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Article

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J. Org. Chem., **Just Accepted Manuscript** • DOI: 10.1021/acs.joc.0c01570 • Publication Date (Web): 26 Aug 2020

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Thioether Ligand-Enabled Cationic Palladium(Ⅱ)-Catalyzed Electrophilic C-H Arylation of α,β-Unsaturated Oxime Ethers

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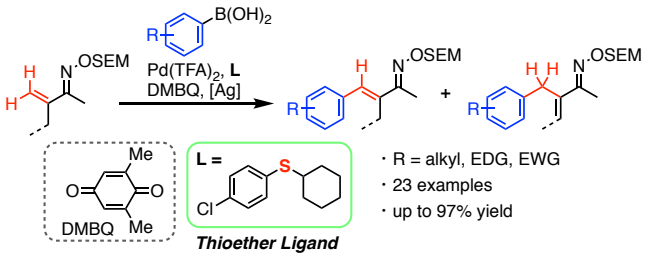
Supporting Information Placeholder



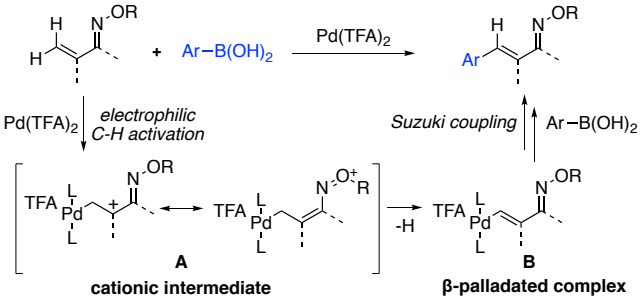
ABSTRACT: We show that cationic palladium(Ⅱ) catalyst realized electrophilic C-H arylation of α,β-unsaturated *O*-SEM oximes with arylboronic acids. This Pd-catalyed electrophilic C-H aryation is facilitated by the use of alkyl aryl thioether ligands, and optimization of the ligand structure greatly improves the yield. The resulting α,β-unsaturated oximes would provide access to multi-substituted heterocyclic compounds.

INTRODUCTION

α,β-Unsaturated oximes, easily prepared by the reaction of hydroxyl amine derivatives and α,β-unsaturated carbonyl compounds, have many applications in organic synthesis and related fields, and studies on the properties and reactivity of oxime derivatives have developed rapidly in the last few decades.[1] In particular, oxime is an excellent directing group, and various transition-metal-catalyzed transformations have been reported,[2] especially in the field of oxime-directed C-H activation, which can provide access to heterocyclic compounds.[2a] Examples include Rh-catalyzed pyridine synthesis,[3] Rh-catalyzed 2,3-dihydropyridine synthesis[4] and Rh- or Co-catalyzed furan and pyrrole synthesis.[5] Another notable property of oxime is its carbonyl umpolung (polarity reversal) reactivity.[6] Because of the electron-donating effect of the oxygen atom on the imine functionality, the HOMO level of the α,β-unsaturated oxime becomes higher, and hence its conjugated system shows a more electron-rich and more nucleophilic character as compared with the corresponding α,β-unsaturated carbonyl compounds.[6b]

Based upon its unique electronic properties, we assumed that α,β-unsaturated oximes react with cationic palladium species, such as $Pd(TFA)_2$, by electrophilic β-palladation to generate resonance-stabilized cationic intermediate **A** (Scheme 1).[6c-e] As a consequence, we envisioned that cationic palladated complex **A** should release β-proton to give β-palladated complex **B**,

Scheme 1. Conceptional Design of This Work; Pd-catalyzed Electrophilic C-H Arylation of α,β-Unsaturated Oximes.

