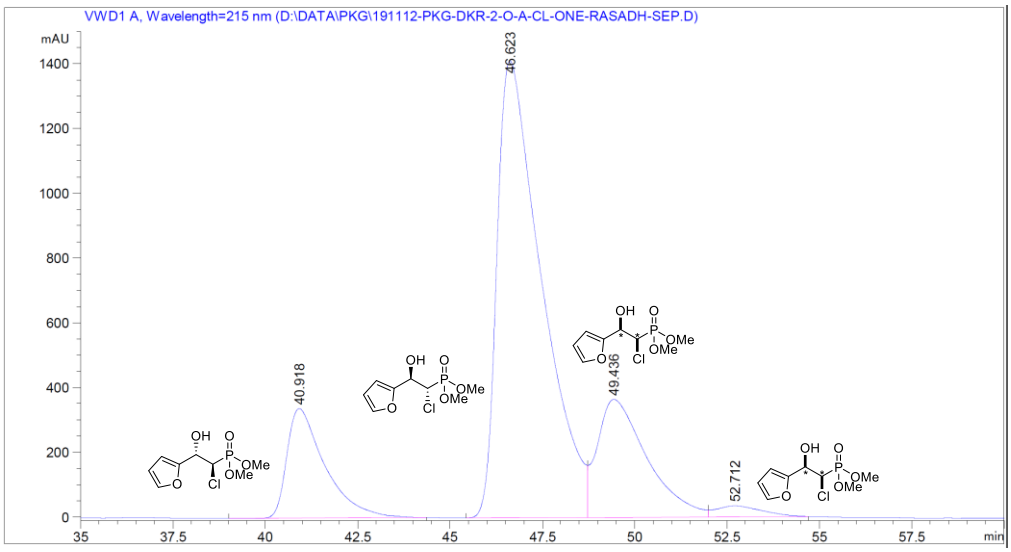
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(furan-2-yl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2p)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	40.895	BB	1.1962	1.53310e5	1870.48474	32.9302
2	47.208	BV	1.2276	1.44143e5	1689.13782	30.9611

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	49.755	VV	1.3048	8.39538e4	925.04303	18.0329
4	52.549	VB	1.5066	8.41537e4	837.98767	18.0758

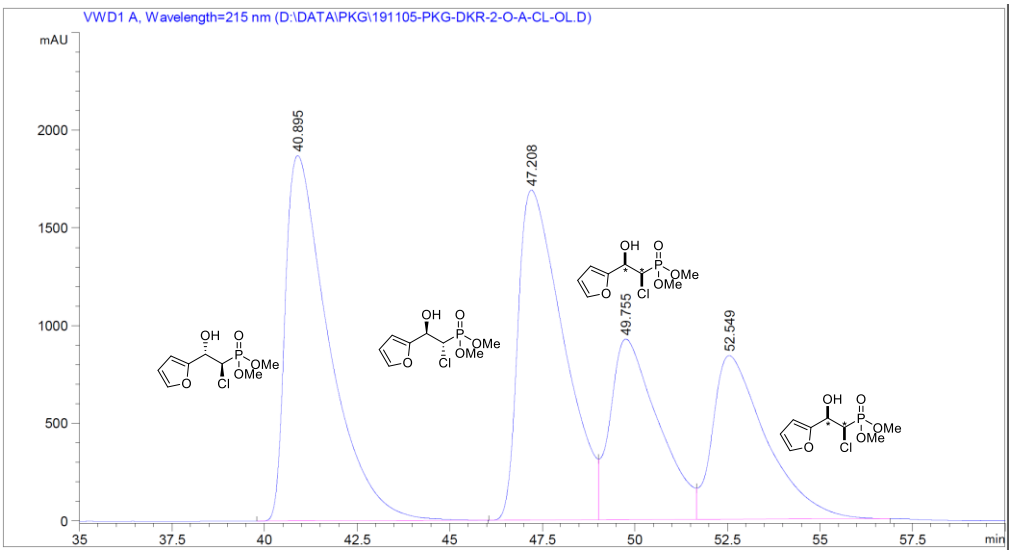


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	40.918	BB	1.0475	2.42810e4	338.65042	13.5363
2	46.623	BV	1.2056	1.18109e5	1410.88879	65.8441

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	49.436	VV	1.3696	3.40766e4	364.20309	18.9972
4	52.712	VB	1.2314	2910.21191	33.73493	1.6224

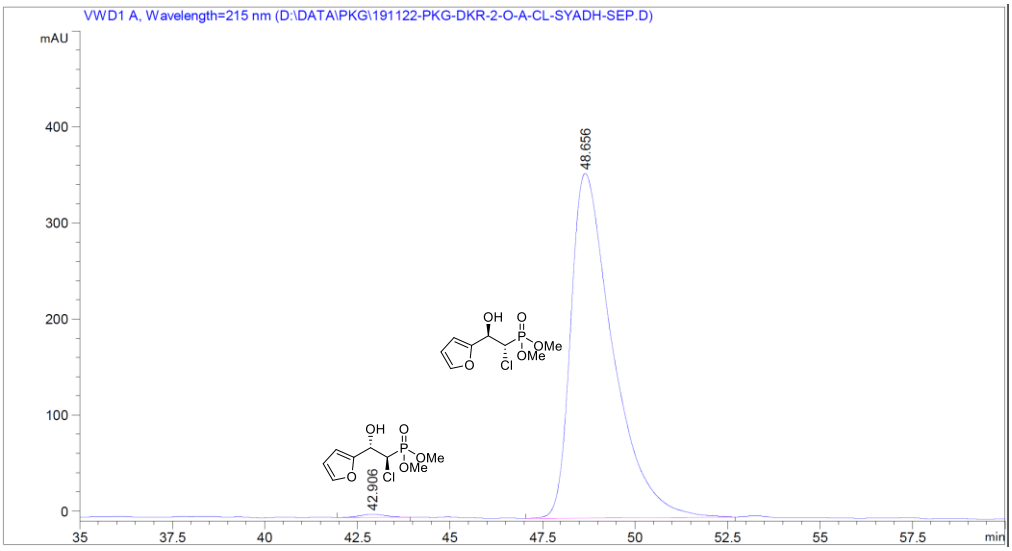
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-(furan-2-yl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2p)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	40.895	BB	1.1962	1.53310e5	1870.48474	32.9302
2	47.208	BV	1.2276	1.44143e5	1689.13782	30.9611

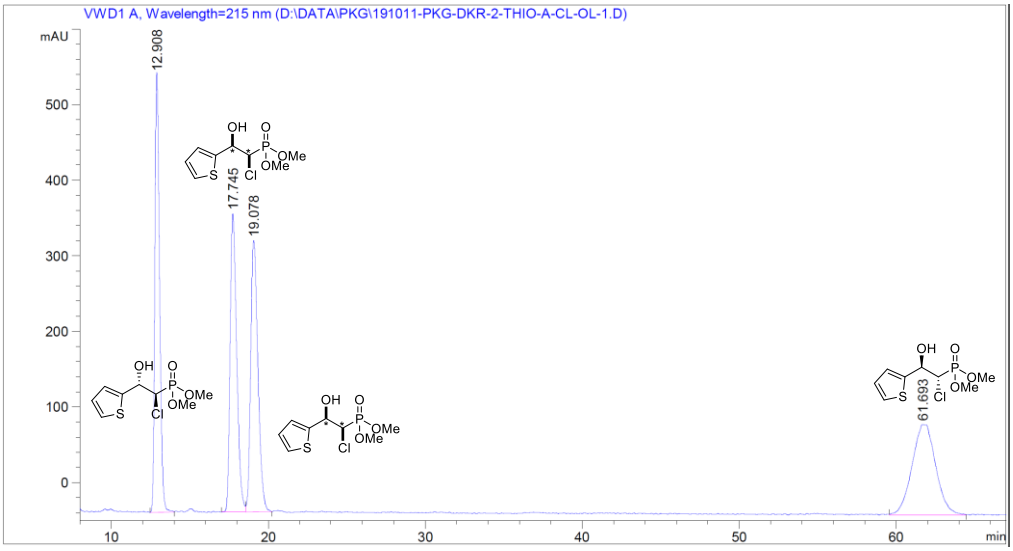
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	49.755	VV	1.3048	8.39538e4	925.04303	18.0329
4	52.549	VB	1.5066	8.41537e4	837.98767	18.0758



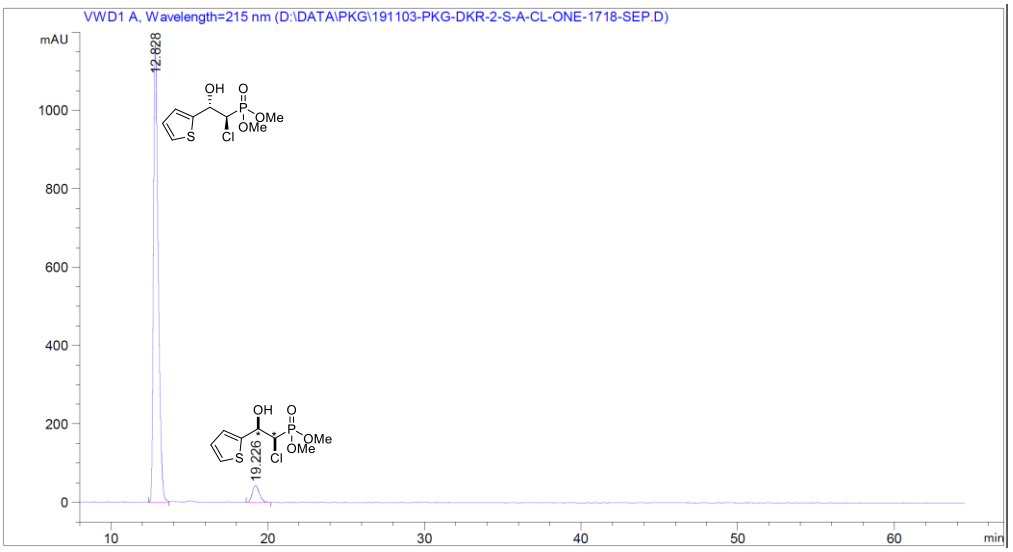
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	42.906	BB	0.6932	162.40822	3.41280	0.5704
2	48.656	BB	1.1677	2.83103e4	358.71710	99.4296

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of SyADH-catalyzed biotransformation.

