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Highly Regio- and Diastereoselective Tethered *Aza*-Wacker Cyclizations of Alkenyl Phosphoramidates

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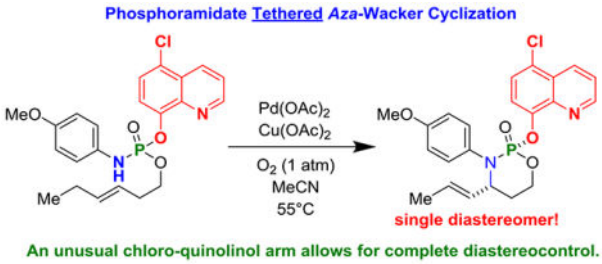
Abstract

We present highly diastereoselective tethered *aza*-Wacker cyclization reactions of alkenyl phosphoramidates. “Arming” the phosphoramidate tether with 5-chloro-8-quinolinol was essential to achieving >20:1 diastereoselectivity in these reactions. The substrate scope with respect to alkenyl alcohols and phosphoramidate tether was extensively explored. The scalability of the oxidative cyclization was demonstrated, and the product cyclophosphoramidates were shown to be valuable synthons, including for tether removal. With chiral alkenyl precursors, enantiopure cyclic phosphoramidates were formed.

Graphical Abstract



Introduction

The regioselective functionalization of olefins remains an area of intense research activity.[1–10] While intermolecular olefin functionalization reactions often rely on subtle steric and electronic effects for selectivity, intramolecular reactions are generally much more predictable due to geometric constraints. A particularly powerful class of intramolecular olefin functionalization reactions is the *tethered aza*-Wacker cyclization.[11–25] In such reactions, a nitrogen containing auxiliary (“the tether”) is appended to an alkenyl alcohol prior to the cyclization event.

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Supporting Information

The Supporting Information is available free of charge on the ACS Publications website. It includes additional experimental details, materials, and methods; ^{1}H NMR, ^{13}C NMR, ^{31}P NMR spectra; Single- molecule X-ray diffraction data for compound **(−)-62** (CIF)

Tethered *aza*-Wacker cyclization reactions are enabling because they free the synthetic practitioner from the constraint of needing a pre-existing C–N bond in order to forge a new one.[26,27]

Phosphoramidates are an important class of heteroatom-rich compounds, and its members have Found applications in diverse fields, ranging from asymmetric catalysis[28] to medicinal chemistry[29] (Figure 1). Cyclic phosphoramidates are traditionally assembled from condensation of amino-alcohols with phosphoryl chlorides, requiring precursor molecules with both amino and alcohol functionalities pre-installed. We envisioned developing a tethered *aza*-Wacker protocol for the synthesis of such heterocycles, allowing for the attachment of a phosphoramidate auxiliary to alkenyl alcohols and subsequent oxidative cyclization. There is sparse precedent for the use of oxidation reactions in cyclo-phosphoramidate construction. To date, such reactions have largely been restricted to phosphoryl azide decomposition with subsequent nitrene insertion[30, 31] and radical Suárez-type oxidations with $Pb(OAc)_4$ or $PhI(OAc)_2/I_2$ (Scheme 1).[32–35] Diastereocontrol remains a challenge with these reactions, with many of these protocols furnishing mixtures of diastereomers. We have Found that “arming” the phosphoramidate tether with an unusual chloro-quinolinol auxiliary allows for complete diastereocontrol during the cyclization event. The use of palladium-chelating auxiliaries is well known in the related field of C–H activation,[36–40] and the Engle group has shown that amino-quinolines appended to amides are excellent for regio-control in olefin mono- and di-functionalization reactions.[41–44] To our knowledge, ours is the first example of the use of an auxiliary to control *diastereoselectivity* in an olefin functionalization process.

Results and Discussion

We began optimizing the reaction with (E)-hex-3-en-1-yl phenyl (4-methoxyphenyl)phosphoramidate, readily prepared from condensation of commercially available *trans*-3-hexen-1-ol and anisidine with phenyl dichlorophosphate (See Supplementary Information for more optimization conditions). Product formation was observed with 20 mol% $PdCl_2$ in MeCN (Table 1, **Entry 1**), giving us hope that our envisioned oxidative cyclization reaction was viable. We saw little improvement upon switching to $Pd(TFA)_2$ (Table 1, **Entry 2**), but product formation did increase with $Pd_2(dba)_3$ (Table 1, **Entry 3**). Solvents other than MeCN were invariably deleterious (Table 1, **Entries 4–7**). Increasing the reaction time led to the most marked improvement in performance (Table 1, **Entries 8–10**). Our optimized protocol involved heating substrate, 20 mol% $Pd(OAc)_2$, and 1 equivalent of Cu(OAc) to 55 °C in MeCN for 65 hours (Table 1, **Entry 10**). In all cases, product was furnished as a roughly 1:1 diastereomeric mixture.Our optimized protocol was not limited to phosphoramidates containing anisidine (Scheme 2). We were pleased to see reasonable yields with phosphoramidates constructed from 3,4-methylenedioxyaniline (Scheme 2, **Entry 2**), 3,4-dimethoxyaniline (Scheme 2, **Entry 3**), *p*-ethoxyaniline (Scheme 2, **Entry 5**), and toluidine (Scheme 2, **Entry 7**). From these structure-reactivity relationship studies, it was clear that electron rich anilines performed much better than electron neutral (Scheme 2, **Entry 8**) ones. Steric factors also played an important role, with 2,4-dimethoxyaniline performing poorly (Scheme 2, **Entry 6**). In all cases, diastereoselectivity ranged from ~1:1 to ~2:1.

A brief survey of alkenyl alcohols with our optimized protocol (Scheme 3) showed that substrates other than those derived from *trans*-hexen-3-ol were fully compatible. Nevertheless, each product was furnished as a mixture of diastereomers. Thus, we concluded that reaction diastereoselectivity was largely insensitive to the nature of the alkenyl alcohol.

We next explored the effect of changing the -OPh arm of the phosphoramidate auxiliary (Scheme 4). Product formation was viable with a variety of phenoxides and alkoxides. Electron-deficient phenoxides (Scheme 4, **Entries 3–4**) afforded better reactions than electron rich ones (Scheme 4, **Entries 5–6**). Even with a chiral auxiliary (Scheme 4, **Entry 2)** or with a secondary alkoxide (Scheme 4, **Entry 7**), we were unable to break a diastereomeric barrier of ~3:1.

Collectively, these results informed us that we were unlikely to further optimize the diastereoselectivity of this oxidative cyclization by tuning simple steric and electronic factors. Inspired by the use of palladium-chelating auxiliaries in C–H activation and Engle's work on regioselective alkene functionalization with amido-quinolines, we wondered if a chelate approach would resolve the diastereoselectivity problem. We hypothesized that a chelate as depicted in Scheme 5 would likely transform our diastereolabile reaction into a fully diastereoselective one. We heated one equivalent of $Pd(OAc)_2$ with **21** to 55 °C in acetonitrile and analyzed an aliquot of the reaction mixture by high resolution mass spectrometry. To our delight, we identified the molecular ion corresponding to our proposed chelate.

We thus examined a range of quinolinol auxiliaries (Scheme 6). We Found that phosphoramidate tethers containing a 5-chloro-8-quinolinoxide arm afforded cyclized product in good yields and, most importantly*, as a single diastereomer* (Scheme 6, **Entry 1**). At present, the differential performance of 5-chloro-8-quinolinol relative to other quinolinol auxiliaries (Scheme 6, **Entries 2–3**) remains unexplained. The presence of a nitrogen, presumably critical for palladium chelation, was essential for diastereoselectivity. With naphthoxide (Scheme 6, **Entry 4**), a 1:1 mixture of diastereomers re-emerged.

The phosphoramidate tether containing a 5-chloro-8-quinolinoxide arm was compatible with a wide range of alkenyl alcohols (Scheme 7). Alkenyl alcohols containing aryl rings adorned with $-CF_3$, $-NMe_2$, -OMe groups all reacted smoothly (Scheme 7, **Entry 1**). Heterocycles such as furan and thiophene (Scheme 7, **Entry 1**) were also well-tolerated. *Cis*-olefins were compatible (Scheme 7, **Entry 2**) but yielded product in slightly lower yields relative to the equivalent *trans*-olefins. *Trans*-olefins containing cyclohexyl, cyclopentyl, and Boc-protected alcohols (Scheme 7, **Entry 4**) furnished cyclized products in good yields. The phosphoramidate tether could be appended to phenols (Scheme 7, **Entry 5**) as well as to secondary alcohols (Scheme 7, **Entry 6**). In all cases, the reactions proceeded with perfect diastereocontrol with respect to the newly formed nitrogen containing stereocenter and the phosphorous stereocenter of the phosphoramidate tether.

Furthermore, the reaction could be scaled greater than ten-fold without much diminishment of product yields; in this larger-scale reaction, product was again furnished as a single diastereomer (Scheme 8). With the 5-chloro-8-quinolinoxide auxiliary, we were no longer

constrained to just using *p*-anisidine; a variety of anilines engaged in good yield and with greater than 20:1 diastereoselectivity (Scheme 9).

The product cyclophosphoramidates were quite versatile. The phosphorous auxiliary could be removed by reduction with lithium aluminum hydride (Scheme 10A). Upon heating with HCl in dioxane, alkenyl azetidine product formed in reasonable yield (Scheme 10B). Finally, epoxidation of the pendant alkene proceeded smoothly with *m*CPBA (Scheme 10C).

The power of a highly diastereoselective oxidative cyclization reaction is further illustrated in Scheme 11. Phosphoramidate **21** was separated into enantiomers using chiral reversed-phase HPLC. Subjecting each to our optimized $Pd(OAc)_2/Cu(OAc)_2$ protocol afforded enantiopure cyclic phosphoramidate products. The absolute structure and conformation of (−)-**62** were determined by x-ray crystallography (CCDC: 2061647). As tether removal is possible with LAH (Scheme 10A), this allows for the synthesis of *chiral amino alcohols* from readily available acyclic precursors.

Conclusion

In summary, we present a protocol for highly diastereoselective tethered *aza*-Wacker cyclization reactions of alkenyl phosphoramidates. We Found that phosphoramidate tethers containing a 5-chloro-8-quinolinoxide “arm” were essential for diastereoselective cyclizations. We hypothesize that such diastereoselectivity arises from a palladium chelation, and we have identified the molecular ion of a putative chelate using high resolution electrospray ionization mass spectrometry. The substrate scope with respect to the alkenyl alcohol and the phosphoramidate tether was extensively explored. In addition, the scalablility of the cyclization reaction was demonstrated, and the product cyclophosphoramidates were shown to be valuable synthons for a variety of further transformations, including tether removal. With chiral alkenyl precursors, enantiopure cyclic phosphoramidates were formed.

Experimental Section

I. General Considerations

All reagents were obtained commercially unless otherwise noted. Solvents were purified by passage under 10 psi N_2 through activated alumina columns. Infrared (IR) spectra were recorded on a Thermo Scientific™ Nicolet™ iS™5 FT-IR Spectrometer; data are reported in frequency of absorption (cm^{-1}). NMR spectra were recorded on a Bruker Avance 400 operating at 400 and 100 MHz. ^1H NMR spectra were recorded at 400 MHz. Data are recorded as: chemical shift in ppm referenced internally using residue solvent peaks, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet or overlap of nonequivalent resonances), integration, coupling constant (Hz). ^{13}C NMR spectra were recorded at 100 MHz. Exact mass spectra were recorded using an electrospray ion source (ESI) either in positive mode or negative mode and with a time-of-flight (TOF) analyzer on a Waters LCT PremierTM mass spectrometer and are given in m/z. TLC was performed on pre-coated glass plates (Merck) and visualized either with a UV lamp (254 nm) or by dipping into a solution of $KMnO_4$–K_2CO_3 in water followed by heating. Flash

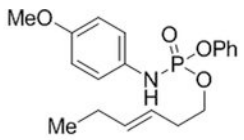
chromatography was performed on silica gel (230–400 mesh). Reversed phase HPLC was performed on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column.

II. Substrate Syntheses Procedures

General Procedure A: To a solution of homoallylic alcohol (10 mmol, 1 equiv) in dichloromethane (50 mL) was added Et_3N (1.4 mL, 10 mmol, 1 equiv) dropwise at 0 °C, and the mixture was stirred for 10 min. $POCl_3$ (0.93 mL, 10 mmol, 1 equiv) was added dropwise, and the mixture was warmed to room temperature over a period of 5 h. The reaction mixture was cooled to 0 °C. Phenol or quinolinol (10 mmol, 1 equiv) in 20 ml dichloromethane was added dropwise followed by Et_3N (1.4 mL, 10 mmol, 1 equiv). The reaction mixture was warmed to room temperature over a period of 12 h. Following this period, the reaction mixture was cooled to 0 °C. A solution of aniline derivative (10 mmol, 1 equiv) in 20 ml of dichloromethane was added dropwise followed by Et_3N (1.4 mL, 10 mmol, 1 equiv). The reaction mixture was warmed to room temperature over a period of 9 h. Subsequently, the reaction was quenched by slow addition of 1M aqueous HCl (10 mL) at 0 °C. The mixture was transferred to a separatory funnel and extracted with 3 portions of dichloromethane. The organic fractions were collected, dried with Na_2SO_4, and concentrated under reduced pressure. The resulting residue was purified by chromatography on silica gel (specific conditions are associated with each compound) to afford the corresponding products.

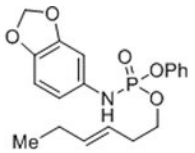
General Procedure B: Et_3N (1.4 mL, 10 mmol, 1 equiv) was added dropwise to a solution of aniline derivative (10 mmol, 1 equiv) in dichloromethane (50 mL) at 0 °C. The reaction mixture was stirred for 10 min. $POCl_3$ (0.93 mL, 10 mmol, 1 equiv) was added dropwise, and the reaction was warmed to room temperature over 6 h. Subsequently, the reaction mixture was cooled to 0 °C. Phenol or quinolinol (10 mmol, 1 equiv) in 20 ml dichloromethane was added dropwise followed by Et_3N (1.4 mL, 10 mmol, 1 equiv). The reaction mixture was warmed to room temperature over a period of 2 h. After cooling to 0 °C, homoallylic alcohol (10 mmol, 1 equiv) in 20 ml dichloromethane was added dropwise followed by Et_3N (1.4 mL, 10 mmol, 1 equiv). The reaction mixture was warmed to room temperature over a period of 12 h. The reaction was quenched by slow addition of 1M aqueous HCl (10 mL) at 0 °C. The mixture was transferred to a separatory funnel and extracted with 3 portions of dichloromethane. The organic fractions were collected, dried with Na_2SO_4, and concentrated under reduced pressure. The resulting residue was purified by chromatography on silica gel (specific conditions are associated with each compound) to afford the corresponding products.

III. Characterization of Substrates



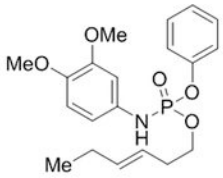
(*E*)-hex-3-en-1-yl phenyl (4-methoxyphenyl)phosphoramidate

Compound 1: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane ; (Colorless solid, 1.88 g, 52% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.0 (t, *J* = 7.4 Hz, 3H), 2.0 (p, *J* = 7.3 Hz, 2H), 2.4 (q, *J* = 6.9 Hz, 2H), 3.8 (s, 3H), 4.1 (dq, *J* = 9.8, 7.1 Hz, 1H), 4.2 (dq, *J* = 9.7, 7.0 Hz, 1H), 5.3 (dt, *J* = 15.2, 6.8 Hz, 1H), 5.6 (dt, *J* = 15.1, 6.3 Hz, 1H), 6.4 (d, *J* = 10.0 Hz, 1H), 6.8 (d, *J* = 8.6 Hz, 2H), 6.9 – 7.1 (m, 2H), 7.1 – 7.2 (m, 3H), 7.2 – 7.4 (m, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 25.6, 33.4 (d, *J* = 7.3 Hz), 55.5, 66.8 (d, *J* = 5.4 Hz), 114.6, 119.7 (d, *J* = 7.1 Hz), 120.5 (d, *J* = 4.7 Hz), 123.4, 124.9 (d, *J* = 1.4 Hz), 129.6, 132.4, 135.6, 150.5 (d, *J* = 6.3 Hz), 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.4 (q, *J* = 8.2 Hz); IR 3149, 2956, 1592, 1511, 1204, 1036, 923, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{24}NO_4PNa^+$ 384.1341; Found 384.1326.



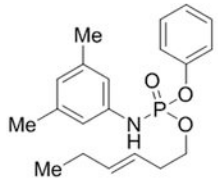
(*E*)-hex-3-en-1-yl phenyl benzo[*d*][1,3]dioxol-5-ylphosphoramidate

Compound 2: Synthesized using Procedure A; Purified using 20% ethyl acetate in hexane; (Brown solid, 2.44 g, 65% yield);^{1}H NMR (400 MHz, $CDCl_3$) δ 0.95 (t, *J* = 7.5 Hz, 3H), 1.99 (dtdd, *J* = 8.8, 7.5, 6.2, 1.4 Hz, 2H), 2.30 – 2.50 (m, 2H), 4.00 – 4.28 (m, 2H), 5.33 (dtt, *J* = 15.2, 6.8, 1.6 Hz, 1H), 5.55 (dtt, *J* = 15.4, 6.3, 1.3 Hz, 1H), 5.92 (s, 2H), 6.47 (dd, *J* = 8.3, 2.3 Hz, 1H), 6.64 – 6.72 (m, 2H), 7.10 – 7.18 (m, 3H), 7.22 – 7.31 (m, 2H);^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 25.7, 33.5 (d, *J* = 7.3 Hz), 67.1 (d, *J* = 5.2 Hz), 101.0 (d, *J* = 7.1 Hz), 101.2, 108.5, 111.0 (d, *J* = 8.0 Hz), 120.6 (d, *J* = 4.7 Hz), 123.5, 125.1, 129.7, 133.8, 135.8, 143.0, 148.3, 150.6 (d, *J* = 6.3 Hz);^{31}P NMR (202 MHz, $CDCl_3$) δ −1.95 (m);IR 3173, 2962, 1502, 1486, 1191, 1020, 934 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{22}NO_5PNa^+$ 398.1133; Found 398.1146.



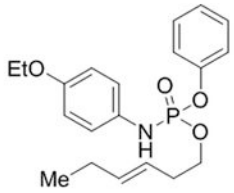
(*E*)-hex-3-en-1-yl phenyl (3,4-dimethoxyphenyl)phosphoramidate

Compound 3: Synthesized using Procedure A; Purified using 30% ethyl acetate in hexane; (Colorless solid, 2.66 g, 68%yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.93 (t, *J* = 7.4 Hz, 3H), 1.93 – 2.02 (m, 2H), 2.38 (q, *J* = 6.9 Hz, 2H), 3.81 (s, 3H), 3.84 (s, 3H), 4.09 (dqd, *J* = 9.8, 7.0, 2.8 Hz, 1H), 4.16 (pd, *J* = 7.2, 3.5 Hz, 1H), 5.32 (dt, *J* = 14.7, 6.8 Hz, 1H), 5.4 7– 5.60 (m, 1H), 6.60 (dd, *J* = 8.6, 2.6 Hz, 1H), 6.65 (d, *J* = 2.6 Hz, 1H), 6.75 (d, *J* = 8.5 Hz, 3H), 7.08 – 7.18 (m, 3H), 7.19 – 7.28 (m, 2H);^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 25.7, 33.6 (d, *J* = 7.3 Hz), 56.0, 56.4, 67.1 (d, *J* = 5.2 Hz), 103.6 (d, *J* = 7.5 Hz), 110.1 (d, *J* = 6.8 Hz), 112.2, 120.6 (d, *J* = 5.0 Hz), 123.4, 125.1, 129.7, 132.9, 135.8, 144.7, 149.6, 150.7 (d, *J* = 6.4 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.7 (d, *J* = 11.8 Hz); IR 3157, 2960, 1512, 1224, 1199, 1014, 777 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{26}NO_5PNa^+$ 414.1446; Found 414.1425.



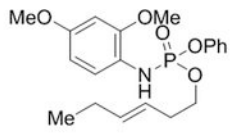
(*E*)-hex-3-en-1-yl phenyl (3,5-dimethylphenyl)phosphoramidate

Compound 4: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane; (Colorless solid, 1.0 g, 28% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.94 (td, *J* = 7.4, 1.0 Hz, 3H), 1.93 – 2.03 (m, 2H), 2.27 (s, 6H), 2.39 (q, *J* = 6.9 Hz, 2H), 4.05 – 4.13 (m, 1H), 4.14 – 4.22 (m, 1H), 5.28 – 5.39 (m, 1H), 5.49 – 5.58 (m, 1H), 5.96 (d, *J* = 9.7 Hz, 1H), 6.64 (s, 1H), 6.67 (s, 1H), 7.09 – 7.14 (m, 1H), 7.16 (dt, *J* = 7.6, 1.2 Hz, 2H), 7.23 – 7.29 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 21.5, 25.7, 33.6 (d, *J* = 7.2 Hz), 67.1 (d, *J* = 5.2 Hz), 115.7 (d, *J* = 7.3 Hz), 120.7 (d, *J* = 4.5 Hz), 123.5, 124.0, 125.2, 129.7, 135.7, 139.1, 139.1, 150.6 (d, *J* = 6.4 Hz);^{31}P NMR (202 MHz, $CDCl_3$) δ −2.0 (d, *J* = 9.7 Hz); IR 3203, 2960, 1602, 1397, 1207, 1005, 768 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{26}NO_3PNa^+$ 382.1548; Found 382.1537.



(*E*)-hex-3-en-1-yl phenyl (4-ethoxyphenyl)phosphoramidate

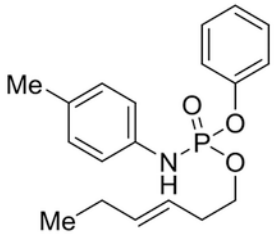
Compound 5: Synthesized using Procedure A; Purified using 22% ethyl acetate in hexane; (Brown solid, 1.39 g, 37% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.94 (t, *J* = 7.4 Hz, 3H), 1.39 (t, *J* = 6.9 Hz, 3H), 1.98 (p, *J* = 7.3 Hz, 2H), 2.37 (q, *J* = 6.8 Hz, 2H), 3.98 (q, *J* = 7.0 Hz, 2H), 4.06 (ddt, *J* = 10.0, 7.0, 3.1 Hz, 1H), 4.15 (dtd, *J* = 13.9, 7.0, 3.3 Hz, 1H), 5.32 (dt, *J* = 14.7, 6.8 Hz, 1H), 5.53 (dt, *J* = 14.9, 6.2 Hz, 1H), 6.79 (d, *J* = 8.4 Hz, 2H), 6.98 (d, *J* = 8.6 Hz, 2H), 7.04 – 7.18 (m, 3H), 7.19 – 7.30 (m, 2H);^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 15.0, 25.7, 33.6 (d, *J* = 7.3 Hz), 63.9, 66.9 (d, *J* = 5.4 Hz), 115.4, 119.8 (d, *J* = 7.2 Hz), 120.6 (d, *J* = 4.8 Hz), 123.6, 125.0, 129.7, 132.4, 135.7, 150.7 (d, *J* = 6.5 Hz), 154.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.32 (m); IR 3153, 2902, 1592, 1509, 1203,1022, 779 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{20}H_{28}NO_4P^+$ 376.1678; Found 376.1688.



(*E*)-hex-3-en-1-yl phenyl (2,4-dimethoxyphenyl)phosphoramidate

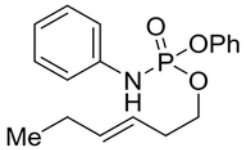
Compound 6: Synthesized using Procedure A; Purified using 20% ethyl acetate in hexane; (Colorless solid, 2.54 g, 65% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.91 (t, *J* = 7.4 Hz, 3H), 1.95 (dtdd, *J* = 8.8, 7.4, 6.2, 1.3 Hz, 2H), 2.29 – 2.46 (m, 2H), 3.75 (d, *J* = 0.7 Hz, 6H), 4.03 – 4.22 (m, 2H), 5.31 (dtt, *J* = 15.7, 8.9, 1.8 Hz, 1H), 5.51 (dddd, *J* = 12.6, 6.3, 2.8, 1.4 Hz, 1H), 6.38 – 6.44 (m, 2H), 7.06 – 7.16 (m, 3H), 7.17 – 7.29 (m, 3H); ^{13}C{^{1}H} NMR

(101 MHz, $CDCl_3$) δ 13.7, 25.64, 33.5 (d, *J* = 7.3 Hz), 55.6, 55.7, 67.0 (d, *J* = 5.7 Hz), 99.1, 104.1, 117.3, 120.5 (d, *J* = 4.6 Hz), 122.2, 123.5, 123.0, 129.6, 135.6, 149.0 (d, *J* = 10.2 Hz), 150.6 (d, *J* = 6.1 Hz), 155.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.57; IR 3391, 2960, 1512, 1199, 1021, 929, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{25}H_{28}NO_5P^+$ 392.1627; Found 392.1629.



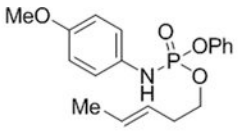
(*E*)-hex-3-en-1-yl phenyl *p*-tolylphosphoramidate

Compound 7: Synthesized using Procedure A ; Purified using 18% ethyl acetate in hexane; (Colorless solid, 967 mg, 28% yield); ^1H NMR (400 MHz, $CDCl_3$) δ 0.95 (t, *J* = 7.4 Hz, 3H), 1.99 (dtdd, *J* = 8.8, 7.5, 6.3, 1.4 Hz, 2H), 2.29 (s, 3H), 2.34 – 2.43 (m, 2H), 3.97 – 4.11 (m, 1H), 4.11 – 4.22 (m, 1H), 5.33 (dtt, *J* = 15.2, 6.8, 1.6 Hz, 1H), 5.54 (dtt, *J* = 15.3, 6.4, 1.4 Hz, 1H), 6.89 – 7.02 (m, 2H), 7.02 – 7.13 (m, 3H), 7.13 – 7.29 (m, 4H);$^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 13.7, 20.7, 25.7, 33.5 (d, *J* = 7.3 Hz), 67.0 (d, *J* = 5.2 Hz), 118.0 (d, *J* = 7.3 Hz), 120.6 (d, *J* = 5.0 Hz), 123.5, 125.1, 129.7, 129.9, 131.5, 135.7, 136.7, 150.6; ^{31}P NMR (202 MHz, CDCl3) δ −1.8 (d, J = 8.9 Hz); IR 3157, 2962, 1224, 1202, 1021, 925, 780 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{24}NO_3PNa^+$ 368.1392; Found 368.1376.



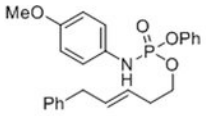
(*E*)-hex-3-en-1-yl phenyl phenylphosphoramidate

Compound 8: Synthesized using Procedure A; Purified using 23% ethyl acetate in hexane; (Colorless solid, 994 mg, 30% yield); ^1H NMR (400 MHz, $CDCl_3$) δ 0.94 (t, *J* = 7.5 Hz, 3H), 1.98 (dtdd, *J* = 8.8, 7.5, 6.3, 1.4 Hz, 2H), 2.39 (dt, *J* = 7.8, 6.3 Hz, 2H), 4.07 – 4.16 (m, 1H), 4.20 (dq, *J* = 9.8, 7.0 Hz, 1H), 5.33 (dtt, *J* = 15.3, 6.8, 1.6 Hz, 1H), 5.55 (dtt, *J* = 15.4, 6.3, 1.4 Hz, 1H), 7.00 (tt, *J* = 7.3, 1.1 Hz, 1H), 7.03 – 7.08 (m, 2H), 7.12 – 7.19 (m, 3H), 7.23 – 7.30 (m, 4H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 13.7, 25.7, 33.5 (d, *J* = 7.3 Hz), 67.2 (d, *J* = 5.2 Hz), 117.9, 118.0, 120.6 (d, *J* = 5.0 Hz), 122.2, 123.5, 125.2, 129.4, 129.7, 135.8, 139.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −2.06; IR 3166, 2964, 1590, 1486, 1202, 1018, 530 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{24}NO_3P^+$ 332.1416; Found 332.1443.



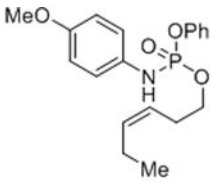
(*E*)-pent-3-en-1-yl phenyl (4-methoxyphenyl)phosphoramidate

Compound 9: Synthesized using General Procedure A; purified using 25% ethyl acetate in hexane (Colorless solid, 2.60 g, 75% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.7 (dt, *J* = 6.5, 1.4 Hz, 3H), 2.4 (q, *J* = 6.9 Hz, 2H), 3.8 (s, 3H), 4.1 (dq, *J* = 9.8, 7.0 Hz, 1H), 4.2 (dq, *J* = 9.9, 6.9 Hz, 1H), 5.4 (dtd, *J* = 15.1, 6.7, 1.7 Hz, 1H), 5.5 – 5.6 (m, 1H), 5.8 (d, *J* = 9.8 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.0 – 7.1 (m, 2H), 7.1 – 7.2 (m, 3H), 7.2 – 7.3 (m, 2H); ^{13}C {^{1}H}NMR (101 MHz, $CDCl_3$) δ 18.0, 33.5 (d, *J* = 7.3 Hz), 55.5, 66.8 (d, *J* = 5.3 Hz), 114.6, 119.7 (d, *J* = 7.0 Hz), 120.5 (d, *J* = 4.7 Hz), 124.9, 125.7, 128.5, 129.6, 132.3, 150.5 (d, *J* = 6.4 Hz), 155.1, ^{31}P NMR (202 MHz, $CDCl_3$) δ −2.1 (q, *J* = 8.1 Hz); IR 3172, 2835, 1591, 1510, 1219, 1082, 923, 831, 750 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{22}NO_4PNa^+$ 370.1184; Found 370.1160.



(*E*)-phenyl (5-phenylpent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

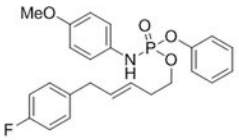
Compound 10: Synthesized using General Procedure A; purified using 30% ethyl acetate in hexane. An analytical sample was purified by reversed phase HPLC (gradient of 100% H_2O with 0.1% TFA to 100% MeCN with 0.1% TFA over 45 minutes on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column; (Colorless solid, 1.44 g, 34% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.4 (q, *J* = 6.8 Hz, 2H), 3.3 (d, *J* = 6.7 Hz, 2H), 3.8 (s, 3H), 4.1 – 4.3 (m, 2H), 5.4 – 5.5 (m, 1H), 5.6 – 5.7 (m, 1H), 5.9 (d, *J* = 9.8 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.0 – 7.0 (m, 2H), 7.1 – 7.2 (m, 6H), 7.2 – 7.3 (m, 4H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.7 (d, *J* = 7.2 Hz), 39.3, 55.8, 66.9, 114.9, 120.0, 120.8 (d, *J* = 4.5 Hz), 125.3, 126.3, 126.4, 128.7, 128.8, 129.9, 132.6, 132.7, 140.7, 150.8 (d, *J* = 6.3 Hz), 156.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.6 (q, *J* = 8.2 Hz); IR 3166, 2834, 1591, 1509, 1205, 1034, 910, 779 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{24}H_{27}NO_4P^+$ 424.1678; Found 424.1676.