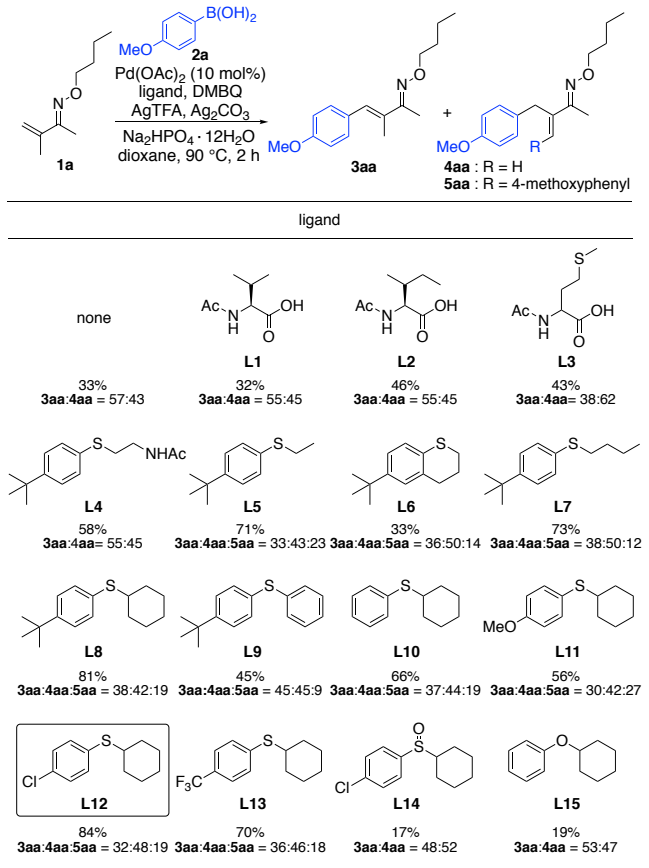


followed by Suzuki-type coupling reaction with arylboronic acid to give β-arylated product. To our knowledge, there are no examples of Pd-catalyzed electrophilic C-H functionalization of α,β-unsaturated oximes. Herein, we report the Pd-catalyzed electrophilic C-H arylation of α,β-unsaturated oxime with aryl boronic acid, featuring the use of alkyl aryl thioether ligands. This method would furnish β-selective C(alkenyl)-H arylation of α,β-unsaturated oximes.

RESULTS AND DISCUSSION

Initially, we examined the reaction of α,β-unsaturated *O*-*n*-butyl oxime **1a** with 4-methoxyphenylboronic acid (**2a**) as a coupling partner by employing 10 mol % of $Pd(OAc)_2$ as a catalyst, Ag_2CO_3 as an oxidant, $Na_2HPO_4{\cdot}12H_2O$ as a base and AgTFA as an additive in dioxane at 90 ℃ for 2 h. To our delight, the desired arylated products **3aa** and its double-bond isomer **4aa** were obtained as a 1.1:1 mixture in 21% yield. Encouraged this result, we conducted an extensive survey of Pd sources, oxidants, silver additives, and solvents. We found that the yield decreased to less than 5% in the absence of AgTFA, which suggests that *in situ*-generated cationic palladium trifluoroacetate is the active species for this C-H arylation. Next, we focused on a report that the addition of 1,4-benzoquinone (BQ) promotes the reductive elimination process in transition-metal-catalyzed couplings with aryl boronic acid,[7] and we examined the effect of adding BQ derivatives. However, the addition of BQ was not so effective and the product yield increased only to 25%, accompanied with troublesome substrate decomposition. Since 2,6-dimethyl-1,4-benzoquinone did not act as an oxidant, the decomposition of the substrate was suppressed, and the product yield improved to 33% (Table 1).

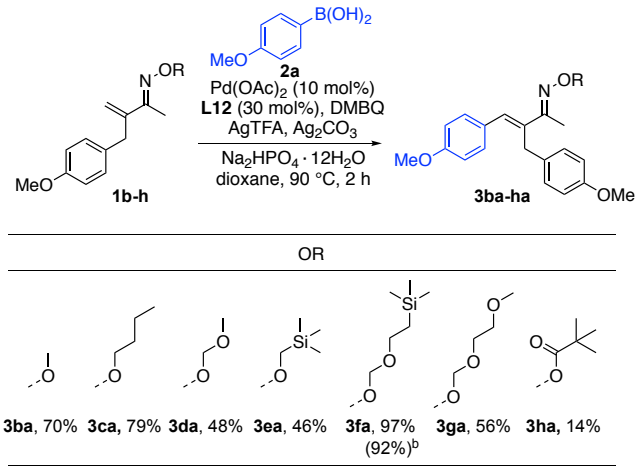
Table 1. Ligand Optimization[a]



[a] Reaction conditions: **1a** (0.2 mmol, 1.0 equiv.), **2a** (3.0 equiv.), $Pd(OAc)_2$ (10 mol%), ligand (30 mol%), Ag_2CO_3 (2.0 equiv.), AgTFA (40 mol%), $Na_2HPO_4{\cdot}12H_2O$ (1.5 equiv.), 2,6-dimethyl-1,4-benzoquinone (1.0 equiv.), dioxane (2.0 mL), 90 ℃, 2 h. Isolated yield.