***anti-(1S, 2S)*-dimethyl (1-chloro-2-hydroxy-2-(thiophen-2-yl)ethyl)phosphonate (*anti-(1S, 2S)*-2q)**



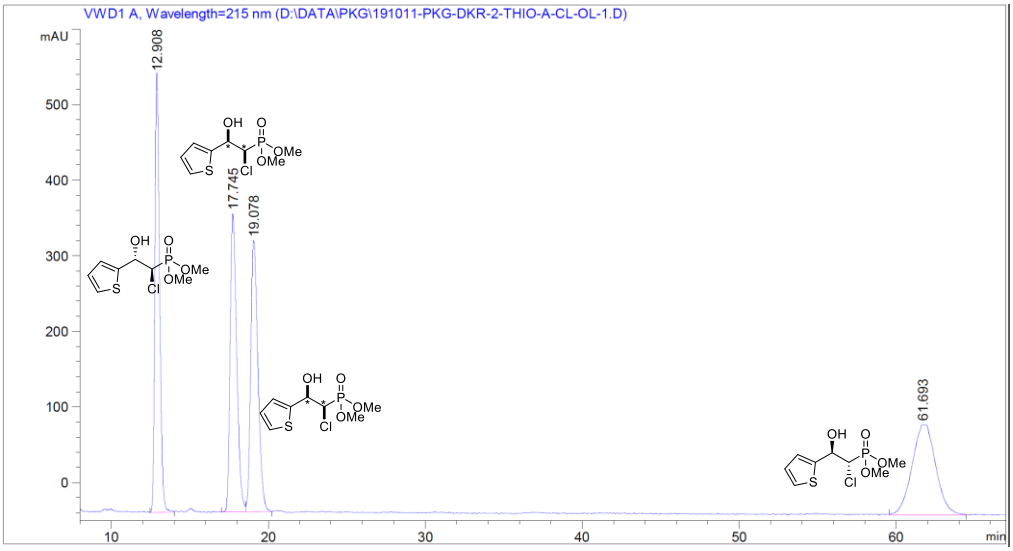
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.908	BV	0.3247	1.22113e4	582.23755	25.4896
2	17.745	BV	0.4530	1.15356e4	394.67957	24.0791
3	19.078	VB	0.4902	1.16250e4	358.63245	24.2659
4	61.693	VV	1.2865	1.25350e4	119.62018	26.1653



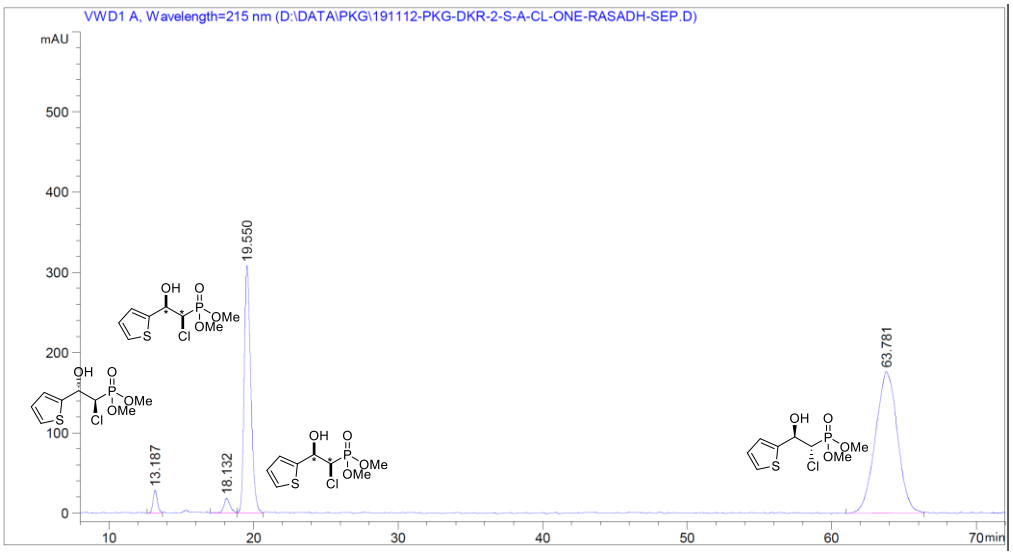
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.828	BV	0.3224	2.47547e4	1172.03979	94.8730
2	19.226	BB	0.4800	1337.77344	42.87193	5.1270

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-hydroxy-2-(thiophen-2-yl)ethyl)phosphonate (*anti-(1R, 2R)*-2q)**



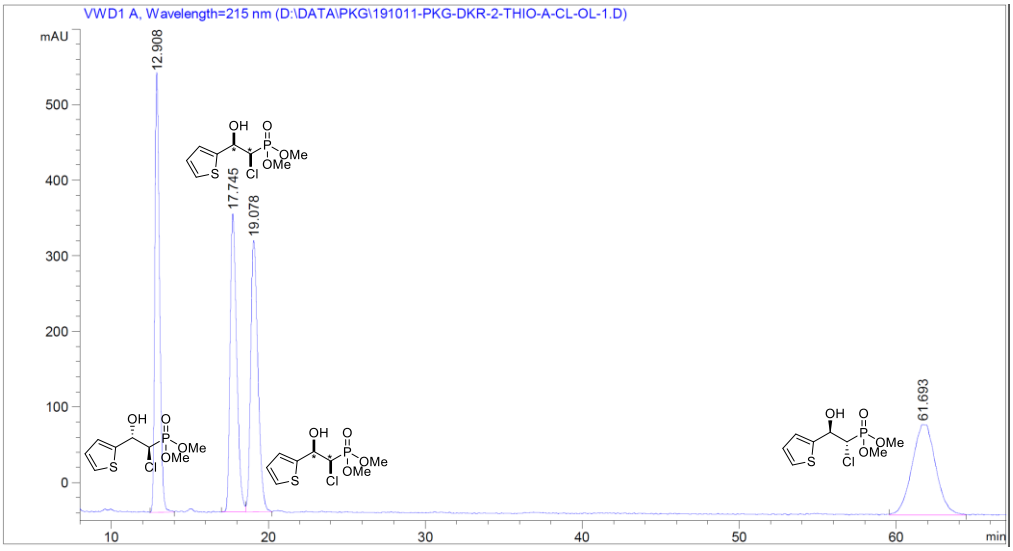
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.908	BV	0.3247	1.22113e4	582.23755	25.4896
2	17.745	BV	0.4530	1.15356e4	394.67957	24.0791
3	19.078	VB	0.4902	1.16250e4	358.63245	24.2659
4	61.693	VV	1.2865	1.25350e4	119.62018	26.1653



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.187	BV	0.3337	623.22748	28.65751	2.0953
2	18.132	BV	0.4529	565.26221	18.47827	1.9004
3	19.550	VV	0.4814	9760.44043	308.27832	32.8151
4	63.781	BV	1.5527	1.87948e4	176.72916	63.1891

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1R, 2R)*-dimethyl (1-chloro-2-hydroxy-2-(thiophen-2-yl)ethyl)phosphonate (*anti-(1R, 2R)*-2q)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	12.908	BV	0.3247	1.22113e4	582.23755	25.4896
2	17.745	BV	0.4530	1.15356e4	394.67957	24.0791

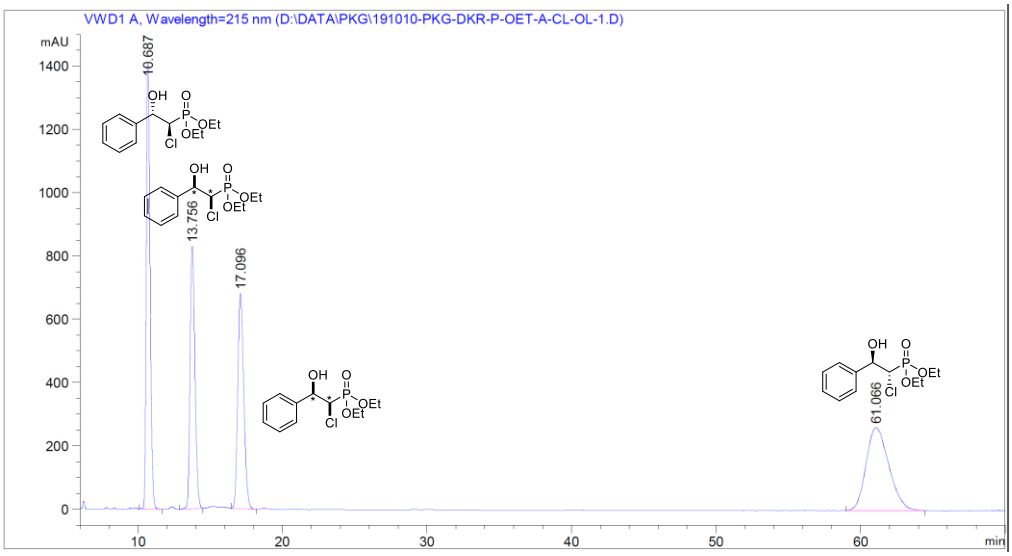
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.078	VB	0.4902	1.16250e4	358.63245	24.2659
4	61.693	VV	1.2865	1.25350e4	119.62018	26.1653

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	13.306	VV	0.3381	254.77347	11.60437	3.7190
2	18.336	VV	0.4905	200.38387	6.34462	2.9251