(*Z*)-hex-3-en-1-yl phenyl (4-methoxyphenyl)phosphoramidate

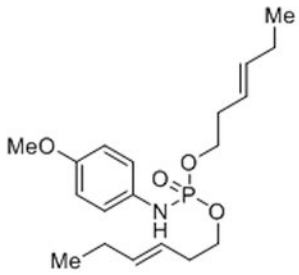
Compound 11: Synthesized using Procedure A ; Purified using 25% ethyl acetate in hexane; (Colorless solid, 1.52 g, 42% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.93 (t, *J* = 7.5 Hz, 3H), 2.00 (pd, *J* = 7.4, 1.5 Hz, 2H), 2.44 (qd, *J* = 7.1, 1.5 Hz, 2H), 3.77 (s, 3H), 4.06 (dq, *J* = 9.9, 7.1 Hz, 1H), 4.15 (dq, *J* = 9.9, 7.0 Hz, 1H), 5.24 – 5.32 (m, 1H), 5.45 – 5.53 (m, 1H), 6.77 – 6.84 (m, 2H), 6.96 – 7.02 (m, 2H), 7.08 – 7.17 (m, 3H), 7.21 – 7.28 (m, 2H);^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 14.3, 20.7, 28.4 (d, *J* = 7.3 Hz), 55.7, 66.7 (d,

J = 5.2 Hz), 114.7, 119.8 (d, *J* = 6.9 Hz), 120.6 (d, *J* = 5.0 Hz), 123.1, 125.1, 129.7, 132.4, 135.1, 150.6 (d, *J* = 6.1 Hz), 155.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.40 (t, *J* = 8.5 Hz);IR 3161, 2873, 1511, 1205, 1033, 922, 778,512 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{19}H_{26}NO_4P^+$ 362.1521; Found 362.1541.



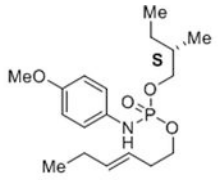
(*E*)-5-(4-fluorophenyl)pent-3-en-1-yl phenyl (4-methoxyphenyl)phosphoramidate

Compound 12: Synthesized using General Procedure A; Purified using 30% ethyl acetate in hexane (Colorless solid, 1.15 g, 26% yield); An analytical sample was purified by reversed phase HPLC (gradient of 100% H_2O with 0.1% TFA to 100% MeCN with 0.1% TFA over 45 minutes on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column; ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.3 (q, *J* = 6.7 Hz, 2H), 3.2 (d, *J* = 6.8 Hz, 2H), 3.7 (s, 3H), 4.0 – 4.2 (m, 2H), 5.3 (dt, *J* = 15.0, 6.8 Hz, 1H), 5.5 – 5.6 (m, 1H), 6.1 (d, *J* = 10.2 Hz, 1H), 6.6 – 6.8 (m, 2H), 6.8 – 6.9 (m, 4H), 7.0 – 7.1 (m, 5H), 7.2 (dd, *J* = 9.0, 6.7 Hz, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.3 (d, *J* = 7.3 Hz), 38.1, 55.5, 66.9 (d, *J* = 5.6 Hz), 114.7, 115.1 (d, *J* = 21.1 Hz), 119.9 (d, *J* = 7.0 Hz), 120.4 (d, *J* = 4.7 Hz), 125.2, 126.2, 129.7, 129.8 (d, *J* = 7.8 Hz), 131.8, 132.4, 135.9 (d, *J* = 3.4 Hz), 150.3, 155.4, 161.4 (d, *J* = 243.8 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.5; IR 3171, 2957, 1510, 1220, 1035, 937, 771 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{25}NO_4PNa^+$ 464.1403; Found 464.1389.



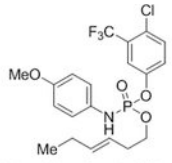
di((*E*)-hex-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 13: Synthesized using Procedure B; Purified using 30% ethyl acetate in hexane; (Deep Red oil, 1.47 g, 40% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.93 (t, *J* = 7.5 Hz, 6H), 1.97 (dtdd, *J* = 8.8, 7.4, 6.2, 1.3 Hz, 4H), 2.34 (dddd, *J* = 8.1, 6.9, 5.6, 1.3 Hz, 4H), 3.76 (s, 3H), 3.98 (dq, *J* = 9.9, 7.1 Hz, 2H), 4.08 (dq, *J* = 9.9, 7.0 Hz, 2H), 5.31 (dtt, *J* = 15.2, 6.8, 1.6 Hz, 2H), 5.52 (dtt, *J* = 15.3, 6.2, 1.4 Hz, 2H), 6.75 – 6.82 (m, 2H), 6.90 – 6.98 (m, 2H);^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 25.7, 33.6 (d, *J* = 6.8 Hz), 55.7, 66.4 (d, *J* = 5.2 Hz), 114.7, 119.3 (d, *J* = 6.9 Hz), 123.7, 132.9, 135.5, 154.9;^{31}P NMR (202 MHz, $CDCl_3$) δ 3.14; IR 3168, 2961, 1756, 1511, 1220, 995, 828 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{30}NO_4PNa^+$ 390.1810; Found 390.1812.



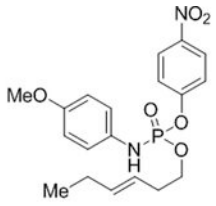
(*E*)-hex-3-en-1-yl ((*S*)-2-methylbutyl) (4-methoxyphenyl)phosphoramidate

Compound 14: Synthesized using Procedure A; Purified using 20% ethyl acetate in hexane; Note: Single diastereomer but relative stereochemistry unassigned; (Brown oil, 1.47 g, 38% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.81 (ddd, *J* = 7.5, 5.9, 1.5 Hz, 3H), 0.84 – 0.89 (m, 3H), 0.91 (t, *J* = 7.5 Hz, 3H), 1.11 (dtt, *J* = 13.2, 7.6, 6.5 Hz, 1H), 1.32 – 1.48 (m, 1H), 1.61 – 1.76 (m, 1H), 1.95 (dtdd, *J* = 8.8, 7.5, 6.2, 1.4 Hz, 2H), 2.33 (qd, *J* = 6.9, 1.3 Hz, 2H), 3.74 (s, 3H), 3.80 – 3.89 (m, 1H), 3.90 – 4.01 (m, 2H), 4.07 (dq, *J* = 9.9, 7.0 Hz, 1H), 5.29 (dtt, *J* = 15.2, 6.8, 1.6 Hz, 1H), 5.49 (dtt, *J* = 15.3, 6.3, 1.4 Hz, 1H), 6.74 – 6.80 (m, 2H), 6.92 – 6.99 (m, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 11.1 (d, *J* = 2.7 Hz), 13.7, 16.1 (d, *J* = 2.8 Hz), 25.6, 25.7 (d, *J* = 2.1 Hz), 33.6 (d, *J* = 7.3 Hz), 35.4 (d, *J* = 7.7 Hz), 55.6, 66.3 (d, *J* = 5.2 Hz), 71.0 (dd, *J* = 5.6, 3.0 Hz), 114.6, 119.1 (dd, *J* = 6.9, 2.9 Hz), 123.7, 133.2, 135.4, 154.7 (d, *J* = 2.8 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ 3.13; IR 3166, 2960, 1510, 1219, 1036, 998, 827 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{30}NO_4PNa^+$ 378.1810; Found 378.1821.



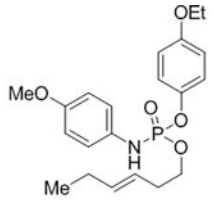
(*E*)-4-chloro-3-(trifluoromethyl)phenyl hex-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 15: Synthesized using General Procedure A; Purified using 30% ethyl acetate in hexane (Light brown oil, 1.58 g, 34% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.5 (q, *J* = 6.8 Hz, 2H), 3.3 (d, *J* = 6.8 Hz, 2H), 3.8 (s, 3H), 4.1 – 4.3 (m, 2H), 5.4 – 5.5 (m, 1H), 5.6 – 5.8 (m, 1H), 6.3 (d, *J* = 10.2 Hz, 1H), 6.8 – 6.9 (m, 2H), 6.9 – 7.1 (m, 4H), 7.1 – 7.3 (m, 3H), 7.3 – 7.3 (m, 2H), 7.4 (dd, *J* = 7.9, 1.3 Hz, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 25.6, 33.4 (d, *J* = 7.2 Hz), 55.5, 67.3 (d, *J* = 5.5 Hz), 114.7, 119.2 – 121.0 (m, 1C), 120.8, 123.1, 123.5, 124.9 (d, *J* = 4.4 Hz), 128.3, 129.3, 131.5, 132.5, 135.9, 149.0 (d, *J* = 6.2 Hz), 155.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.3 (d, *J* = 9.0 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ −63.0; IR 3170, 2962, 1510, 1418, 1141, 1034, 943, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{22}ClNO_4PF_3Na^+$ 486.0825; Found 486.0786.



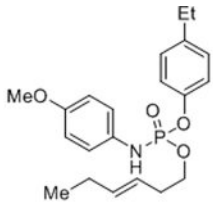
(*E*)-hex-3-en-1-yl (4-nitrophenyl) (4-methoxyphenyl)phosphoramidate

Compound 16: Synthesized using General Procedure A; Purified using 30% ethyl acetate in hexane (Light yellow solid, 935 mg, 23% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.5 Hz, 3H), 1.9 – 2.1 (m, 2H), 2.4 (dddt, *J* = 7.9, 6.8, 5.7, 1.1 Hz, 2H), 3.8 (s, 3H), 4.0 – 4.3 (m, 2H), 5.3 – 5.4 (m, 1H), 5.5 – 5.6 (m, 2H), 6.8 – 6.9 (m, 2H), 6.9 – 7.0 (m, 2H), 7.3 – 7.3 (m, 2H), 8.1 – 8.2 (m, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 25.6, 33.4 (d, *J* = 7.1 Hz), 55.5, 67.4 (d, *J* = 5.5 Hz), 114.7, 119.9 (d, *J* = 7.0 Hz), 121.0 (d, *J* = 5.1 Hz), 123.0, 125.5, 131.5, 136.0, 144.7, 155.4 (d, *J* = 5.9 Hz), 155.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −2.1 (q, *J* = 8.1 Hz); IR 3167, 2963, 1591, 1511, 1219, 1009, 912, 750 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{24}N_2O_6PNa^+$ 429.1191; Found 429.1204.



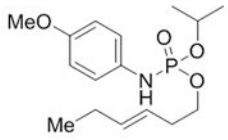
(*E*)-4-ethoxyphenyl hex-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 17: Synthesized using General Procedure A; Purified using 27% ethyl acetate in hexane; (Colorless solid, 1.05 g, 26% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.4 Hz, 3H), 1.4 (t, *J* = 6.9 Hz, 3H), 2.0 (ddd, *J* = 7.6, 6.2, 1.3 Hz, 2H), 2.3 – 2.5 (m, 2H), 3.8 (s, 3H), 3.9 (q, *J* = 6.9 Hz, 2H), 4.1 (m, 2H), 5.3 (s, 1H), 5.5 (dtt, *J* = 15.2, 6.2, 1.3 Hz, 1H), 6.5 (s, 1H), 6.6 – 6.8 (m, 2H), 6.8 – 6.9 (m, 2H), 6.9 – 7.1 (m, 4H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ ^{13}C NMR (101 MHz, $CDCl_3$) δ 13.6, 14.8, 25.6, 33.4 (d, *J* = 7.3 Hz), 55.5, 63.8, 66.7 (d, *J* = 5.3 Hz), 114.5, 115.1, 119.5 (d, *J* = 7.1 Hz), 121.3 (d, *J* = 4.4 Hz), 123.5, 132.6, 135.5, 143.9 (d, *J* = 6.4 Hz), 154.9, 156.0 (d, *J* = 1.5 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.7 (d, *J* = 8.7 Hz); IR 3169, 2962, 1505, 1198, 1006, 940, 750 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{29}NO_5P^+$ 406.1783; Found 406.1769.



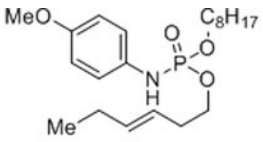
(*E*)-4-ethylphenyl hex-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 18: Synthesized using General Procedure A; Purified using 27% ethyl acetate in hexane (Light brown oil, 2.26 g, 58% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.5 Hz, 3H), 1.2 (t, *J* = 7.6 Hz, 3H), 1.9 – 2.1 (m, 2H), 2.4 (dtd, *J* = 7.8, 6.8, 1.2 Hz, 2H), 2.6 (q, *J* = 7.6 Hz, 2H), 3.8 (s, 3H), 4.0 – 4.2 (m, 2H), 5.3 (dtt, *J* = 15.2, 6.8, 1.5 Hz, 1H), 5.5 (dtt, *J* = 15.3, 6.2, 1.3 Hz, 1H), 5.7 (d, *J* = 9.7 Hz, 1H), 6.7 – 6.9 (m, 2H), 7.0 – 7.0 (m, 2H), 7.0 – 7.1 (m, 4H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 15.6, 25.6, 28.2, 33.5 (d, *J* = 7.3 Hz), 55.5, 66.9 (d, *J* = 5.5 Hz), 114.6, 119.7 (d, *J* = 6.9 Hz), 120.2 (d, *J* = 4.7 Hz), 123.5, 128.9, 132.3, 135.6, 140.9, 148.4, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.5 (d, *J* = 8.6 Hz); IR 3169, 2962, 1507, 1211, 929, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{28}NO_4PNa^+$ 412.1654; Found 412.1636.



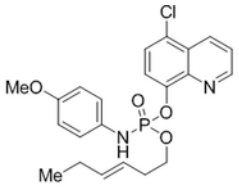
(*E*)-hex-3-en-1-yl isopropyl (4-methoxyphenyl)phosphoramidate

Compound 19: Synthesized using Procedure A; Purified using 22% ethyl acetate in hexane; (Brown oil, 458 mg, 14% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.5 Hz, 3H), 1.2 (d, *J* = 6.2 Hz, 3H), 1.4 (d, *J* = 6.2 Hz, 3H), 1.9 (qdd, *J* = 7.5, 6.2, 1.3 Hz, 2H), 2.3 (qd, *J* = 6.8, 1.3 Hz, 2H), 3.7 (s, 3H), 3.9 (dq, *J* = 9.9, 7.0 Hz, 1H), 4.1 (dq, *J* = 9.9, 6.9 Hz, 1H), 4.7 (dh, *J* = 7.5, 6.2 Hz, 1H), 5.3 (dtt, *J* = 15.2, 6.8, 1.5 Hz, 1H), 5.5 (dtt, *J* = 15.3, 6.3, 1.4 Hz, 1H), 6.5 (d, *J* = 9.6 Hz, 1H), 6.7 – 6.8 (m, 2H), 6.9 – 7.0 (m, 2H).;^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 23.8 (dd, *J* = 25.2, 4.6 Hz), 25.7, 33.6 (d, *J* = 7.2 Hz), 55.6, 66.1 (d, *J* = 4.8 Hz), 71.8 (d, *J* = 4.9 Hz), 114.6, 119.0 (d, *J* = 6.9 Hz), 123.8, 133.4, 135.4, 154.7; ^{31}P NMR (202 MHz, $CDCl_3$) δ 2.1; IR 3166, 2961, 1510, 1240, 1219, 994, 828 cm^{-1};HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{26}NO_4PNa^+$ 350.1497; Found 350.1483.



(*E*)-hex-3-en-1-yl octyl (4-methoxyphenyl)phosphoramidate

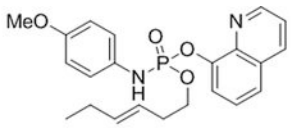
Compound 20: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane; (Deep Red oil, 874 mg, 22% yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.86 (t, *J* = 7.0 Hz, 3H), 0.93 (t, *J* = 7.5 Hz, 3H), 1.18 – 1.32 (m, 10H), 1.59 – 1.67 (m, 2H), 1.93 – 2.00 (m, 2H), 2.31 – 2.37 (m, 2H), 3.75 (s, 3H), 3.98 (dqd, *J* = 10.1, 6.9, 3.4 Hz, 2H), 4.06 (dtd, *J* = 11.1, 6.9, 4.3 Hz, 2H), 5.25 – 5.38 (m, 1H), 5.51 (dt, *J* = 15.3, 6.2 Hz, 1H), 6.75 – 6.82 (m, 2H), 6.91 – 6.96 (m, 2H);^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 14.2, 22.7, 25.6, 25.7, 29.2, 29.3, 30.3 (d, *J* = 7.2 Hz), 31.9, 33.6 (d, *J* = 7.2 Hz), 55.6, 66.4 (d, *J* = 5.1 Hz), 66.9 (d, *J* = 5.1 Hz), 114.7, 119.2 (d, *J* = 6.8 Hz), 123.7, 133.0, 135.5, 154.9; ^{31}P NMR (202 MHz, $CDCl_3$) δ 3.16;IR 3166, 2926, 1510, 1220, 1036, 998, 827 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{38}NO_4P^+$ 398.2460; Found 398.2478.



(*E*)-5-chloroquinolin-8-yl hex-3-en-1-yl (4-methoxyphenyl)phosphoramidate

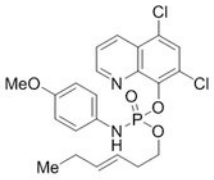
Compound 21: Synthesized using General Procedure A; Purified using 33% ethyl acetate in hexane (Colorless solid, 1.83 g, 41% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.5 Hz, 3H), 2.0 (tt, *J* = 7.5, 1.3 Hz, 2H), 2.3 – 2.6 (m, 2H), 3.7 (s, 3H), 4.3 (dt, *J* = 7.9, 6.9 Hz, 2H), 5.2 – 5.4 (m, 1H), 5.4 – 5.7 (m, 1H), 6.8 (d, *J* = 8.9 Hz, 2H), 6.8 (d, *J* = 7.5 Hz, 1H), 7.0 (d, *J* = 8.9 Hz, 2H), 7.5 – 7.8 (m, 3H), 8.6 (dt, *J* = 8.6, 1.3 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 25.6, 33.5 (d, *J* = 7.1 Hz), 55.5, 67.8 (d,

J = 6.5 Hz), 114.6 (2C), 120.1 (d, *J* = 7.2 Hz), 120.8, 122.5, 123.5, 126.6 (d, *J* = 2.1 Hz), 127.6 (d, *J* = 19.4 Hz), 132.3, 133.6, 135.5, 141.8, 145.8, 150.6, 155.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.9 – −0.4 (m); IR 3170, 2960, 1591, 1511, 1221, 1033, 874, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{24}ClN_2O_4PNa^+$ 469.1060; Found 469.1027.



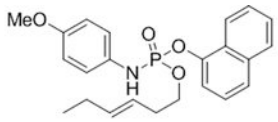
(*E*)-hex-3-en-1-yl quinolin-8-yl (4-methoxyphenyl)phosphoramidate

Compound 22: Synthesized using General Procedure A; Purified using 70% ethyl acetate in hexane (Brown semi-solid, 1.44 g, 35% yield); An analytical sample was purified by reversed phase HPLC (gradient of 100% H_2O with 0.1% TFA to 100% MeCN with 0.1% TFA over 45 minutes on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.0 (t, *J* = 7.5 Hz, 3H), 2.0 (qdd, *J* = 7.5, 6.2, 1.3 Hz, 2H), 2.4 – 2.5 (m, 2H), 3.8 (s, 3H), 4.3 (dtd, *J* = 8.4, 7.0, 1.7 Hz, 2H), 5.4 (dtt, *J* = 15.2, 6.7, 1.5 Hz, 1H), 5.6 (dtt, *J* = 15.2, 6.2, 1.3 Hz, 1H), 6.7 – 6.9 (m, 2H), 7.0 – 7.1 (m, 2H), 7.3 (d, *J* = 8.4 Hz, 1H), 7.4 – 7.6 (m, 2H), 7.6 – 7.8 (m, 2H), 8.2 (dd, *J* = 8.3, 1.7 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.7 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 25.6, 33.5 (d, *J* = 7.0 Hz), 55.6, 67.7 (d, *J* = 6.6 Hz), 114.6, 119.9 (d, *J* = 7.2 Hz), 121.4 (d, *J* = 4.0 Hz), 121.8, 123.6, 125.0 (d, *J* = 1.9 Hz), 126.9 (d, *J* = 2.1 Hz), 129.9, 132.7, 135.4, 136.6, 141.3, 146.6 (d, *J* = 7.4 Hz), 150.0, 155.0; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (q, *J* = 7.5 Hz); IR 3169, 2959, 1510, 1225, 1012, 824, 755 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{25}N_2O_4PNa^+$ 435.1450; Found 435.1473.



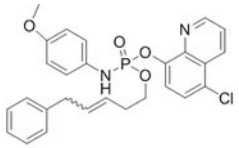
(E)-5,7-dichloroquinolin-8-yl hex-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 23: Synthesized using General Procedure A; Purified using 35% ethyl acetate in hexane (Yellow oil, 1.20 g, 25% yield); An analytical sample was purified by reversed phase HPLC (gradient of 100% H_2O with 0.1% TFA to 100% MeCN with 0.1% TFA over 45 minutes on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.94 (t, *J* = 7.5 Hz, 3H), 1.93 – 2.06 (m, 2H), 2.44 (q, *J* = 6.9 Hz, 2H), 3.76 (s, 3H), 4.37 (dtt, *J* = 10.0, 6.5, 2.8 Hz, 2H), 5.31 – 5.40 (m, 1H), 5.56 (dtd, *J* = 15.3, 6.3, 1.2 Hz, 1H), 6.77 – 6.83 (m, 2H), 7.02 – 7.10 (m, 2H), 7.62 (dd, *J* = 8.5, 4.3 Hz, 1H), 7.72 (s, 1H), 8.60 (dd, *J* = 8.6, 1.5 Hz, 1H), 9.02 (dd, *J* = 4.3, 1.6 Hz, 1H);^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.8, 25.7, 33.7 (d, *J* = 7.4 Hz), 55.7, 68.4 (d, *J* = 6.6 Hz), 114.7, 120.6 (d, *J* = 7.3 Hz), 122.7, 123.6, 126.4, 127.2, 127.3 (d, *J* = 5.1 Hz), 127.7, 128.3, 132.5, 134.2, 135.6, 142.4, 151.1, 155.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.13 (d, *J* = 9.7 Hz); IR 3170, 2960, 1774, 1586, 1511, 1203, 1091, 893 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{23}Cl_2N_2O_4PNa^+$ 503.0670; Found 503.0671.



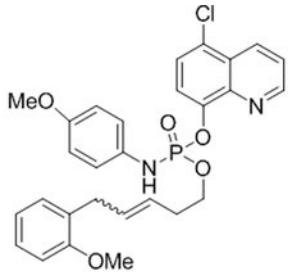
(*E*)-hex-3-en-1-yl naphthalen-1-yl (4-methoxyphenyl)phosphoramidate

Compound 24: Synthesized using General Procedure A; Purified using 30% ethyl acetate in hexane; (Brown oil, 1.27 g, 31% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.4 Hz, 3H), 2.0 (dtdd, *J* = 8.8, 7.5, 6.2, 1.4 Hz, 2H), 2.4 (dddt, *J* = 7.8, 6.8, 5.7, 1.1 Hz, 2H), 3.8 (s, 3H), 4.1 – 4.3 (m, 2H), 5.2 – 5.4 (m, 1H), 5.5 (dtt, *J* = 15.3, 6.2, 1.3 Hz, 1H), 6.3 (d, *J* = 9.7 Hz, 1H), 6.7 – 6.8 (m, 2H), 6.9 – 7.1 (m, 2H), 7.3 (t, *J* = 7.9 Hz, 1H), 7.4 – 7.5 (m, 3H), 7.6 (dt, *J* = 8.3, 1.0 Hz, 1H), 7.8 – 7.8 (m, 1H), 8.1 (ddd, *J* = 8.0, 1.7, 0.7 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.6, 25.6, 33.5 (d, *J* = 7.1 Hz), 55.5, 67.1 (d, *J* = 5.5 Hz), 114.6, 115.1 (d, *J* = 3.4 Hz), 120.2 (d, *J* = 6.8 Hz), 121.9, 123.4, 124.7, 125.5 (d, *J* = 1.7 Hz), 126.1, 126.5, 126.6 (d, *J* = 6.5 Hz), 127.6, 132.1, 134.8, 135.7, 146.7 (d, *J* = 6.7 Hz), 155.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.2 (d, *J* = 8.6 Hz); IR 3166, 2959, 1509, 1222, 1009, 768 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{23}H_{26}NO_4PNa^+$ 434.1497; Found 434.1476.



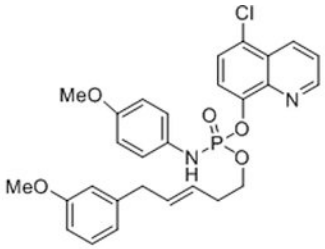
5-chloroquinolin-8-yl (5-phenylpent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 25: Synthesized using Procedure A; Purified using 30% ethyl acetate in hexane; (isolated as a 1:0.16 mixture of trans:cis isomers) (Black oil, 661 mg, 13% yield); Trans isomer characterization: ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.46 (q, *J* = 6.8 Hz, 2H), 3.29 (d, *J* = 6.7 Hz, 2H), 3.73 (s, 3H), 4.31 (dt, *J* = 8.1, 6.9 Hz, 2H), 5.46 (dtt, *J* = 15.2, 6.8, 1.4 Hz, 1H), 5.66 (dddd, *J* = 15.0, 8.1, 4.8, 1.4 Hz, 1H), 6.72 – 6.79 (m, 2H), 6.99 – 7.05 (m, 2H), 7.11 – 7.21 (m, 3H), 7.23 – 7.29 (m, 2H), 7.54 – 7.64 (m, 3H), 8.59 (dd, *J* = 8.6, 1.6 Hz, 1H), 8.98 (dd, *J* = 4.2, 1.6 Hz, 1H);^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 33.6 (d, *J* = 7.2 Hz), 39.1, 55.6, 67.7 (d, *J* = 6.5 Hz), 114.7, 120.2 (d, *J* = 6.6 Hz), 121.0 (d, *J* = 3.8 Hz), 122.7, 126.1 (d, *J* = 5.6 Hz), 126.3, 126.8, 127.7, 127.9 (d, *J* = 2.7 Hz), 128.5, 128.6 (d, *J* = 4.5 Hz), 132.4, 132.5, 133.8, 140.5, 141.9 (d, *J* = 3.8 Hz), 145.9 (d, *J* = 7.2 Hz), 150.7, 155.3;^{31}P NMR (202 MHz, $CDCl_3$) δ −0.69 (d, *J* = 8.7 Hz); IR 3166, 3061, 1590, 1495, 1510, 1220, 1032, 874 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{26}ClN_2O_4PNa^+$ 531.1216; Found 531.1209.



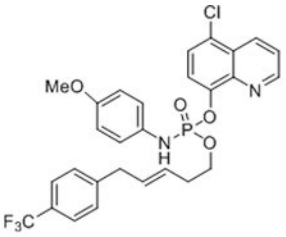
5-chloroquinolin-8-yl (5-(2-methoxyphenyl)pent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 26: Synthesized using Procedure B; Purified using 35% ethyl acetate in hexane; (Brown oil, 808 mg, 15% yield) (2.5:1; trans:cis); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.40 – 2.49 (m, 2H), 3.29 (t, *J* = 5.9 Hz, 2H), 3.78(m, 6H), 4.29 (dt, *J* = 8.0, 6.8 Hz, 2H), 5.42 (dddd, *J* = 13.4, 11.8, 6.8, 3.2 Hz, 1H), 5.63 – 5.73 (m, 1H), 6.72 – 6.81 (m, 2H), 6.82 – 6.94 (m, 2H), 7.00 – 7.11 (m, 3H), 7.11 – 7.24 (m, 1H), 7.56 – 7.67 (m, 3H), 8.64 (dd, *J* = 8.7, 1.6 Hz, 1H), 9.02 (d, *J* = 4.6 Hz, 1H);^{13}C{^{1}H}NMR (101 MHz, $CDCl_3$) δ 33.2, 33.6 (d, *J* = 7.0 Hz), 55.4, 55.7, 67.8 (d, *J* = 6.6 Hz), 110.4, 114.7, 119.5, 120.2 (d, *J* = 7.3 Hz), 120.6, 121.0 (d, *J* = 3.8 Hz), 122.7, 125.8, 125.9, 126.9, 127.4, 129.0, 129.8, 130.2, 131.9, 132.0, 132.4, 133.9, 150.6, 155.3, 157.3; ^{1}P NMR (202 MHz, $CDCl_3$) δ −0.55 (d, *J* = 24.4 Hz); IR 3168, 2954, 1589, 1510, 1240, 1029, 875, 752 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{28}ClN_2O_5PNa^+$ 561.1322; Found 561.1332.



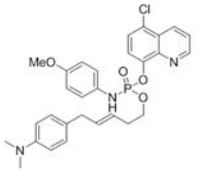
(*E*)-5-chloroquinolin-8-yl (5-(3-methoxyphenyl)pent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 27: Synthesized using Procedure B; Purified using 35% ethyl acetate in hexane; (Brown oil, 1.02 g, 19% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.20 (q, *J* = 6.8 Hz, 2H), 2.99 (d, *J* = 6.7 Hz, 2H), 3.45 (s, 3H), 3.50 (s, 3H), 4.04 (qd, *J* = 6.8, 1.9 Hz, 2H), 5.15 – 5.24 (m, 1H), 5.38 (dtt, *J* = 14.9, 6.7, 1.3 Hz, 1H), 6.39 – 6.53 (m, 4H), 6.71 – 6.82 (m, 3H), 6.91 (t, *J* = 7.8 Hz, 1H), 7.31 (m, 2H), 7.31 – 7.40 (m, 1H), 8.30 (dd, *J* = 8.6, 1.5 Hz, 1H), 8.70 (dd, *J* = 4.2, 1.6 Hz, 1H);^{13}C{^{1}H}NMR (101 MHz, $CDCl_3$) δ 33.6 (d, *J* = 7.0 Hz), 39.2, 55.3, 55.7, 67.7 (d, *J* = 6.5 Hz), 111.4, 114.4, 114.7, 120.2 (d, *J* = 7.3 Hz), 120.9 (d, *J* = 3.9 Hz), 121.0, 122.7, 126.4, 126.8, 127.6, 127.9, 129.5, 132.3, 132.4, 133.7, 141.9, 142.2, 145.9 (d, *J* = 7.1 Hz), 150.70, 155.29, 159.82;^{31}P NMR (202 MHz, $CDCl_3$) δ −0.68 (t, *J* = 8.4 Hz); IR 3167, 2954, 1591, 1511, 1221, 1034, 875, 734 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{28}ClN_2O_5PNa^+$ 561.1322; Found 561.1306.



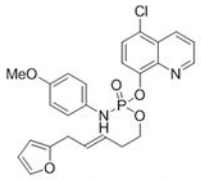
(*E*)-5-chloroquinolin-8-yl (5-(4-(trifluoromethyl)phenyl)pent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 28: Synthesized using Procedure B; Purified using 35% ethyl acetate in hexane; (Brown solid, 1.38 g, 24% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.53 (q, *J* = 6.7 Hz, 2H), 3.38 (d, *J* = 6.7 Hz, 2H), 3.77 (s, 3H), 4.37 (dt, *J* = 8.1, 6.7 Hz, 2H), 5.54 (dtt, *J* = 15.1, 6.8, 1.3 Hz, 1H), 5.61 – 5.77 (m, 1H), 6.74 – 6.84 (m, 2H), 7.04 – 7.16 (m, 2H), 7.25 – 7.34 (m, 2H), 7.54 (d, *J* = 8.1 Hz, 2H), 7.58 – 7.70 (m, 3H), 8.64 (dd, *J* = 8.6, 1.5 Hz, 1H), 9.03 (d, *J* = 4.7 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.5 (d, *J* = 7.0 Hz), 38.8, 55.6, 67.5 (d, *J* = 6.2 Hz), 114.7, 120.1 (d, *J* = 7.2 Hz), 120.9 (d, *J* = 3.8 Hz), 122.7, 123.1, 125.4 (q, *J* = 3.9 Hz), 126.8, 127.5, 127.7, 127.9, 128.8, 128.9, 131.3, 132.4, 133.9, 141.7, 144.6, 145.8, 150.6, 155.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.57. ^{19}F NMR (471 MHz, $CDCl_3$) δ −62.31; IR 2253, 1383, 1264, 905, 1240, 729, 650 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{25}ClF_3N_2O_4PNa^+$ 599.1090; Found 599.1086.