Next, we tested mono-*N*-protected amino acid (MPAA) ligands **L1**-**L3**, known as useful ligands for C-H activation of tethered arenes (Table 1).[8] Although none of them did not improve the yield, methionine derivative **L3** changed the ratio of the products (**3aa** and **4aa**). This finding suggests that the sulfur atom of **L3** could influence the reaction mode via coordination to the Pd catalyst. To further examine the effect of sulfur-containing ligands, we prepared acetyl-protected aminoethyl thioether **L4**, recently reported by Yu and co-workers.[9] Fortunately, **L4** improved the reactivity and afforded the desired products in 58% yield. Surprisingly, the reaction employing ligand **L5** lacking an acetylamino group increased the yield of products to 71%, including **5aa**, which was probably produced by further arylation of **4aa**.[10] Thus, the use of **L5** significantly improved the reactivity. Recently, Carrow and co-workers have reported that thioether ligands affect the kinetics of Pd-catalyzed undirected C-H alkenylation of heteroarenes.[11] Thus, thioether ligands may dissociate aggregated states of Pd, leading to the generation of highly electrophilic reactive species, i.e., the monomeric thioether-Pd complex. To investigate the effect of ligand structure on the reaction efficiency, we carried out systematic ligand modification of **L5**. Thus, **L6**, with reduced steric hindrance around the sulfur atom, gave a poor product yield. Ligands with bulkier side chains, *n*-butyl (**L7**) and cyclohexyl (**L8**) groups, were also examined. Notably, cyclohexyl phenyl thioether **L8** significantly increased the reactivity and afforded 81% yield. On the other hand, replacement of the cyclohexyl group of **L8** with a phenyl group (**L9**) reduced the yield, suggesting the importance of the alkyl aryl thioether structure. Next, we focused on modification of the phenyl group (**L10**-**L13**). Among them, **L12** gave the best result, increasing the yield to 84%. Replacing the thioether with sulfoxide (**L14**) or ether (**L15**) led to loss of reactivity.

Table 2. Oxime Ether Optimization[a]

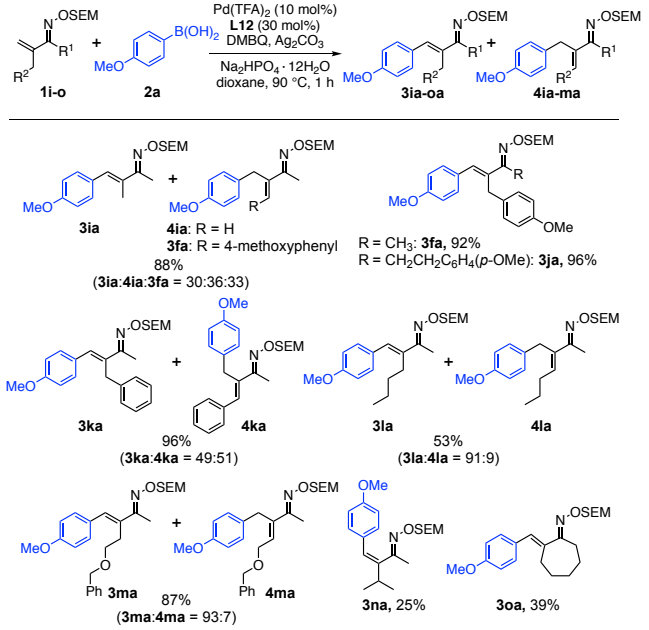


[a] Reaction conditions: **1** (0.1 mmol, 1.0 equiv.), **2a** (3.0 equiv.), $Pd(OAc)_2$ (10 mol%), **L12** (30 mol%), Ag_2CO_3 (2.0 equiv.), AgTFA (40 mol%), $Na_2HPO_4{\cdot}12H_2O$ (1.5 equiv.), 2,6-dimethyl-1,4-benzoquinone (30 mol%), dioxane (2.0 mL), 90 ℃, 2 h. Isolated yield. [b] Reaction conditions: **1** (0.1 mmol, 1.0 equiv.), **2a** (3.0 equiv.), $Pd(TFA)_2$ (10 mol%), **L12** (30 mol%), Ag_2CO_3 (2.0 equiv.), $Na_2HPO_4{\cdot}12H_2O$ (1.5 equiv.), 2,6-dimethyl-1,4-benzoquinone (30 mol%), dioxane (2.0 mL), 90 ℃, 2 h. Isolated yield.

With the electrophilic nature of the palladium species in mind, we turned our attention to modifying the oxime ether moiety. Since α,β-unsaturated oximes show reversed polarity compared to the carbonyl group, we thought it might be possible to change the electronic state of the conjugated system by tuning the structure of the oxime ether moiety. Using oxime derivative **1** as a pilot substrate, the structure-reactivity relationship of the oxime ether moiety was examined (Table 2). With *O*-methyl **1b** or *O*-*n*-butyl oxime **1c**, the arylated product **3ba** or **3ca** was obtained in 70% or 79% yield, respectively. *O*-Methoxymethyl oxime **1d** or *O*-methyl trimethylsilyl oxime **1e**, with a hetero atom-containing ether moiety did not improve the reactivity. However, with *O*-SEM oxime **1f**, the yield increased dramatically to 97%. On the other hand, the *O*-MEM oxime **1g**, in which the TMS group in the SEM group is replaced by the MeO group, was ineffective, suggesting that the structure of the SEM group is essential for high reactivity. This increased reactivity of **1f** may be due to the more electron-rich and more nucleophilic character of the conjugated system arising from the stronger electron-donating effect of the SEM oxy group in the imino functionality. As expected, *O*-pivaloyl derivative **1h** was significantly less reactive, presumably due to its electron-withdrawing character.