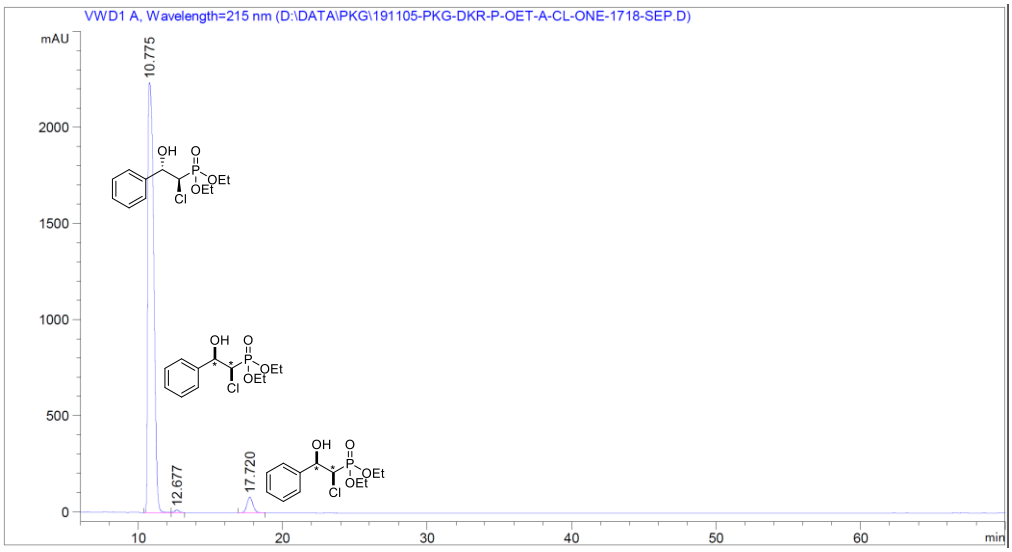
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	19.882	BV	0.3215	49.80699	2.09434	0.7271
4	63.404	BV	1.3154	6345.57324	59.35052	92.6288

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of SyADH-catalyzed biotransformation.

anti-(1S, 2S)-diethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (_anti-(1S, 2S)_-2r)



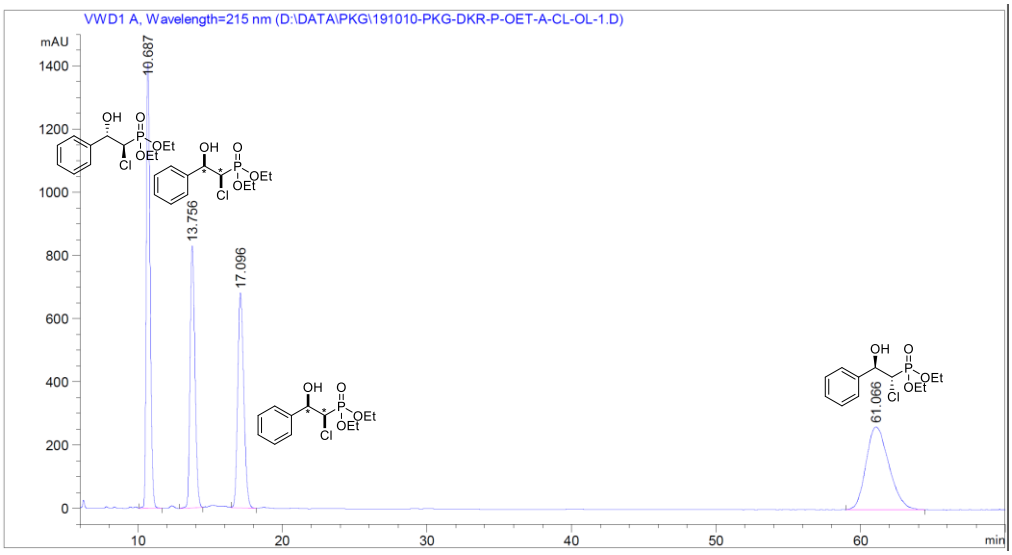
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	10.687	VV	0.2911	2.62207e4	1408.87109	27.8613
2	13.756	BB	0.3625	1.92218e4	829.11328	20.4245
3	17.096	VB	0.4500	1.97186e4	680.64618	20.9524
4	61.066	VV	1.4903	2.89504e4	262.57397	30.7618



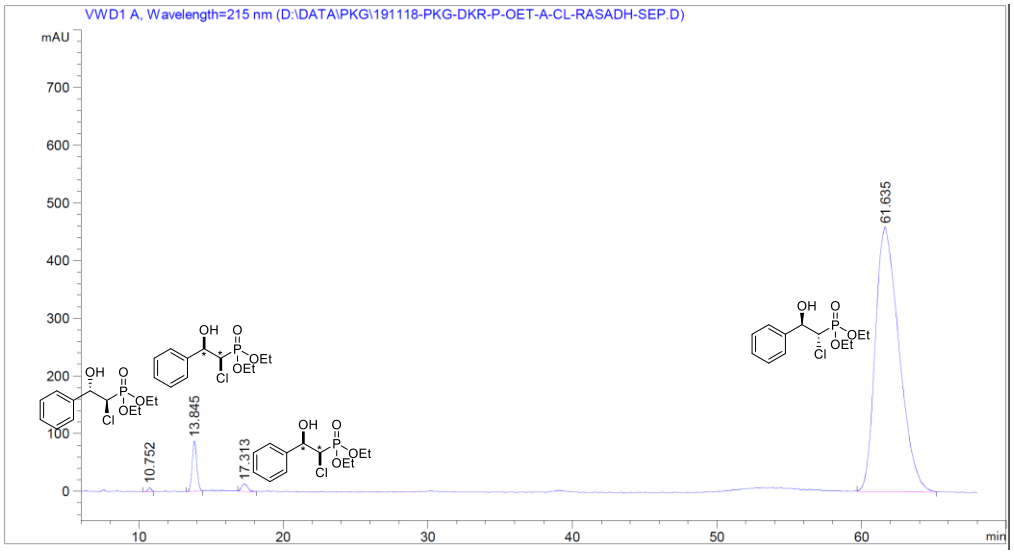
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	10.775	BV	0.4686	6.41770e4	2237.64746	95.9965
2	12.677	VV	0.3402	309.46725	13.66512	0.4629
3	17.720	BV	0.4545	2367.00732	80.63863	3.5406

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-diethyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti-(1R, 2R)*-2r)**



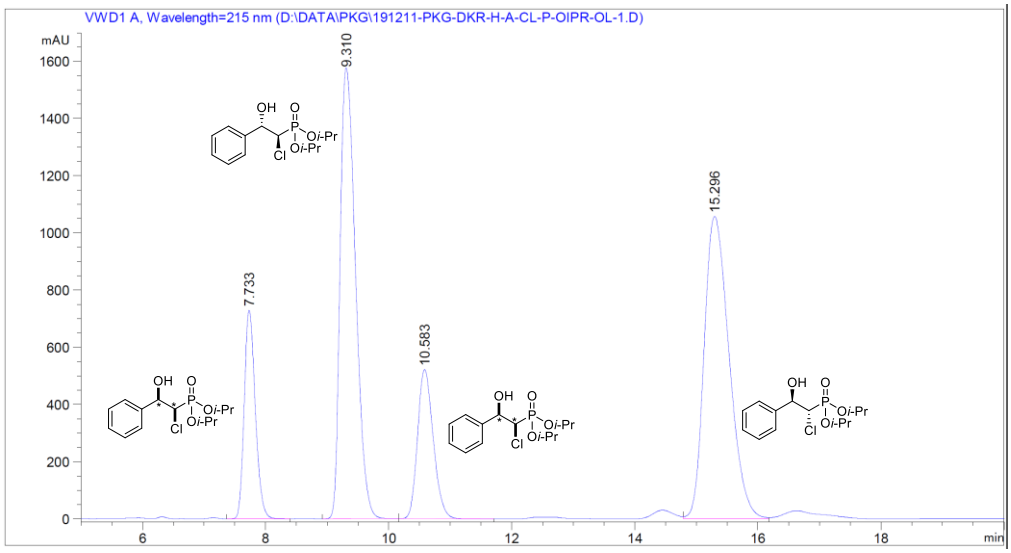
峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	10.687	VV	0.2911	2.62207e4	1408.87109	27.8613
2	13.756	BB	0.3625	1.92218e4	829.11328	20.4245
3	17.096	VB	0.4500	1.97186e4	680.64618	20.9524
4	61.066	VV	1.4903	2.89504e4	262.57397	30.7618



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	10.752	BV	0.2482	119.56527	7.33267	0.2180
2	13.845	BB	0.3457	1932.02246	86.80666	3.5220
3	17.313	VV	0.4941	378.57678	12.54551	0.6901
4	61.635	VV	1.6007	5.24249e4	458.94388	95.5698

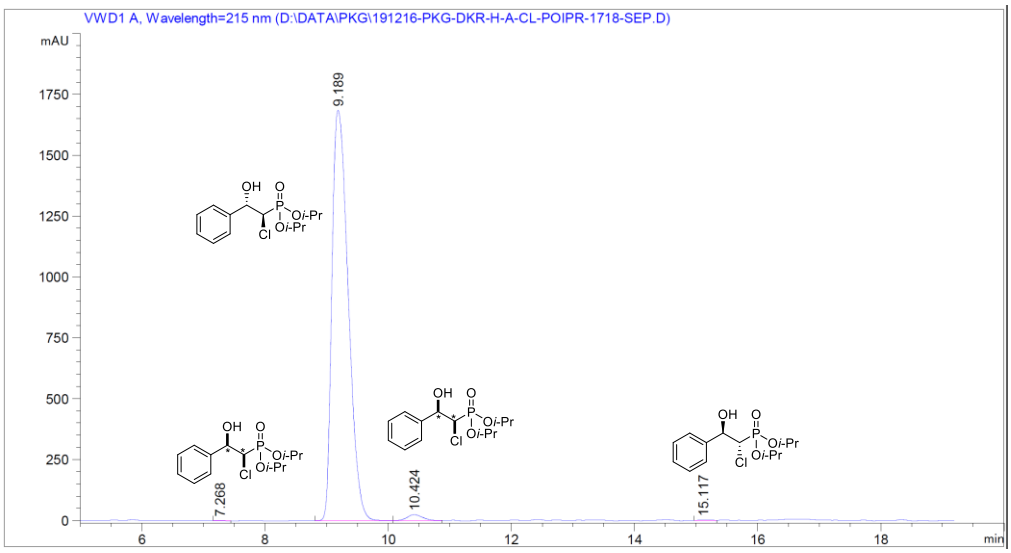
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1S, 2S)*-diisopropyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti-(1S, 2S)*-2s)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.733	VV	0.1943	9139.82031	728.97040	12.1029
2	9.310	BB	0.2743	2.73562e4	1577.44873	36.2250