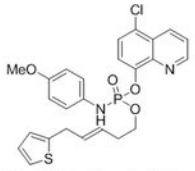
(*E*)-5-chloroquinolin-8-yl (5-(4-(dimethylamino)phenyl)pent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 29: Synthesized using General Procedure A; Purified using 52% ethyl acetate in hexane; An analytical sample was purified by reversed phase HPLC (gradient of 100% H_2O with 0.1% TFA to 100% MeCN with 0.1% TFA over 45 minutes on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column); (Light yellow oil, 1.43 g, Yield 26%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.4 – 2.5 (m, 2H), 2.9 (s, 6H), 3.2 (d, *J* = 6.7 Hz, 2H), 3.7 (s, 3H), 4.3 (dtd, *J* = 7.9, 6.9, 2.4 Hz, 2H), 5.4 (dtt, *J* = 15.1, 6.8, 1.4 Hz, 1H), 5.6 (dtt, *J* = 14.9, 6.8, 1.3 Hz, 1H), 6.6 – 6.7 (m, 2H), 6.7 – 6.8 (m, 2H), 6.9 – 7.1 (m, 5H), 7.5 – 7.6 (m, 2H), 7.6 (dd, *J* = 8.3, 1.9 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.5 (d, *J* = 7.0 Hz), 38.1, 41.0, 55.5, 67.6 (d, *J* = 6.3 Hz), 113.1, 114.6, 120.0 (d, *J* = 7.2 Hz), 120.7 (d, *J* = 3.9 Hz), 122.5, 125.4, 126.6 (d, *J* = 2.0 Hz), 127.5, 127.7 (d, *J* = 2.3 Hz), 128.6, 129.1, 132.4, 133.2, 133.5, 141.8 (d, *J* = 4.2 Hz), 145.8 (d, *J* = 7.1 Hz), 149.2, 150.6, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (q, *J* = 7.8 Hz); IR 3168, 2894, 1612, 1510, 1219, 1012, 872, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{29}H_{32}ClN_3O_4P^+$ 552.1819; Found 552.1799.



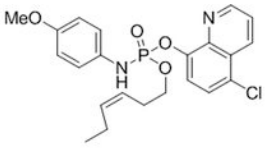
(*E*)-5-chloroquinolin-8-yl (5-(furan-2-yl)pent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 30: Synthesized using General Procedure A; Purified using 46% ethyl acetate in hexane; (Light yellow oil, 1.89 g, Yield 38%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.4 – 2.5 (m, 2H), 3.3 (dt, *J* = 6.5, 1.2 Hz, 2H), 3.7 (s, 3H), 4.3 (dtd, *J* = 8.1, 6.8, 1.3 Hz, 2H), 5.4 – 5.6 (m, 1H), 5.6 – 5.7 (m, 1H), 6.0 (dq, *J* = 3.0, 1.0 Hz, 1H), 6.3 (dd, *J* = 3.2, 1.9 Hz, 1H), 6.6 – 6.8 (m, 2H), 6.9 – 7.1 (m, 3H), 7.2 – 7.3 (m, 1H), 7.5 – 7.7 (m, 3H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 8.9 – 9.1 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 31.4, 33.4 (d, *J* = 7.1 Hz), 55.5, 67.4 (d, *J* = 6.4 Hz), 105.4, 110.3, 114.5, 120.1 (d, *J* = 7.2 Hz), 120.7 (d, *J* = 3.9 Hz), 122.6, 126.7 (d, *J* = 2.0 Hz), 127.3, 127.6 (d, *J* = 20.2 Hz), 128.8, 132.3, 133.7, 141.2, 141.6, 145.8, 150.5, 154.1, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (q, *J* = 8.0 Hz); IR 3168, 2955, 1590, 1510, 1218, 1031, 872, 733 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{25}H_{24}ClN_2O_5PNa^+$ 521.1009; Found 521.0969.



(*E*)-5-chloroquinolin-8-yl (5-(thiophen-2-yl)pent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

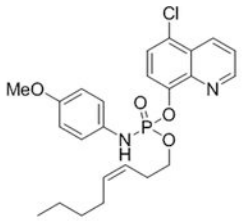
Compound 31: Synthesized using General Procedure A; Purified using 45% ethyl acetate in hexane; (Light yellow oil, 1.24 g, Yield 24%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.5 (q, *J* = 6.8 Hz, 2H), 3.5 (dt, *J* = 6.7, 1.1 Hz, 2H), 3.7 (s, 3H), 4.3 (dtd, *J* = 7.9, 6.8, 2.5 Hz, 2H), 5.5 (dtt, *J* = 15.0, 6.7, 1.3 Hz, 1H), 5.7 (dtt, *J* = 14.6, 6.6, 1.3 Hz, 1H), 6.7 – 6.8 (m, 3H), 6.9 (dd, *J* = 5.2, 3.4 Hz, 1H), 7.0 – 7.1 (m, 2H), 7.1 – 7.1 (m, 2H), 7.5 – 7.6 (m, 2H), 7.6 (dd, *J* = 8.3, 1.9 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.3, 1.6 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.0, 33.3 (d, *J* = 7.0 Hz), 55.5, 67.4 (d, *J* = 6.3 Hz), 114.5, 120.0 (d, *J* = 7.3 Hz), 120.6 (d, *J* = 3.9 Hz), 122.6, 123.5, 124.4, 126.6 (d, *J* = 2.0 Hz), 126.8, 126.9, 127.5, 127.7 (d, *J* = 2.2 Hz), 131.4, 132.3, 133.6, 141.7 (d, *J* = 4.3 Hz), 143.4, 145.8 (d, *J* = 7.1 Hz), 150.6, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (q, *J* = 8.0 Hz); IR 3169, 2955, 1590, 1510, 1219, 1032, 967, 837, 770 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{25}H_{24}ClN_2SO_4PNa^+$ 537.0781; Found 537.0757.



(*Z*)-5-chloroquinolin-8-yl hex-3-en-1-yl (4-methoxyphenyl)phosphoramidate

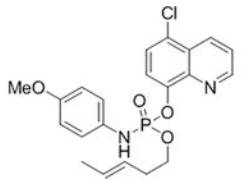
Compound 32: Synthesized using General Procedure A; Purified using 30% ethyl acetate in hexane (Colorless oil, 2.68 g, 60% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.9 (t, *J* = 7.5 Hz, 3H), 2.0 (qd, *J* = 7.1, 6.7, 1.2 Hz, 2H), 2.4 – 2.5 (m, 2H), 3.8 (s, 3H), 4.2 – 4.3 (m, 2H),

5.2 – 5.3 (m, 1H), 5.4 – 5.5 (m, 1H), 6.8 – 6.8 (m, 2H), 6.93 (s, 1H), 7.0 – 7.1 (m, 2H), 7.6 – 7.7 (m, 2H), 7.7 (dd, *J* = 8.4, 1.8 Hz, 1H), 8.7 (dd, *J* = 8.6, 1.5 Hz, 1H), 9.1 (dd, *J* = 4.4, 1.6 Hz, 1H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 14.1, 20.6, 28.3 (d, *J* = 7.0 Hz), 55.5, 67.6, 114.6, 120.3 (d, *J* = 7.1 Hz), 121.0 (d, *J* = 3.8 Hz), 122.6, 122.9, 127.1, 127.6, 127.7, 132.1, 134.8, 135.0, 140.5, 145.2, 150.1, 155.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.5 (d, *J* = 8.5 Hz); 3130, 2950, 1593, 1514, 1230, 1033, 830, 749; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{24}ClN_2O_4PNa^+$ 469.1060; Found 469.1050.



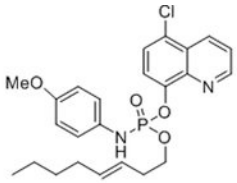
(*Z*)-5-chloroquinolin-8-yl oct-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 33: Synthesized using Procedure A; Purified using 35% ethyl acetate in hexane; (Colorless solid, 1.14 g, Yield 24%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.8 – 0.9 (m, 3H), 1.2 – 1.4 (m, 4H), 1.8 – 2.1 (m, 2H), 2.3 – 2.5 (m, 2H), 3.7 (s, 3H), 4.3 (q, *J* = 7.3 Hz, 2H), 5.2 – 5.4 (m, 1H), 5.4 – 5.5 (m, 1H), 6.7 – 6.8 (m, 2H), 6.8 (d, *J* = 19.3 Hz, 1H), 7.0 – 7.1 (m, 2H), 7.5 – 7.7 (m, 3H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.3, 1.6 Hz, 1H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 13.9, 22.3, 27.0, 28.5 (d, *J* = 7.0 Hz), 31.7, 55.5, 67.5 (d, *J* = 6.5 Hz), 114.6, 120.1 (d, *J* = 7.1 Hz), 121.0 (d, *J* = 3.8 Hz), 122.6, 123.5, 126.8 (d, *J* = 2.1 Hz), 127.6, 127.8, 132.2, 133.3, 134.1, 141.3, 145.6, 150.4, 155.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (d, *J* = 8.5 Hz); IR 3173, 2956, 1512, 1222, 1015, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{24}H_{28}ClN2O_4P^+$ 475.1548; Found 475.1510.



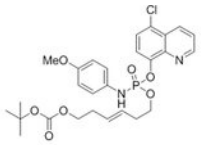
(*E*)-5-chloroquinolin-8-yl pent-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 34: Synthesized using General Procedure A; Purified using 33% ethyl acetate in hexane; (Colorless solid, 2.16 g, Yield 50%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.6 (dq, *J* = 6.3, 1.3 Hz, 3H), 2.4 (qt, *J* = 6.9, 1.5 Hz, 2H), 3.7 (s, 3H), 4.3 (dtd, *J* = 7.9, 6.8, 0.9 Hz, 2H), 5.4 (dtq, *J* = 15.1, 6.8, 1.5 Hz, 1H), 5.4 – 5.5 (m, 1H), 6.7 – 6.8 (m, 2H), 7.0 (d, *J* = 7.5 Hz, 1H), 7.0 – 7.1 (m, 2H), 7.5 – 7.6 (m, 2H), 7.6 (dd, *J* = 8.3, 1.9 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.6 Hz, 1H); $^{13}C\{^{1}H\}$NMR (101 MHz, $CDCl_3$) δ 18.0, 33.5 (d, *J* = 7.1 Hz), 55.5, 67.7 (d, *J* = 6.3 Hz), 114.5, 120.0 (d, *J* = 7.2 Hz), 120.7 (d, *J* = 3.8 Hz), 122.5, 125.8, 126.6, 127.5, 127.7, 128.4, 132.4, 133.6, 141.8 (d, *J* = 4.3 Hz), 145.8 (d, *J* = 7.2 Hz), 150.6, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.7 (d, *J* = 4.5 Hz); IR 3171, 2957, 1511, 1219, 1011, 871, 785 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{23}ClN_2O_4P^+$ 433.1084; Found 433.1097.



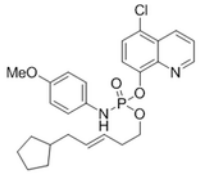
(*E*)-5-chloroquinolin-8-yl oct-3-en-1-yl (4-methoxyphenyl)phosphoramidate

Compound 35: Synthesized using General Procedure B; Purified using 27% ethyl acetate in hexane; (Pale brown solid, 1.14 g, 24% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.82 – 0.91 (m, 3H), 1.22 – 1.33 (m, 4H), 1.89 – 2.01 (m, 2H), 2.42 (q, *J* = 6.8 Hz, 2H), 3.74 (s, 3H), 4.27 (dt, *J* = 8.0, 7.0 Hz, 2H), 5.33 (dtt, *J* = 15.1, 6.8, 1.4 Hz, 1H), 5.49 (dtt, *J* = 14.2, 6.4, 1.2 Hz, 1H), 6.72 – 6.80 (m, 2H), 7.03 (m, 2H), 7.55 – 7.67 (m, 3H), 8.59 (dd, *J* = 8.6, 1.7 Hz, 1H), 9.00 (dd, *J* = 4.1, 1.6 Hz, 1H);^{13}C{^{1}H}NMR (101 MHz, $CDCl_3$) δ 14.0, 22.3, 31.6, 32.4, 33.7 (d, *J* = 6.7 Hz), 55.7, 67.9 (d, *J* = 6.6 Hz), 114.7, 120.2 (d, *J* = 7.2 Hz), 121.1 (d, *J* = 3.8 Hz), 122.7, 124.5, 126.9, 127.7, 127.9, 132.4, 134.0, 134.2, 141.7, 145.9, 150.5, 155.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.57; IR 3167, 2955, 1590, 1511, 1220, 1032, 875 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{28}ClN_2O_4PNa^+$ 497.1373; Found 497.1375.



(*E*)-*tert*-butyl (6-((((5-chloroquinolin-8-yl)oxy)((4-methoxyphenyl)amino)phosphoryl)oxy)hex-3-en-1-yl) carbonate

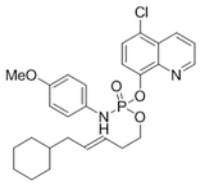
Compound 36: Synthesized using General Procedure A; Purified using 45% ethyl acetate in hexane; (Colorless solid, 1.80 g, Yield 32%;); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.5 (s, 9H), 2.2 – 2.3 (m, 2H), 2.4 – 2.5 (m, 2H), 3.7 (s, 3H), 4.0 (t, *J* = 6.9 Hz, 2H), 4.3 (dtd, *J* = 8.3, 6.9, 1.5 Hz, 2H), 5.3 – 5.6 (m, 2H), 6.6 – 6.9 (m, 2H), 7.0 (dd, *J* = 8.7, 2.2 Hz, 3H), 7.5 – 7.7 (m, 3H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 27.8, 32.0, 33.5 (d, *J* = 7.1 Hz), 55.5, 66.3, 67.3 (d, *J* = 6.3 Hz), 81.9, 114.5, 120.0 (d, *J* = 7.2 Hz), 120.7 (d, *J* = 3.9 Hz), 122.6, 126.6, 127.5, 127.7, 127.9, 128.5, 132.3, 133.6, 141.6 (d, *J* = 4.3 Hz), 145.7 (d, *J* = 7.1 Hz), 150.6, 153.5, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (q, *J* = 7.8 Hz); IR 3171, 2976, 1736, 1511, 1219, 1012, 823, 786 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{27}H_{32}ClN_2NaO_7P^+$ 585.1533; Found 585.1528.



(*E*)-5-chloroquinolin-8-yl (5-cyclopentylpent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

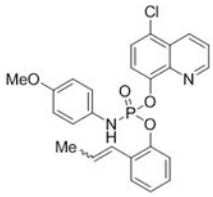
Compound 37: Synthesized using General Procedure A; Purified using 37% ethyl acetate in hexane; (Light yellow oil, 1.80 g, Yield 36%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.0 – 1.0 (m, 2H), 1.3 – 1.5 (m, 4H), 1.5 – 1.7 (m, 3H), 1.9 (t, *J* = 7.0 Hz, 2H), 2.3 (q, *J* = 6.9 Hz, 2H), 3.7 (d, *J* = 1.7 Hz, 3H), 4.2 (q, *J* = 7.5 Hz, 2H), 5.3 (dtd, *J* = 16.8, 6.7, 1.5 Hz, 1H),

5.3 – 5.5 (m, 1H), 6.6 – 6.8 (m, 2H), 6.9 (d, *J* = 7.3 Hz, 1H), 7.0 (td, *J* = 5.9, 2.9 Hz, 2H), 7.4 – 7.6 (m, 3H), 8.5 (dd, *J* = 8.5, 1.7 Hz, 1H), 8.8 – 9.1 (m, 1H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 25.1, 32.2, 33.6 (d, *J* = 7.0 Hz), 39.0, 39.8, 55.5, 67.8 (d, *J* = 6.6 Hz), 114.5, 120.0 (d, *J* = 7.1 Hz), 120.9 (d, *J* = 3.7 Hz), 122.5, 124.8, 126.8, 127.5, 127.7, 132.3, 133.4, 133.9, 141.5, 145.7, 150.4, 155.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (d, *J* = 7.5 Hz); IR 3169, 2947, 1510, 1219, 1012, 872, 786 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{26}H_{30}ClN_2NaO_4P^+$ 523.1529; Found 523.1537.



(*E*)-5-chloroquinolin-8-yl (5-cyclohexylpent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

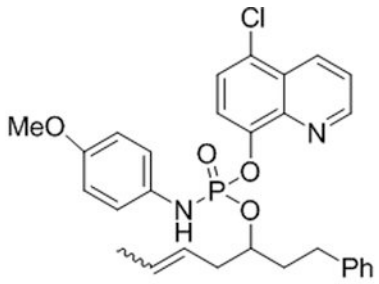
Compound 38: Synthesized using General Procedure A; Purified using 40% ethyl acetate in hexane; (Light Brown oil, 1.44 g, Yield 28%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.8 (qd, *J* = 11.6, 10.9, 5.2 Hz, 2H), 0.9 – 1.3 (m, 5H), 1.5 – 1.7 (m, 4H), 1.8 (td, *J* = 6.9, 1.2 Hz, 2H), 2.3 – 2.5 (m, 2H), 3.7 (s, 3H), 4.3 (qd, *J* = 7.1, 1.8 Hz, 2H), 5.2 – 5.4 (m, 1H), 5.5 (dtt, *J* = 15.4, 7.0, 1.3 Hz, 1H), 6.6 – 6.8 (m, 2H), 6.9 – 7.1 (m, 3H), 7.4 – 7.7 (m, 3H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.6 Hz, 1H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 26.3, 26.6, 33.1, 33.6 (d, *J* = 7.2 Hz), 37.8, 40.6, 55.5, 67.8 (d, *J* = 6.5 Hz), 114.5, 120.0 (d, *J* = 7.3 Hz), 120.7 (d, *J* = 3.8 Hz), 122.5, 124.2, 125.4, 126.7 (d, *J* = 2.0 Hz), 127.6 (d, *J* = 16.4 Hz), 132.4, 132.5, 133.7, 141.7, 145.7, 150.5, 155.1. ; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.6 (q, *J* = 8.0 Hz); IR 3168, 2920, 1590, 1511, 1220, 1013, 874, 786 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{27}H_{32}ClN_2NaO_4P^+$ 537.1686; Found 537.1646.



5-chloroquinolin-8-yl (2-(prop-1-en-1-yl)phenyl) (4-methoxyphenyl)phosphoramidate

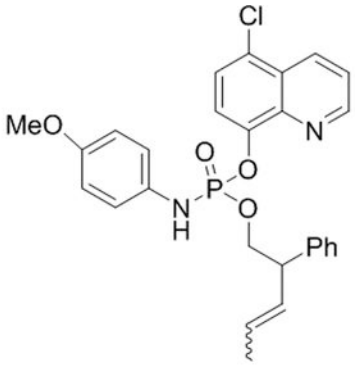
Compound 39: Synthesized using General Procedure A; Purified using 30% ethyl acetate in hexane; An analytical sample was purified by reversed phase HPLC (gradient of 100% H_2O with 0.1% TFA to 100% MeCN with 0.1% TFA over 45 minutes on a Hamilton PRP-1.7 μm, 21.2 × 250 mm, C18 column; (Brown oil , 1.01 g, Yield 21%); 1H NMR (400 MHz, CDCl3) δ 1.5 – 1.9 (m, 3H), 3.8 (d, J = 1.9 Hz, 3H), 6.1 (dq, J = 15.8, 6.6 Hz, 1H), 6.5 (dq, J = 15.9, 1.8 Hz, 1H), 6.7 – 6.9 (m, 2H), 7.1 – 7.3 (m, 5H), 7.4 (dt, J = 7.6, 1.6 Hz, 1H), 7.5 (dt, J = 8.1, 1.4 Hz, 1H), 7.5 – 7.7 (m, 3H), 8.6 (dt, J = 8.6, 2.0 Hz, 1H), 9.0 (td, J = 5.3, 4.8, 1.6 Hz, 1H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 18.6, 55.5, 114.4 (d, *J* = 6.1 Hz), 120.6 (d, *J* = 2.6 Hz), 121.0, 121.1 (d, *J* = 2.6 Hz), 122.6 (d, *J* = 3.8 Hz), 124.5 (d, *J* = 7.6 Hz), 125.1, 126.4, 126.7, 127.5, 127.6, 127.7, 127.9 (d, *J* = 3.4 Hz), 129.8 (d, *J* = 6.4 Hz), 131.8, 133.8, 141.4, 145.6 (d, *J* = 7.6 Hz), 147.5 (d, *J* = 7.9 Hz), 150.5, 155.5; ^{31}P NMR (202 MHz,

$CDCl_3$) δ 4.7; IR 3166, 1511, 1259, 994, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{25}H_{22}ClN_2O_4PK$ 519.0643; Found 519.0626.



5-chloroquinolin-8-yl (1-phenylhept-5-en-3-yl) (4-methoxyphenyl)phosphoramidate

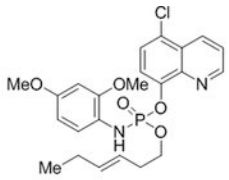
Compound 40: Synthesized using General Procedure B; Purified using 30% ethyl acetate in hexane; (Brown oil, 805 mg, 15% yield, cis& trans mixture); ^1H NMR (400 MHz, $CDCl_3$) δ 1.51 – 1.64 (m, 3H), 1.97 (dddd, *J* = 14.3, 12.2, 7.9, 5.0 Hz, 2H), 2.39 – 2.77 (m, 4H), 3.73 (s, 3H), 4.67 – 4.85 (m, 1H), 5.34 – 5.60 (m, 2H), 6.72 – 6.81 (m, 3H), 7.06 – 7.23 (m, 6H), 7.54 – 7.69 (m, 3H), 8.52 – 8.71 (m, 1H), 9.01 (dq, *J* = 5.0, 1.7 Hz, 1H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 13.2, 31.3, 32.8 (d, *J* = 3.6 Hz), 38.5, 55.7, 79.5 (m), 114.67 (d, *J* = 2.3 Hz), 120.2 (dd, *J* = 13.9, 7.2 Hz), 121.1, 122.7, 124.7 (d, *J* = 2.5 Hz), 125.6, 125.9 (d, *J* = 3.1 Hz), 126.9, 127.2, 127.2, 127.7, 127.8, 128.5 (d, *J* = 4.4 Hz), 129.0 (d, *J* = 4.4 Hz), 132.6, 133.9, 141.8 (d, *J* = 4.6 Hz), 150.5, 155.2 (d, *J* = 7.3 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.33;IR 3166, 2934, 1610, 1590, 1510, 1219, 995, 866 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{29}H_{30}ClN_2O_4PNa^+$ 559.1529; Found 559.1530.



5-chloroquinolin-8-yl (2-phenylpent-3-en-1-yl) (4-methoxyphenyl)phosphoramidate

Compound 41: Synthesized using Procedure B; Purified using 28% ethyl acetate in hexane; (Colorless solid, 865 mg, 17% yield) (cis/trans mixture); ^1H NMR (400 MHz, $CDCl_3$) δ 1.54 – 1.66 (m, 3H), 3.73 (d, *J* = 1.7 Hz, 3H), 4.05 (m, 1H), 4.33 – 4.52 (m, 2H), 5.47 – 5.68 (m, 2H), 6.72 (ddq, *J* = 10.8, 6.8, 4.1 Hz, 3H), 6.89 – 7.00 (m, 2H), 7.10 – 7.28 (m, 4H), 7.43 – 7.62 (m, 3H), 8.59 (dt, *J* = 8.6, 1.5 Hz, 1H), 8.97 (d, *J* = 4.2 Hz, 1H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 13.3, 43.9 (d, *J* = 7.6 Hz), 55.7, 71.0 (d, *J* = 6.6 Hz), 114.6, 120.4 (t, *J* = 6.3 Hz), 121.2 (d, *J* = 3.2 Hz), 122.6, 126.8, 127.1 (d, *J* = 15.2 Hz), 127.6, 128.0, 128.1,

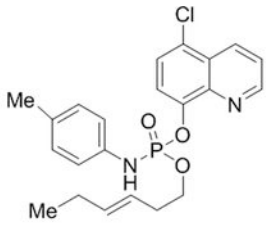
128.5, 128.6, 129.4 (d, J = 9.3 Hz), 130.1, 132.3, 134.5, 141.0 (d, J = 4.3 Hz), 145.5, 150.1, 155.3;^{31}P NMR (202 MHz, $CDCl_3$) δ −0.75; IR 3166, 3061, 1590, 1510, 1220, 1032, 875 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{26}ClN_2O_4PNa^+$ 531.1216; Found 531.1214.



(*E*)-5-chloroquinolin-8-yl hex-3-en-1-yl (2,4-dimethoxyphenyl)phosphoramidate

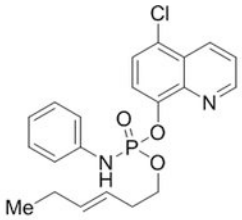
Compound 83: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane; (Red oil, 1.67 g, 35%yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.91 (t, J = 7.4 Hz, 3H), 1.89 – 2.05 (m, 2H), 2.36 – 2.49 (m, 2H), 3.72 (s, 3H), 3.75 (s, 3H), 4.27 (dt, J = 7.9, 6.9 Hz, 2H), 5.33 (dtt, J = 15.2, 6.8, 1.5 Hz, 1H), 5.50 – 5.54 (m, 1H), 6.35 – 6.43 (m, 2H), 7.36 – 7.44 (m, 1H), 7.53 – 7.58 (m, 2H), 7.62 (dd, J = 8.3, 1.9 Hz, 1H), 8.52 (ddd, J = 11.9, 8.6, 1.6 Hz, 1H), 8.98 (dd, J = 4.2, 1.6 Hz, 1H);

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.7, 25.6, 33.6 (d, J = 7.0 Hz), 55.6, 55.7, 67.8 (d, J = 6.4 Hz), 99.1, 104.2, 117.9 (d, J = 1.8 Hz), 120.6 (d, J = 4.0 Hz), 122.5 (m), 123.6, 126.6 (d, J = 2.0 Hz), 127.4 (d, J = 9.0 Hz), 127.6 (d, J = 2.2 Hz), 133.4, 135.5, 141.8 (d, J = 4.3 Hz), 145.9 (d, J = 7.2 Hz), 149.0, 149.1, 150.6, 155.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.40 (q, J = 8.3 Hz); IR 2961, 1590, 1515, 1207, 1034, 873 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{27}ClN_2O_5P^+$ 477.1346; Found 477.1342.



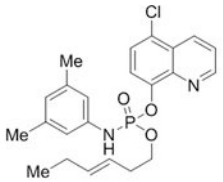
(*E*)-5-chloroquinolin-8-yl hex-3-en-1-yl *p*-tolylphosphoramidate

Compound 84: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane; (Colorless solid, 1.08 g, 25%yield); ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.92 (t, J = 7.5 Hz, 3H), 1.96 (p, J = 7.3 Hz, 2H), 2.24 (s, 3H), 2.43 (q, J = 6.9 Hz, 2H), 4.28 (qt, J = 7.0, 3.4 Hz, 2H), 5.28 – 5.38 (m, 1H), 5.53 (dt, J = 15.4, 6.2 Hz, 1H), 6.98 (d, J = 1.8 Hz, 4H), 7.46 – 7.69 (m, 3H), 8.56 (dd, J = 8.6, 1.7 Hz, 1H), 8.99 (dd, J = 4.3, 1.7 Hz, 1H); ^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 13.7, 20.7, 25.7, 33.58 (d, J = 7.2 Hz), 67.8 (d, J = 6.1 Hz), 118.1 (d, J = 7.5 Hz), 120.7 (d, J = 3.8 Hz), 122.6, 123.5, 126.7, 127.5, 127.7, 129.8, 131.3, 133.7, 135.6, 136.8, 141.7 (d, J = 4.4 Hz), 145.7 (d, J = 7.1 Hz), 150.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.92 (q, J = 7.9 Hz); IR 2961, 2242, 1615, 1568, 1124, 873 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{23}ClN_2O_3PNa^+$ 453.1111; Found 453.1112.



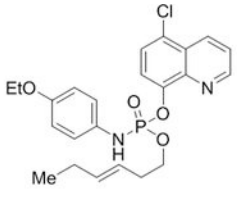
(*E*)-5-chloroquinolin-8-yl hex-3-en-1-yl phenylphosphoramidate

Compound 85: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane; (Colorless oil, 833 mg, 20%yield); ^{1}H NMR (600 MHz, $CDCl_3$) δ 0.93 (t, *J* = 7.4 Hz, 3H), 1.96 (qdd, *J* = 7.5, 6.2, 1.4 Hz, 2H), 2.43 (qd, *J* = 6.9, 1.3 Hz, 2H), 4.30 (dt, *J* = 7.9, 6.9 Hz, 2H), 5.35 (dtt, *J* = 15.3, 6.9, 1.6 Hz, 1H), 5.54 (dtt, *J* = 15.4, 6.3, 1.4 Hz, 1H), 6.93 (tt, *J* = 7.4, 1.1 Hz, 1H), 7.08 (dq, *J* = 7.0, 1.4 Hz, 2H), 7.18 – 7.23 (m, 2H), 7.56 – 7.64 (m, 3H), 8.59 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.01 (dd, *J* = 4.3, 1.6 Hz, 1H);^{13}C{^{1}H}NMR (126 MHz, $CDCl_3$) δ 13.7, 25.6, 33.5 (d, *J* = 7.2 Hz), 67.8 (d, *J* = 6.2 Hz), 117.9 (d, *J* = 7.9 Hz), 120.7 (d, *J* = 3.7 Hz), 121.8, 122.6, 123.4, 126.6 (d, *J* = 2.3 Hz), 127.5, 127.7 (d, *J* = 2.4 Hz), 129.2, 133.6, 135.6, 139.5, 141.6 (d, *J* = 4.3 Hz), 145.7 (d, *J* = 7.1 Hz), 150.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.14 (d, *J* = 9.4 Hz); IR 3170, 2963, 1604, 1497, 1230, 1069, 973 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{23}ClN_2O_3P^+$ 417.1135; Found 417.1134.



(*E*)-5-chloroquinolin-8-yl hex-3-en-1-yl (3,5-dimethylphenyl)phosphoramidate

Compound 86: Synthesized using Procedure A; Purified using 28% ethyl acetate in hexane; (Colorless solid, 1.11 g, 25%yield); ^{1}H NMR (600 MHz, $CDCl_3$) δ 0.92 (t, *J* = 7.4 Hz, 3H), 1.96 (p, *J* = 7.1 Hz, 2H), 2.23 (s, 6H), 2.43 (q, *J* = 6.9 Hz, 2H), 4.28 (q, *J* = 7.2 Hz, 2H), 5.30 – 5.39 (m, 1H), 5.53 (dt, *J* = 15.2, 6.3 Hz, 1H), 6.58 (s, 1H), 6.71 (s, 2H), 7.53 – 7.67 (m, 3H), 8.59 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.03 (dd, *J* = 4.3, 1.6 Hz, 1H);^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 13.7, 21.4, 25.6, 33.5 (d, *J* = 7.2 Hz), 67.7 (d, *J* = 6.3 Hz), 115.7 (d, *J* = 7.9 Hz), 120.5 (d, *J* = 4.1 Hz), 122.6, 123.5, 123.7, 126.6, 127.4, 127.6 (d, *J* = 2.5 Hz), 133.5, 135.5, 138.8, 139.2, 141.7 (d, *J* = 4.5 Hz), 145.7 (d, *J* = 6.6 Hz), 150.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −1.01 (q, *J* = 8.8 Hz); IR 3196, 2961, 1457, 1223, 1013, 873 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{27}ClN_2O_3P^+$ 445.1448; Found 445.1447.