Ultimately, we discovered that the use of 10 mol % palladium trifluoroacetate as a catalyst, instead of the $Pd(OAc)_2$ / AgTFA system, along with 30 mol % DMBQ also worked well to afford the arylated product. Interestingly, in the absence of DMBQ, unexpected byproducts[12,13] presumably generated by the decomposition of **L12** were isolated, indicating that DMBQ as an additive not only promotes the reductive elimination process in the Pd-catalyzed arylation, but also suppresses the decomposition of the thioether ligand **L12**.

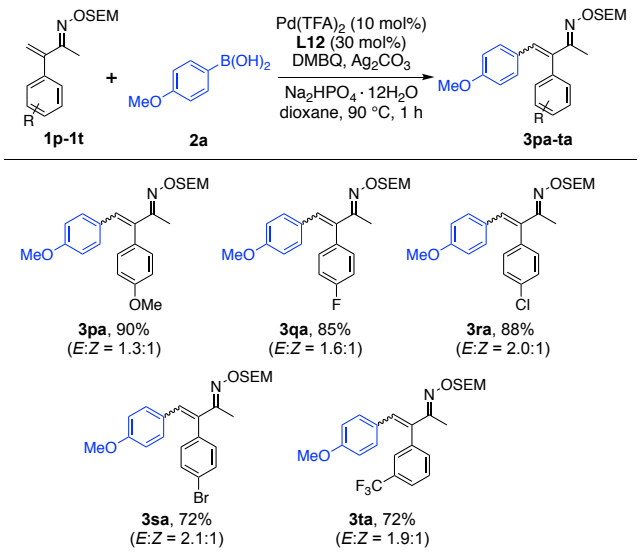
Table 3. α,β-Unsaturated Oxime Ether Scope[a]



[a] Reaction conditions: **1** (0.1 mmol, 1.0 equiv.), **2a** (3.0 equiv.), $Pd(TFA)_2$ (10 mol%), **L12** (30 mol%), Ag_2CO_3 (2.0 equiv.), $Na_2HPO_4{\cdot}12H_2O$ (1.5 equiv.), 2,6-dimethyl-1,4-benzoquinone (30 mol%), dioxane (2.0 mL), 90 ℃, 1 h. Isolated yield.

Having identified an effective catalyst system and reaction conditions, we next explored the substrate scope, using a range of α,β-unsaturated oximes (Table 3). Oxime **1i** lacking the R^2 substituent gave the arylation products in good yield (**3ia**, **4ia**, **3fa**). Formation of di-4-methoxyphenyl-substituted product **3fa** shows that aryl-substituted oximes are well tolerated. In the case of phenyl-substituted oxime **1k**, the arylated products **3ka** and **4ka** were obtained in 96% yield as a 49:51 mixture. This transformation of R^1-substituted oxime **1j** proceeded smoothly to give desired product **3ja** in excellent yield. Oximes **1l** and **1m** with linear alkyl substituents on R^2 were acceptable. Thus, arylation of *n*-butyl-substituted substrate **1l** gave the desired products (**3la** and **4la**) in 53% yield as a 91:9 mixture. Interestingly, reaction of substrate **1m** containing benzyl ether at the β-position proceeded smoothly and afforded the desired products (**3ma** and **4ma**) in 87% yield. The more sterically hindered α-isopropyl-substituted oxime **1n** gave 25% yield of *Z*-isomer (**3na**), presumably due to steric repulsion. The substrate cyclized at R^1 and R^2 **1o** was tolerated, and the desired product **3oa** was obtained in 39% yield as a single isomer.