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	10.583	BB	0.2748	9240.74219	521.44006	12.2366
4	15.296	VV	0.4405	2.97806e4	1057.63123	39.4354

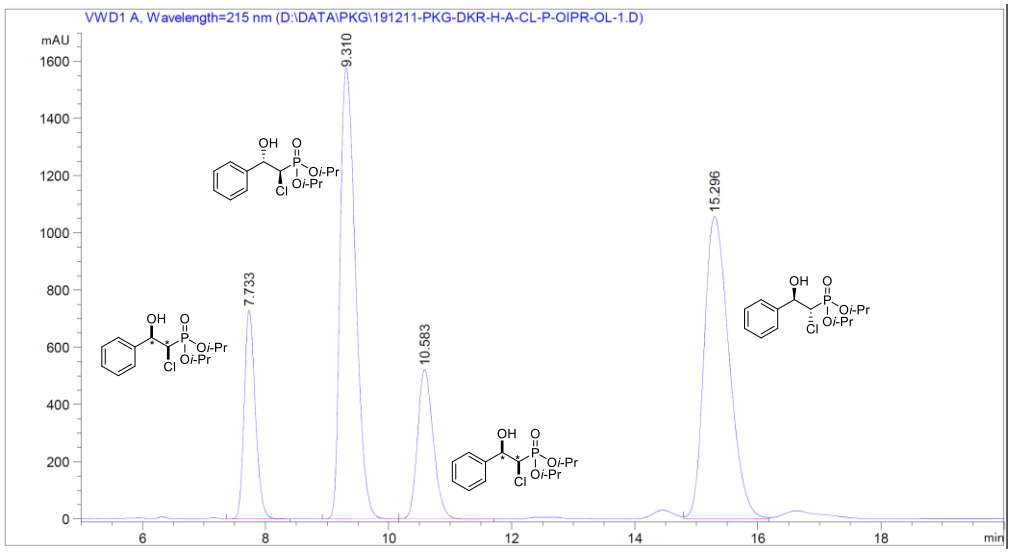


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.268	VB	0.1499	23.51264	2.45118	0.0745
2	9.189	VV	0.2923	3.09725e4	1686.45618	98.1963

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	10.424	VV	0.2878	494.98877	25.79893	1.5693
4	15.117	VV	0.2213	50.42398	3.24408	0.1599

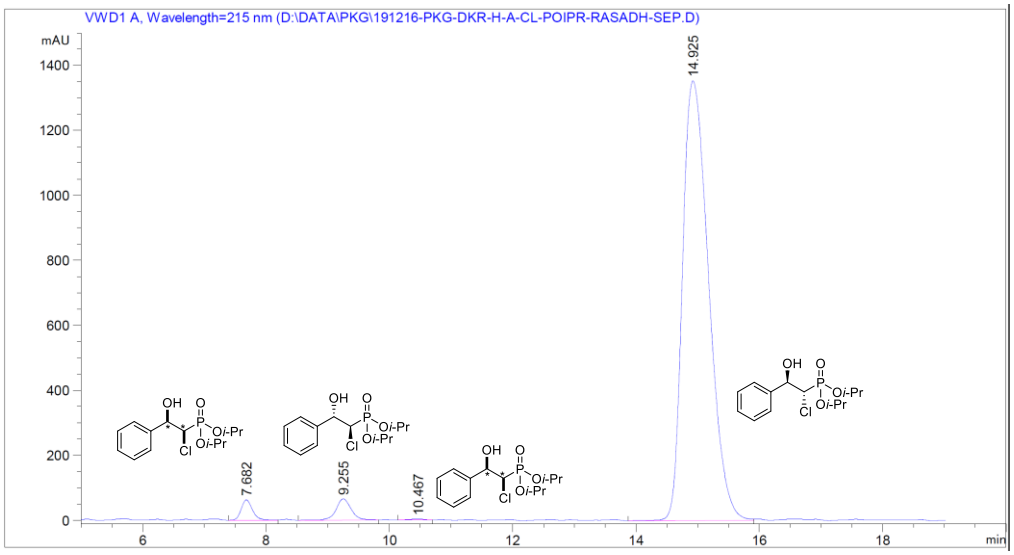
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of KmCR2-catalyzed biotransformation.

***anti-(1R, 2R)*-diisopropyl (1-chloro-2-hydroxy-2-phenylethyl)phosphonate (*anti-(1R, 2R)*-2s)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.733	VV	0.1943	9139.82031	728.97040	12.1029
2	9.310	BB	0.2743	2.73562e4	1577.44873	36.2250

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	10.583	BB	0.2748	9240.74219	521.44006	12.2366
4	15.296	VV	0.4405	2.97806e4	1057.63123	39.4354

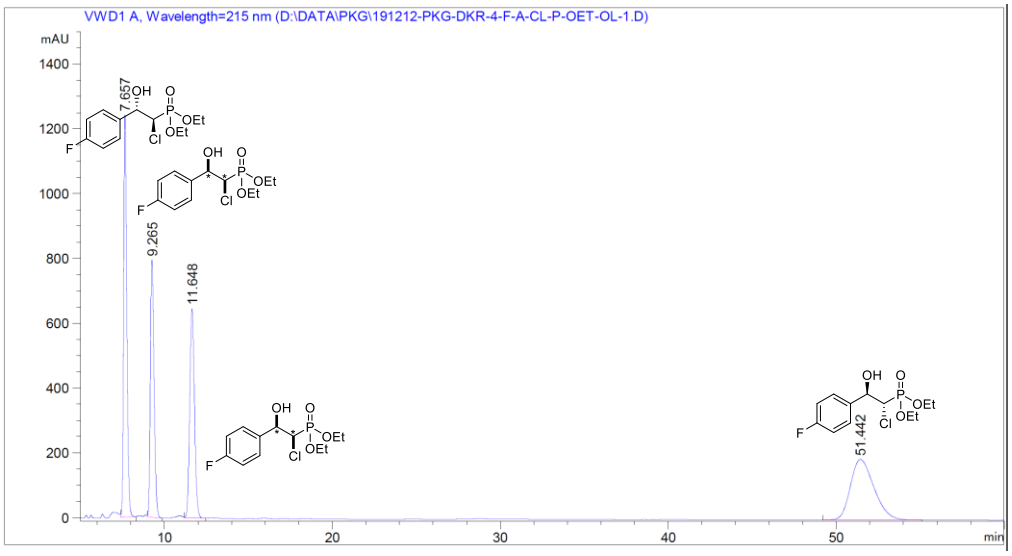


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.682	BV	0.1951	801.41235	62.70750	1.9255
2	9.255	BB	0.2581	1091.60315	64.92796	2.6227

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	10.467	BV	0.2329	45.68265	3.01225	0.1098
4	14.925	BV	0.4662	3.96823e4	1352.84302	95.3420

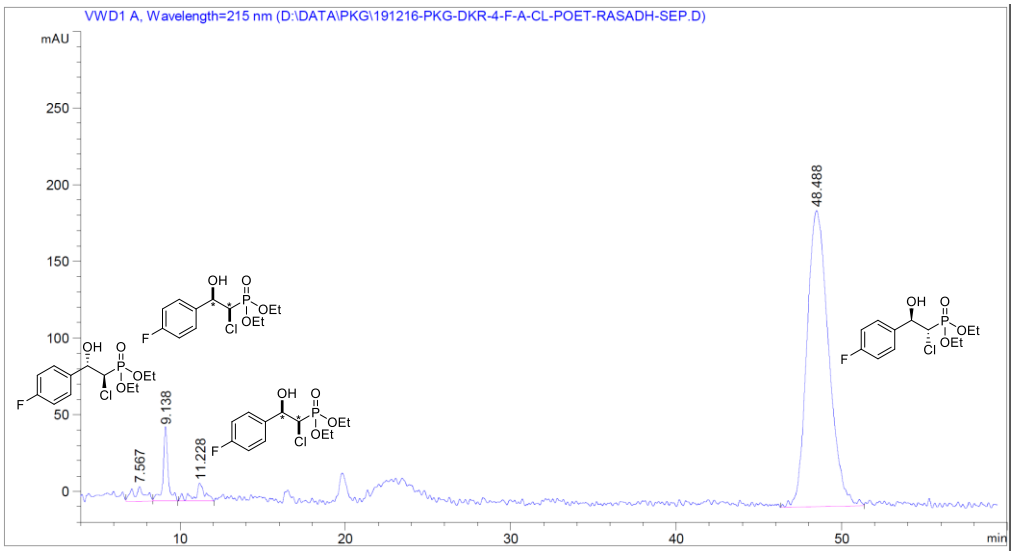
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1R, 2R)*-diethyl (1-chloro-2-(4-fluorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2t)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.657	VB	0.2050	1.62797e4	1241.21570	27.5110
2	9.265	VB	0.2395	1.22171e4	793.87048	20.6456

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	11.648	VB	0.3045	1.26539e4	646.11481	21.3839
4	51.442	BB	1.5061	1.80245e4	186.08458	30.4595

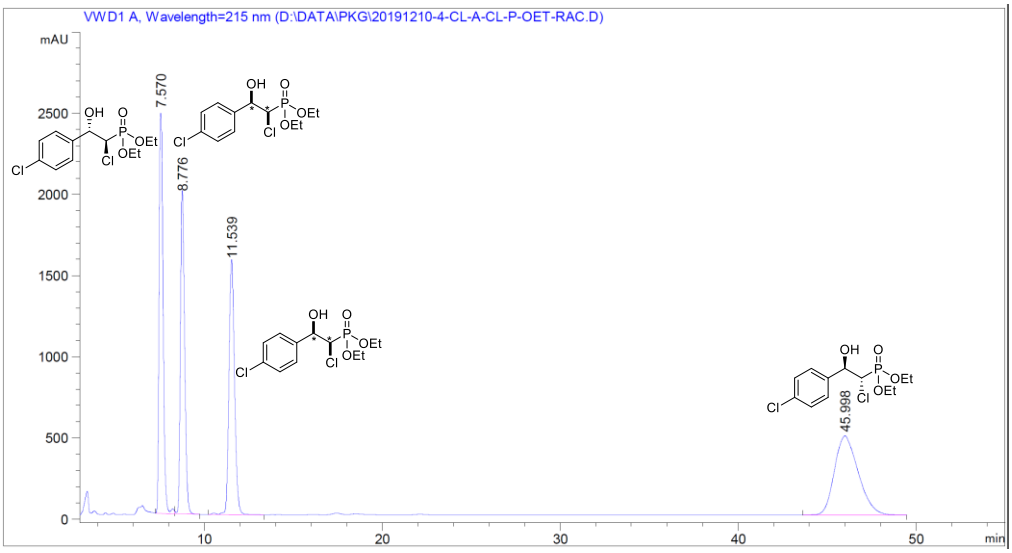


峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.567	VV	0.6685	479.28305	9.50220	2.4392
2	9.138	VB	0.3298	1017.45184	47.52305	5.1780