(*E*)-5-chloroquinolin-8-yl hex-3-en-1-yl (4-ethoxyphenyl)phosphoramidate

Compound 87: Synthesized using Procedure A; Purified using 25% ethyl acetate in hexane; (Colorless solid, 823 mg, 18%yield); ^{1}H NMR (600 MHz, $CDCl_3$) δ 0.93 (t, *J* = 7.4 Hz, 3H), 1.37 (t, *J* = 7.0 Hz, 3H), 1.93 – 2.00 (m, 2H), 2.42 (q, *J* = 6.9 Hz, 2H), 3.95 (q, *J* = 7.0 Hz, 2H), 4.27 (q, *J* = 7.2 Hz, 2H), 5.30 – 5.38 (m, 1H), 5.54 (dt, *J* = 15.2, 6.4 Hz, 1H), 6.77 (t, *J* = 12.6 Hz, 2H), 6.98 – 7.04 (m, 2H), 7.55 – 7.65 (m, 3H), 8.61 (d, *J* = 8.1 Hz, 1H), 9.01 (dd, *J* = 4.0, 1.8 Hz, 1H);^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 13.7, 15.0, 25.7, 33.6 (d, *J* = 7.2 Hz), 63.8, 67.8 (d, *J* = 6.4 Hz), 115.3, 120.0 (d, *J* = 7.1 Hz), 120.9 (d, *J* = 3.7 Hz), 122.7, 123.5, 126.8, 127.6, 127.8, 132.3, 133.9, 135.6, 141.7, 145.8 (d, *J* = 6.8 Hz), 150.6, 154.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −0.59 (q, *J* = 8.2 Hz); IR 3178, 2961, 1604, 1497, 1236, 1034, 883 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{27}ClN_2O_4P^+$ 461.1397; Found 461.1396.

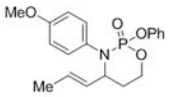
IV. General Procedure C: Oxidative Cyclization of alkenyl phosphoramidates

A 10 mL microwave vial with a magnetic stirring pellet was charged with phosphoramidate starting material (0.2 mmol, 1 equiv), $Pd(OAc)_2$ (0.04 mmol, 20 mol%) and $Cu(OAc)_2$ (0.2 mmol, 1 equiv) followed by acetonitrile (4 mL, final concentration: 0.05 M). The reaction mixture was sparged with oxygen for fifteen minutes, and then the vial was sealed. The reaction vial was affixed with a balloon of O_2 (~1 atm), submerged in an oil bath preheated to 55 °C, and kept at this temperature for 65 hours. Subsequently, the reaction mixture was filtered through a small plug of silica and evaporated to dryness under vacuum. The resulting crude mixture was then purified by chromatography on silica gel (specific conditions are associated with each product) to afford the corresponding products.

V. Characterization of Cyclophosphoramidate Products

Note: In almost all cases, unless explicitly indicated, diastereomers have been fully separated and characterized individually. Combined yields and diastereomeric ratios are reported in the main text for the sake of clarity.

Compound 42



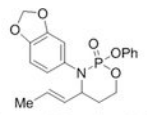
(*E*)-3-(4-methoxyphenyl)-2-phenoxy-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 42 and 52: Synthesized using General Procedure C; Purified using 25–45% ethyl acetate in hexane; 52.5 mg, Yield = 73%, Dr = 1:1.3.

Data for major diastereomer: Beige solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.5 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.1 (dtdd, *J* = 14.3, 4.1, 2.9, 1.3 Hz, 1H), 2.1 – 2.3 (m, 1H), 3.8 (s, 3H), 4.3 (ddt, *J* = 12.2, 8.3, 3.5 Hz, 1H), 4.3 – 4.5 (m, 2H), 5.2 (ddq, *J* = 15.2, 8.2, 1.6 Hz, 1H), 5.4 – 5.6 (m, 1H), 6.7 – 6.9 (m, 2H), 7.0 – 7.1 (m, 3H), 7.1 – 7.3 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 33.7 (d, *J* = 4.4 Hz), 55.7, 63.2 (d, *J* = 1.9 Hz), 67.2 (d, *J* = 7.3 Hz), 114.3 (d, *J* = 1.5 Hz), 120.4 (d, *J* = 4.8 Hz), 124.7, 129.7, 129.8, 130.2 (d, *J* = 3.4 Hz), 130.7 (d, *J* = 7.7 Hz), 132.8, 151.7 (d, *J* = 9.0 Hz), 158.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.6 (d,

J = 20.6 Hz); IR 2920, 1509, 1344, 1220, 943, 742 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{19}H_{23}NO_4P^+$ 360.1365; Found 360.1361.

Data for minor diastereomer: Beige solid; ^1H NMR (400 MHz, $CDCl_3$) δ 1.6 (dd, J = 6.5, 1.7 Hz, 3H), 2.0 (dtdd, J = 14.3, 5.1, 2.6, 1.1 Hz, 1H), 2.3 – 2.6 (m, 1H), 3.8 (s, 3H), 4.1 (ddd, J = 18.1, 8.7, 4.8 Hz, 1H), 4.4 (dddd, J = 16.6, 11.1, 5.3, 3.8 Hz, 1H), 4.5 – 4.7 (m, 1H), 5.3 – 5.5 (m, 1H), 5.6 – 5.8 (m, 1H), 6.7 – 6.9 (m, 2H), 7.1 (ddq, J = 8.5, 6.8, 1.1 Hz, 1H), 7.2 – 7.2 (m, 2H), 7.2 – 7.3 (m, 2H), 7.3 – 7.4 (m, 2H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 17.7, 32.4 (d, J = 6.0 Hz), 55.4, 64.3 (d, J = 2.9 Hz), 65.9 (d, J = 7.3 Hz), 114.4, 120.3 (d, J = 4.9 Hz), 124.5, 128.7, 129.1 (d, J = 3.6 Hz), 129.22, 129.24, 134.4 (d, J = 3.3 Hz), 151.3 (d, J = 8.2 Hz), 158.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.9 (td, J = 17.3, 7.8 Hz); IR 2853, 1509, 1280, 914, 750 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{19}H_{23}NO_4P^+$ 360.1365; Found 360.1364.

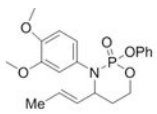


(*E*)-3-(benzo[*d*][1,3]dioxol-5-yl)-2-phenoxy-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 43: Synthesized using General Procedure C; Purified using 18–25% ethyl acetate in hexane; 42.6 mg, Yield = 57%, Dr = 1.73:1.

Data for major diastereomer: Yellow solid; ^1H NMR (400 MHz, $CDCl_3$) δ 1.54 (dd, J = 6.3, 1.8 Hz, 3H), 2.01 – 2.10 (m, 1H), 2.11 – 2.27 (m, 1H), 4.26 (tt, J = 8.8, 3.4 Hz, 1H), 4.35 – 4.52 (m, 2H), 5.21 (ddq, J = 15.2, 8.2, 1.7 Hz, 1H), 5.50 (dq, J = 15.4, 6.5 Hz, 1H), 5.94 (s, 2H), 6.71 (d, J = 8.0 Hz, 1H), 6.79 (dt, J = 10.3, 2.0 Hz, 2H), 7.04 – 7.18 (m, 3H), 7.26 – 7.31 (m, 2H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 17.7, 33.6 (d, J = 4.4 Hz), 63.3, 67.1 (d, J = 7.4 Hz), 101.5, 108.0, 110.2 (d, J = 3.6 Hz), 120.2 (d, J = 4.6 Hz), 122.7 (d, J = 3.7 Hz), 124.6, 129.7 (d, J = 2.9 Hz), 130.3, 130.4, 133.7, 146.5, 147.8, 151.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.79. IR 2918, 1591, 1502, 1485, 1284, 1191, 922 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{20}NO_5PNa^+$ 396.0977; Found 396.0955.

Data for minor diastereomer: Yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 1.66 (dd, J = 6.4, 1.7 Hz, 3H), 1.94 – 2.03 (m, 1H), 2.39 – 2.52 (m, 1H), 4.09 (ddt, J = 19.1, 9.1, 3.9 Hz, 1H), 4.42 (dddd, J = 16.7, 11.1, 5.3, 3.8 Hz, 1H), 4.53 – 4.63 (m, 1H), 5.44 (dq, J = 15.4, 6.5 Hz, 1H), 5.74 (ddq, J = 15.3, 8.3, 1.7 Hz, 1H), 5.94 (s, 2H), 6.69 – 6.78 (m, 3H), 7.15 (t, J = 7.2 Hz, 1H), 7.23 – 7.26 (m, 2H), 7.33 (dd, J = 8.6, 7.2 Hz, 2H); ^{13}C {^1H}NMR (101 MHz, $CDCl_3$) δ 17.8, 32.5 (d, J = 5.9 Hz), 64.6 (d, J = 2.9 Hz), 66.1 (d, J = 7.3 Hz), 101.6, 108.3, 109.6 (d, J = 3.7 Hz), 120.4 (d, J = 5.1 Hz), 121.9 (d, J = 4.1 Hz), 124.7, 129.4, 129.5, 129.8, 135.6 (d, J = 3.1 Hz), 146.4, 148.0, 151.4 (d, J = 8.1 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.09 (m).IR 2919, 1503, 1483, 1282, 1192, 1010, 915 cm^{-1}; ; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{20}NO_5PNa^+$ 396.0977; Found 396.0964.

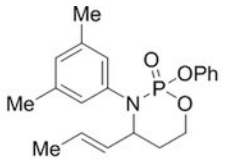


(*E*)-3-(3,4-dimethoxyphenyl)-2-phenoxy-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 44: Synthesized using General Procedure C; Purified using 28–40% ethyl acetate in hexane; 42.1 mg, Yield = 54%, Dr = 1.19:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.52 (dd, *J* = 6.4, 1.7 Hz, 3H), 2.09 (dd, *J* = 14.5, 3.8 Hz, 1H), 2.19 (dtd, *J* = 14.1, 9.6, 4.4 Hz, 1H), 3.82 (s, 3H), 3.85 (s, 3H), 4.30 (td, *J* = 8.6, 4.1 Hz, 1H), 4.40 – 4.55 (m, 2H), 5.23 (ddt, *J* = 15.2, 8.3, 1.7 Hz, 1H), 5.49 (dq, *J* = 13.1, 6.4 Hz, 1H), 6.77 (d, *J* = 8.6 Hz, 1H), 6.79 – 6.83 (m, 1H), 6.87 (dt, *J* = 8.6, 2.0 Hz, 1H), 7.09 – 7.13 (m, 2H), 7.23 – 7.29 (m, 3H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.7, 33.6 (d, *J* = 4.6 Hz), 56.1, 63.2, 67.1, 67.1, 111.0, 112.9, 120.2 (d, *J* = 5.1 Hz), 121.2 (d, *J* = 3.6 Hz), 124.6, 129.56, 129.7, 130.4 (d, *J* = 7.8 Hz), 132.9, 148.1, 148.9, 151.20; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.73 (d, *J* = 20.2 Hz). IR 2960, 1592, 1512, 1234, 1026, 920, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_5PNa^+$ 412.1290; Found 412.1298.

Data for minor diastereomer: Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.65 (dd, *J* = 6.5, 1.6 Hz, 3H), 2.01 (dq, *J* = 11.9, 4.4, 3.9 Hz, 1H), 2.49 (ddt, *J* = 14.7, 9.6, 4.6 Hz, 1H), 3.77 (s, 3H), 3.84 (s, 3H), 4.12 (ddt, *J* = 18.1, 9.2, 5.1 Hz, 1H), 4.38 – 4.50 (m, 1H), 4.61 (tdd, *J* = 10.4, 7.7, 2.5 Hz, 1H), 5.42 (dq, *J* = 13.3, 6.4 Hz, 1H), 5.70 – 5.80 (m, 1H), 6.73 – 6.78 (m, 2H), 6.84 (dt, *J* = 8.6, 1.8 Hz, 1H), 7.14 (t, *J* = 7.3 Hz, 1H), 7.21 – 7.26 (m, 2H), 7.32 (t, *J* = 7.9 Hz, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 32.5 (d, *J* = 5.9 Hz), 55.9, 56.1, 64.4 (d, *J* = 2.9 Hz), 66.1 (d, *J* = 7.3 Hz), 111.3, 112.1 (d, *J* = 3.8 Hz), 120.4 (d, *J* = 3.7 Hz), 120.5 (d, *J* = 5.0 Hz), 124.7, 129.3, 129.7, 134.7 (d, *J* = 3.0 Hz), 147.8, 149.1, 151.4, 151.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.04 (t, *J* = 19.9 Hz). IR 2921, 1592, 1513, 1278, 1024, 915, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_5PNa^+$ 412.1290; Found 412.1294.

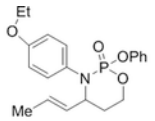


(*E*)-3-(3,5-dimethylphenyl)-2-phenoxy-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 45: Synthesized using General Procedure C; Purified using 25–35% ethyl acetate in hexane; 26.4 mg, Yield = 37%, Dr = 1.47:1.

Data for major diastereomer: Colorless solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.56 (dd, *J* = 6.7, 1.6 Hz, 3H), 2.10 – 2.20 (m, 2H), 2.26 (s, 6H), 4.35 (ddd, *J* = 12.6, 7.4, 5.1 Hz, 1H), 4.39 – 4.51 (m, 2H), 5.27 (ddd, *J* = 15.3, 7.6, 1.9 Hz, 1H), 5.56 (dq, *J* = 15.4, 6.5 Hz, 1H), 6.80 (s, 1H), 6.90 (s, 2H), 7.08 – 7.12 (m, 3H), 7.25 – 7.30 (m, 2H); ^{13}C {^{1}H}NMR (101 MHz, $CDCl_3$) δ 17.7, 21.4, 33.2 (d, *J* = 5.7 Hz), 62.5, 67.0 (d, *J* = 7.3 Hz), 120.3 (d, *J* = 5.1 Hz), 124.7, 125.6 (d, *J* = 3.7 Hz), 128.1, 129.4, 129.7, 130.1 (d, *J* = 6.5 Hz), 138.4, 139.9, 151.5 (d, *J* = 8.9 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.27 (d, *J* = 18.6 Hz). IR 2920, 2851, 1594, 1286, 1038, 915, 830, 690 cm^{-1}. HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_3PNa^+$ 380.1392; Found 380.1375.

Data for minor diastereomer: Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.57 (dd, *J* = 6.6, 1.7 Hz, 3H), 1.84 – 1.96 (m, 1H), 2.17 (s, 6H), 2.42 (ddt, *J* = 15.0, 10.0, 4.8 Hz, 1H), 4.11 – 4.22 (m, 1H), 4.33 (ddt, *J* = 15.8, 11.0, 4.3 Hz, 1H), 4.49 (tdd, *J* = 10.5, 7.8, 2.7 Hz, 1H), 5.37 (dq, *J* = 15.4, 6.5 Hz, 1H), 5.65 (ddq, *J* = 15.3, 7.8, 1.6 Hz, 1H), 6.73 (s, 1H), 6.80(s, 2H), 7.06 (t, *J* = 7.2 Hz, 1H), 7.14 – 7.29 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 21.5, 32.4 (d, *J* = 6.2 Hz), 63.7, 65.9 (d, *J* = 7.3 Hz), 120.5 (d, *J* = 5.0 Hz), 124.7, 125.1, 125.1, 128.1, 128.8, 129.7 (d, *J* = 2.3 Hz), 138.8, 141.9 (d, *J* = 3.6 Hz), 151.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.29 (td, *J* = 17.4, 7.5 Hz). IR 2916, 1667, 1594, 1488, 1206, 1284, 1070, 914, 828, 774 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_3PNa^+$ 380.1392; Found 380.1397.

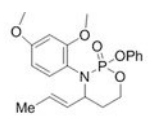


(*E*)-3-(4-ethoxyphenyl)-2-phenoxy-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 46: Synthesized using General Procedure C; Purified using 22–30% ethyl acetate in hexane; 45.6 mg, Yield = 61%, Dr = 1.44:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.41 (t, *J* = 7.0 Hz, 3H), 1.53 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.06 – 2.12 (m, 1H), 2.20 (dtd, *J* = 14.0, 9.7, 4.3 Hz, 1H), 4.01 (q, *J* = 7.0 Hz, 2H), 4.31 (ddt, *J* = 12.3, 8.3, 3.5 Hz, 1H), 4.39 – 4.54 (m, 2H), 5.22 (ddt, *J* = 15.3, 8.2, 1.7 Hz, 1H), 5.50 (dq, *J* = 15.4, 6.5 Hz, 1H), 6.80 – 6.84 (m, 2H), 7.10 – 7.13 (m, 3H), 7.20 – 7.23 (m, 2H), 7.25 – 7.30 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 14.9, 17.6, 33.6 (d, *J* = 4.4 Hz), 63.1, 63.7, 67.1 (d, *J* = 7.4 Hz), 114.7, 120.2 (d, *J* = 5.0 Hz), 124.5, 129.6, 129.6, 130.1 (d, *J* = 3.5 Hz), 130.5 (d, *J* = 7.4 Hz), 132.4, 151.6 (d, *J* = 8.2 Hz), 157.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.64 (d, *J* = 20.3 Hz). IR 2981, 1591, 1507, 1490, 1204, 1047, 916, 733 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_4PNa^+$ 396.1341; Found 396.1344.

Data for minor diastereomer: Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.39 (t, *J* = 7.0 Hz, 3H), 1.62 – 1.66 (m, 3H), 1.95 – 2.02 (m, 1H), 2.48 (ddt, *J* = 14.6, 9.6, 4.6 Hz, 1H), 3.99 (q, *J* = 7.0 Hz, 2H), 4.10 (ddq, *J* = 18.4, 9.2, 5.2, 4.4 Hz, 1H), 4.43 (dddd, *J* = 16.7, 11.2, 5.3, 3.8 Hz, 1H), 4.59 (tdd, *J* = 10.6, 8.0, 2.6 Hz, 1H), 5.36 – 5.45 (m, 1H), 5.70 – 5.77 (m, 1H), 6.78 – 6.84 (m, 2H), 7.12 – 7.19 (m, 3H), 7.22 – 7.27 (m, 2H), 7.32 (t, *J* = 7.9 Hz, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 14.9, 17.8, 32.5 (d, *J* = 6.2 Hz), 63.7, 64.5 (d, *J* = 2.9 Hz), 66.1 (d, *J* = 7.2 Hz), 115.0, 120.5 (d, *J* = 5.1 Hz), 124.6, 129.2, 129.4 (d, *J* = 3.6 Hz), 129.7, 134.3 (d, *J* = 3.5 Hz), 151.5 (d, *J* = 8 Hz), 157.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.85(m). IR 2978, 2917, 1591, 1508, 1201, 1010, 912, 815 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_4PNa^+$ 396.1341; Found 396.1339.

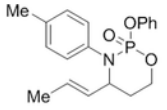


(*E*)-3-(2,4-dimethoxyphenyl)-2-phenoxy-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 47: Synthesized using General Procedure C; Purified using 20–30% ethyl acetate in hexane; 28.04 mg, Yield = 36%, Dr = 2:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.50 (dd, *J* = 6.6, 1.7 Hz, 3H), 1.98 – 2.18 (m, 2H), 3.70 (s, 3H), 3.79 (s, 3H), 4.36 – 4.58 (m, 3H), 5.23 (ddq, *J* = 15.1, 8.4, 1.6 Hz, 1H), 5.48 (dq, *J* = 15.2, 6.5 Hz, 1H), 6.35 – 6.49 (m, 2H), 7.03 – 7.14 (m, 2H), 7.22 – 7.30 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.5, 33.2 (d, *J* = 4.2 Hz), 55.4, 61.6, 67.1, 67.2, 99.4, 103.9, 119.9 (d, *J* = 5.1 Hz), 120.8, 123.9, 128.6, 129.3, 130.2 (d, *J* = 6.7 Hz), 132.8, 151.8, 158.1, 159.8; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.75 (d, *J* = 20.1 Hz); IR 2918, 1607, 1587, 1507, 1205, 1041, 998, 916 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_5PNa^+$ 412.1290; Found 412.1295.

Data for minor diastereomer: Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.61 (dd, 3H), 2.12 (ddt, *J* = 14.4, 6.9, 5.1 Hz, 1H), 2.29 – 2.39 (m, 1H), 3.77 (s, 3H), 3.82 (s, 3H), 3.97 (dq, *J* = 14.5, 7.2 Hz, 1H), 4.52 (ddd, *J* = 12.0, 5.8, 4.8 Hz, 2H), 5.33 (ddt, *J* = 15.5, 7.0, 6.0 Hz, 1H), 5.59 (ddq, *J* = 15.2, 8.2, 1.6 Hz, 1H), 6.33 (dd, *J* = 8.6, 2.7 Hz, 1H), 6.47 (d, *J* = 2.7 Hz, 1H), 6.92 (dd, *J* = 8.6, 1.3 Hz, 1H), 7.11 – 7.17 (m, 1H), 7.26 – 7.38 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.7, 31.7, 55.6, 56.0, 62.8, 66.7 (d, *J* = 6.7 Hz), 100.2, 104.1, 120.6 (d, *J* = 5.0 Hz), 123.2, 124.4, 128.3, 129.6, 130.4, 131.8, 156.5, 151.9, 159.9; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.36 (q, *J* = 13.0 Hz); IR 2928, 1601, 1586, 1513, 1202, 1012, 908, 761 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{24}NO_5PNa^+$ 412.1290; Found 412.1286.



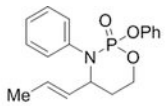
(*E*)-2-phenoxy-4-(prop-1-en-1-yl)-3-(*p*-tolyl)-1,3,2-oxazaphosphinane 2-oxide

Compound 48: Synthesized using General Procedure C; Purified using 18–25% ethyl acetate in hexane; 36.4 mg, Yield = 53%, Dr = 1.4:1.

Data for major diastereomer: Colorless solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.53 (dd, *J* = 6.3, 1.7 Hz, 3H), 2.15 (dddd, *J* = 27.0, 14.6, 9.7, 4.4 Hz, 2H), 2.30 (s, 3H), 4.36 (tt, *J* = 8.2, 4.0 Hz, 1H), 4.40 – 4.51 (m, 2H), 5.23 (ddt, *J* = 15.2, 7.9, 1.6 Hz, 1H), 5.47 – 5.60 (m, 1H), 7.09 (m, *J* = 8.4 Hz, 5H), 7.19 (d, *J* = 7.9 Hz, 2H), 7.22 – 7.29 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.6, 21.1, 33.4 (d, *J* = 5.1 Hz), 62.6, 66.9 (d, *J* = 7.8 Hz), 120.2 (d, *J* = 5.0 Hz), 124.5, 128.0 (d, *J* = 3.4 Hz), 129.5, 129.5, 129.6, 130.4 (d, *J* = 7.0 Hz), 135.9, 137.5, 151.7; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.02 (d, *J* = 19.8 Hz). IR 3028, 2918, 1590, 1489, 1283, 995, 916, 532 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{22}NO_3PNa^+$ 366.1235; Found 366.1231.

Data for minor diastereomer: Yellow solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.65 (dd, *J* = 6.5, 1.6 Hz, 3H), 1.93 – 2.04 (m, 1H), 2.31 (s, 3H), 2.50 (ddt, *J* = 14.6, 9.6, 4.6 Hz, 1H), 4.19 (ddt, *J* = 18.0, 8.8, 5.2 Hz, 1H), 4.38 – 4.49 (m, 1H), 4.59 (tdd, *J* = 10.6, 7.9, 2.6 Hz, 1H), 5.45 (dq, *J* = 15.3, 6.5 Hz, 1H), 5.74 (ddq, *J* = 15.3, 8.1, 1.7 Hz, 1H), 7.10 (d, *J* = 8.2 Hz, 2H), 7.14 – 7.18 (m, 3H), 7.23 – 7.26 (m, 2H), 7.32 (dd, *J* = 8.6, 7.2 Hz, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 21.1, 32.5 (d, *J* = 6.3 Hz), 63.8 (d, *J* = 2.3 Hz), 66.0

(d, *J* = 7.3 Hz), 120.5 (d, *J* = 4.6 Hz), 124.6, 127.3 (d, *J* = 3.7 Hz), 129.0, 129.7, 129.8, 135.9, 139.3 (d, *J* = 3.6 Hz), 151.4, 151.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.22 (m). IR 2918, 1591, 1489, 1283, 1202, 915, 813 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{22}NO_3PNa^+$ 366.1235; Found 366.1223.

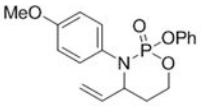


(*E*)-2-phenoxy-3-phenyl-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 49: Synthesized using General Procedure C; Purified using 23–30% ethyl acetate in hexane; 19.1 mg, Yield = 29%, Dr = 1.4:1.

Data for major diastereomer: Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.52 – 1.58 (m, 3H), 2.10 – 2.30 (m, 2H), 4.35 – 4.55 (m, 3H), 5.19 – 5.32 (m, 1H), 5.57 (ddt, *J* = 15.6, 7.0, 6.1 Hz, 1H), 7.03 – 7.12 (m, 3H), 7.16 (ddq, *J* = 7.2, 5.8, 1.7 Hz, 1H), 7.22 – 7.44 (m, 6H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.6, 33.3 (d, *J* = 5.4 Hz), 62.4, 67.0 (d, *J* = 7.5 Hz), 120.2 (d, *J* = 5.0 Hz), 124.6, 126.1, 127.8 (d, *J* = 3.6 Hz), 128.9, 129.7, 130.1, 130.2, 140.4, 151.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.39 (d, *J* = 20.2 Hz). IR 3045, 2986, 2305, 1592, 1490, 1264, 1007, 925, 815, 703cm^{-1}. HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{20}NO_3PNa^+$ 352.1079; Found 352.1079.

Data for minor diastereomer :Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.65 (dd, *J* = 6.5, 1.6 Hz, 3H), 1.96 – 2.08 (m, 1H), 2.52 (ddt, *J* = 14.6, 9.7, 4.7 Hz, 1H), 4.20 – 4.34 (m, 1H), 4.45 (ddt, *J* = 16.0, 11.1, 4.4 Hz, 1H), 4.60 (tdd, *J* = 10.8, 8.1, 2.8 Hz, 1H), 5.46 (dq, *J* = 15.3, 6.4 Hz, 1H), 5.74 (ddq, *J* = 15.4, 7.9, 1.7 Hz, 1H), 7.12 – 7.21 (m, 2H), 7.22 – 7.26 (m, 2H), 7.29 – 7.35 (m, 6H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 32.4 (d, *J* = 6.1 Hz), 63.6, 66.1 (d, *J* = 7.0 Hz), 120.5 (d, *J* = 5.1 Hz), 124.8, 126.1, 127.0 (d, *J* = 3.8 Hz), 129.1, 129.2, 129.6, 129.8, 142.2, 151.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.47 (td, *J* = 17.3, 7.7 Hz). IR 2918, 1732, 1592, 1488, 1279, 1201, 1012, 915, 758 cm^{-1}. HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{20}NO_3PNa^+$ 352.1079; Found 352.1070.



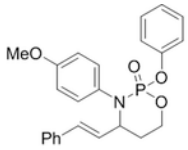
3-(4-methoxyphenyl)-2-phenoxy-4-vinyl-1,3,2-oxazaphosphinane 2-oxide

Compound 50 Synthesized using General Procedure C; Purified using 25–40% ethyl acetate in hexane; 35.9 mg, Yield = 52%, Dr = 1:1.3.

Data for major diastereomer: Beige solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.0 – 2.2 (m, 1H), 2.2 – 2.3 (m, 1H), 3.8 (s, 3H), 4.3 – 4.6 (m, 3H), 5.0 (dq, *J* = 10.1, 0.9 Hz, 1H), 5.1 (dt, *J* = 17.1, 1.0 Hz, 1H), 5.6 (ddd, *J* = 17.1, 10.2, 8.0 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.1 – 7.1 (m, 3H), 7.2 – 7.3 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.2 (d, *J* = 4.6 Hz), 55.4, 63.5 (d, *J* = 2.2 Hz), 66.9 (d, *J* = 7.3 Hz), 114.1, 118.2, 120.1 (d, *J* = 4.8 Hz), 124.5, 129.6, 129.8 (d, *J* = 3.5 Hz), 132.4, 137.5 (d, *J* = 7.9 Hz), 151.4, 158.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.0

(d, J = 20.7 Hz); IR 3054, 2917, 1507, 1227, 1040, 914, 807 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{20}NO_4PNa^+$ 368.1028 Found 368.1008.

Data for minor diastereomer: Beige solid; ^1H NMR (400 MHz, $CDCl_3$) δ 2.0 – 2.1 (m, 1H), 2.4 – 2.6 (m, 1H), 3.8 (s, 3H), 4.1 – 4.3 (m, 1H), 4.4 (dddd, J = 16.6, 11.1, 5.3, 3.8 Hz, 1H), 4.6 (dddd, J = 10.9, 9.7, 8.0, 2.6 Hz, 1H), 5.1 (dt, J = 17.1, 1.1 Hz, 1H), 5.1 (dt, J = 10.4, 1.0 Hz, 1H), 6.1 (ddd, J = 17.1, 10.3, 7.9 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.1 – 7.2 (m, 1H), 7.2 – 7.3 (m, 4H), 7.3 – 7.4 (m, 2H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 31.9 (d, J = 6.0 Hz), 55.4, 64.8 (d, J = 2.9 Hz), 65.9 (d, J = 7.4 Hz), 114.5, 117.9, 120.3 (d, J = 5.0 Hz), 124.6, 129.1 (d, J = 3.5 Hz), 129.6, 134.3, 136.8, 151.3, 158.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.1 (td, J = 17.0, 7.7 Hz); IR 3070, 1508, 1280, 1004, 911, 809, 690; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{18}H_{20}NO_4PNa^+$ 368.1028 Found 368.1010.

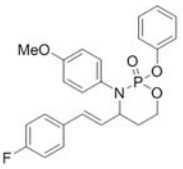


(*E*)-3-(4-methoxyphenyl)-2-phenoxy-4-styryl-1,3,2-oxazaphosphinane 2-oxide

Compound 51: Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 50.6 mg, Yield = 60%, Dr = 2.2:1.

Data for major diastereomer: Beige solid; ^1H NMR (500 MHz, $CDCl_3$) δ 2.2 (dq, J = 14.3, 4.0 Hz, 1H), 2.2 – 2.3 (m, 1H), 3.7 (s, 3H), 4.4 – 4.6 (m, 3H), 5.9 (dd, J = 15.8, 8.2 Hz, 1H), 6.3 (d, J = 15.8 Hz, 1H), 6.7 – 6.8 (m, 2H), 7.0 – 7.1 (m, 3H), 7.1 – 7.2 (m, 3H), 7.2 – 7.2 (m, 6H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 33.3 (d, J = 4.8 Hz), 55.3, 63.4 (d, J = 2.9 Hz), 67.1 (d, J = 6.9 Hz), 114.3 (d, J = 1.4 Hz), 120.1 (d, J = 4.9 Hz), 124.8, 126.4, 128.0, 128.45 (d, J = 7.2 Hz), 128.52, 129.6, 129.9 (d, J = 3.4 Hz), 131.9, 133.2 (d, J = 1.6 Hz), 136.0, 151.2 (d, J = 9.1 Hz), 158.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.0 (d, J = 19.8 Hz); IR 2960, 1508, 1279, 917, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{24}NNaO_4P^+$ 444.1335 Found 444.1383.

Data for minor diastereomer: Brown oil; ^1H NMR (400 MHz, $CDCl_3$) δ 2.0 – 2.1 (m, 1H), 2.4 – 2.6 (m, 1H), 3.7 (s, 3H), 4.2 – 4.3 (m, 1H), 4.3 – 4.5 (m, 1H), 4.5 – 4.7 (m, 1H), 6.3 (d, J = 15.9 Hz, 1H), 6.4 (dd, J = 15.9, 8.0 Hz, 1H), 6.7 – 6.8 (m, 2H), 7.1 (ddt, J = 8.2, 6.0, 1.1 Hz, 1H), 7.1 – 7.3 (m, 11H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 32.6 (d, J = 5.9 Hz), 55.7, 64.7 (d, J = 3.0 Hz), 66.2 (d, J = 7.3 Hz), 114.8, 120.6 (d, J = 4.9 Hz), 124.9, 126.8, 128.2, 128.3, 129.0, 129.6 (d, J = 3.5 Hz), 130.0, 133.1, 134.6, 136.5, 151.6 (d, J = 8.0 Hz), 158.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.1 (td, J = 17.1, 8.0 Hz); IR 2928, 1508, 1280, 912, 807 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{24}NNaO_4P^+$ 444.1335; Found 444.1374.