Table 4. α-Phenyl Substituted Oxime Ether Scope[a]

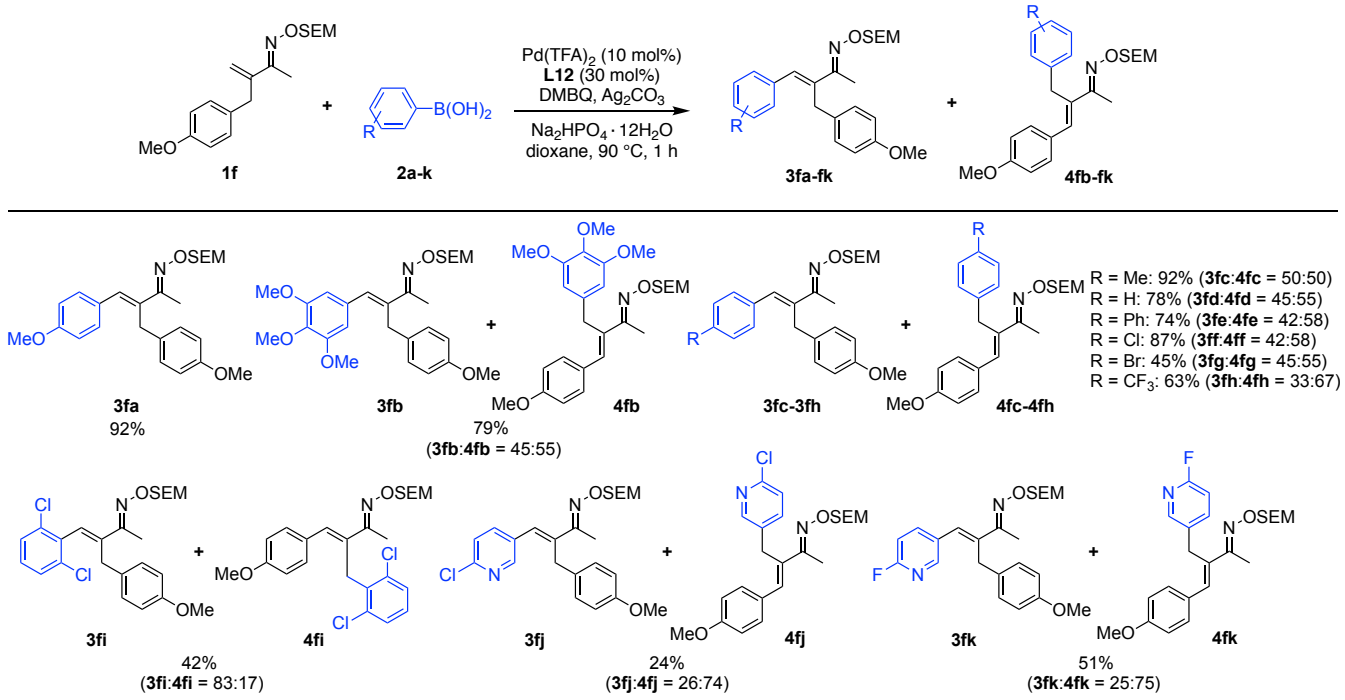


[a] Reaction conditions: **1** (0.1 mmol, 1.0 equiv.), **2a** (3.0 equiv.), $Pd(TFA)_2$ (10 mol%), **L12** (30 mol%), Ag_2CO_3 (2.0 equiv.), $Na_2HPO_4{\cdot}12H_2O$ (1.5 equiv.), 2,6-dimethyl-1,4-benzoquinone (30 mol%), dioxane (2.0 mL), 90 ℃, 1 h. Isolated yield.

This reaction also worked well with α-phenyl-substituted oximes (Table 4), giving the arylated products in excellent yields as mixtures of *E*/*Z* isomers. Varying the substituents on the phenyl group of **1** showed that a wide range of substituents such as an electron-donating group (**1p**), halogens (**1q-1s**), and an electron-withdrawing group (**1t**) were well tolerated and afforded the desired products in good yield.

Next, we explored the scope of boronic acids (Table 5). The coupling of **1f** with electron-donating or electron-neutral boronic acids gave the desired products in good yield (**3fa-3fe** and **4fb-4fe**), and the products were obtained as a mixture of two isomers. Furthermore, this reaction worked well with a variety of electron-withdrawing arylboronic acids (**2f-2h**), affording moderate to good yields.

Table 5. Boronic Acid Scope[a]

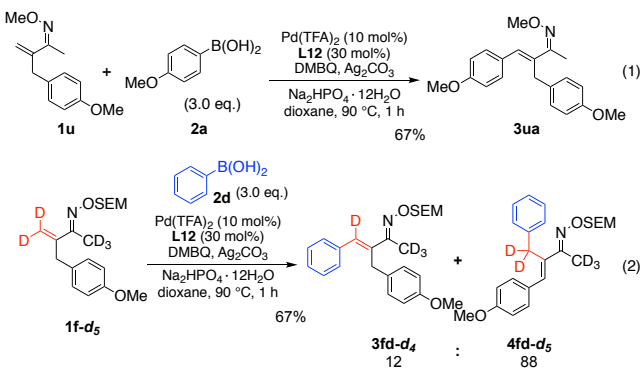


[a] Reaction conditions: **1f** (0.1 mmol, 1.0 equiv.), **2** (3.0 equiv.), $Pd(TFA)_2$ (10 mol%), **L12** (30 mol%), Ag_2CO_3 (2.0 equiv.), $Na_2HPO_4{\cdot}12H_2O$ (1.5 equiv.), 2,6-dimethyl-1,4-benzoquinone (30 mol%), dioxane (2.0 mL), 90 ℃, 1 h. Isolated yield.