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	11.228	BB	0.6104	505.71307	11.12337	2.5737
4	48.488	BV	1.4188	1.76469e4	192.98209	89.8091

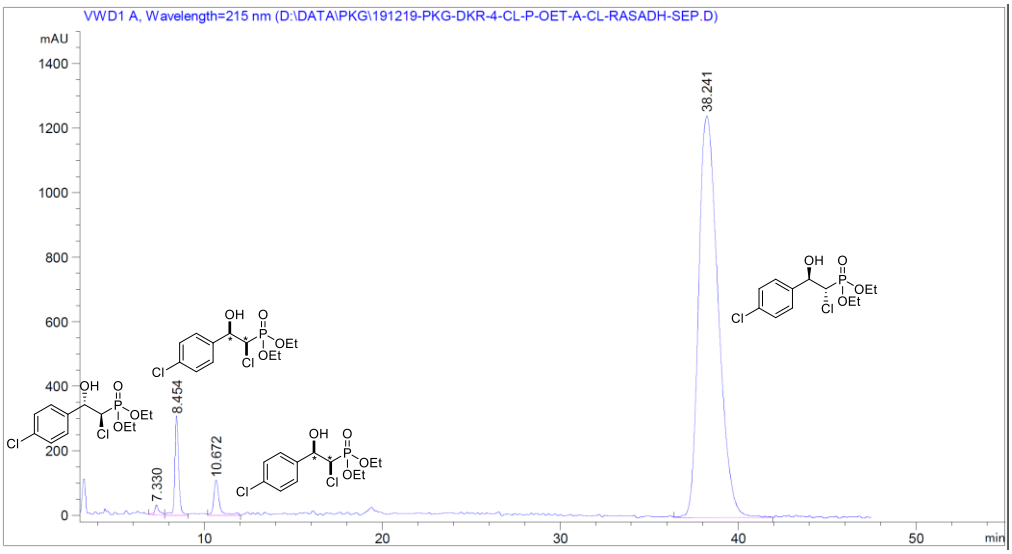
The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

***anti-(1R, 2R)*-diethyl (1-chloro-2-(4-chlorophenyl)-2-hydroxyethyl)phosphonate (*anti-(1R, 2R)*-2u)**



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.570	BV	0.2620	3.86005e4	2475.03760	25.6509
2	8.776	VB	0.2740	3.26592e4	1964.12537	21.7028

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	11.539	BB	0.3528	3.42063e4	1554.08582	22.7309
4	45.998	BBA	1.4305	4.50177e4	486.97180	29.9153



峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
1	7.330	VV	0.3083	585.74255	29.93237	0.5710
2	8.454	VV	0.2581	4613.32910	302.12650	4.4970

峰 #	保留时间 [min]	类型	峰宽 [min]	峰面积 [mAU*s]	峰高 [mAU]	峰面积 %
3	10.672	VB	0.3543	2319.69434	104.75653	2.2612
4	38.241	VB	1.1790	9.50684e4	1244.77454	92.6709

The top spectrum is the chiral HPLC analysis of the racemic synthetic standard. The bottom spectrum is the chiral HPLC analysis of RasADH-catalyzed biotransformation.

Crystal data

Crystallographic data for compound *anti*-(1*S*, 2*S*)-**2k** (CCDC-1975103) has been deposited with the Cambridge Crystallographic Data Centre, Copies of the data can be obtained, free of charge, on application to CCDC (Email:deposit@ccdc.cam.ac.uk)

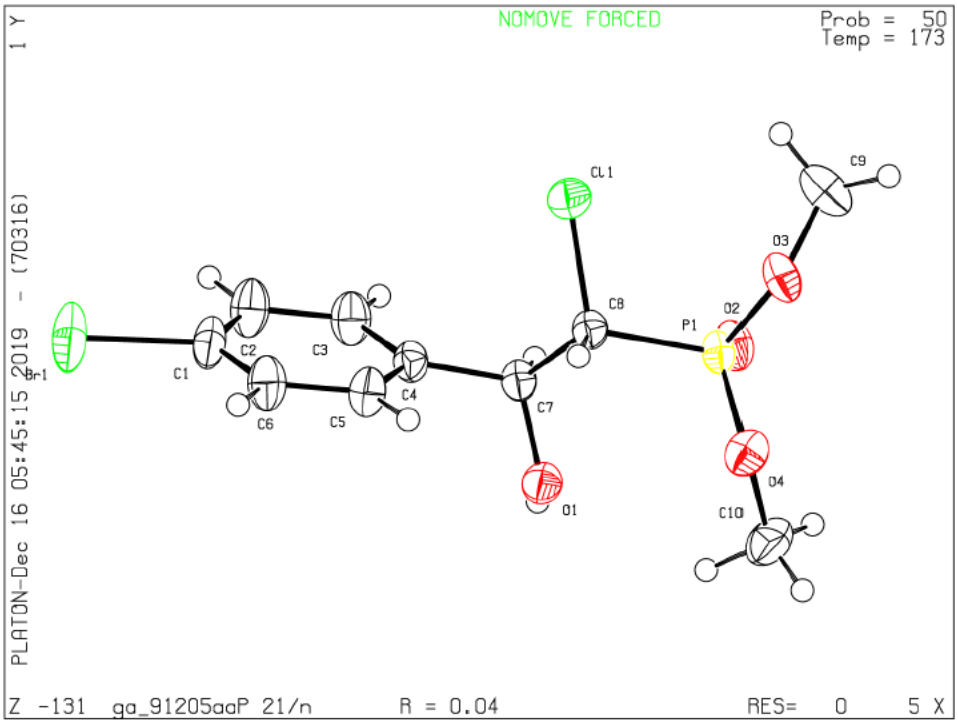


Table 1. Crystal data and structure refinement for ga_91205aa_a.

Identification code	ga_91205aa_a	
Empirical formula	C10 H13 Br Cl O4 P	
Formula weight	343.53	
Temperature	173(2) K	
Wavelength	1.34138 Å	
Crystal system	Monoclinic	
Space group	$P2_1/n$	
Unit cell dimensions	a = 8.7086(8) Å	α= 90 °.
	b = 9.0359(7) Å	β= 102.801(3) °.
	c = 17.1804(16) Å	γ = 90 °.
Volume	1318.3(2) $Å^3$	
Z	4	
Density (calculated)	1.731 Mg/m^3	
Absorption coefficient	4.829 mm^{-1}	
F(000)	688	
Crystal size	0.040 x 0.031 x 0.027 mm^3	
Theta range for data collection	4.592 to 58.483 °.	

Index ranges	-11<=h<=11, -11<=k<=11, -21<=l<=21
Reflections collected	17962
Independent reflections	2825 [R(int) = 0.0489]
Completeness to theta = 53.594 °	99.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.752 and 0.618
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2825 / 1 / 160
Goodness-of-fit on F^2	1.150
Final R indices [I>2sigma(I)]	R1 = 0.0440, wR2 = 0.1134
R indices (all data)	R1 = 0.0450, wR2 = 0.1140
Extinction coefficient	n/a
Largest diff. peak and hole	1.047 and -0.831 e.$Å^{-3}$

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3)
for ga_91205aa_a. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
Br(1)	10228(1)	7592(1)	4189(1)	59(1)
P(1)	3255(1)	443(1)	3622(1)	27(1)
Cl(1)	6692(1)	597(1)	3898(1)	39(1)
O(1)	3464(3)	3734(3)	3558(1)	32(1)
O(2)	2784(3)	356(3)	2752(1)	36(1)
O(3)	3703(3)	-1070(2)	4058(1)	35(1)
O(4)	1994(3)	1029(3)	4060(1)	38(1)
C(1)	8662(4)	6080(4)	3985(2)	39(1)
C(2)	8330(5)	5409(4)	3259(2)	45(1)
C(3)	7110(4)	4388(4)	3087(2)	39(1)
C(4)	6260(3)	4030(3)	3652(2)	28(1)
C(5)	6679(4)	4693(4)	4395(2)	35(1)
C(6)	7874(4)	5725(4)	4569(2)	41(1)
C(7)	4850(3)	3018(3)	3439(2)	27(1)
C(8)	4969(3)	1626(3)	3957(2)	26(1)
C(9)	4092(6)	-2344(4)	3639(3)	51(1)
C(10)	539(4)	1716(5)	3639(3)	50(1)

Table 3. Bond lengths [Å] and angles [°] for ga_91205aa_a.