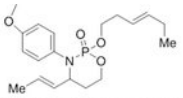


(*E*)-4-(4-fluorostyryl)-3-(4-methoxyphenyl)-2-phenoxy-1,3,2-oxazaphosphinane 2-oxide

Compound 53: Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 54.5 mg, Yield = 62%, Dr = 1:1.1.

Data for major diastereomer: Light yellow solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.1 – 2.4 (m, 2H), 3.7 (s, 3H), 4.4 – 4.7 (m, 3H), 5.9 (dd, *J* = 15.9, 8.2 Hz, 1H), 6.4 (d, *J* = 15.8 Hz, 1H), 6.7 – 6.9 (m, 2H), 6.9 – 7.0 (m, 2H), 7.0 – 7.2 (m, 5H), 7.2 – 7.3 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.4 (d, *J* = 4.7 Hz), 55.4, 63.1, 66.9 (d, *J* = 7.2 Hz), 114.3 (d, *J* = 1.5 Hz), 115.4, 115.6, 120.1 (d, *J* = 4.8 Hz), 124.5, 128.0 (d, *J* = 8.1 Hz), 128.6 (d, *J* = 9.1 Hz), 129.6, 129.8 (d, *J* = 3.4 Hz), 131.8, 132.4, 151.4 (d, *J* = 8.9 Hz), 158.2, 162.5 (d, *J* = 245 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.0 (d, *J* = 20.4 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ −113.8 (td, *J* = 8.6, 4.3 Hz); IR 2921, 1594, 1508, 1229, 1279, 1027, 919, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{24}H_{23}NFKO_4P^+$ 478.0986; Found 478.0992.

Data for minor diastereomer: Light brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.0 – 2.2 (m, 1H), 2.6 (ddt, *J* = 14.3, 9.3, 4.6 Hz, 1H), 3.8 (s, 3H), 4.3 (ddt, *J* = 17.3, 7.1, 5.2 Hz, 1H), 4.4 – 4.6 (m, 1H), 4.6 – 4.7 (m, 1H), 6.2 – 6.4 (m, 2H), 6.8 – 6.9 (m, 2H), 6.9 – 7.1 (m, 2H), 7.1 – 7.2 (m, 1H), 7.2 – 7.3 (m, 6H), 7.3 – 7.4 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 32.3 (d, *J* = 6.1 Hz), 55.4, 64.4 (d, *J* = 3.0 Hz), 66.0 (d, *J* = 7.4 Hz), 114.5, 115.6 (d, *J* = 21.6 Hz), 120.3 (d, *J* = 5.0 Hz), 124.7, 127.6, 128.0 (d, *J* = 8.0 Hz), 129.3 (d, *J* = 3.6 Hz), 129.7, 131.6, 132.3 (d, *J* = 3.5 Hz), 134.2, 151.3 (d, *J* = 8.1 Hz), 158.2, 162.6 (d, *J* = 247.6 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.1 (td, *J* = 16.9, 8.1 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ −113.6 (m); IR 2959, 1594, 1507, 1281, 1202, 1011, 914, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{24}H_{23}NFKO_4P^+$ 478.0986; Found 478.1005.



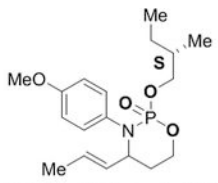
2-(((*E*)-hex-3-en-1-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 54: Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 46 mg, Yield = 63%, Dr = 2.4:1.

Data for major diastereomer: Yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.99 (t, *J* = 7.4 Hz, 3H), 1.62 (dd, *J* = 6.5, 1.7 Hz, 3H), 1.88 (dt, *J* = 14.4, 4.0 Hz, 1H), 1.99 – 2.06 (m, 2H), 2.33 – 2.44 (m, 3H), 3.77 (s, 3H), 4.04 (ddp, *J* = 12.2, 6.4, 3.1 Hz, 3H), 4.29 – 4.38 (m, 1H), 4.39 – 4.46 (m, 1H), 5.33 – 5.46 (m, 2H), 5.55 – 5.71 (m, 2H), 6.78 – 6.83 (m, 2H), 7.16 – 7.20 (m, 2H); ^{13}C {^{1}H} NMR (126 MHz, $CDCl_3$) δ 13.8, 17.6, 25.8, 33.6 (d, *J* = 3.8 Hz), 33.8 (d, *J* = 6.6 Hz), 55.5, 62.9, 66.2 (d, *J* = 6.6 Hz), 66.7 (d, *J* = 7.2 Hz), 114.0, 124.2, 129.1, 129.8 (d, *J* = 2.9 Hz), 130.9 (d, *J* = 7.2 Hz), 133.3, 135.2, 157.9; ^{31}P NMR (202 MHz, $CDCl_3$) δ

0.42 (d, *J* = 18.1 Hz). IR 2960, 1607, 1508, 1236, 1021, 994 cm $^{-1}$; HRMS (ESI-TOF) m/z: [M + Na]$^{+}$ Calcd for $C_{19}H_{28}NO_4PNa^{+}$ 388.1654; Found 388.1653.

Data for minor diastereomer: Yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.95 (t, *J* = 7.5 Hz, 3H), 1.49 (dd, *J* = 6.5, 1.6 Hz, 3H), 1.99 (tt, *J* = 9.0, 5.8 Hz, 3H), 2.04 – 2.11 (m, 1H), 2.24 – 2.29 (m, 2H), 3.76 (s, 3H), 3.88 – 3.96 (m, 2H), 4.15 (tt, *J* = 8.4, 3.9 Hz, 1H), 4.32 (ddd, *J* = 17.2, 7.1, 4.2 Hz, 2H), 5.15 – 5.23 (m, 1H), 5.28 – 5.33 (m, 1H), 5.38 – 5.45 (m, 1H), 5.52 (dtt, *J* = 15.6, 6.3, 1.5 Hz, 1H), 6.76 – 6.81 (m, 2H), 7.13 – 7.19 (m, 2H). ^{13}C {^{1}H} NMR (126 MHz, $CDCl_3$) δ 13.8, 17.8, 25.8, 32.81 (d, *J* = 5.4 Hz), 33.92 (d, *J* = 7.2 Hz), 55.52, 64.14 (d, *J* = 2.6 Hz), 65.24 (d, *J* = 7.2 Hz), 66.57 (d, *J* = 6.5 Hz), 114.34, 124.43, 128.73, 129.28 (d, *J* = 3.7 Hz), 130.19, 134.88 (d, *J* = 2.9 Hz), 135.27, 157.89; ^{31}P NMR (202 MHz, $CDCl_3$) δ 0.62 (q, *J* = 11.8, 9.7 Hz).). IR 2960, 1734, 1508, 1243, 1009, 810, 792 cm^{-1}; HRMS (ESI-TOF) m/z: [M + Na]$^{+}$ Calcd for $C_{19}H_{28}NO_4PNa^{+}$ 388.1654; Found 388.1659.

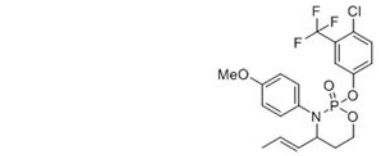


3-(4-methoxyphenyl)-2-((*S*)-2-methylbutoxy)-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 55: Synthesized using General Procedure C; Purified using 20–25% ethyl acetate in hexane; 42.4 mg, Yield = 55%, Dr = 2.4:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (400 MHz, CDCl3) δ 0.85 (ddd, *J* = 9.3, 7.0, 1.7 Hz, 6H), 1.05 – 1.18 (m, 1H), 1.39 (dddd, *J* = 13.2, 8.0, 5.5, 2.8 Hz, 1H), 1.50 (dd, *J* = 6.4, 1.6 Hz, 3H), 1.64 (d, *J* = 13.6 Hz, 1H), 1.95 – 2.14 (m, 2H), 3.66 – 3.74 (m, 2H), 3.77 (s, 3H), 4.16 (tt, J = 8.4, 4.0 Hz, 1H), 4.25 – 4.41 (m, 2H), 5.14 – 5.24 (m, 1H), 5.44 (dq, J = 15.4, 6.5 Hz, 1H), 6.78 – 6.81 (m, 2H), 7.15 – 7.19 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 11.3, 16.2 (d, *J* = 3.1 Hz), 17.6, 25.8, 33.7 (d, *J* = 4.3 Hz), 35.6 (d, *J* = 6.6 Hz), 55.5, 62.9, 66.2 (d, *J* = 6.8 Hz), 71.5 (d, *J* = 7.3 Hz), 114.0, 129.1, 129.8 (d, *J* = 3.6 Hz), 130.9 (d, *J* = 6.7 Hz), 133.3, 157.9; ^{31}P NMR (202 MHz, CDCl3) δ 0.47 (d, J = 18.9 Hz). IR 2932, 1736, 1508, 1234, 1020, 992, 809 cm^{-1}. HRMS (ESI-TOF) m/z: [M + Na]$^{+}$ Calcd for $C_{18}H_{28}NO_4PNa^{+}$ 376.1654; Found 376.1662.

Data for minor diastereomer: Brown oil; ^{1}H NMR (400 MHz, CDCl3) δ 0.90 – 0.99 (m, 6H), 1.21 (ddd, J = 13.6, 7.9, 1.9 Hz, 1H), 1.49 (dddd, *J* = 12.5, 9.5, 4.9, 2.3 Hz, 1H), 1.63 (dd, *J* = 6.4, 1.7 Hz, 3H), 1.72 (dt, *J* = 12.3, 6.1 Hz, 1H), 1.89 (dt, *J* = 14.6, 4.0 Hz, 1H), 2.41 (td, *J* = 9.6, 4.8 Hz, 1H), 3.77 (s, 3H), 3.80 – 4.07 (m, 3H), 4.38 (dtd, *J* = 22.6, 11.3, 10.5, 4.5 Hz, 2H), 5.40 (dq, *J* = 15.4, 6.4 Hz, 1H), 5.60 – 5.72 (m, 1H), 6.78 – 6.84 (m, 2H), 7.14 – 7.22 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, CDCl3) δ 11.3 (d, *J* = 6.6 Hz), 16.4, 17.8, 25.9 (d, *J* = 5.2 Hz), 32.7 (d, *J* = 5.5 Hz), 35.6 (d, *J* = 8.2 Hz), 55.5, 63.9 (d, *J* = 3.3 Hz), 65.2 (d, *J* = 6.8 Hz), 71.4 (dd, *J* = 7.1, 3.0 Hz), 114.4, 128.7, 129.2 (d, *J* = 4.4 Hz), 130.2, 134.9, 157.8; ^{31}P NMR (202 MHz, CDCl3) δ 0.69 (d, *J* = 18.5 Hz); IR 2253, 1509, 1464, 1247, 1018, 904, 728 cm^{-1}. HRMS (ESI-TOF) m/z: [M + Na]$^{+}$ Calcd for $C_{18}H_{28}NO_4PNa^{+}$ 376.1654; Found 376.1650.



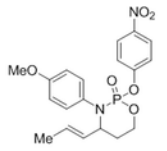
(*E*)-2-(4-chloro-3-(trifluoromethyl)phenoxy)-3-(4-methoxyphenyl)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 56:

Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 63.7 mg, Yield = 69%, Dr = 1.1:1.

Data for major diastereomer: Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.5 (dd, *J* = 6.5, 1.6 Hz, 3H), 2.0 – 2.3 (m, 2H), 3.8 (s, 3H), 4.3 (tt, *J* = 8.3, 3.6 Hz, 1H), 4.4 – 4.6 (m, 2H), 5.2 (ddq, *J* = 15.2, 8.3, 1.6 Hz, 1H), 5.5 (dtd, *J* = 15.0, 6.8, 6.1 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.2 (ddd, *J* = 10.6, 8.9, 2.3 Hz, 3H), 7.3 – 7.4 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.5, 33.3 (d, *J* = 4.6 Hz), 55.4, 63.1 (d, *J* = 2.3 Hz), 67.3 (d, *J* = 7.4 Hz), 114.2 (d, *J* = 1.6 Hz), 119.5 – 119.8 (m), 120.9, 123.6, 124.6 (d, *J* = 4.2 Hz), 127.4, 129.1, 129.4, 130.0 (dd, *J* = 7.2, 2.7 Hz), 131.7, 132.5, 150.1 (d, *J* = 8.3 Hz), 158.3 (d, *J* = 1.8 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.9 – −4.6 (m); ^{19}F NMR (471 MHz, $CDCl_3$) δ −63.0; IR 2920, 1508, 1253, 1034, 988, 809 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{20}ClF_3NNaO_4P^+$ 484.0663; Found 484.0681.

Data for minor diastereomer: Beige solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.7 (dd, *J* = 6.5, 1.6 Hz, 3H), 1.9 – 2.1 (m, 1H), 2.4 – 2.6 (m, 1H), 3.8 (s, 3H), 4.0 – 4.2 (m, 1H), 4.5 (dddd, *J* = 16.6, 11.2, 5.4, 3.8 Hz, 1H), 4.6 (dddd, *J* = 11.0, 9.8, 8.2, 2.7 Hz, 1H), 5.3 – 5.5 (m, 1H), 5.6 – 5.8 (m, 1H), 6.8 – 6.9 (m, 2H), 7.1 – 7.2 (m, 2H), 7.3 – 7.5 (m, 2H), 7.48 – 7.51 (m, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.7, 32.3 (d, *J* = 6.2 Hz), 55.4, 64.4 (d, *J* = 3.1 Hz), 66.4 (d, *J* = 7.5 Hz), 114.5, 119.5 – 120.5 (m), 120.9, 123.6, 124.9 (d, *J* = 4.3 Hz), 127.6, 129.2, 129.5 (d, *J* = 3.6 Hz), 129.7, 132.6, 133.6 (d, *J* = 3.2 Hz), 149.9 (d, *J* = 7.7 Hz), 158.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.8 (td, *J* = 17.2, 8.2 Hz); ^{19}F NMR (471 MHz, $CDCl_3$) δ −62.9; IR 2920, 1509, 1285, 937, 811 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{20}ClF_3NNaO_4P^+$ 484.0663; Found 484.0698.



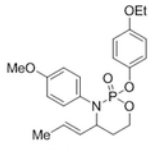
(*E*)-3-(4-methoxyphenyl)-2-(4-nitrophenoxy)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 57: Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 56.6 mg, Yield = 70%, Dr = 1:1.1.

Data for major diastereomer: Beige solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.5 (dd, *J* = 6.5, 1.6 Hz, 3H), 2.0 – 2.3 (m, 2H), 3.8 (s, 3H), 4.3 (tt, *J* = 8.4, 3.5 Hz, 1H), 4.4 – 4.6 (m, 2H), 5.2 (ddq, *J* = 15.2, 8.2, 1.6 Hz, 1H), 5.4 – 5.6 (m, 1H), 6.7 – 6.9 (m, 2H), 7.1 – 7.3 (m, 4H), 8.0 – 8.2 (m, 2H) ; ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.5, 33.3 (d, *J* = 4.7 Hz), 55.4, 63.1 (d, *J* = 2.3 Hz), 67.4 (d, *J* = 7.5 Hz), 114.2 (d, *J* = 1.5 Hz), 120.5 (d, *J* = 5.2 Hz), 125.4,

129.79 (d, *J* = 7.7 Hz), 129.86, 129.99, 130.0, 130.0, 131.5, 144.1, 156.6 (d, *J* = 8.2 Hz), 158.3 (d, *J* = 1.8 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.3 – −5.0 (m); IR 2855, 1509, 1344, 1220, 913, 742 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{19}H_{22}N_2O_6P^+$ 405.1216; Found 405.1230.

Data for minor diastereomer: light yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.7 (dd, *J* = 6.5, 1.7 Hz, 3H), 1.9 – 2.1 (m, 1H), 2.4 – 2.6 (m, 1H), 3.8 (s, 3H), 4.1 (ddd, *J* = 18.0, 8.5, 4.9 Hz, 1H), 4.5 (dddd, *J* = 16.7, 11.1, 5.3, 3.8 Hz, 1H), 4.5 – 4.7 (m, 1H), 5.4 – 5.5 (m, 1H), 5.7 (ddq, *J* = 15.2, 8.4, 1.6 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.1 – 7.2 (m, 2H), 7.3 – 7.4 (m, 2H), 8.1 – 8.3 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.0, 31.5 (d, *J* = 6.0 Hz), 54.7, 63.8 (d, *J* = 2.8 Hz), 65.8 (d, *J* = 7.6 Hz), 113.8, 120.0 (d, *J* = 5.4 Hz), 124.8, 128.3, 128.8 (d, *J* = 3.5 Hz), 129.0, 132.8 (d, *J* = 3.2 Hz), 143.5, 155.7 (d, *J* = 7.4 Hz), 157.7; ^{31}P NMR (202 MHz, $CDCl_3$) δ −5.3 (td, *J* = 17.5, 8.0 Hz); IR 2931, 1509, 1218, 905, 741 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{19}H_{21}N_2O_6PNa^+$ 427.1035; Found 427.1037.

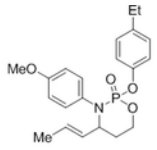


(*E*)-2-(4-ethoxyphenoxy)-3-(4-methoxyphenyl)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 58: Synthesized using General Procedure C; Purified using 25–40% ethyl acetate in hexane; 27.4 mg, Yield = 34%, Dr = 1.4:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.4 (t, *J* = 7.0 Hz, 3H), 1.5 (dd, *J* = 6.5, 1.6 Hz, 3H), 2.0 – 2.1 (m, 1H), 2.1 – 2.2 (m, 1H), 3.8 (s, 3H), 4.0 (q, *J* = 7.0 Hz, 2H), 4.2 – 4.4 (m, 1H), 4.4 – 4.5 (m, 2H), 5.2 (ddd, *J* = 15.3, 8.2, 1.7 Hz, 1H), 5.4 – 5.5 (m, 1H), 6.7 – 6.9 (m, 4H), 7.0 – 7.1 (m, 2H), 7.2 – 7.2 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 14.8, 17.5, 33.4 (d, *J* = 4.5 Hz), 55.4, 62.9 (d, *J* = 2.0 Hz), 63.9, 66.8 (d, *J* = 7.3 Hz), 114.0 (d, *J* = 1.5 Hz), 115.2, 120.9 (d, *J* = 4.6 Hz), 129.4 (d, *J* = 1.6 Hz), 129.9 (d, *J* = 3.5 Hz), 130.4 (d, *J* = 7.4 Hz), 132.6, 144.9 (d, *J* = 8.8 Hz), 155.6, 157.9; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.2 (d, *J* = 20.3 Hz); IR 2922, 1502, 1197, 915, 823 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{27}NO_5P^+$ 404.1627; Found 404.1617.

Data for minor diastereomer: Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.4 (t, *J* = 7.0 Hz, 3H), 1.6 (dd, *J* = 6.3, 1.7 Hz, 3H), 1.9 – 2.1 (m, 1H), 2.4 – 2.5 (m, 1H), 3.8 (s, 3H), 4.0 (q, *J* = 7.0 Hz, 2H), 4.0 – 4.2 (m, 1H), 4.4 (dddd, *J* = 16.6, 11.1, 5.5, 3.8 Hz, 1H), 4.6 (dddd, *J* = 11.0, 9.6, 8.2, 2.7 Hz, 1H), 5.4 (dqd, *J* = 15.3, 6.5, 0.9 Hz, 1H), 5.7 (ddq, *J* = 15.1, 8.3, 1.6 Hz, 1H), 6.7 – 6.9 (m, 4H), 7.0 – 7.2 (m, 4H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 15.1, 18.0, 32.7 (d, *J* = 6.1 Hz), 55.7, 64.2, 64.6 (d, *J* = 2.9 Hz), 66.2 (d, *J* = 7.2 Hz), 114.6, 115.5, 121.5 (d, *J* = 4.8 Hz), 129.3, 129.6 (d, *J* = 3.6 Hz), 130.0, 134.7, 145.2 (d, *J* = 8.2 Hz), 156.1, 158.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.4 (td, *J* = 16.5, 7.8 Hz); IR 2986, 1504, 1275, 1199, 912, 764 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{27}NO_5P^+$ 404.1627; Found 404.1614.

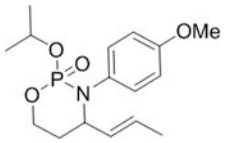


(*E*)-2-(4-ethylphenoxy)-3-(4-methoxyphenyl)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 59: Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 42.6 mg, Yield = 55%, Dr = 1.4:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.2 (t, *J* = 7.6 Hz, 3H), 1.5 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.0 – 2.1 (m, 1H), 2.1 – 2.2 (m, 1H), 2.6 (q, *J* = 7.6 Hz, 2H), 3.8 (s, 3H), 4.3 (tt, *J* = 8.2, 3.5 Hz, 1H), 4.4 – 4.5 (m, 2H), 5.1 – 5.3 (m, 1H), 5.4 – 5.6 (m, 1H), 6.7 – 6.9 (m, 2H), 7.0 – 7.0 (m, 2H), 7.0 – 7.1 (m, 2H), 7.1 – 7.3 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 15.7, 17.5, 28.2, 33.5 (d, *J* = 4.4 Hz), 55.4, 62.9 (d, *J* = 2.0 Hz), 66.9 (d, *J* = 7.3 Hz), 114.0 (d, *J* = 1.4 Hz), 119.9 (d, *J* = 4.8 Hz), 128.8, 129.4 (d, *J* = 1.6 Hz), 129.9 (d, *J* = 3.5 Hz), 130.4 (d, *J* = 7.7 Hz), 132.6, 140.4, 149.3 (d, *J* = 8.8 Hz), 158.0 (d, *J* = 1.7 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.4 (d, *J* = 20.7 Hz); IR 2964, 1507, 1277, 916, 750 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{26}NO_4PNa^+$ 410.1497; Found 410.1498.

Data for minor diastereomer: Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.2 (t, *J* = 7.6 Hz, 3H), 1.6 (dd, *J* = 6.4, 1.7 Hz, 3H), 1.9 – 2.0 (m, 1H), 2.4 – 2.5 (m, 1H), 2.6 (q, *J* = 7.6 Hz, 2H), 3.8 (s, 3H), 4.1 (ddd, *J* = 17.7, 9.2, 4.8 Hz, 1H), 4.4 (dddd, *J* = 16.6, 11.1, 5.3, 3.8 Hz, 1H), 4.5 – 4.6 (m, 1H), 5.3 – 5.5 (m, 1H), 5.7 – 5.8 (m, 1H), 6.8 – 6.9 (m, 2H), 7.1 (s, 4H), 7.2 – 7.2 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 16.0, 18.0, 28.5, 32.7 (d, *J* = 5.9 Hz), 55.7, 64.6 (d, *J* = 2.7 Hz), 66.1 (d, *J* = 7.4 Hz), 114.6, 120.4 (d, *J* = 4.9 Hz), 129.1, 129.3, 129.6 (d, *J* = 3.7 Hz), 129.9, 134.7, 140.8, 149.5 (d, *J* = 8.0 Hz), 158.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.7 (td, *J* = 17.1, 7.9 Hz); IR 2963, 1505, 1279, 1011, 910, 750 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{26}NO_4PNa^+$ 410.1497; Found 410.1498.



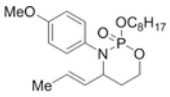
(*E*)-2-isopropoxy-3-(4-methoxyphenyl)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 60: Synthesized using General Procedure C; Purified using 30–40% ethyl acetate in hexane; 39.7 mg, Yield = 61%, Dr = 3:1.

Data for major diastereomer: Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.12 (d, *J* = 6.2 Hz, 3H), 1.27 (d, *J* = 6.2 Hz, 3H), 1.49 (dd, *J* = 6.5, 1.6 Hz, 3H), 1.95 – 2.13 (m, 2H), 3.76 (s, 3H), 4.14 (tt, *J* = 8.4, 3.9 Hz, 1H), 4.32 (ddd, *J* = 15.8, 7.9, 3.9 Hz, 2H), 4.54 (ddd, *J* = 12.2, 6.1, 1.3 Hz, 1H), 5.19 (ddt, *J* = 15.3, 8.2, 1.5 Hz, 1H), 5.41 (dq, *J* = 15.3, 6.5 Hz, 1H), 6.76 – 6.80 (m, 2H), 7.13 – 7.20 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, CDCl3) δ 17.6, 23.8 (d, *J* = 5.2 Hz), 33.6 (d, *J* = 3.8 Hz), 55.5, 62.9, 66.1 (d, *J* = 7.1 Hz), 71.6 (d, *J* = 6.9 Hz), 113.9, 128.9, 129.8 (d, *J* = 3.6 Hz), 131.0 (d, *J* = 7 Hz), 133.4, 157.8; ^{31}P NMR (202 MHz, CDCl3)

δ −0.37; IR 3454, 2976, 1607, 1508, 1234, 984, 817, 571 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{24}NO_4PNa^+$ 348.1341; Found 348.1352.

Data for minor diastereomer: Brown oil; ^1H NMR (400 MHz, $CDCl_3$) δ 1.28 (d, *J* = 6.2 Hz, 3H), 1.34 (d, *J* = 6.2 Hz, 3H), 1.62 (dd, *J* = 6.5, 1.7 Hz, 3H), 1.89 (dq, *J* = 15.3, 4.1, 3.3 Hz, 1H), 2.39 (ddt, *J* = 14.1, 9.4, 4.7 Hz, 1H), 3.77 (s, 3H), 4.04 (ddt, *J* = 13.9, 8.9, 5.1 Hz, 1H), 4.28 – 4.49 (m, 2H), 4.64 (dhept, *J* = 7.7, 6.2 Hz, 1H), 5.38 (dq, *J* = 15.3, 6.4 Hz, 1H), 5.61 – 5.69 (m, 1H), 6.77 – 6.85 (m, 2H), 7.16 – 7.22 (m, 2H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 17.8, 24.1 (t, *J* = 5.1 Hz), 32.9 (d, *J* = 5.2 Hz), 55.5, 64.0, 65.1 (d, *J* = 6.9 Hz), 71.7 (d, *J* = 6.6 Hz), 114.3, 128.6, 129.3 (d, *J* = 3.6 Hz), 130.3, 135.0, 157.9; ^{31}P NMR (202 MHz, $CDCl_3$) δ 0.02 (t, *J* = 13.4 Hz). IR 3433, 2976, 1668, 1508, 1243, 977, 811, 564 cm^{-1}. HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{16}H_{24}NO_4PNa^+$ 348.1341; Found 348.1334.

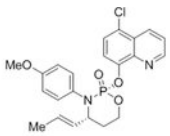


(*E*)-3-(4-methoxyphenyl)-2-(octyloxy)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 61: Synthesized using General Procedure C; Purified using 25–30% ethyl acetate in hexane; 43.5 mg, Yield = 55%, Dr = 2.4:1.

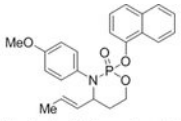
Data for major diastereomer: Brown oil; ^1H NMR (500 MHz, $CDCl_3$) δ 0.87 (t, *J* = 7.0 Hz, 3H), 1.19 – 1.34 (m, 10H), 1.50 (dt, *J* = 6.6, 1.1 Hz, 3H), 1.56 (h, *J* = 6.6 Hz, 2H), 1.99 – 2.15 (m, 2H), 3.77 (s, 3H), 3.92 (q, *J* = 6.9 Hz, 2H), 4.15 (tt, *J* = 8.6, 4.3 Hz, 1H), 4.27 – 4.43 (m, 2H), 5.20 (ddt, *J* = 15.3, 8.2, 1.5 Hz, 1H), 5.42 (dq, *J* = 15.5, 6.4 Hz, 1H), 6.74 – 6.85 (m, 2H), 7.12 – 7.19 (m, 2H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 14.2, 17.6, 22.8, 25.6, 29.2, 29.3, 30.4 (d, *J* = 6.5 Hz), 31.8, 33.4 (d, *J* = 4.5 Hz), 55.5, 63.3 (d, *J* = 2.7 Hz), 66.6 (d, *J* = 6.6 Hz), 67.9, 114.2, 129.6, 130.1 (d, *J* = 3.6 Hz), 130.4 (d, *J* = 6.5 Hz), 132.4, 158.3; IR 2924, 1771, 1509, 1236, 1159, 1031, 829 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{36}NO_4P^+$ 396.2304; Found 396.2322.

Data for minor diastereomer: Brown oil; ^1H NMR (500 MHz, $CDCl_3$) δ 0.88 (t, *J* = 6.9 Hz, 3H), 1.24 – 1.33 (m, 8H), 1.39 (ddt, *J* = 15.0, 11.2, 4.2 Hz, 2H), 1.63 (dd, *J* = 6.5, 1.6 Hz, 3H), 1.64 – 1.71 (m, 2H), 1.89 (dtd, *J* = 14.3, 5.2, 3.0 Hz, 1H), 2.39 (ddt, *J* = 14.3, 9.5, 4.6 Hz, 1H), 3.77 (s, 3H), 3.95 – 4.12 (m, 3H), 4.28 – 4.49 (m, 2H), 5.39 (dq, *J* = 15.4, 6.5 Hz, 1H), 5.59 – 5.71 (m, 1H), 6.78 – 6.84 (m, 2H), 7.16 – 7.21 (m, 2H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 14.2, 17.8, 22.8, 25.9, 29.3, 29.4, 30.6 (d, *J* = 7.0 Hz), 31.9, 32.8 (d, *J* = 5.4 Hz), 55.5, 64.0, 65.3 (d, *J* = 6.7 Hz), 67.1 (d, *J* = 6.7 Hz), 114.4, 128.7, 129.2 (d, *J* = 3.6 Hz), 130.3, 134.9, 157.9; IR 2924, 1581, 1509, 1272, 1244, 1011, 811 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{34}NO_4PNa^+$ 418.2123; Found 418.2112.



2-({5-chloroquinolin-8-yl}oxy)-3-(4-methoxyphenyl)-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 62: Synthesized using General Procedure C; Purified using 33% ethyl acetate in hexane; 66.7 mg, 75% (in case of trans substrate) and 51mg, 57% (in case of cis substrate); single diastereomer; Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.7 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.1 – 2.2 (m, 1H), 2.5 – 2.6 (m, 1H), 3.8 (s, 3H), 4.1 (ddt, *J* = 18.9, 9.3, 4.8 Hz, 1H), 4.3 (ddt, *J* = 19.6, 11.1, 4.2 Hz, 1H), 5.0 (tdd, *J* = 10.9, 5.7, 2.3 Hz, 1H), 5.4 – 5.5 (m, 1H), 6.4 – 6.5 (m, 1H), 6.8 – 6.9 (m, 2H), 7.3 – 7.3 (m, 2H), 7.5 – 7.6 (m, 2H), 7.8 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.7 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.7, 32.7 (d, *J* = 5.7 Hz), 55.4, 65.4 (d, *J* = 2.5 Hz), 66.6 (d, *J* = 7.3 Hz), 114.3, 119.7 (d, *J* = 3.0 Hz), 122.3, 126.5 (d, *J* = 1.7 Hz), 126.6, 127.3, 128.9, 129.8 (d, *J* = 3.7 Hz), 130.4, 133.0, 134.5 (d, *J* = 3.0 Hz), 141.8 (d, *J* = 6.5 Hz), 146.8 (d, *J* = 8.4 Hz), 150.4, 158.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.0 (td, *J* = 19.6, 5.7 Hz); IR 2915, 1509, 1279, 1034, 851 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{22}H_{22}ClN_2NaO_4P^+$ 467.0898; Found 467.0908.

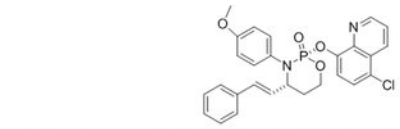


(*E*)-3-(4-methoxyphenyl)-2-(naphthalen-1-yloxy)-4-(prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 65: Synthesized using General Procedure C; Purified using 30% ethyl acetate in hexane; 38.5mg, Yield = 47%, Dr = 1:1.1.