Thus, 4-chlorophenyl and 4-trifluoromethylphenyl boronic acids **2f** and **2h** coupled well with oxime **1f** to give the corresponding arylated products in 87% (**3ff** and **4ff**) and 62% (**3fh** and **4fh**) yield, respectively. Even labile 4-bromophenyl boronic acid **2g** gave the arylated products **3fg** and **4fg** in moderate yield. Pleasingly, sterically hindered 2,6-dichlorophenyl boronic acid **2i** was also acceptable, although the yield was only moderate (**3fi** and **4fi**). In general, heteroaryl compounds having strong coordination ability often deactivate Pd catalysts. Even so, less Lewis-basic pyridines, such as 2-chloro- and 2-fluoropyridines afforded the heteroarylated products (**3fj**, **4fj** and **3fk**, **4fk**), suggesting that substrates with weak coordination ability could be used in this arylation reaction.

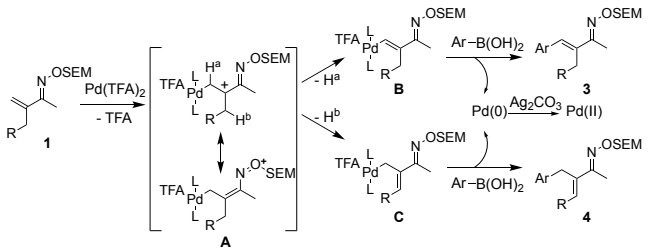
Some additional experiments were conducted to gain insight into the reaction mechanism (Scheme 2). Initially, we assumed that the reaction was an oxime-directed C-H activation that was triggered by coordination of the Pd catalyst to the nitrogen atom of the α,β-unsaturated oxime. However, even the *Z*-isomer of *O*-methyl oxime **1u** afforded the arylated product **3ua** in 67% yield, comparable to the yield of the *E*-isomer (70%), with retention of *Z*-geometry of the oxime moiety (Scheme 2, eq. 1 vs Table 2, **3ba**). This result indicates that coordination of the Pd catalyst to the oxime nitrogen is not essential for this C-H arylation. An isotope-labeling experiment provided valuable insight into the reaction mechanism (Scheme 2, eq. 2). When the reaction was performed with β-deuterated oxime (**1f-*d*$_5$**), the product isomer ratio of **3fd-*d*$_4$** and **4fd-*d*$_5$** was 12:88, which was drastically different from that obtained from unlabeled oxime **1f** (**3fd**:**4fd** = 45:55, Table 5). This result clearly indicates that this reaction involves a deprotonation event at the oxime β-position, and that the ease of C-H bond cleavage of the β-proton is largely related to the product distribution of the two isomers.

Scheme 2. Mechanistic Experiment

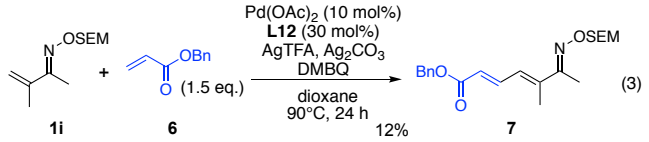


Based on these observations, we propose the following catalytic cycle involving the cationic intermediate **A** stabilized by the electron-donating effect of the imine functionality (Scheme 3).[6,14] Thus, the oxime **1** reacts with cationic palladium species to generate cationic intermediate **A**, which kinetically releases proton H^a or H^b to give vinyl palladium **B** or allyl palladium (or π-allyl complex) **C**, respectively.[10] Complexes **B** and **C** undergo Suzuki-type coupling reaction with arylboronic acid to yield products **3** and **4**, and then oxidation of the Pd(0) species with Ag oxidant regenerates the active catalyst. This step should be rapid, since brominated products **3sa** (Table 4), **3fg** and **4fg** (Table 5) were obtained. The result of the deuterated labeling experiment (Scheme 2) is consistent with this electrophilic metalation followed by deprotonation process.

Scheme 3. Proposed Reaction Mechanism



In accordance with the above proposal, treatment of **1i** with acrylate **6** under the same reaction conditions afforded azatriene **7** in 12% yield, probably through Heck-type reaction via β-palladated complex **B** (eq. 3). Further mechanistic studies will be required in order to confirm the mechanism of this counterintuitive C-H arylation reaction.