Br(1)-C(1)	1.908(3)
P(1)-O(2)	1.462(2)
P(1)-O(4)	1.556(2)
P(1)-O(3)	1.567(2)
P(1)-C(8)	1.822(3)
Cl(1)-C(8)	1.787(3)
O(1)-C(7)	1.424(4)
O(1)-H(1)	0.819(19)
O(3)-C(9)	1.438(4)
O(4)-C(10)	1.452(5)
C(1)-C(2)	1.358(5)
C(1)-C(6)	1.374(5)
C(2)-C(3)	1.388(5)
C(2)-H(2)	0.9500
C(3)-C(4)	1.383(4)
C(3)-H(3)	0.9500
C(4)-C(5)	1.384(5)
C(4)-C(7)	1.510(4)
C(5)-C(6)	1.380(5)
C(5)-H(5)	0.9500
C(6)-H(6)	0.9500
C(7)-C(8)	1.531(4)
C(7)-H(7)	1.0000
C(8)-H(8)	1.0000
C(9)-H(9A)	0.9800
C(9)-H(9B)	0.9800
C(9)-H(9C)	0.9800
C(10)-H(10A)	0.9800
C(10)-H(10B)	0.9800
C(10)-H(10C)	0.9800
O(2)-P(1)-O(4)	116.44(14)
O(2)-P(1)-O(3)	115.21(13)
O(4)-P(1)-O(3)	101.08(13)
O(2)-P(1)-C(8)	112.35(13)
O(4)-P(1)-C(8)	105.31(14)

O(3)-P(1)-C(8)	105.10(13)
C(7)-O(1)-H(1)	101(4)
C(9)-O(3)-P(1)	121.4(2)
C(10)-O(4)-P(1)	122.4(2)
C(2)-C(1)-C(6)	121.8(3)
C(2)-C(1)-Br(1)	119.2(3)
C(6)-C(1)-Br(1)	119.0(3)
C(1)-C(2)-C(3)	119.3(3)
C(1)-C(2)-H(2)	120.4
C(3)-C(2)-H(2)	120.4
C(4)-C(3)-C(2)	120.6(3)
C(4)-C(3)-H(3)	119.7
C(2)-C(3)-H(3)	119.7
C(3)-C(4)-C(5)	118.3(3)
C(3)-C(4)-C(7)	120.3(3)
C(5)-C(4)-C(7)	121.3(3)
C(6)-C(5)-C(4)	121.6(3)
C(6)-C(5)-H(5)	119.2
C(4)-C(5)-H(5)	119.2
C(1)-C(6)-C(5)	118.3(3)
C(1)-C(6)-H(6)	120.9
C(5)-C(6)-H(6)	120.9
O(1)-C(7)-C(4)	111.1(2)
O(1)-C(7)-C(8)	103.9(2)
C(4)-C(7)-C(8)	114.2(2)
O(1)-C(7)-H(7)	109.2
C(4)-C(7)-H(7)	109.2
C(8)-C(7)-H(7)	109.2
C(7)-C(8)-Cl(1)	110.1(2)
C(7)-C(8)-P(1)	110.62(19)
Cl(1)-C(8)-P(1)	108.44(16)
C(7)-C(8)-H(8)	109.2
Cl(1)-C(8)-H(8)	109.2
P(1)-C(8)-H(8)	109.2
O(3)-C(9)-H(9A)	109.5
O(3)-C(9)-H(9B)	109.5
H(9A)-C(9)-H(9B)	109.5
O(3)-C(9)-H(9C)	109.5

H(9A)-C(9)-H(9C)	109.5
H(9B)-C(9)-H(9C)	109.5
O(4)-C(10)-H(10A)	109.5
O(4)-C(10)-H(10B)	109.5
H(10A)-C(10)-H(10B)	109.5
O(4)-C(10)-H(10C)	109.5
H(10A)-C(10)-H(10C)	109.5
H(10B)-C(10)-H(10C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for ga_91205aa_a. The anisotropic displacement factor exponent takes the form: $-2\pi^2[\ h^2\ a^{*2}U^{11} + ... + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
Br(1)	51(1)	57(1)	63(1)	10(1)	-1(1)	-32(1)
P(1)	29(1)	24(1)	26(1)	1(1)	2(1)	-6(1)
Cl(1)	29(1)	36(1)	50(1)	4(1)	5(1)	3(1)
O(1)	27(1)	32(1)	35(1)	8(1)	2(1)	1(1)
O(2)	40(1)	32(1)	31(1)	-2(1)	-1(1)	-8(1)
O(3)	47(1)	24(1)	33(1)	3(1)	4(1)	-6(1)
O(4)	33(1)	42(1)	40(1)	2(1)	11(1)	-4(1)
C(1)	30(2)	37(2)	45(2)	9(1)	0(1)	-14(1)
C(2)	49(2)	47(2)	43(2)	7(2)	15(2)	-17(2)
C(3)	45(2)	41(2)	31(2)	0(1)	8(1)	-12(2)
C(4)	27(1)	25(1)	30(1)	4(1)	3(1)	-3(1)
C(5)	36(2)	38(2)	32(2)	0(1)	8(1)	-11(1)
C(6)	42(2)	42(2)	36(2)	-3(1)	1(1)	-15(2)
C(7)	27(1)	26(1)	25(1)	3(1)	1(1)	-3(1)
C(8)	25(1)	25(1)	25(1)	2(1)	2(1)	-2(1)
C(9)	71(3)	28(2)	55(2)	-1(2)	12(2)	4(2)
C(10)	27(2)	58(2)	62(2)	-9(2)	6(2)	-3(2)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for ga_91205aa_a.

	x	y	z	U(eq)
H(1)	3090(60)	4040(60)	3108(17)	67(16)
H(2)	8926	5635	2874	55
H(3)	6857	3932	2577	47
H(5)	6130	4430	4795	42
H(6)	8145	6179	5080	49
H(7)	4693	2720	2866	32
H(8)	5032	1921	4524	31
H(9A)	3578	-2266	3072	77
H(9B)	3727	-3242	3862	77
H(9C)	5236	-2394	3696	77
H(10A)	758	2724	3483	75
H(10B)	-208	1752	3990	75
H(10C)	86	1136	3162	75

Table 6. Torsion angles [°] for ga_91205aa_a.

O(2)-P(1)-O(3)-C(9)	18.4(3)
O(4)-P(1)-O(3)-C(9)	144.8(3)
C(8)-P(1)-O(3)-C(9)	-105.8(3)
O(2)-P(1)-O(4)-C(10)	-11.4(3)
O(3)-P(1)-O(4)-C(10)	-137.0(3)
C(8)-P(1)-O(4)-C(10)	113.8(3)
C(6)-C(1)-C(2)-C(3)	3.2(6)
Br(1)-C(1)-C(2)-C(3)	-175.1(3)
C(1)-C(2)-C(3)-C(4)	-1.4(6)
C(2)-C(3)-C(4)-C(5)	-1.3(5)
C(2)-C(3)-C(4)-C(7)	174.9(3)
C(3)-C(4)-C(5)-C(6)	2.2(5)
C(7)-C(4)-C(5)-C(6)	-173.9(3)
C(2)-C(1)-C(6)-C(5)	-2.2(6)
Br(1)-C(1)-C(6)-C(5)	176.1(3)
C(4)-C(5)-C(6)-C(1)	-0.5(6)
C(3)-C(4)-C(7)-O(1)	-121.1(3)
C(5)-C(4)-C(7)-O(1)	55.0(4)
C(3)-C(4)-C(7)-C(8)	121.8(3)
C(5)-C(4)-C(7)-C(8)	-62.1(4)
O(1)-C(7)-C(8)-Cl(1)	-178.63(18)
C(4)-C(7)-C(8)-Cl(1)	-57.5(3)
O(1)-C(7)-C(8)-P(1)	61.5(3)
C(4)-C(7)-C(8)-P(1)	-177.4(2)
O(2)-P(1)-C(8)-C(7)	41.2(2)
O(4)-P(1)-C(8)-C(7)	-86.5(2)
O(3)-P(1)-C(8)-C(7)	167.2(2)
O(2)-P(1)-C(8)-Cl(1)	-79.69(18)
O(4)-P(1)-C(8)-Cl(1)	152.60(15)
O(3)-P(1)-C(8)-Cl(1)	46.32(18)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for ga_91205aa_a [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(1)-H(1)...O(2)#1	0.819(19)	1.92(3)	2.703(3)	161(5)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1/2,y+1/2,-z+1/2

Crystallographic data for compound *anti*-(1*R*, 2*R*)-**2k** (CCDC-1975107) has been deposited with the Cambridge Crystallographic Data Centre, Copies of the data can be obtained, free of charge, on application to CCDC (Email:deposit@ccdc.cam.ac.uk)

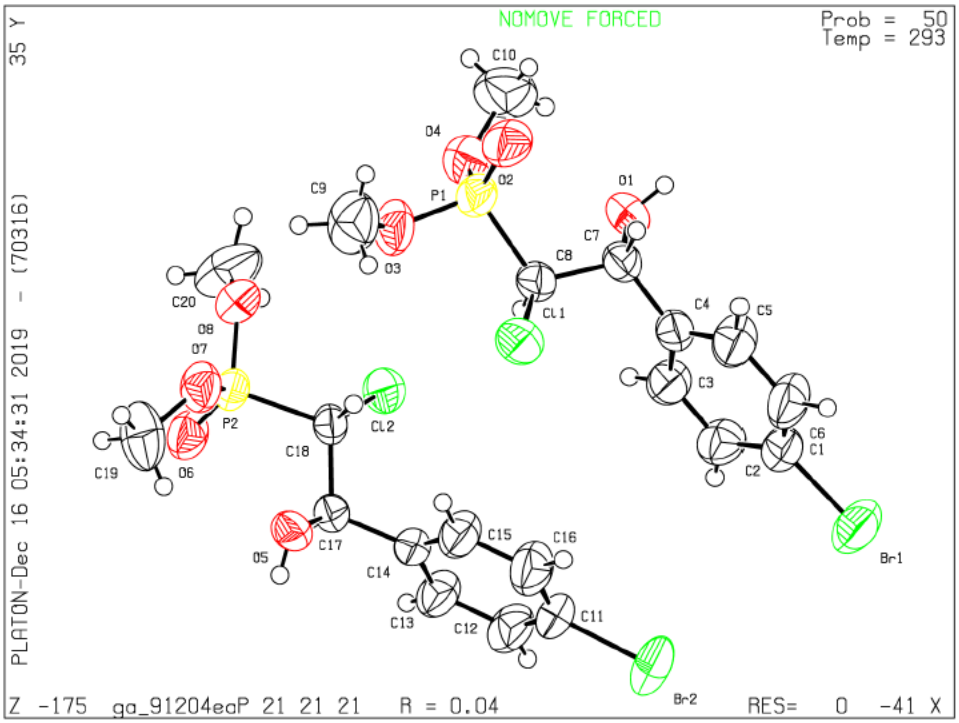


Table 1. Crystal data and structure refinement for ga_91204ea_a.