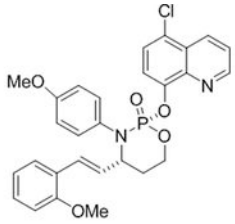
Data for major diastereomer: Beige solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.5 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.1 (dtdd, *J* = 14.6, 4.3, 2.9, 1.3 Hz, 1H), 2.2 – 2.3 (m, 1H), 3.8 (s, 3H), 4.4 – 4.6 (m, 3H), 5.2 (ddq, *J* = 15.2, 8.2, 1.6 Hz, 1H), 5.5 (dqd, *J* = 15.3, 6.5, 0.7 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.3 – 7.4 (m, 3H), 7.4 (dt, *J* = 7.7, 1.3 Hz, 1H), 7.4 – 7.5 (m, 2H), 7.6 (dd, *J* = 8.1, 1.2 Hz, 1H), 7.8 – 7.9 (m, 1H), 7.9 – 8.1 (m, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.5, 33.6 (d, *J* = 4.3 Hz), 55.4, 63.0 (d, *J* = 2.1 Hz), 67.1 (d, *J* = 7.4 Hz), 114.1 (d, *J* = 1.6 Hz), 114.7 (d, *J* = 3.0 Hz), 121.3, 124.1, 125.8, 126.2 (d, *J* = 27.8 Hz), 126.5, 126.5, 127.8, 129.6 (d, *J* = 1.6 Hz), 130.0 (d, *J* = 3.3 Hz), 130.4 (d, *J* = 7.5 Hz), 132.4, 134.7, 147.2 (d, *J* = 9.0 Hz), 158.1 (d, *J* = 1.8 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.7 (d, *J* = 21.0 Hz); IR 2917, 1508, 1228, 1041, 915, 773 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{25}NO_4P^+$ 410.1521; Found 410.1527.

Data for minor diastereomer: Light brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.7 (ddd, *J* = 6.5, 1.7, 0.6 Hz, 3H), 1.9 – 2.2 (m, 1H), 2.5 – 2.7 (m, 1H), 3.8 (s, 3H), 4.1 – 4.3 (m, 1H), 4.4 – 4.6 (m, 1H), 4.6 (dddd, *J* = 12.6, 10.3, 7.7, 2.5 Hz, 1H), 5.5 (dqd, *J* = 15.3, 6.5, 1.0 Hz, 1H), 5.8 (ddq, *J* = 15.3, 8.1, 1.6 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.2 – 7.3 (m, 2H), 7.4 (t, *J* = 8.0 Hz, 1H), 7.5 – 7.6 (m, 3H), 7.6 – 7.7 (m, 1H), 7.8 – 7.9 (m, 1H), 8.1 – 8.3 (m, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.7, 32.2 (d, *J* = 5.7 Hz), 55.4, 64.2 (d, *J* = 2.8 Hz), 66.1 (d, *J* = 7.4 Hz), 114.4, 114.6 (d, *J* = 3.0 Hz), 121.7, 124.0, 125.8, 126.0, 126.3, 127.9, 129.1, 129.5 (d, *J* = 3.7 Hz), 129.7, 134.4, 134.8, 147.3, 147.4, 158.1; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.8 (td, *J* = 17.5, 7.6 Hz); IR 2917, 1507, 1225, 1011, 909, 770 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{23}H_{24}NO_4PNa^+$ 432.1341; Found 432.1329.



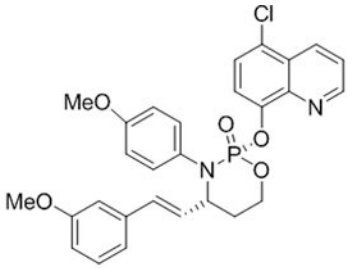
2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-styryl)-1,3,2-oxazaphosphinane 2-oxide

Compound 66: Synthesized using General Procedure C; Purified using 28% ethyl acetate in hexane; 81.1 mg, Yield = 80%, Dr > 20:1;Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.12 (ddt, *J* = 14.1, 3.6, 1.8 Hz, 1H), 2.57 – 2.80 (m, 1H), 3.71 – 3.74 (m, 1H), 3.75 (s, 3H), 4.19 – 4.40 (m, 2H), 5.05 (tdd, *J* = 11.4, 4.5, 2.1 Hz, 1H), 6.34 (d, *J* = 15.8 Hz, 1H), 6.72 – 6.94 (m, 2H), 7.27 – 7.32 (m, 2H), 7.33 – 7.39 (m, 2H), 7.48 – 7.51 (m, 2H), 7.53 – 7.59 (m, 2H), 7.59 – 7.65 (m, 1H), 7.92 (dd, *J* = 8.4, 1.5 Hz, 1H), 8.62 (dd, *J* = 8.6, 1.7 Hz, 1H), 9.07 (dd, *J* = 4.1, 1.7 Hz, 1H). ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.1 (d, *J* = 5.1 Hz), 55.5, 65.8 (d, *J* = 2.2 Hz), 66.7 (d, *J* = 7.3 Hz), 114.6, 119.6 (d, *J* = 2.9 Hz), 122.6, 126.7, 126.7, 127.6, 127.9, 128.7, 129.2, 129.9 (d, *J* = 3.7 Hz), 132.7, 133.3, 134.5 (d, *J* = 2.7 Hz), 136.9, 141.9 (d, *J* = 6.7 Hz), 146.9, 146.9, 150.6, 158.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.15 (t, *J* = 20.4 Hz). IR 2927, 2835, 1589, 1508, 1218, 1064, 1011, 807 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}ClN_2O_4PNa^+$ 529.1060; Found 529.1060.



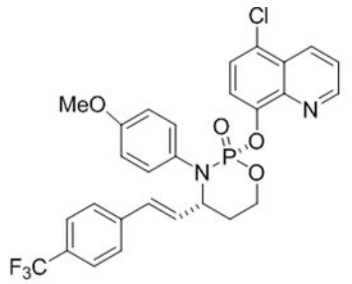
2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-2-methoxystyryl)-1,3,2-oxazaphosphinane 2-oxide

Compound 67: Synthesized using General Procedure C; Purified using 30% ethyl acetate in hexane; 65.5 mg, Yield = 61%, Dr > 20:1;Yellow Powder; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.06 (dtt, *J* = 14.0, 3.4, 1.6 Hz, 1H), 2.53 – 2.63 (m, 1H), 3.66 (d, *J* = 3.2 Hz, 6H), 4.16 – 4.29 (m, 2H), 4.95 (tdd, *J* = 11.4, 4.8, 2.1 Hz, 1H), 6.59 (d, *J* = 15.9 Hz, 1H), 6.70 – 6.76 (m, 3H), 6.80 (td, *J* = 7.6, 1.1 Hz, 1H), 7.09 – 7.19 (m, 1H), 7.22 – 7.31 (m, 2H), 7.40 (dd, *J* = 15.9, 9.3 Hz, 1H), 7.47 (d, *J* = 8.4 Hz, 1H), 7.49 – 7.52 (m, 1H), 7.66 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.80 (dd, *J* = 8.5, 1.5 Hz, 1H), 8.51 (dd, *J* = 8.6, 1.7 Hz, 1H), 8.94 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.2 (d, *J* = 5.2 Hz), 55.5 (d, *J* = 3.0 Hz), 66.1, 66.7, 66.8, 111.0, 114.6, 120.8, 122.5, 125.9, 126.7, 126.8, 126.9, 127.1, 127.5, 128.9, 129.3, 129.9 (d, *J* = 3.7 Hz), 133.4, 134.6 (d, *J* = 2.6 Hz), 141.9, 146.8, 146.9, 150.6, 156.7, 158.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.03 (t, *J* = 20.4 Hz). IR 2253, 1509, 1384, 1195, 1163, 905, 729 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{26}ClN_2O_5PNa^+$ 559.1166; Found 559.1174.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-3-methoxystyryl)-1,3,2-oxazaphosphinane 2-oxide

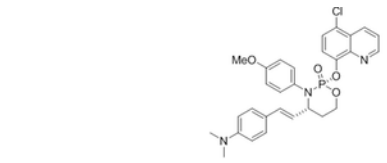
Compound 68: Synthesized using General Procedure C; Purified using 30% ethyl acetate in hexane; 69.8 mg, Yield = 65%, Dr > 20:1;Yellow solid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.04 (ddq, *J* = 14.4, 3.9, 2.1 Hz, 1H), 2.56 – 2.66 (m, 1H), 3.67 (dd, *J* = 3.9, 1.2 Hz, 6H), 4.21 (dddd, *J* = 24.9, 13.6, 8.4, 4.0 Hz, 2H), 4.98 (ddt, *J* = 13.2, 11.4, 2.3 Hz, 1H), 6.23 (d, *J* = 15.7 Hz, 1H), 6.67 – 6.78 (m, 3H), 6.95 – 6.99 (m, 2H), 7.12 – 7.20 (m, 1H), 7.25 – 7.30 (m, 2H), 7.48 – 7.56 (m, 3H), 7.83 (dd, *J* = 8.4, 1.5 Hz, 1H), 8.54 (dt, *J* = 8.7, 1.4 Hz, 1H), 9.03 (dd, *J* = 4.1, 1.5 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 33.0 (d, *J* = 5.2 Hz), 55.4, 55.5, 65.8, 66.7 (d, *J* = 7.3 Hz), 112.8, 113.0, 114.6, 119.5, 119.7 (d, *J* = 2.8 Hz), 122.5, 126.8, 127.5, 129.6, 129.6, 129.9 (d, *J* = 4.0 Hz), 132.6, 133.4, 134.5, 138.3, 141.8, 146.8, 146.9, 150.8, 158.5, 159.9; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.12 (t, *J* = 20.5 Hz). IR 2961, 2238, 1509, 1274, 1062, 1019, 860, 778 cm^{-1}. HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{28}H_{27}ClN_2O_5P^+$ 537.1346; Found 537.1343.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-4-(trifluoromethyl)styryl)-1,3,2-oxazaphosphinane 2-oxide

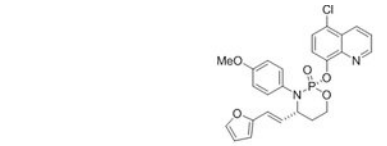
Compound 69: Synthesized using General Procedure C; Purified using 32% ethyl acetate in hexane; 56.3 mg, Yield = 49%, Dr > 20:1;Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.12 (ddt, *J* = 13.9, 3.8, 1.9 Hz, 1H), 2.65 – 2.79 (m, 1H), 3.75 (s, 3H), 4.31 (ddt, *J* = 21.1, 11.1, 3.8 Hz, 2H), 5.05 (tdd, *J* = 11.6, 4.4, 2.1 Hz, 1H), 6.38 (d, *J* = 15.9 Hz, 1H), 6.80 – 6.86 (m, 2H), 7.30 – 7.39 (m, 2H), 7.54 (d, *J* = 8.2 Hz, 2H), 7.60 (d, *J* = 4.6 Hz, 2H), 7.63 (d, *J* = 3.3 Hz, 1H), 7.64 – 7.67 (m, 1H), 7.74 (dd, *J* = 15.8, 9.3 Hz, 1H), 7.94 (dd, *J* = 8.4, 1.5 Hz, 1H), 8.65 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.04 (dd, *J* = 4.1, 1.6 Hz, 1H). ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 32.8 (d, *J* = 5.1 Hz), 55.5, 65.6, 66.6 (d, *J* = 7.4 Hz), 114.7, 119.8 (d, *J* = 2.9 Hz), 122.7, 122.9, 125.6 (q, *J* = 4.1 Hz), 126.9, 127.0, 127.6, 129.8, 128.9, 129.5, 129.8 (d, *J* = 3.7 Hz), 131.4, 131.9, 133.7, 134.3 (d, *J* = 2.9 Hz), 140.4, 146.7 (d, *J* = 8.6 Hz), 150.5, 158.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.25 (t, *J* = 20.9 Hz). ^{19}F NMR (471 MHz, $CDCl_3$)

δ −62.48. IR 2933, 1590, 1509, 1322, 1064, 852, 733 cm^{-1}. HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{28}H_{23}ClF_3N_2O_4PNa^+$ 597.0934; Found 597.0939.



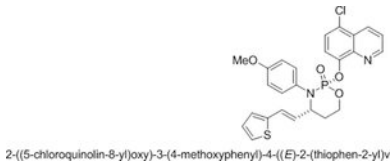
2-((5-chloroquinolin-8-yl)oxy)-4-((*E*)-4-(dimethylamino)styryl)-3-(4-methoxyphenyl)-1,3,2-oxazaphosphinane 2-oxide

Compound 70: Synthesized using General Procedure C; Purified using 50% ethyl acetate in hexane; 58.3 mg, Yield = 53%, dr > 20:1; Brown oil; ^1H NMR (400 MHz, $CDCl_3$) δ 2.0 (ddt, *J* = 13.9, 4.2, 2.3 Hz, 1H), 2.5 – 2.6 (m, 1H), 2.9 (s, 6H), 3.6 (s, 3H), 4.0 – 4.3 (m, 2H), 5.0 (tdd, *J* = 11.4, 4.8, 2.0 Hz, 1H), 6.1 (d, *J* = 15.7 Hz, 1H), 6.5 – 6.6 (m, 2H), 6.7 – 6.8 (m, 2H), 7.1 – 7.2 (m, 2H), 7.2 – 7.3 (m, 3H), 7.5 (d, *J* = 8.4 Hz, 1H), 7.5 (dd, *J* = 8.6, 4.1 Hz, 1H), 7.8 (dd, *J* = 8.4, 1.5 Hz, 1H), 8.5 (dd, *J* = 8.6, 1.7 Hz, 1H), 9.0 (dd, *J* = 4.2, 1.7 Hz, 1H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 33.3 (d, *J* = 5.0 Hz), 40.5, 55.4, 66.1 (d, *J* = 2.2 Hz), 66.7 (d, *J* = 7.3 Hz), 112.4, 114.4, 119.6 (d, *J* = 3.0 Hz), 122.4, 124.6, 125.2, 126.6, 126.6 (d, *J* = 1.3 Hz), 127.4, 127.7, 129.9 (d, *J* = 3.7 Hz), 132.5, 133.1, 134.5 (d, *J* = 2.6 Hz), 141.8 (d, *J* = 6.6 Hz), 146.9 (d, *J* = 8.5 Hz), 150.2, 150.6, 158.3.; ^{31}P NMR (202 MHz, $CDCl_3$) δ −3.9 (t, *J* = 20.3 Hz); IR 2923, 1607, 1508, 1218, 1010, 807, 776 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{29}H_{29}ClN_3NaO_4P^+$ 572.1482 Found 572.1456.



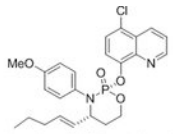
2-((5-chloroquinolin-8-yl)oxy)-4-((*E*)-2-(furan-3-yl)vinyl)-3-(4-methoxyphenyl)-1,3,2-oxazaphosphinane 2-oxide

Compound 71: Synthesized using General Procedure C; Purified using 40% ethyl acetate in hexane; 53.7 mg, Yield = 54%, single diastereomer. Colorless solid; ^1H NMR (400 MHz, $CDCl_3$) δ 2.1 – 2.3 (m, 1H), 2.6 (ddt, *J* = 15.2, 10.3, 4.6 Hz, 1H), 3.8 (s, 3H), 4.3 (dddd, *J* = 29.2, 18.9, 10.2, 4.3 Hz, 2H), 5.0 (dddd, *J* = 13.7, 10.4, 5.5, 2.3 Hz, 1H), 6.1 – 6.3 (m, 2H), 6.3 (dd, *J* = 3.3, 1.9 Hz, 1H), 6.7 – 6.9 (m, 2H), 7.2 (dd, *J* = 15.8, 9.1 Hz, 1H), 7.3 – 7.4 (m, 3H), 7.5 (d, *J* = 8.4 Hz, 1H), 7.6 (dd, *J* = 8.6, 4.2 Hz, 1H), 7.8 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.1 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C {^1H} NMR (101 MHz, $CDCl_3$) δ 32.7 (d, *J* = 5.5 Hz), 55.4, 65.4 (d, *J* = 2.6 Hz), 66.6 (d, *J* = 7.2 Hz), 108.3, 111.4, 114.5, 119.6 (d, *J* = 3.0 Hz), 121.1, 122.4, 126.6 (d, *J* = 1.6 Hz), 126.7, 127.3, 127.5, 129.7 (d, *J* = 3.6 Hz), 133.2, 134.3 (d, *J* = 2.9 Hz), 141.6, 142.1, 146.6 (d, *J* = 8.4 Hz), 150.6, 152.3, 158.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.4 (td, *J* = 19.5, 5.1 Hz); IR 2950, 1508, 1560, 1237, 1063, 857, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{25}H_{22}ClN_2KO_5P^+$ 535.0592; Found 535.0612.



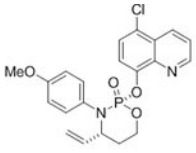
2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-2-(thiophen-2-yl)vinyl)-1,3,2-oxazaphosphinane 2-oxide

Compound 72: Synthesized using General Procedure C; Purified using 40% ethyl acetate in hexane; 65.6 mg, Yield = 64%, Dr >20:1; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.1 – 2.2 (m, 1H), 2.7 (ddt, *J* = 15.9, 10.0, 4.6 Hz, 1H), 3.8 (s, 3H), 4.3 (dddd, *J* = 29.6, 19.0, 8.5, 4.3 Hz, 2H), 5.1 (tdd, *J* = 11.3, 5.1, 2.1 Hz, 1H), 6.5 (d, *J* = 15.6 Hz, 1H), 6.8 – 6.9 (m, 2H), 6.9 – 7.0 (m, 2H), 7.1 – 7.2 (m, 1H), 7.3 (dd, *J* = 15.6, 9.2 Hz, 1H), 7.3 – 7.4 (m, 2H), 7.6 (d, *J* = 8.4 Hz, 1H), 7.6 (dd, *J* = 8.6, 4.2 Hz, 1H), 7.9 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.1 (dd, *J* = 4.2, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 32.7 (d, *J* = 5.3 Hz), 55.4, 65.7 (d, *J* = 2.6 Hz), 66.6 (d, *J* = 7.3 Hz), 114.5, 119.6 (d, *J* = 2.9 Hz), 122.5, 124.7, 125.9, 126.1, 126.6 (d, *J* = 1.6 Hz), 126.7 (d, *J* = 1.4 Hz), 127.4, 127.4, 128.3, 129.8 (d, *J* = 3.6 Hz), 133.1, 134.3 (d, *J* = 2.7 Hz), 141.7, 141.8, 146.7 (d, *J* = 8.4 Hz), 150.8, 158.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.2 (td, *J* = 20.6, 4.9 Hz); IR 2989, 1590, 1508, 1267, 1010, 905, 854, 732 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{25}H_{22}ClN_2NaSO_4P^+$ 535.0624; Found 535.0605.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-((*E*)-pent-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

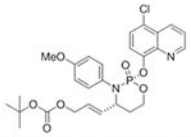
Compound 74 and 76: Synthesized using General Procedure C; Purified using 35% ethyl acetate in hexane; 62.4 mg, Yield = 66% (in case of trans substrate) and 44% (in case of cis substrate), single diastereomer, Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.8 (t, *J* = 7.4 Hz, 3H), 1.3 (h, *J* = 7.3 Hz, 2H), 1.8 – 2.1 (m, 2H), 2.2 (dtdd, *J* = 13.1, 3.9, 2.7, 1.6 Hz, 1H), 2.4 – 2.6 (m, 1H), 3.8 (s, 3H), 4.1 (ddt, *J* = 18.6, 9.5, 5.0 Hz, 1H), 4.4 (ddt, *J* = 19.4, 11.1, 4.3 Hz, 1H), 4.9 – 5.1 (m, 1H), 5.4 (dt, *J* = 15.2, 6.7 Hz, 1H), 6.3 (ddt, *J* = 15.2, 9.2, 1.5 Hz, 1H), 6.7 – 6.9 (m, 2H), 7.1 – 7.4 (m, 2H), 7.5 (d, *J* = 8.4 Hz, 1H), 7.6 (dd, *J* = 8.6, 4.3 Hz, 1H), 7.8 (dd, *J* = 8.4, 1.5 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.1 (dd, *J* = 4.3, 1.6 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 13.2, 21.7, 32.3 (d, *J* = 5.8 Hz), 33.8, 55.1, 65.2 (d, *J* = 2.8 Hz), 66.6 (d, *J* = 7.3 Hz), 114.0, 119.6 (d, *J* = 3.1 Hz), 122.1, 126.4, 126.5, 127.0, 128.7, 129.8 (d, *J* = 3.6 Hz), 132.7 – 133.8 (m), 134.1, 137.0, 140.2, 145.9 (d, *J* = 8.2 Hz), 149.8, 158.0; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.0 (td, *J* = 19.2, 5.8 Hz); IR 2958, 1509, 1246, 1035, 810, 787 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{24}H_{26}ClN_2NaO_4P^+$ 495.1211; Found 495.1177.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-vinyl-1,3,2-oxazaphosphinane 2-oxide

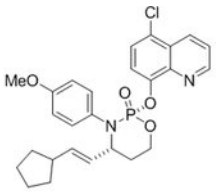
Compound 75: Synthesized using General Procedure C; Purified using 33% ethyl acetate in hexane; 66.3 mg, Yield = 77%; single diastereomer; Colorless solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.2 (dtdd, *J* = 14.5, 4.5, 2.4, 1.2 Hz, 1H), 2.6 (m, 1H), 3.8 (s, 3H), 4.2 (ddt, *J* = 18.7, 9.3, 4.9 Hz, 1H), 4.3 (ddt, *J* = 19.5, 11.2, 4.3 Hz, 1H), 5.0 – 5.1 (m, 2H), 5.1 (dt, *J* = 10.3, 0.9 Hz, 1H), 6.8 (ddd, *J* = 17.0, 10.2, 8.9 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.2 – 7.4 (m, 2H), 7.4 – 7.6 (m, 2H), 7.8 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* =

4.2, 1.6 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 32.3 (d, *J* = 5.8 Hz), 55.4, 66.0, 66.5 (d, *J* = 7.3 Hz), 114.4, 117.9, 119.9, 122.4, 126.5, 126.8, 127.3, 129.6 (d, *J* = 3.8 Hz), 133.1, 134.3, 137.5, 141.8 (d, *J* = 6.1 Hz), 146.6 (d, *J* = 8.7 Hz), 150.6, 158.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.2 (td, *J* = 18.9, 5.9 Hz); IR 2932, 1589, 1246, 1063, 852, 749 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{21}H_{20}ClN_2NaO_4P^+$ 453.0741; Found 453.0788.



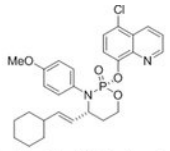
tert-butyl ((*E*)-2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-2-oxido-1,3,2-oxazaphosphinan-4-yl)allyl) carbonate

Compound 77: Synthesized using General Procedure C; Purified using 45% ethyl acetate in hexane; 69.6 mg, Yield = 62%, single diastereomer; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.4 (s, 9H), 2.0 – 2.2 (m, 1H), 2.6 (ddt, *J* = 15.5, 10.2, 4.6 Hz, 1H), 3.8 (s, 3H), 4.0 – 4.4 (m, 2H), 4.6 (dd, *J* = 6.2, 1.4 Hz, 2H), 5.0 (tdd, *J* = 11.3, 5.1, 2.1 Hz, 1H), 5.5 – 5.7 (m, 1H), 6.7 – 6.9 (m, 2H), 7.0 (ddt, *J* = 15.4, 9.1, 1.4 Hz, 1H), 7.2 – 7.4 (m, 2H), 7.5 – 7.6 (m, 2H), 7.8 (dd, *J* = 8.3, 1.6 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.7 Hz, 1H), 9.1 (dd, *J* = 4.2, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 27.7, 32.3 (d, *J* = 5.4 Hz), 55.4, 64.6 (d, *J* = 2.5 Hz), 66.4 (d, *J* = 7.3 Hz), 66.7, 82.2, 114.5, 119.6 (d, *J* = 3.0 Hz), 122.4, 126.5 (d, *J* = 1.6 Hz), 126.7, 127.2, 127.3, 129.6 (d, *J* = 3.7 Hz), 133.1, 134.1, 134.2 (d, *J* = 2.9 Hz), 141.6 (d, *J* = 6.5 Hz), 146.6 (d, *J* = 8.5 Hz), 150.6, 153.2, 158.3; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.4 (td, *J* = 20.4, 19.9, 4.8 Hz); IR 2933, 1737, 1509, 1248, 1034, 852, 788 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{27}H_{30}ClN_2KO_7P^+$ 599.1116; Found 599.1093.



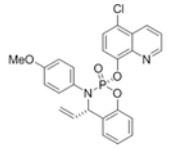
2-((5-chloroquinolin-8-yl)oxy)-4-((*E*)-2-cyclopentylvinyl)-3-(4-methoxyphenyl)-1,3,2-oxazaphosphinane 2-oxide

Compound 78: Synthesized using General Procedure C; Purified using 35% ethyl acetate in hexane; 74.8 mg, Yield = 75%, Single diastereomer, Light brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.1 – 1.3 (m, 3H), 1.5 – 1.6 (m, 3H), 1.6 – 1.8 (m, 2H), 2.0 – 2.2 (m, 1H), 2.3 – 2.4 (m, 1H), 2.4 – 2.6 (m, 1H), 3.8 (s, 3H), 4.0 (ddt, *J* = 19.0, 9.5, 4.8 Hz, 1H), 4.3 (ddq, *J* = 18.7, 11.7, 3.8, 3.3 Hz, 1H), 5.0 (tdt, *J* = 11.8, 5.8, 2.9 Hz, 1H), 5.3 (dd, *J* = 15.3, 7.2 Hz, 1H), 6.4 (ddd, *J* = 15.2, 9.3, 1.3 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.2 – 7.3 (m, 2H), 7.5 – 7.6 (m, 2H), 7.8 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.1, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 25.0 (d, *J* = 3.4 Hz), 32.6 (d, *J* = 3.6 Hz), 32.7, 42.6, 55.4, 65.7 (d, *J* = 2.3 Hz), 66.7 (d, *J* = 7.3 Hz), 114.2, 114.5, 119.7 (d, *J* = 3.1 Hz), 122.4, 126.5 (d, *J* = 1.6 Hz), 126.7, 127.3, 130.1 (d, *J* = 3.8 Hz), 133.0, 134.3 (d, *J* = 2.8 Hz), 139.1, 141.8 (d, *J* = 6.6 Hz), 146.8 (d, *J* = 8.3 Hz), 150.4, 158.3 (d, *J* = 1.3 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.0 (td, *J* = 19.7, 5.6 Hz); IR 2865, 1509, 1276, 1064, 854, 770 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{26}H_{28}ClN_2KO_4P^+$ 537.1112; Found 537.1112.



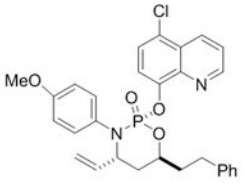
2-((5-chloroquinolin-8-yl)oxy)-4-((*E*)-2-cyclohexylvinyl)-3-(4-methoxyphenyl)-1,3,2-oxazaphosphinane 2-oxide

Compound 79: Synthesized using General Procedure C; Purified using 40% ethyl acetate in hexane; 66.7 mg, Yield = 65%, Dr > 20:1; Brown oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.9 – 1.0 (m, 2H), 1.0 – 1.3 (m, 3H), 1.5 – 1.8 (m, 5H), 1.9 (qd, *J* = 9.7, 8.5, 4.1 Hz, 1H), 2.0 – 2.2 (m, 1H), 2.5 (ddt, *J* = 15.1, 9.9, 4.6 Hz, 1H), 3.8 (d, *J* = 1.3 Hz, 3H), 4.0 (ddt, *J* = 19.1, 9.4, 4.8 Hz, 1H), 4.3 (ddt, *J* = 19.6, 10.9, 4.3 Hz, 1H), 5.0 (td, *J* = 10.3, 5.4 Hz, 1H), 5.3 (dd, *J* = 15.4, 6.4 Hz, 1H), 6.3 – 6.4 (m, 1H), 6.8 – 6.9 (m, 2H), 7.2 – 7.3 (m, 2H), 7.5 (dd, *J* = 8.4, 1.3 Hz, 1H), 7.6 (ddd, *J* = 8.6, 4.2, 1.3 Hz, 1H), 7.8 (dt, *J* = 8.4, 1.5 Hz, 1H), 8.6 (dt, *J* = 8.6, 1.5 Hz, 1H), 9.0 – 9.1 (m, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 25.9, 26.1, 32.5, 32.6, 40.1, 55.4, 65.7 (d, *J* = 2.3 Hz), 66.6 (d, *J* = 7.3 Hz), 114.2, 119.6 (d, *J* = 3.1 Hz), 122.3, 126.4, 126.5 (d, *J* = 1.9 Hz), 127.3, 130.1 (d, *J* = 3.7 Hz), 133.0, 134.3 (d, *J* = 2.8 Hz), 140.2, 141.8 (d, *J* = 6.6 Hz), 146.7, 146.8, 150.4, 158.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.0 (td, *J* = 19.6, 5.7 Hz); IR 2922, 1508, 1278, 1063, 775 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{27}H_{30}ClN_2KO_4P^+$ 551.1269; Found 551.1260.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-4-vinyl-3,4-dihydrobenzo[*e*][1,3,2]oxazaphosphinine 2-oxide

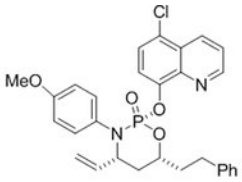
Compound 80: Synthesized using General Procedure C; Purified using 30% ethyl acetate in hexane; 35.4 mg, Yield = 37%, single diastereomer; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.8 (s, 3H), 5.1 (dd, *J* = 21.8, 8.5 Hz, 1H), 5.1 – 5.2 (m, 2H), 6.7 (ddd, *J* = 16.9, 10.0, 8.5 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.0 (dd, *J* = 8.0, 1.1 Hz, 1H), 7.1 – 7.2 (m, 2H), 7.2 – 7.3 (m, 1H), 7.4 – 7.5 (m, 3H), 7.5 (d, *J* = 8.3 Hz, 1H), 7.7 (dd, *J* = 8.3, 1.8 Hz, 1H), 8.5 (dd, *J* = 8.5, 1.7 Hz, 1H), 8.8 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 55.5, 69.6, 114.6, 117.7, 119.2, 119.3, 119.5, 122.4, 124.1, 125.3 (d, *J* = 7.2 Hz), 126.2, 127.3, 127.9, 129.1, 129.7, 132.8, 133.6, 137.4, 141.6, 146.4, 149.4 (d, *J* = 7.8 Hz), 150.6, 158.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −8.1 (d, *J* = 22.0 Hz); IR 2932, 1611, 1510, 1225, 1065, 864, 758 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{25}H_{20}ClN_2NaO_4P^+$ 501.0741; Found 501.0742.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-6-phenethyl-4-vinyl-1,3,2-oxazaphosphinane 2-oxide

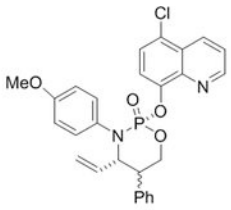
Compound 81 (trans ds): Synthesized using General Procedure C; Purified using 25% ethyl acetate in hexane; 36.4 mg, Yield = 34%; Brown oil;^{1}H NMR (400 MHz, $CDCl_3$) δ

1.81 (dddt, *J* = 14.3, 10.4, 6.4, 4.0 Hz, 1H), 1.95 – 2.06 (m, 2H), 2.34 (ddd, *J* = 13.9, 10.1, 6.2 Hz, 1H), 2.44 (ddd, *J* = 14.2, 11.4, 5.4 Hz, 1H), 2.60 (ddd, *J* = 13.7, 10.4, 5.3 Hz, 1H), 3.78 (s, 3H), 4.15 (dddd, *J* = 21.7, 8.5, 5.3, 2.5 Hz, 1H), 5.08 (dt, *J* = 17.0, 1.0 Hz, 1H), 5.20 (dd, *J* = 10.2, 1.6 Hz, 1H), 5.30 (dddd, *J* = 10.8, 8.8, 3.8, 1.8 Hz, 1H), 6.84 – 6.89 (m, 2H), 6.96 (ddt, *J* = 8.0, 4.7, 2.0 Hz, 3H), 7.09 – 7.17 (m, 3H), 7.38 – 7.43 (m, 2H), 7.56 (dd, *J* = 8.5, 3.8 Hz, 2H), 7.82 (dd, *J* = 8.3, 1.7 Hz, 1H), 8.58 (dd, *J* = 8.6, 1.6 Hz, 1H), 8.95 (dd, *J* = 4.1, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 31.0, 38.2 (d, *J* = 3.6 Hz), 38.3, 55.5, 65.8 (d, *J* = 3.7 Hz), 76.7, 114.6, 117.9, 120.1 (d, *J* = 3.0 Hz), 122.5, 126.0, 126.7, 126.8, 127.4, 128.3, 128.5, 129.6 (d, *J* = 3.7 Hz), 133.3, 134.5 (d, *J* = 3.4 Hz), 137.9, 141.2, 141.7, 146.8 (d, *J* = 8.7 Hz), 150.5, 158.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.57 (d, *J* = 21.6 Hz). IR 3019, 2253, 1555, 1465, 1020, 905, 730 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{29}H_{28}ClN_2O_4PNa^+$ 557.1373; Found 557.1384.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-6-phenethyl-4-vinyl-1,3,2-oxazaphosphinane 2-oxide

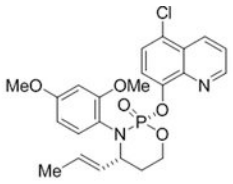
Compound 81 (cis diastereomer): Synthesized using General Procedure C; Purified using 25% ethyl acetate in hexane; 33.2 mg, Yield = 31%; Brown oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.88 (ddp, *J* = 13.7, 10.8, 3.5 Hz, 1H), 1.99 – 2.12 (m, 2H), 2.60 – 2.85 (m, 2H), 3.07 (dt, *J* = 14.9, 11.5 Hz, 1H), 3.75 (s, 3H), 4.13 – 4.27 (m, 1H), 4.68 (ddp, *J* = 12.4, 5.7, 1.9 Hz, 1H), 4.82 – 4.93 (m, 2H), 5.79 (ddd, *J* = 17.1, 10.2, 8.7 Hz, 1H), 6.76 – 6.82 (m, 2H), 7.10 (ddt, *J* = 10.2, 7.0, 1.5 Hz, 4H), 7.17 – 7.21 (m, 1H), 7.25 – 7.30 (m, 2H), 7.53 – 7.61 (m, 2H), 7.83 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.59 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.02 (dd, *J* = 4.1, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 31.0, 36.7, 38.0 (d, *J* = 6.5 Hz), 55.5, 64.7 (d, *J* = 4.5 Hz), 78.9 (d, *J* = 7.2 Hz), 114.4, 117.7, 120.2 (d, *J* = 3.2 Hz), 122.5, 126.2, 126.7, 126.8, 127.5, 128.6, 130.2 (d, *J* = 3.5 Hz), 133.1 (d, *J* = 3.9 Hz), 133.4, 138.5, 141.2, 146.7 (d, *J* = 7.9 Hz), 150.6, 158.2; ^{31}P NMR (202 MHz, $CDCl_3$) δ −3.43 (d, *J* = 10.4 Hz); IR 3026, 2238, 1509, 1242, 1008, 830, 700 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{29}H_{28}ClN_2O_4PNa^+$ 557.1373; Found 557.1386.