CONCLUSION

In conclusion, we have developed an efficient Pd-catalyzed electrophilic C-H arylation of α,β-unsaturated *O*-SEM oximes. Substantial effects of alkyl aryl thioether ligands and 2,6-dimethyl-1,4-benzoquinone were observed, and systematic ligand modification led to **L12** as the optimal structure. Since the products **3** and **4** still have α,β-unsaturated oxime moieties, they can be converted into various heterocycles.[15] Therefore this method provides easy access to multi-substituted heterocyclic compounds from α,β-unsaturated oximes. Current investigation is directed to detailed mechanistic insights into the generation of β-palladated cationic intermediate stabilized by the electron-donating effect of the oxime ether moiety.

EXPERIMENTAL SECTION

General Information. ^{1}H and ^{13}C NMR spectra were recorded with JEOL JNM-ECZ400S or BRUKER AV300M spectrometer at room temperature, with tetramethylsilane ($\delta = 0$) as an internal standard ($CDCl_3$ solution). Chemical shifts were expressed in ppm, and coupling constants (*J*) in Hz. Infrared (IR) spectra were recorded with a Shimadzu FTIR-8200A spectrometer. Mass spectra were recorded on JEOL JMS-700 and JMS-T100LP spectrometers. Melting points were determined by using a Yanaco melting point apparatus MP-S3. Merck silica gel 60 (1.09385) and Merck silica gel 60 F254 were used for column chromatography and thin layer chromatography (TLC), respectively.

Preparation of Thioether Ligands. Ligands **L1**, **L2**, **L3**, **L9** and **L15** were purchased from commercially sources and used without further purification. Ligands **L4**, **L5**, **L6**, **L7**, **L8**, **L10**, **L11**, **L12**, **L13** and **L14** were synthesized according to the experimental section.

Procedure for the Synthesis of L4. *N-(2-((4-(tert-butyl)phenyl)thio)ethyl)acetamide (**L4**)*. NEt_3 (0.14 mL, 2.0 eq.) and Ac_2O (80 mg, 1.6 eq.) were added to the solution of 2-((4-(tert-butyl) phenyl)thio)ethan-1-amine (100 mg, 0.48 mmol, 1.0 eq.) in CH_2Cl_2 (2.5 mL) and the reaction mixture was stirred at room temperature for overnight. After completion, the reaction mixture was concentrated in vacuo, and the resulting mixture was purified by flash column chromatography on silica gel (hexane : AcOEt = 3 : 1) to afford the title compound (61 mg, 50% yield) as white solid. mp 57-58 ℃; IR (KBr) 3465, 2360, 1651, 1557, 1275, 750 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.33 (4H, s), 5.88 (1H, br), 3.45 (2H, m), 3.03 (2H, t, J = 6.0 Hz), 1.93 (3H, s), 1.30 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.1, 150.1, 131.2, 130.2, 126.2, 38.7, 34.5, 34.1, 31.2, 23.2; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{14}H_{21}NOS$ 251.1344; Found 251.1335.

Procedure for the Synthesis of L5. *4-(tert-butyl)phenyl ethyl sulfane (**L5**)*. To a solution of 4-*tert*-butyl benzenethiol (341 mg, 2.1 mmol, 1.0 eq.) in MeOH (6 mL) were added KOH (118 mg, 1.0 eq.) and iodoethane (0.17 mL, 1,0 eq.). After the resulting mixture was stirred at room temperature for 12 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo* to afford the title compound (400 mg, 98% yield) as colorless oil. IR (KBr) 2963, 2868, 1497, 1458, 1362, 1267, 1121, 1013, 821, 749, 547 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.31 (2H, d, *J* = 9.0 Hz), 7.27 (2H, d, *J* = 9.0 Hz), 2.91 (2H, q, *J* = 7.2 Hz), 1.30 (3H, t, *J* = 7.2 Hz), 1.30 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 149.1, 133.0, 129.3, 125.8, 34.4, 31.3, 28.1, 14.5 ; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{12}H_{18}S$ 194.1129; Found 194.1129.