Identification code	ga_91204ea_a	
Empirical formula	C10 H13 Br Cl O4 P	
Formula weight	343.53	
Temperature	293(2) K	
Wavelength	1.34138 Å	
Crystal system	Orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions	a = 8.7884(3) Å	α= 90 °.
	b = 9.1062(3) Å	β= 90 °.
	c = 34.6640(10) Å	γ = 90 °.
Volume	2774.12(15) $Å^3$	
Z	8	
Density (calculated)	1.645 Mg/m^3	
Absorption coefficient	4.590 mm^{-1}	
F(000)	1376	
Crystal size	0.370 x 0.170 x 0.080 mm^3	
Theta range for data collection	4.367 to 56.467 °.	
Index ranges	-10<=h<=10, -11<=k<=10, -43<=l<=42	

Reflections collected	32076
Independent reflections	5576 [R(int) = 0.0478]
Completeness to theta = 53.594 °	99.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.702 and 0.412
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	5576 / 2 / 319
Goodness-of-fit on F^2	1.057
Final R indices [I>2sigma(I)]	R1 = 0.0424, wR2 = 0.1136
R indices (all data)	R1 = 0.0441, wR2 = 0.1148
Absolute structure parameter	0.079(8)
Extinction coefficient	n/a
Largest diff. peak and hole	0.532 and -0.601 e.$Å^{-3}$

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3)
for ga_91204ea_a. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
Br(1)	-332(1)	9348(1)	4183(1)	98(1)
Cl(1)	6738(2)	5857(2)	4312(1)	78(1)
P(1)	6796(2)	2685(2)	4432(1)	61(1)
O(1)	3421(5)	3049(5)	4496(1)	67(1)
O(2)	7047(6)	2693(6)	4846(1)	81(1)
O(3)	8227(5)	2804(6)	4172(1)	80(1)
O(4)	6072(6)	1268(5)	4263(1)	79(1)
C(1)	1142(7)	7895(7)	4283(2)	65(1)
C(2)	1526(8)	6910(7)	3999(2)	69(2)
C(3)	2540(7)	5800(7)	4085(2)	64(1)
C(4)	3212(6)	5677(6)	4444(1)	54(1)
C(5)	2831(8)	6709(8)	4714(2)	75(2)
C(6)	1808(9)	7847(9)	4636(2)	84(2)
C(7)	4215(6)	4396(6)	4546(1)	54(1)
C(8)	5611(6)	4219(6)	4285(1)	57(1)
C(9)	9716(9)	3226(11)	4307(3)	102(3)
C(10)	5250(13)	238(8)	4491(3)	110(3)
Br(2)	2963(1)	10417(1)	3315(1)	124(1)
Cl(2)	6485(1)	3676(2)	3195(1)	65(1)
P(2)	9768(2)	3499(2)	3049(1)	53(1)
O(5)	9511(4)	6771(4)	3000(1)	60(1)
O(6)	9786(5)	3354(5)	2632(1)	70(1)
O(7)	11232(4)	4138(5)	3239(1)	69(1)
O(8)	9589(5)	2045(5)	3282(1)	73(1)
C(11)	4488(7)	9008(7)	3203(2)	74(2)
C(12)	4469(8)	8279(8)	2863(2)	79(2)
C(13)	5642(7)	7306(7)	2784(2)	68(2)
C(14)	6779(6)	7040(5)	3040(1)	49(1)
C(15)	6762(8)	7782(7)	3390(2)	68(2)
C(16)	5616(9)	8766(9)	3475(2)	84(2)
C(17)	8112(6)	6046(5)	2944(1)	50(1)
C(18)	8227(5)	4687(5)	3206(1)	47(1)

C(19)	12415(8)	4807(12)	3028(3)	103(3)
C(20)	8943(12)	771(9)	3128(3)	116(3)

Table 3. Bond lengths [Å] and angles [°] for ga_91204ea_a.

Br(1)-C(1)	1.884(6)
Cl(1)-C(8)	1.793(6)
P(1)-O(2)	1.452(4)
P(1)-O(3)	1.551(5)
P(1)-O(4)	1.553(5)
P(1)-C(8)	1.815(5)
O(1)-C(7)	1.421(7)
O(1)-H(1)	0.83(5)
O(3)-C(9)	1.442(9)
O(4)-C(10)	1.425(9)
C(1)-C(6)	1.358(9)
C(1)-C(2)	1.374(9)
C(2)-C(3)	1.380(8)
C(2)-H(2)	0.9300
C(3)-C(4)	1.383(8)
C(3)-H(3)	0.9300
C(4)-C(5)	1.370(8)
C(4)-C(7)	1.504(8)
C(5)-C(6)	1.398(9)
C(5)-H(5A)	0.9300
C(6)-H(6)	0.9300
C(7)-C(8)	1.532(7)
C(7)-H(7)	0.9800
C(8)-H(8)	0.9800
C(9)-H(9A)	0.9600
C(9)-H(9B)	0.9600
C(9)-H(9C)	0.9600
C(10)-H(10A)	0.9600
C(10)-H(10B)	0.9600
C(10)-H(10C)	0.9600
Br(2)-C(11)	1.896(6)
Cl(2)-C(18)	1.787(5)
P(2)-O(6)	1.453(4)
P(2)-O(7)	1.558(4)
P(2)-O(8)	1.559(4)
P(2)-C(18)	1.817(5)

O(5)-C(17)	1.409(7)
O(5)-H(5)	0.79(2)
O(7)-C(19)	1.409(9)
O(8)-C(20)	1.398(10)
C(11)-C(12)	1.352(10)
C(11)-C(16)	1.386(10)
C(12)-C(13)	1.387(9)
C(12)-H(12)	0.9300
C(13)-C(14)	1.359(8)
C(13)-H(13)	0.9300
C(14)-C(15)	1.388(8)
C(14)-C(17)	1.518(7)
C(15)-C(16)	1.380(9)
C(15)-H(15)	0.9300
C(16)-H(16)	0.9300
C(17)-C(18)	1.538(6)
C(17)-H(17)	0.9800
C(18)-H(18)	0.9800
C(19)-H(19A)	0.9600
C(19)-H(19B)	0.9600
C(19)-H(19C)	0.9600
C(20)-H(20A)	0.9600
C(20)-H(20B)	0.9600
C(20)-H(20C)	0.9600

O(2)-P(1)-O(3)	116.7(3)
O(2)-P(1)-O(4)	116.1(3)
O(3)-P(1)-O(4)	99.8(3)
O(2)-P(1)-C(8)	111.1(3)
O(3)-P(1)-C(8)	104.4(3)
O(4)-P(1)-C(8)	107.4(3)
C(7)-O(1)-H(1)	103(6)
C(9)-O(3)-P(1)	124.4(5)
C(10)-O(4)-P(1)	123.0(5)
C(6)-C(1)-C(2)	121.3(6)
C(6)-C(1)-Br(1)	119.1(5)
C(2)-C(1)-Br(1)	119.6(5)
C(1)-C(2)-C(3)	118.8(5)

C(1)-C(2)-H(2)	120.6
C(3)-C(2)-H(2)	120.6
C(2)-C(3)-C(4)	121.9(5)
C(2)-C(3)-H(3)	119.0
C(4)-C(3)-H(3)	119.0
C(5)-C(4)-C(3)	117.2(5)
C(5)-C(4)-C(7)	121.0(5)
C(3)-C(4)-C(7)	121.6(5)
C(4)-C(5)-C(6)	122.2(6)
C(4)-C(5)-H(5A)	118.9
C(6)-C(5)-H(5A)	118.9
C(1)-C(6)-C(5)	118.5(6)
C(1)-C(6)-H(6)	120.8
C(5)-C(6)-H(6)	120.8
O(1)-C(7)-C(4)	110.7(4)
O(1)-C(7)-C(8)	103.4(4)
C(4)-C(7)-C(8)	114.4(4)
O(1)-C(7)-H(7)	109.4
C(4)-C(7)-H(7)	109.4
C(8)-C(7)-H(7)	109.4
C(7)-C(8)-Cl(1)	109.0(4)
C(7)-C(8)-P(1)	112.1(4)
Cl(1)-C(8)-P(1)	108.0(3)
C(7)-C(8)-H(8)	109.3
Cl(1)-C(8)-H(8)	109.3
P(1)-C(8)-H(8)	109.3
O(3)-C(9)-H(9A)	109.5
O(3)-C(9)-H(9B)	109.5
H(9A)-C(9)-H(9B)	109.5
O(3)-C(9)-H(9C)	109.5
H(9A)-C(9)-H(9C)	109.5
H(9B)-C(9)-H(9C)	109.5
O(4)-C(10)-H(10A)	109.5
O(4)-C(10)-H(10B)	109.5
H(10A)-C(10)-H(10B)	109.5
O(4)-C(10)-H(10C)	109.5
H(10A)-C(10)-H(10C)	109.5
H(10B)-C(10)-H(10C)	109.5

O(6)-P(2)-O(7)	116.4(3)
O(6)-P(2)-O(8)	116.1(3)
O(7)-P(2)-O(8)	100.4(3)
O(6)-P(2)-C(18)	111.2(2)
O(7)-P(2)-C(18)	105.5(2)
O(8)-P(2)-C(18)	106.0(2)
C(17)-O(5)-H(5)	108(4)
C(19)-O(7)-P(2)	123.5(5)
C(20)-O(8)-P(2)	123.2(5)
C(12)-C(11)-C(16)	121.5(5)
C(12)-C(11)-Br(2)	120.2(5)
C(16)-C(11)-Br(2)	118.3(5)
C(11)-C(12)-C(13)	118.5(6)
C(11)-C(12)-H(12)	120.8
C(13)-C(12)-H(12)	120.8
C(14)-C(13)-C(12)	122.1(6)
C(14)-C(13)-H(13)	119.0
C(12)-C(13)-H(13)	119.0
C(13)-C(14)-C(15)	118.5(5)
C(13)-C(14)-C(17)	122.0(5)
C(15)-C(14)-C(17)	119.4(5)
C(16)-C(15)-C(14)	120.7(6)
C(16)-C(15)-H(15)	119.7
C(14)-C(15)-H(15)	119.7
C(15)-C(16)-C(11)	118.7(6)
C(15)-C(16)-H(16)	120.6
C(11)-C(16)-H(16)	120.6
O(5)-C(17)-C(14)	111.4(4)
O(5)-C(17)-C(18)	103.8(4)
C(14)-C(17)-C(18)	113.6(4)
O(5)-C(17)-H(17)	109.3
C(14)-C(17)-H(17)	109.3
C(18)-C(17)-H(17)	109.3
C(17)-C(18)-Cl(2)	110.2(3)
C(17)-C(18)-P(2)	110.5(3)
Cl(2)-C(18)-P(2)	109.0(3)
C(17)-C(18)-H(18)	109.0
Cl(2)-C(18)-H(18)	109.0