(2*R*,4*S*)-2-((5-chloroquinolin-8-yl)oxy)-3-(4-methoxyphenyl)-5-phenyl-4-vinyl-1,3,2-oxazaphosphinane 2-oxide

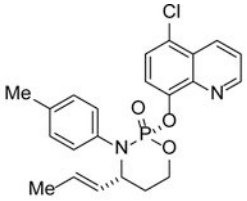
Compound 82: Synthesized using General Procedure C; Purified using 25% ethyl acetate in hexane; 47.7 mg, 47% yield as a mixture of 2 diastereomers; Yellow oil; Characterization shown is for one of the two diastereomers. ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.64 (s, 3H), 3.83 (td, *J* = 7.5, 3.5 Hz, 1H), 4.12 (ddd, *J* = 16.3, 8.9, 7.0 Hz, 1H), 4.51 (td, *J* = 11.1, 7.8 Hz,

1H), 4.61 (d, *J* = 17.1 Hz, 1H), 4.72 (ddd, *J* = 12.7, 11.0, 3.5 Hz, 1H), 4.85 (dd, *J* = 10.2, 1.3 Hz, 1H), 6.27 (ddd, *J* = 17.1, 10.1, 9.0 Hz, 1H), 6.61 – 6.74 (m, 2H), 7.04 – 7.12 (m, 2H), 7.16 – 7.32 (m, 5H), 7.42 – 7.54 (m, 2H), 7.73 (dd, *J* = 8.4, 1.7 Hz, 1H), 8.47 – 8.54 (m, 1H), 8.99 (m, 1H); ^{13}C {^{1}H} NMR (126 MHz, $CDCl_3$) δ 46.6, 55.5, 71.1 (d, *J* = 7.1 Hz), 72.3 (d, *J* = 3.4 Hz), 114.6, 119.0, 120.4, 122.6, 126.9, 127.0, 127.6, 127.8, 128.5, 128.6, 129.0, 130.2 (d, *J* = 3.5 Hz), 133.7 (d, *J* = 3.0 Hz), 134.0, 137.0, 138.9, 146.2, 150.5, 158.4; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.06 (q, *J* = 13.9, 13.4 Hz). IR 2253, 1510, 1384, 1264, 905, 729, 650 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{27}H_{24}ClN_2O_4PNa^+$ 529.1060; Found 529.1047.



2-((5-chloroquinolin-8-yl)oxy)-3-(2,4-dimethoxyphenyl)-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

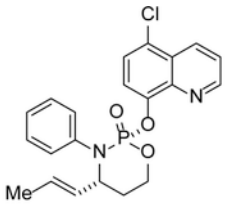
Compound 88: Synthesized using Procedure C; Purified using 35% ethyl acetate in hexane; (Yellow solid, 61.7 mg, 65 % yield), single diastereomer; ^{1}H NMR (400 MHz, CDCl3) δ 1.53 (dd, *J* = 6.4, 1.7 Hz, 3H), 2.31 – 2.49 (m, 2H), 3.76 (s, 3H), 3.82 (s, 3H), 3.95 (ddt, *J* = 15.4, 9.0, 6.1 Hz, 1H), 4.44 (dddd, *J* = 14.1, 10.6, 6.9, 3.6 Hz, 1H), 4.80 (tdd, *J* = 10.5, 7.6, 3.2 Hz, 1H), 5.28 (dtd, *J* = 15.5, 6.8, 6.0 Hz, 1H), 6.01 (ddq, *J* = 15.0, 9.1, 1.6 Hz, 1H), 6.33 (dd, *J* = 8.6, 2.7 Hz, 1H), 6.48 (d, *J* = 2.7 Hz, 1H), 7.04 (dd, *J* = 8.6, 1.3 Hz, 1H), 7.52 – 7.61 (m, 2H), 7.86 (dd, *J* = 8.4, 1.5 Hz, 1H), 8.58 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.05 (dd, *J* = 4.2, 1.6 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, CDCl3) δ 17.7, 31.9 (d, *J* = 7.3 Hz), 55.5, 56.0, 63.6, 67.3 (d, *J* = 7.0 Hz), 100.1, 104.0, 119.7 (d, *J* = 3.0 Hz), 122.4, 122.8, 126.4, 126.6 (d, *J* = 1.6 Hz), 127.4, 128.2, 130.7, 131.9 (d, *J* = 2.6 Hz), 133.1, 141.9 (d, *J* = 6.8 Hz), 146.9 (d, *J* = 7.3 Hz), 150.5, 157.3 (d, *J* = 4.2 Hz), 159.9 (d, *J* = 1.3 Hz); ^{31}P NMR (202 MHz, $CDCl_3$) δ −3.61 (q, *J* = 14.0 Hz); IR 2934, 1734, 1652, 1558, 1457, 1280, 1036, 852 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{25}ClN_2O_5P^+$ 475.1190; Found 475.1194.



2-((5-chloroquinolin-8-yl)oxy)-4-((*E*)-prop-1-en-1-yl)-3-(*p*-tolyl)-1,3,2-oxazaphosphinane 2-oxide

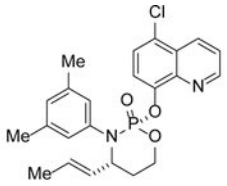
Compound 89: Synthesized using Procedure C; Purified using 30% ethyl acetate in hexane; (Yellow solid, 65.2 mg, 76% yield); single diastereomer; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.66 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.12 (dtdd, *J* = 14.3, 4.1, 2.4, 1.3 Hz, 1H), 2.31 (s, 3H), 2.48 – 2.61 (m, 1H), 4.10 – 4.24 (m, 1H), 4.24 – 4.37 (m, 1H), 4.99 (tdd, *J* = 11.0, 5.6, 2.3 Hz, 1H), 5.45 (dqd, *J* = 15.3, 6.5, 0.8 Hz, 1H), 6.51 (ddq, *J* = 15.2, 9.0, 1.6 Hz, 1H), 7.07 – 7.15 (m, 2H), 7.24 – 7.33 (m, 2H), 7.50 – 7.63 (m, 2H), 7.82 (dd, *J* = 8.3, 1.6 Hz, 1H), 8.57 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.04 (dd, *J* = 4.2, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ

17.8, 21.1, 32.9 (d, J = 5.8 Hz), 65.1 (d, J = 2.2 Hz), 66.7 (d, J = 7.3 Hz), 119.9 (d, J = 3.1 Hz), 122.4, 126.6 (d, J = 1.7 Hz), 126.7, 127.4, 128.0 (d, J = 3.9 Hz), 128.8, 129.9, 130.6, 133.1, 136.3, 139.4 (d, J = 3.0 Hz), 141.9 (d, J = 6.5 Hz), 146.8 (d, J = 8.3 Hz), 150.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.17 (td, J = 19.8, 5.1 Hz). IR 2919, 1511, 1464, 1218, 1013, 904 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{23}ClN_2O_3P^+$ 429.1135; Found 429.1134.



2-((5-chloroquinolin-8-yl)oxy)-3-phenyl-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

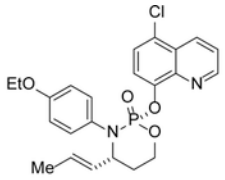
Compound 90: Synthesized using Procedure C; Purified using 30% ethyl acetate in hexane; (Yellow solid, 62.2 mg, 75 % yield); single diastereomer; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.52 (dd, J = 6.5, 1.7 Hz, 3H), 1.94 – 2.06 (m, 1H), 2.42 (ddt, J = 15.2, 10.1, 4.6 Hz, 1H), 4.03 – 4.25 (m, 2H), 4.85 (tdd, J = 11.0, 5.6, 2.3 Hz, 1H), 5.32 (dq, J = 15.2, 6.4 Hz, 1H), 6.32 – 6.43 (m, 1H), 7.05 (t, J = 7.4 Hz, 1H), 7.17 (t, J = 7.7 Hz, 2H), 7.27 (d, J = 7.9 Hz, 2H), 7.38 – 7.46 (m, 2H), 7.67 (dd, J = 8.3, 1.6 Hz, 1H), 8.43 (dd, J = 8.5, 1.6 Hz, 1H), 8.89 (dd, J = 4.2, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 32.9 (d, J = 5.7 Hz), 64.9 (d, J = 1.8 Hz), 66.8 (d, J = 7.4 Hz), 119.9 (d, J = 3.2 Hz), 122.5, 126.4, 126.6 (d, J = 1.7 Hz), 126.8, 127.5, 127.9 (d, J = 4.0 Hz), 128.9, 129.2, 130.5, 133.2, 142.2 (d, J = 3.5 Hz), 146.8 (d, J = 8.4 Hz), 150.6; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.42 (td, J = 19.6, 5.2 Hz). IR 2919, 2359, 1652, 1558, 1507, 1281, 1061, 856 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{21}ClN_2O_3P^+$ 415.0978; Found 415.0979.



2-((5-chloroquinolin-8-yl)oxy)-3-(3,5-dimethylphenyl)-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

Compound 91: Synthesized using Procedure C; Purified using 30% ethyl acetate in hexane; (Yellow solid, 63.8 mg, 72% yield); single diastereomer; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.67 (dd, J = 6.4, 1.7 Hz, 3H), 2.07 – 2.14 (m, 1H), 2.27 (s, 6H), 2.55 (ddt, J = 15.2, 10.1, 4.5 Hz, 1H), 4.07 – 4.37 (m, 2H), 4.98 (tdd, J = 11.0, 5.4, 2.3 Hz, 1H), 5.40 – 5.53 (m, 1H), 6.50 (ddq, J = 15.1, 8.8, 1.6 Hz, 1H), 6.84 (s, 1H), 7.02 (s, 2H), 7.52 – 7.62 (m, 2H), 7.84 (dd, J = 8.4, 1.6 Hz, 1H), 8.58 (dd, J = 8.6, 1.7 Hz, 1H), 9.04 (dd, J = 4.1, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.9, 21.4, 32.9 (d, J = 5.8 Hz), 64.9 (d, J = 2.1 Hz), 66.6 (d, J = 7.4 Hz), 119.9 (d, J = 2.9 Hz), 122.4, 125.8 (d, J = 4.0 Hz), 126.7, 126.8, 127.5, 128.4, 128.7, 130.5, 133.2, 138.7, 141.8, 141.9 (d, J = 6.4 Hz), 146.9 (d, J = 8.5 Hz), 150.5; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.26 (td, J = 19.9, 5.1 Hz). IR 2917, 1558, 1457, 1297,

1037, 914 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{25}ClN_2O_3P^+$ 443.1291; Found 443.1293.



2-((5-chloroquinolin-8-yl)oxy)-3-(4-ethoxyphenyl)-4-((*E*)-prop-1-en-1-yl)-1,3,2-oxazaphosphinane 2-oxide

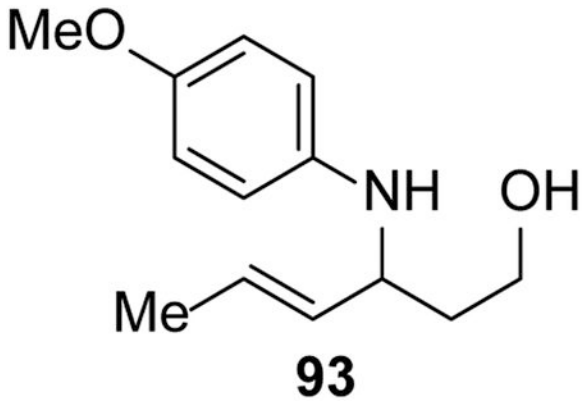
Compound 92: Synthesized using Procedure C; Purified using 30% ethyl acetate in hexane; (Yellow solid, 64.2 mg, 70 % yield); single diastereomer; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.37 (t, *J* = 7.0 Hz, 3H), 1.64 (dd, *J* = 6.5, 1.7 Hz, 3H), 2.03 – 2.15 (m, 1H), 2.51 (ddtd, *J* = 14.8, 9.5, 4.0, 2.0 Hz, 1H), 3.97 (q, *J* = 7.0 Hz, 2H), 4.02 – 4.13 (m, 1H), 4.21 – 4.35 (m, 1H), 4.96 (tdd, *J* = 10.9, 5.7, 2.3 Hz, 1H), 5.39 (dqd, *J* = 13.7, 6.5, 0.7 Hz, 1H), 6.47 (ddq, *J* = 15.1, 9.1, 1.6 Hz, 1H), 6.76 – 6.86 (m, 2H), 7.22 – 7.33 (m, 2H), 7.48 – 7.59 (m, 2H), 7.78 (dd, *J* = 8.3, 1.6 Hz, 1H), 8.55 (dd, *J* = 8.6, 1.7 Hz, 1H), 9.02 (dd, *J* = 4.1, 1.7 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 14.9, 17.8, 32.8 (d, *J* = 5.5 Hz), 63.7, 65.5 (d, *J* = 2.5 Hz), 66.7 (d, *J* = 7.3 Hz), 114.9, 119.8 (d, *J* = 3.2 Hz), 122.4, 126.7 (dd, *J* = 4.8, 1.6 Hz), 127.4, 128.9, 129.8 (d, *J* = 3.7 Hz), 130.5, 133.1, 134.4 (d, *J* = 3.0 Hz), 141.9, 141.9, 146.9 (d, *J* = 8.4 Hz), 150.5, 157.7; ^{31}P NMR (202 MHz, $CDCl_3$) δ −3.96 (td, *J* = 19.5, 5.4 Hz). IR 2978, 2359, 1590, 1495, 1283, 1012, 901 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{25}ClN_2O_4P^+$ 459.1240; Found 459.1239.

VI. Gram Scale Procedure

A 100 mL round bottom flask with a magnetic stirring pellet was charged with phosphoramidate **21** (1.00 g, 2.24 mmol, 1 equiv), $Pd(OAc)_2$ (101 mg, 0.45 mmol, 20 mol%) and $Cu(OAc)_2$ (408 mg, 2.24 mmol, 1 equiv) followed by acetonitrile (45 mL, final concentration: 0.05 M). The mixture was sparged with O_2 for fifteen minutes, and then the flask was sealed with a rubber septum. The reaction vessel was submerged in an oil bath preheated to 55 °C and kept at this temperature under a balloon of O_2 (~1 atm) for 65 hours. Subsequently, the reaction mixture was filtered through a plug of silica and evaporated to dryness under vacuum. The resulting crude mixture was then purified by chromatography on silica gel using 33% ethyl acetate in hexane as to afford the product **62** in 82% (816 mg) yield as a single diastereomer.

VII. Procedures for Tether Removal, Azetidine Synthesis, and Epoxidation

Tether Removal—

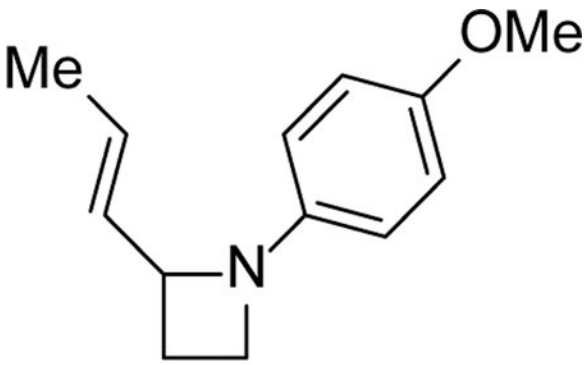


93

To a stirred suspension of LAH (23 mg, 0.6 mmol, 3 equiv.) in THF (4 mL) at 0 °C was added a solution of **62** (89 mg, 0.2 mmol, 1 equiv.) in THF (1 mL) dropwise. The reaction was heated to 60 °C for 6 h. Then the reaction mixture was cooled to 0 °C and quenched with careful dropwise addition of H_2O (0.2 mL), 15% aqueous NaOH (0.4 mL), and H_2O (0.6 mL). The solution was stirred for 30 min. The mixture was transferred to a separatory funnel and extracted with 3 portions of ethyl acetate. The organic fractions were collected, dried with Na_2SO_4, and concentrated under reduced pressure. The resulting residue was purified by chromatography on silica gel (30% EtOAC in hexanes) to afford compound **93** as a brown oil.

(42 mg, 95% yield); ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.7 (ddd, *J* = 6.5, 1.6, 0.8 Hz, 3H), 1.8 (td, *J* = 6.4, 4.5 Hz, 2H), 3.7 (s, 3H), 3.8 – 3.9 (m, 2H), 3.9 – 3.9 (m, 1H), 5.4 (ddq, *J* = 15.4, 6.8, 1.6 Hz, 1H), 5.6 (dqd, *J* = 15.4, 6.4, 1.1 Hz, 1H), 6.6 – 6.7 (m, 2H), 6.7 – 6.8 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.7, 38.0, 55.8, 56.2, 61.2, 114.8, 116.2, 126.5, 132.6, 141.0, 152.8; IR 3366, 2932, 1511, 1234, 1037, 820 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{20}NO_2$ 222.1494; Found 222.1526.

Azetidine Synthesis—



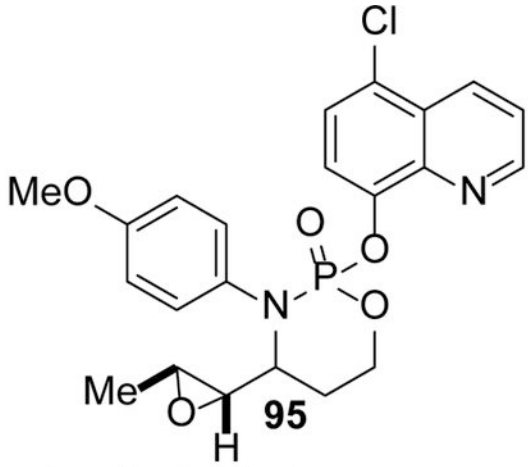
94

To a stirred solution of **62** (89 mg, 0.2 mmol, 1 equiv) in 1,4-dioxane (4 mL) was added HCl solution (4M in dioxane, 0.1 mL, 2 equiv.) dropwise at room temperature. The reaction mixture was heated to 90 °C for 5h. Then, the reaction mixture was cooled to 0 °C and quenched with saturated aqueous sodium bicarbonate. The mixture was transferred to a

separatory funnel and extracted with 3 portions of ethyl acetate. The organic fractions were collected, dried with Na_2SO_4, and concentrated under reduced pressure. The resulting residue was purified by chromatography on silica gel (gradient of 5–10% EtOAC in hexanes) to afford compound **94** as dark brown oil in 42% (20 mg) yield.

^{1}H NMR (400 MHz, $CDCl_3$) δ 1.7 (dd, *J* = 6.4, 1.6 Hz, 3H), 1.9 – 2.0 (m, 1H), 2.1 (dq, *J* = 13.5, 6.7 Hz, 1H), 3.6 (ddd, *J* = 10.9, 7.3, 6.0 Hz, 1H), 3.7 (dt, *J* = 10.9, 6.3 Hz, 1H), 3.7 (s, 3H), 4.0 (d, *J* = 7.2 Hz, 1H), 5.3 (ddq, *J* = 15.3, 7.0, 1.7 Hz, 1H), 5.7 (dqd, *J* = 13.9, 6.4, 1.1 Hz, 1H), 6.6 (d, *J* = 8.5 Hz, 2H), 6.7 – 6.8 (m, 2H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.8, 38.5, 41.9, 54.1, 55.8, 114.9, 115.3, 127.5, 131.8, 141.2, 152.4; IR 3388, 2934, 1508, 1231, 1036, 966, 818, 654 cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{18}NO^+$ 204.1388; Found 204.1395.

Epoxidation—



note: single diastereomer, relative stereochemistry depicted

A 10 ml round bottom flask was charged with compound 62 (89 mg, 0.2 mmol, 1 equiv) and 2 mL of CH_2Cl_2. The flask was cooled to 0 °C, and mCPBA (70wt%) (98 mg, 0.4 mmol, 2 equiv) was added in portions. Over a period of 5 hours, the reaction mixture was warmed to room temperature under an atmosphere of N_2. Following this time, the reaction was quenched with aqueous sodium thiosulfate and transferred to a separatory funnel with CH_2Cl_2. The organic layer was collected, and the aqueous layer was extracted with two additional portions of CH_2Cl_2. The organic portions were pooled, dried with Na_2SO_4, and the solvent was removed under reduced pressure. The resulting crude residue was purified by chromatography on silica gel (35% ethyl acetate in hexanes) to yield 95% as a brown solid (56 mg, 61%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 1.2 (d, *J* = 5.2 Hz, 3H), 2.4 (tdd, *J* = 7.9, 3.5, 2.0 Hz, 2H), 2.4 – 2.6 (m, 1H), 3.0 – 3.2 (m, 1H), 3.78 (s, 3H), 4.0 (dd, *J* = 9.2, 2.1 Hz, 1H), 4.3 (ddt, *J* = 20.0, 11.4, 4.0 Hz, 1H), 5.1 (tdd, *J* = 11.4, 4.8, 2.4 Hz, 1H), 6.8 – 6.9 (m, 2H), 7.3 – 7.4 (m, 2H), 7.5 – 7.6 (m, 2H), 7.8 (dd, *J* = 8.3, 1.6 Hz, 1H), 8.6 (dd, *J* = 8.6, 1.6 Hz, 1H), 9.0 (dd, *J* = 4.3, 1.6 Hz, 1H); ^{13}C {^{1}H} NMR (101 MHz, $CDCl_3$) δ 17.3, 28.5 (d, *J* = 5.7 Hz), 55.5,

56.6, 57.3, 65.1 (d, J = 2.3 Hz), 66.6 (d, J = 7.4 Hz), 114.7, 119.4 (d, J = 2.9 Hz), 122.5, 126.6 (d, J = 1.7 Hz), 126.8, 127.4, 129.6 (d, J = 3.7 Hz), 133.1, 134.1 (d, J = 2.7 Hz), 141.5, 146.5 (d, J = 8.3 Hz), 150.6, 158.7; ^{31}P NMR (202 MHz, $CDCl_3$) δ −4.6 (td, J = 20.4, 19.9, 4.6 Hz); IR 2961, 1509, 1238, 1059, 853, cm^{-1}; HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{22}H_{23}ClN_2O_5P^+$ 461.1033; Found 461.1001.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

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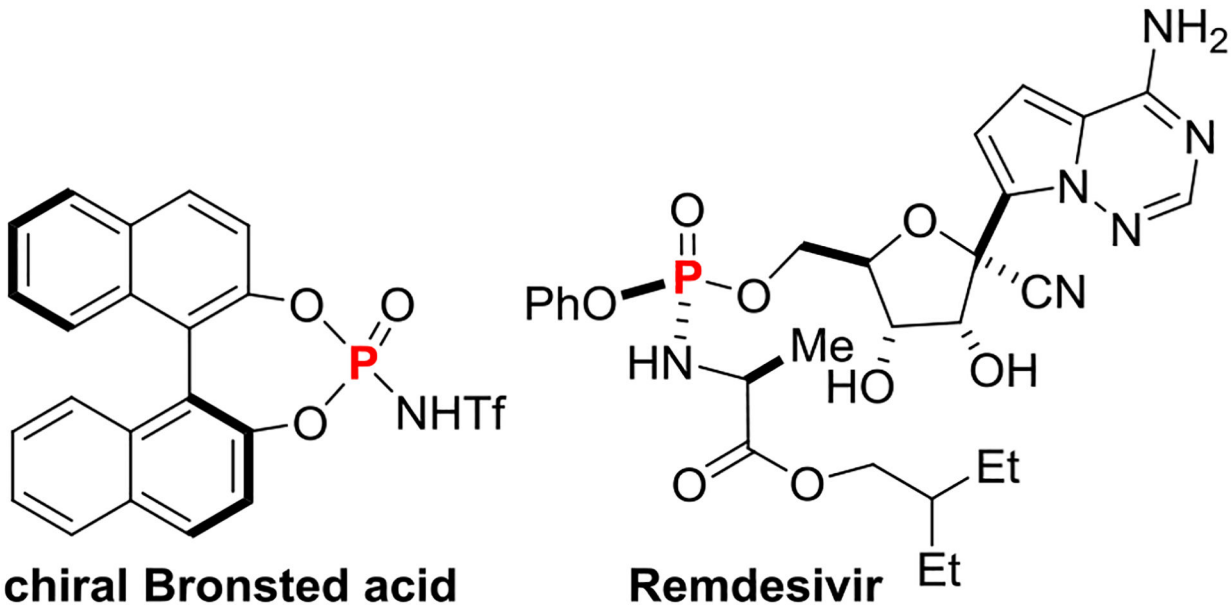
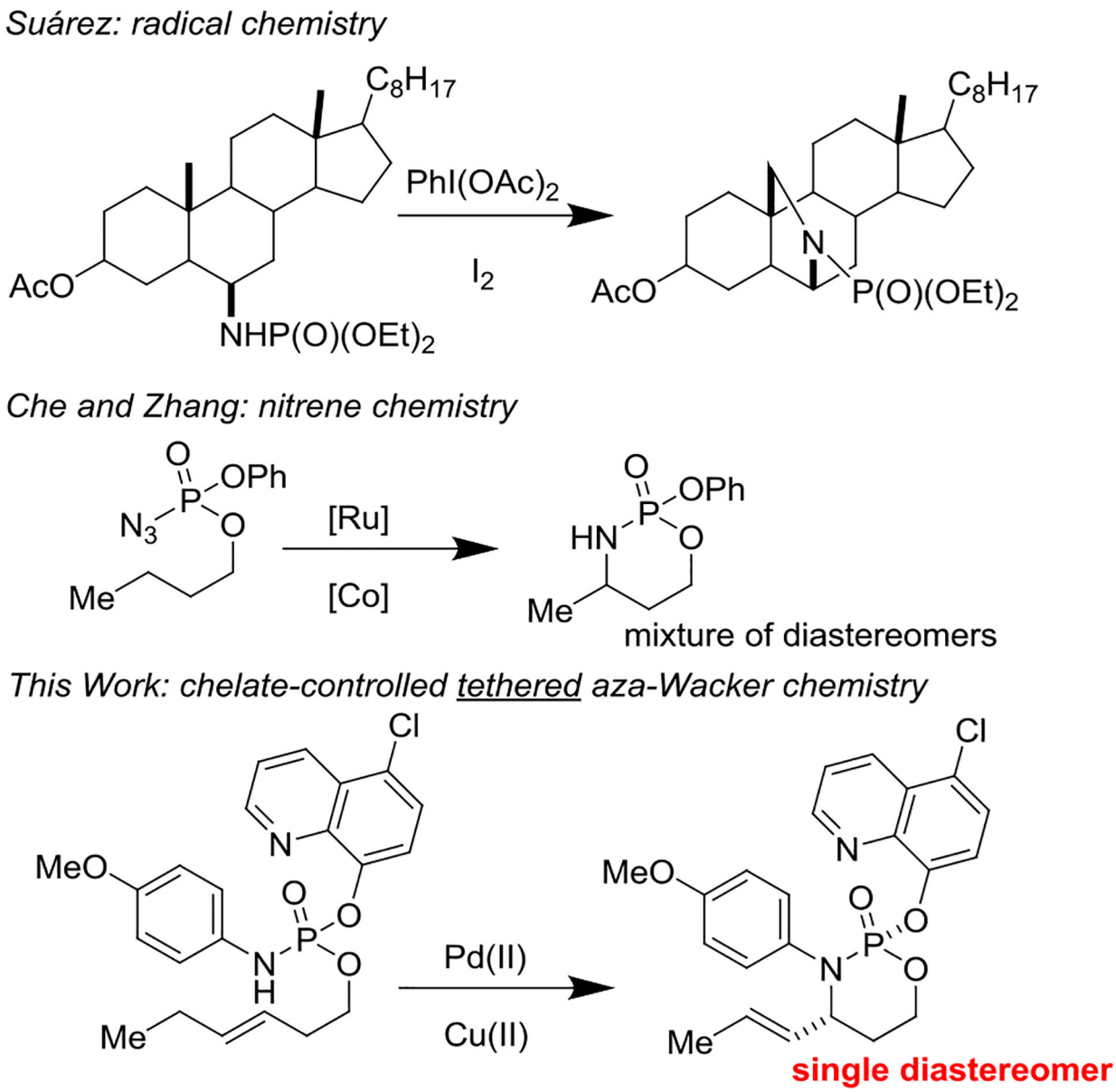
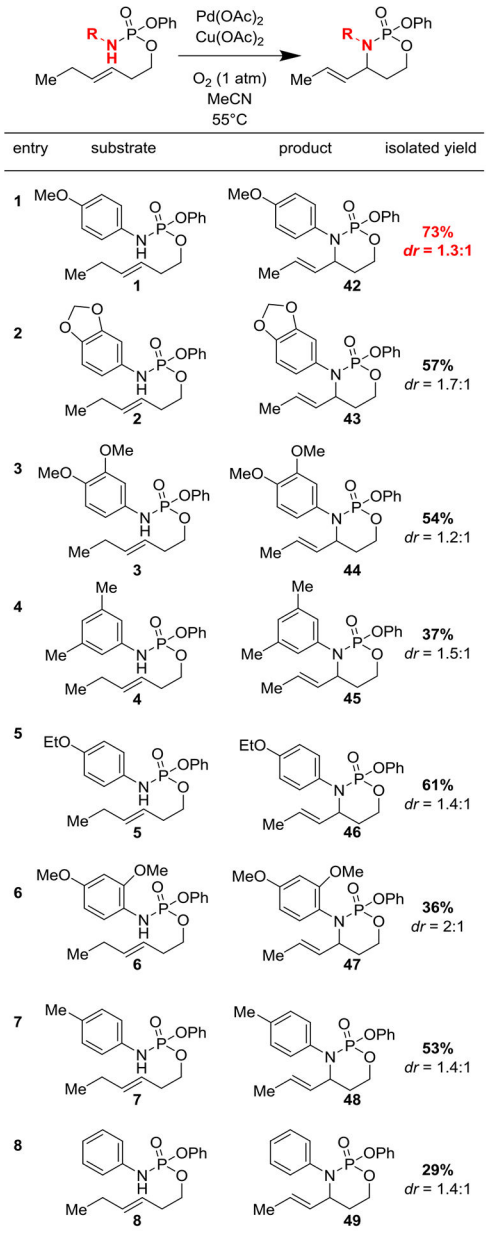


Figure 1.
Phosphoramidates are indispensable to catalysis and medicine.