P(2)-C(18)-H(18)	109.0
O(7)-C(19)-H(19A)	109.5
O(7)-C(19)-H(19B)	109.5
H(19A)-C(19)-H(19B)	109.5
O(7)-C(19)-H(19C)	109.5
H(19A)-C(19)-H(19C)	109.5
H(19B)-C(19)-H(19C)	109.5
O(8)-C(20)-H(20A)	109.5
O(8)-C(20)-H(20B)	109.5
H(20A)-C(20)-H(20B)	109.5
O(8)-C(20)-H(20C)	109.5
H(20A)-C(20)-H(20C)	109.5
H(20B)-C(20)-H(20C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for ga_91204ea_a. The anisotropic displacement factor exponent takes the form: $-2\pi^2[\ h^2\ a^{*2}U^{11} + ... + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
Br(1)	96(1)	98(1)	98(1)	2(1)	-6(1)	47(1)
Cl(1)	68(1)	72(1)	95(1)	16(1)	13(1)	-6(1)
P(1)	58(1)	70(1)	54(1)	4(1)	-2(1)	16(1)
O(1)	68(2)	71(2)	62(2)	11(2)	16(2)	-6(2)
O(2)	87(3)	97(3)	59(2)	9(2)	-11(2)	28(3)
O(3)	49(2)	116(4)	75(3)	0(3)	1(2)	22(2)
O(4)	87(3)	71(3)	79(3)	-4(2)	12(2)	5(2)
C(1)	58(3)	69(3)	68(3)	3(3)	1(3)	14(3)
C(2)	71(4)	78(4)	59(3)	2(3)	-10(3)	13(3)
C(3)	74(3)	68(3)	52(3)	-4(2)	-3(2)	13(3)
C(4)	47(2)	65(3)	50(2)	5(2)	4(2)	4(2)
C(5)	74(4)	99(5)	51(3)	-11(3)	-8(3)	28(4)
C(6)	84(4)	96(5)	72(4)	-16(3)	3(3)	37(4)
C(7)	50(2)	67(3)	46(2)	7(2)	4(2)	4(2)
C(8)	53(3)	72(3)	45(2)	10(2)	2(2)	10(3)
C(9)	61(4)	112(6)	132(7)	-4(5)	1(4)	-2(4)
C(10)	144(8)	67(4)	117(6)	9(4)	15(6)	-13(5)
Br(2)	109(1)	128(1)	136(1)	14(1)	31(1)	74(1)
Cl(2)	46(1)	68(1)	80(1)	8(1)	6(1)	-2(1)
P(2)	49(1)	59(1)	52(1)	-1(1)	5(1)	15(1)
O(5)	47(2)	68(2)	66(2)	18(2)	9(2)	-2(2)
O(6)	74(3)	77(3)	59(2)	-10(2)	4(2)	23(2)
O(7)	47(2)	89(3)	73(2)	0(2)	1(2)	10(2)
O(8)	76(3)	63(2)	80(3)	8(2)	7(2)	20(2)
C(11)	61(3)	71(4)	89(4)	13(3)	15(3)	29(3)
C(12)	63(3)	94(5)	80(4)	9(4)	-12(3)	29(4)
C(13)	66(3)	75(4)	62(3)	-3(3)	-10(3)	23(3)
C(14)	45(2)	48(2)	55(3)	7(2)	6(2)	5(2)
C(15)	70(3)	78(4)	57(3)	-4(3)	-5(3)	26(3)
C(16)	86(4)	98(5)	69(4)	-11(3)	6(3)	32(4)
C(17)	49(2)	56(3)	44(2)	5(2)	7(2)	9(2)
C(18)	40(2)	55(2)	47(2)	0(2)	6(2)	4(2)
C(19)	44(3)	147(8)	120(6)	-13(6)	14(3)	-10(4)

C(20)	114(7)	63(4)	170(9)	11(5)	-26(6)	8(5)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for ga_91204ea_a.

	x	y	z	U(eq)
H(1)	2990(100)	2930(90)	4708(18)	90(30)
H(2)	1109	6990	3753	83
H(3)	2778	5115	3895	77
H(5A)	3267	6652	4958	90
H(6)	1589	8554	4822	100
H(7)	4546	4486	4814	65
H(8)	5276	4070	4018	68
H(9A)	9788	4277	4314	152
H(9B)	10477	2841	4136	152
H(9C)	9875	2840	4562	152
H(10A)	5414	445	4760	164
H(10B)	5598	-738	4434	164
H(10C)	4184	312	4434	164
H(5)	9620(60)	7340(50)	2830(11)	37(12)
H(12)	3686	8425	2686	95
H(13)	5652	6820	2548	81
H(15)	7531	7614	3569	82
H(16)	5602	9258	3710	101
H(17)	8034	5729	2675	60
H(18)	8424	5007	3471	57
H(19A)	12619	4244	2800	155
H(19B)	13316	4850	3184	155
H(19C)	12117	5784	2957	155
H(20A)	7979	1004	3013	174
H(20B)	8796	63	3330	174
H(20C)	9609	369	2936	174

Table 6. Torsion angles [°] for ga_91204ea_a.

O(2)-P(1)-O(3)-C(9)	-13.6(7)
O(4)-P(1)-O(3)-C(9)	-139.6(6)
C(8)-P(1)-O(3)-C(9)	109.5(6)
O(2)-P(1)-O(4)-C(10)	19.8(7)
O(3)-P(1)-O(4)-C(10)	146.3(7)
C(8)-P(1)-O(4)-C(10)	-105.1(7)
C(6)-C(1)-C(2)-C(3)	4.0(11)
Br(1)-C(1)-C(2)-C(3)	-176.2(5)
C(1)-C(2)-C(3)-C(4)	-1.9(10)
C(2)-C(3)-C(4)-C(5)	-0.1(9)
C(2)-C(3)-C(4)-C(7)	174.9(6)
C(3)-C(4)-C(5)-C(6)	0.0(10)
C(7)-C(4)-C(5)-C(6)	-174.9(7)
C(2)-C(1)-C(6)-C(5)	-4.0(12)
Br(1)-C(1)-C(6)-C(5)	176.2(6)
C(4)-C(5)-C(6)-C(1)	2.0(12)
C(5)-C(4)-C(7)-O(1)	117.6(6)
C(3)-C(4)-C(7)-O(1)	-57.1(6)
C(5)-C(4)-C(7)-C(8)	-126.0(6)
C(3)-C(4)-C(7)-C(8)	59.3(7)
O(1)-C(7)-C(8)-Cl(1)	179.5(3)
C(4)-C(7)-C(8)-Cl(1)	59.0(5)
O(1)-C(7)-C(8)-P(1)	-61.1(5)
C(4)-C(7)-C(8)-P(1)	178.4(4)
O(2)-P(1)-C(8)-C(7)	-46.4(5)
O(3)-P(1)-C(8)-C(7)	-173.1(4)
O(4)-P(1)-C(8)-C(7)	81.5(4)
O(2)-P(1)-C(8)-Cl(1)	73.6(4)
O(3)-P(1)-C(8)-Cl(1)	-53.1(3)
O(4)-P(1)-C(8)-Cl(1)	-158.5(3)
O(6)-P(2)-O(7)-C(19)	11.8(7)
O(8)-P(2)-O(7)-C(19)	138.1(6)
C(18)-P(2)-O(7)-C(19)	-112.0(6)
O(6)-P(2)-O(8)-C(20)	-22.9(7)
O(7)-P(2)-O(8)-C(20)	-149.3(6)
C(18)-P(2)-O(8)-C(20)	101.1(7)

C(16)-C(11)-C(12)-C(13)	-2.2(11)
Br(2)-C(11)-C(12)-C(13)	177.1(5)
C(11)-C(12)-C(13)-C(14)	1.8(11)
C(12)-C(13)-C(14)-C(15)	-0.7(10)
C(12)-C(13)-C(14)-C(17)	-176.3(6)
C(13)-C(14)-C(15)-C(16)	0.0(10)
C(17)-C(14)-C(15)-C(16)	175.7(6)
C(14)-C(15)-C(16)-C(11)	-0.5(11)
C(12)-C(11)-C(16)-C(15)	1.6(12)
Br(2)-C(11)-C(16)-C(15)	-177.7(6)
C(13)-C(14)-C(17)-O(5)	125.2(6)
C(15)-C(14)-C(17)-O(5)	-50.4(6)
C(13)-C(14)-C(17)-C(18)	-118.0(6)
C(15)-C(14)-C(17)-C(18)	66.4(6)
O(5)-C(17)-C(18)-Cl(2)	176.6(3)
C(14)-C(17)-C(18)-Cl(2)	55.4(5)
O(5)-C(17)-C(18)-P(2)	-62.9(4)
C(14)-C(17)-C(18)-P(2)	175.9(4)
O(6)-P(2)-C(18)-C(17)	-42.8(4)
O(7)-P(2)-C(18)-C(17)	84.2(4)
O(8)-P(2)-C(18)-C(17)	-169.8(3)
O(6)-P(2)-C(18)-Cl(2)	78.4(3)
O(7)-P(2)-C(18)-Cl(2)	-154.5(3)
O(8)-P(2)-C(18)-Cl(2)	-48.6(3)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for ga_91204ea_a [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(5)-H(5)...O(6)#1	0.79(2)	1.92(3)	2.693(5)	166(5)
O(1)-H(1)...O(2)#2	0.83(5)	1.85(6)	2.667(6)	169(8)

Symmetry transformations used to generate equivalent atoms:

#1 -x+2,y+1/2,-z+1/2 #2 x-1/2,-y+1/2,-z+1