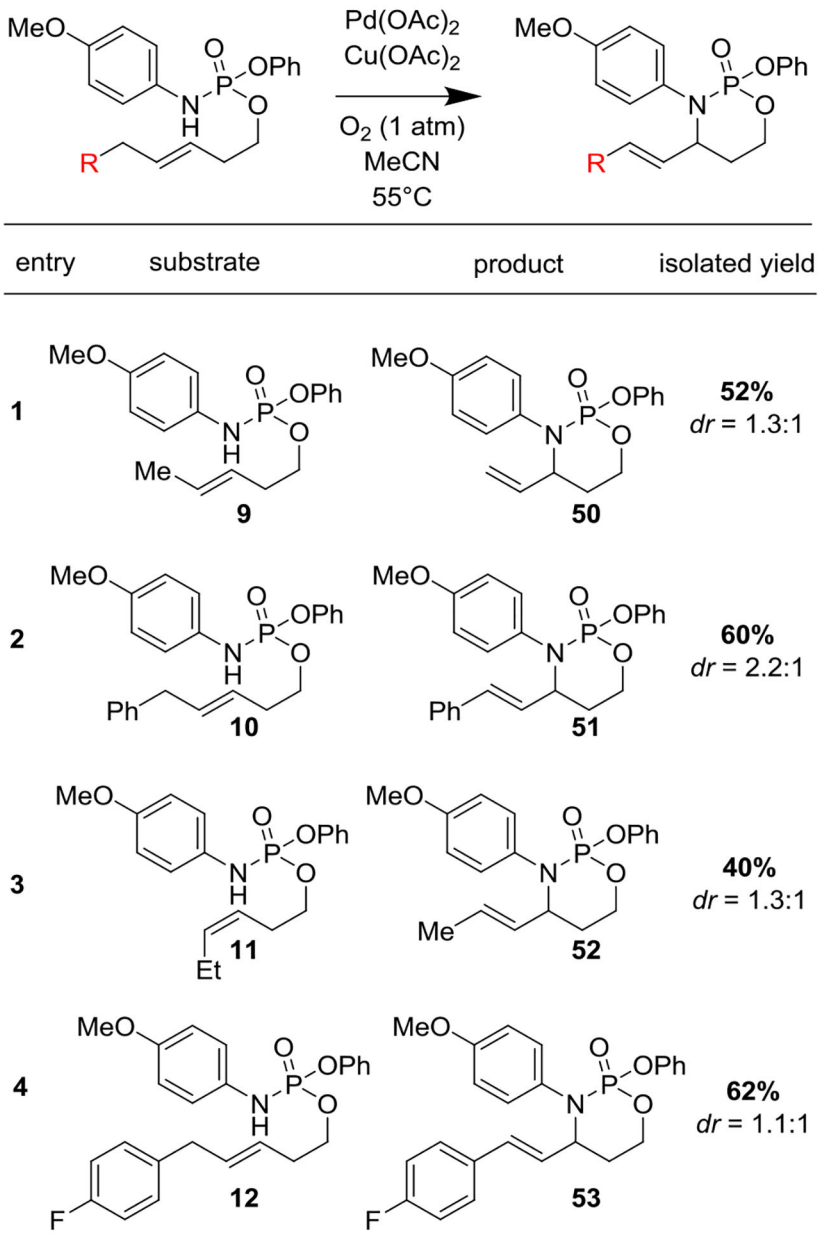
Scheme 1.
Oxidative Strategies for Phosphoramidate Construction.



Scheme 2.

Aniline-reactivity relationship.

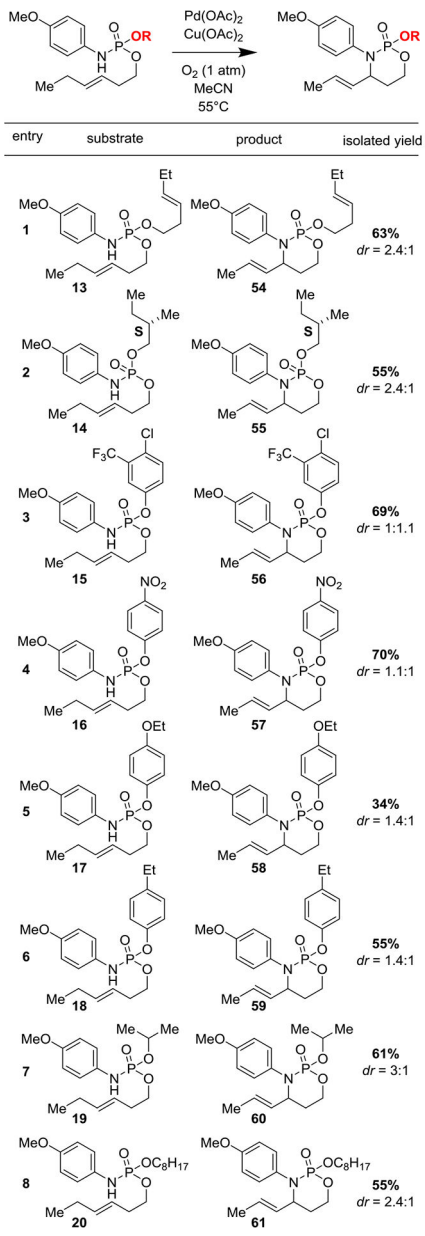
Reaction conditions: $Pd(OAc)_2$ (20 mol%), $Cu(OAc)_2$ (1 equiv.), O_2 (1 atm), CH_3CN, 55 °C, 65 h



Scheme 3.

Substrate Scope with –Oph containing phosphoramidates.

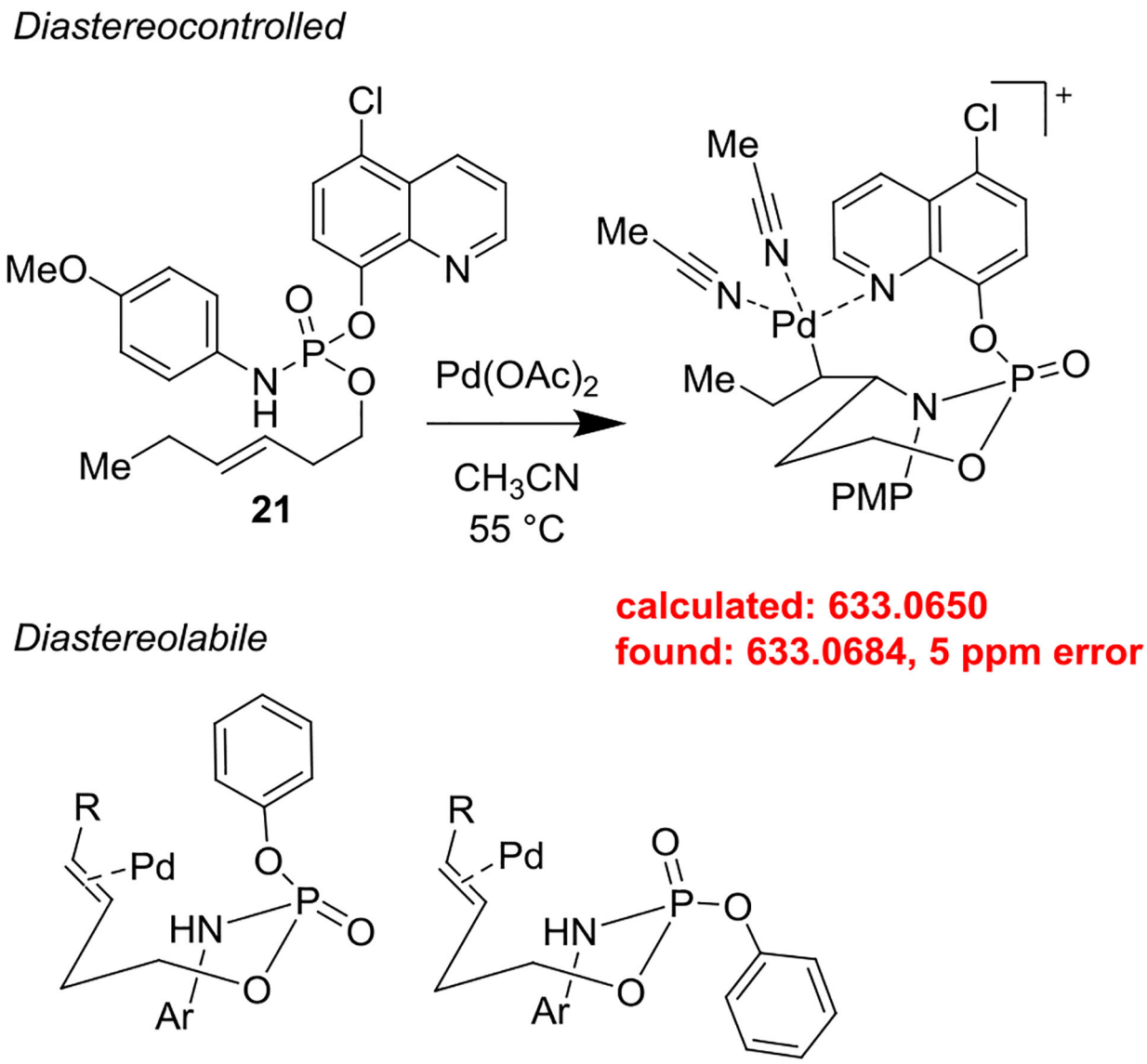
Reaction conditions: $Pd(OAc)_2$ (20 mol%), $Cu(OAc)_2$ (1 equiv.), O_2 (1 atm), CH_3CN, 55 °C, 65 h



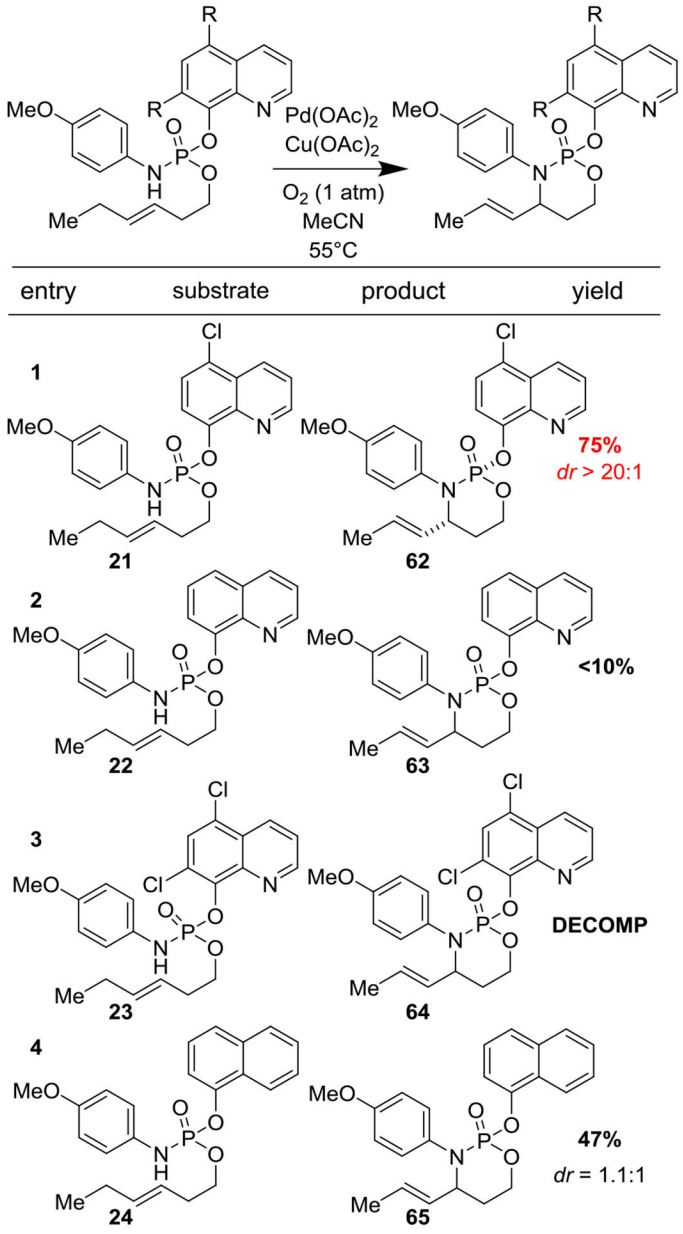
Scheme 4.

Changing the alkoxy substituent.

Reaction conditions: $Pd(OAc)_2$ (20 mol%), $Cu(OAc)_2$ (1 equiv.), O_2 (1 atm), CH_3CN, 55 °C, 65 h



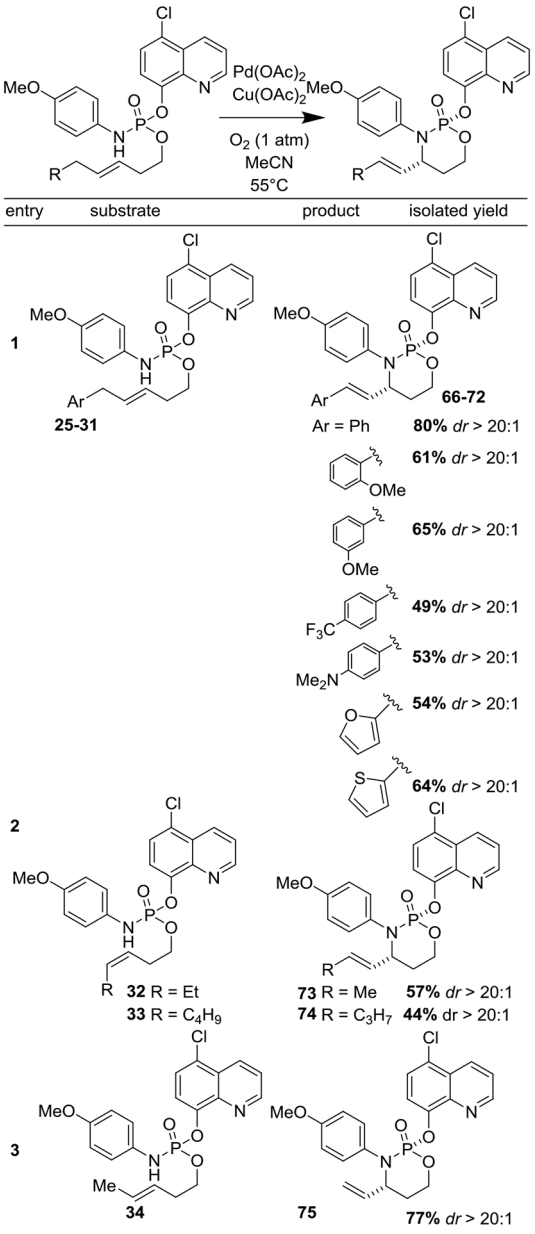
Scheme 5.
HRMS analysis identifies a putative chelate for diastereocontrol in the oxidative cyclization.

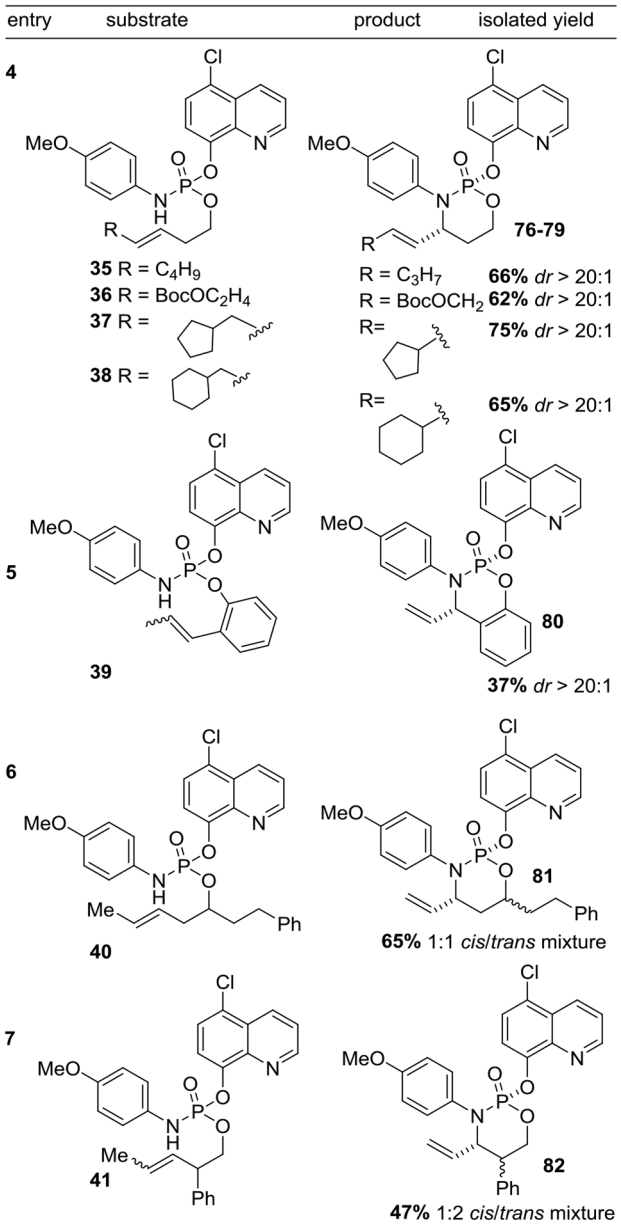


Scheme 6.

Chelate Comparison

Reaction conditions: $Pd(OAc)_2$ (20 mol%), $Cu(OAc)_2$ (1 equiv.), O_2 (1 atm), CH_3CN, 55 °C, 65 h

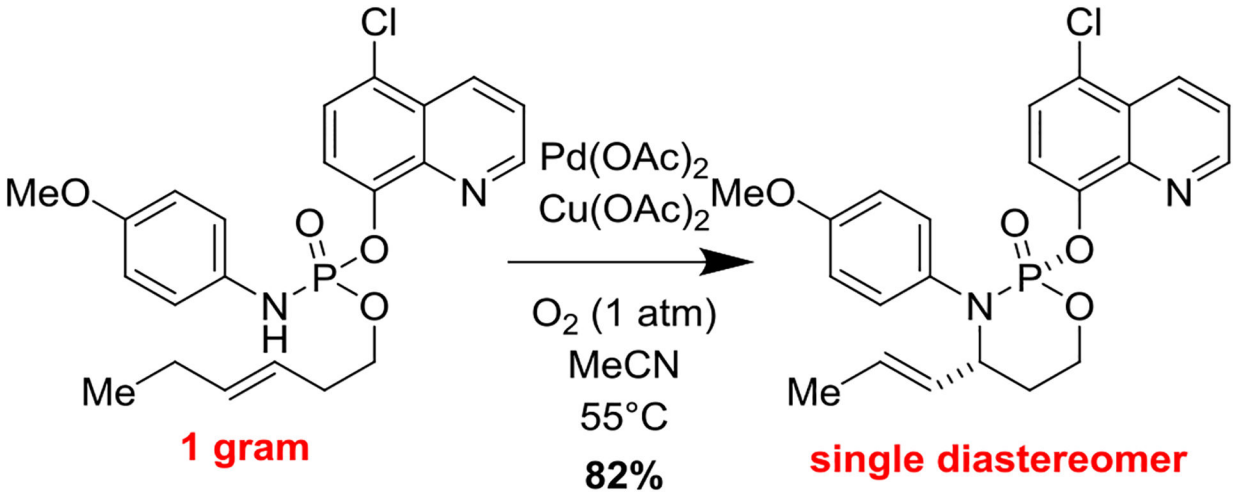




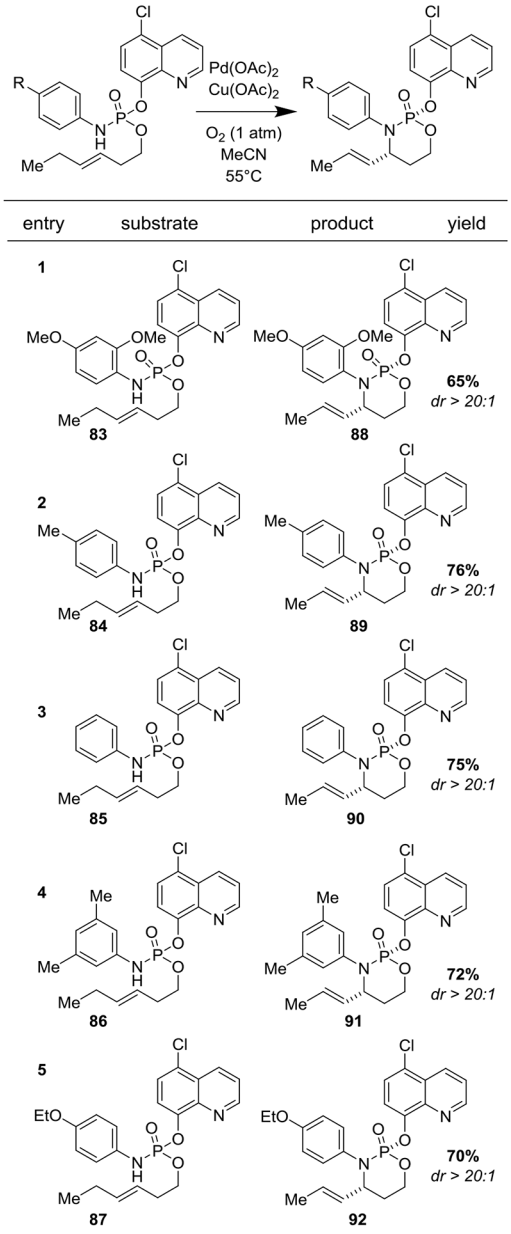
Scheme 7.

Substrate Scope with Auxiliary-Induced Diastereocontrol

Reaction conditions: $Pd(OAc)_2$ (20 mol%), $Cu(OAc)_2$ (1 equiv.), O_2 (1 atm), CH_3CN, 55 °C, 65 h



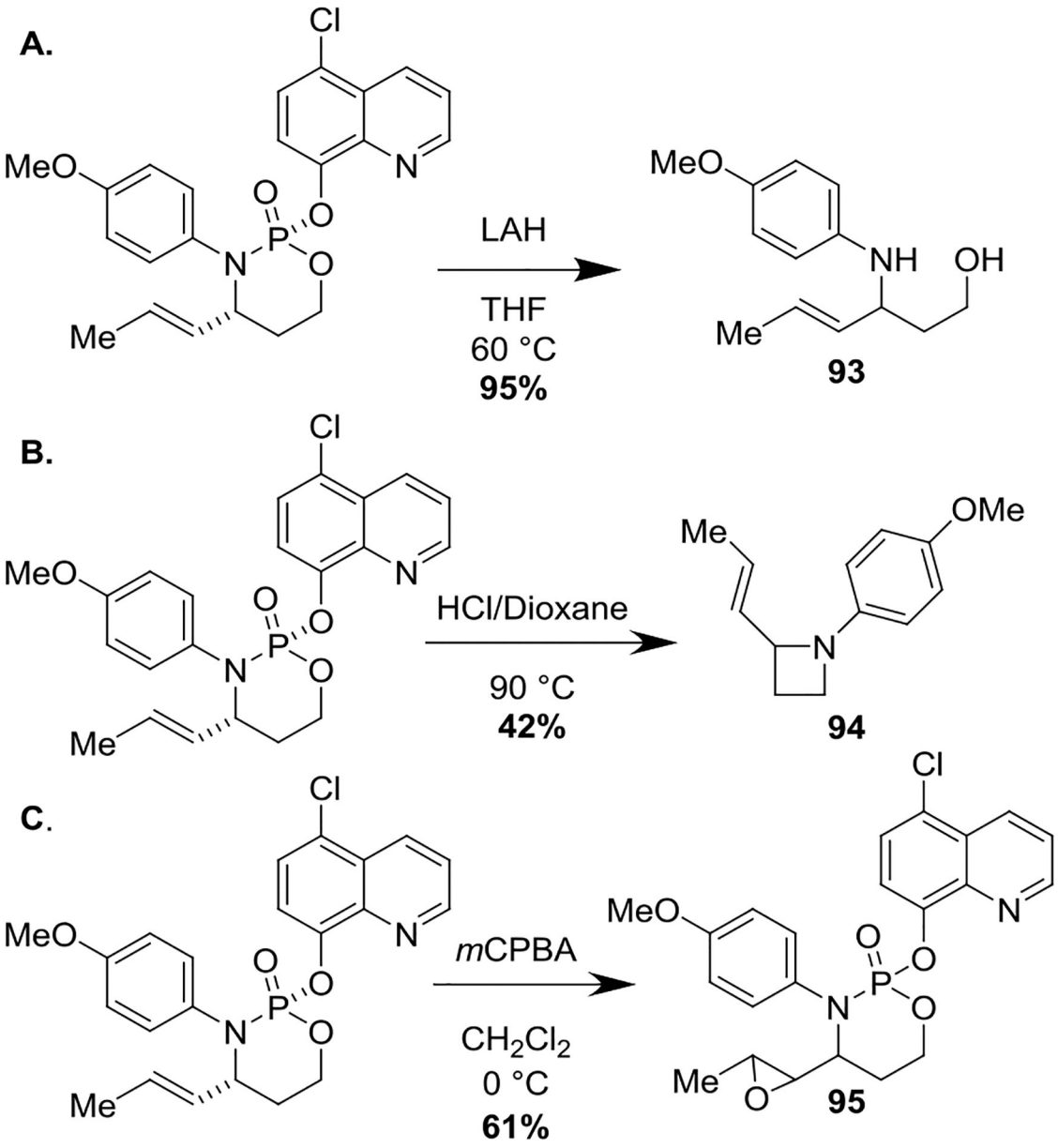
Scheme 8.
Oxidative cyclization scales successfully.



Scheme 9.

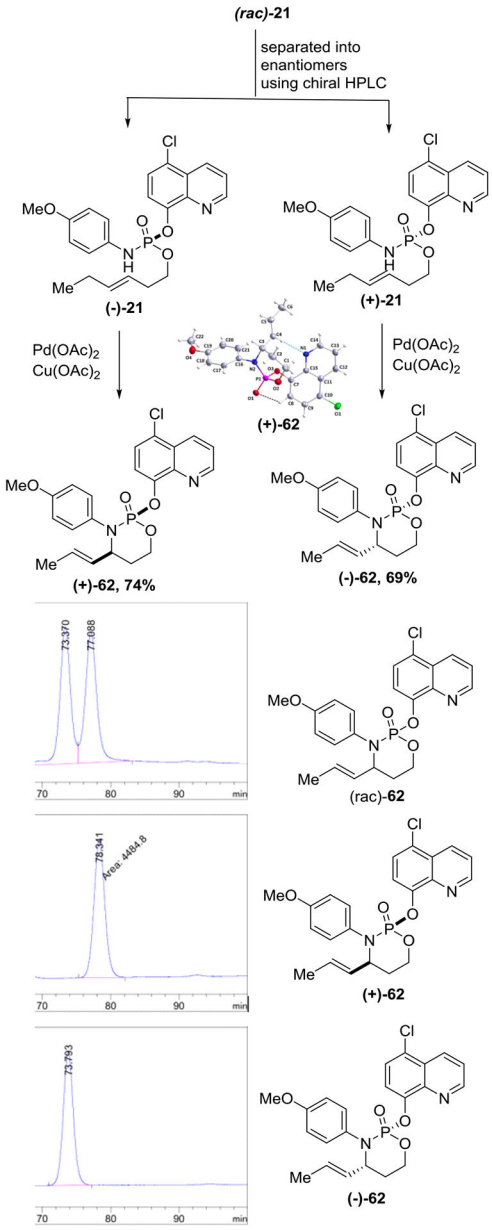
Aniline Scope with Auxiliary-Induced Diasterocontrol.

Reaction conditions: $Pd(OAc)_2$ (20 mol%), $Cu(OAc)_2$ (1 equiv.), O_2 (1 atm), CH_3CN, 55 °C, 65 h



Scheme 10.

A. Removal of the phosphorous tether using LAH reduction. **B.** Treatment with HCI/ Dioxane led to azetidine formation. **C.** Epoxidation proceeded smoothly with *m*CPBA. Please note that **95** is a single diasteromer, but the relative stereochemistry is unassigned.

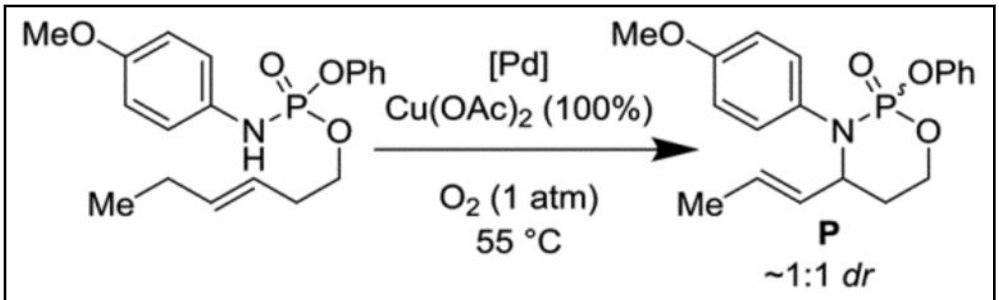


Scheme 11.

Chiral resolution and highly diastereoselective oxidative cyclization reactions afford enantiopure cyclic phosphoramidated. Note: CCDC 2061647

Table 1.

Reaction Optimization.



	[Pd] (mol%)	Solvent	Time	P/RSM[a]
1	$PdCl_2$ (20)	MeCN	17h	31/18
2	$Pd(TFA)_2$ (20)	MeCN	17h	36/23
3	$Pd_2(dba)_3$ (15)	MeCN	17h	53/30
4	$Pd_2(dba)_3$ (15)	DCE	17h	26/50
5	$Pd_2(dba)_3$ (15)	DMF	17h	20/80
6	$Pd_2(dba)_3$ (15)	DMSO	17h	30/70
7	$Pd_2(dba)_3$ (15)	EtOAc	17h	11/62
8	$Pd_2(dba)_3$ (10)	MeCN	40h	58/18
9	$Pd_2(dba)_3$ (10)	MeCN	65h	63/14
10	$Pd(OAc)_2$ (20)	MeCN	65h	73/10

[a]Percent product estimated from ^{1}H NMR integration with 1,3,5-trimethoxybenzene as an internal standard.