Procedure for the Synthesis of L6. *6-(tert-butyl)thiochromane (**L6**)*. To a solution of 3-((4-(*tert*-butyl)phenyl)thio)propanoic acid (100 mg, 0.42 mmol, 1.0 eq.) in CH_2Cl_2 (2 mL) were added oxalyl chloride (2.0 eq.) and catalytic DMF. After the resulting mixture was stirred at room temperature for 30 min, the reaction mixture was concentrated in *vacuo*. The residue was dissolved in HFIP and stirred at room temperature for overnight. After completion, the solvent was removed in *vacuo* and the resulting residue was purified by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) to afford 6-(*tert*-butyl)thiochroman-4-one (90 mg, 98% yield) as white solid. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.15 (1H, d, *J* = 2.4 Hz), 7.44 (1H, dd, *J* = 8.1 Hz, 2.4 Hz), 7.22 (1H, d, *J* = 8.1 Hz), 3.22 (2H, m), 2.98 (2H, m), 1.31 (9H, s). To a solution of 6-(*tert*-butyl)thiochroman-4-one (90 mg, 0.26 mmol, 1.0 eq.) in TFA (1.4 mL) was added Et_3SiH (350 mg, 3.0 eq.). After the resulting mixture was stirred at 100 ℃ (silicone oil bath) for 2 h, the reaction was concentrated in *vacuo*. The resulting residue was purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the title compound (54 mg, 63% yield) as colorless oil. IR (KBr) 2958, 1482, 1361, 1275, 1262, 1120, 1061, 815, 749 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.10 (1H, dd, *J* = 8.4 Hz, 2.4 Hz), 7.03 (1H, s), 7.01 (1H, d, *J* = 8.4 Hz), 3.01 (2H, m), 2.81 (2H, m), 2.10 (2H, m), 1.28 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 147.0, 133.2, 129.4, 127.0, 126.2, 123.7, 34.2, 31.3, 30.0, 27.5, 23.1; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{13}H_{18}S$ 206.1129; Found 206.1127.

Procedure for the Synthesis of L7. *butyl-4-(tert-butyl)phenyl sulfane (**L7**)*. To a solution of 4-*tert*-butyl benzenethiol (200 mg, 1.23 mmol, 1.0 eq.) in MeOH (4 mL) were added KOH (90 mg, 1.3 eq.) and 1-iodobutane (0.18 mL, 1,3 eq.). After the resulting mixture was stirred at room temperature for 12 h, the reaction was quenched with water. The aqueous layer was

extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo* to afford the title compound (270 mg, quant.) as colorless oil. IR (KBr) 2959, 1503, 1463, 1395, 1363, 1260, 1120, 1013, 817, 749, 551, 439 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.28 (4H, m), 2.90 (2H, t, J = 7.2 Hz), 1.61 (2H, dt, J = 7.2 Hz, 8.1 Hz), 1.44 (2H, dd, J = 7.2 Hz, 8.1 Hz), 1.30 (9H, s), 0.92 (3H, t, J = 7.2 Hz); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 148.9, 133.4, 129.1, 125.8, 34.4, 33.7, 31.34, 31.28, 21.9, 13.6; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{14}H_{22}S$ 222.1442; Found 222.1445.

Procedure for the Synthesis of L8. *4-(tert-butyl)phenyl cyclohexyl sulfane (**L8**)*. To a solution of 4-*tert*-butyl benzenethiol (200 mg, 1.23 mmol, 1.0 eq.) in DMF (5 mL) were added K_2CO_3 (340 mg, 2.0 eq.) and cyclohexyl bromide (300 mg, 1.5 eq.). After the resulting mixture was stirred at 100 ℃ (silicone oil bath) for 18 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the title compound (287 mg, 66% yield) as colorless oil. IR (KBr) 2929, 2852, 2489, 1448, 1266, 1120, 1013, 827, 749, 557 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.28-7.20 (4H, m), 2.98 (1H, m), 1.92-1.88 (2H, m), 1.71-1.66 (2H, m), 1.55-1.52 (1H, m), 1.30-1.16 (5H, m), 1.30 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 149.9, 132.1, 131.4, 125.7, 46.8, 34.5, 33.4, 31.3, 26.1, 25.8; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{16}H_{24}S$ 248.1599; Found 248.1598.

Procedure for the Synthesis of L10. *Cyclohexyl phenyl sulfane (**L10**)*. To a solution of benzenethiol (100 mg, 0.91 mmol, 1.0 eq.) in DMF (4 mL) were added K_2CO_3 (252 mg, 2.0 eq.) and cyclohexyl bromide (223 mg, 1.5 eq.). After the resulting mixture was stirred at 100 ℃ (silicone oil bath) for 21 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the title compound (121 mg, 69% yield) as colorless oil. IR (KBr) 2929, 2852, 1583, 1479, 1447, 1263, 1090, 1024, 997, 749, 691, 497 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.40 (2H, d, J = 8.1 Hz), 7.38-7.20 (3H, m), 3.10 (1H, m), 2.02-1.95 (2H, m), 1.79-1.74 (2H, m), 1.64-1.60 (1H, m), 1.43-1.25 (5H, m); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 135.2, 131.8, 128.7, 126.5, 46.5, 33.3, 26.0, 25.7; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{12}H_{16}S$ 192.0973; Found 192.0970.

Procedure for the Synthesis of L11. *Cyclohexyl 4-methoxyphenyl sulfane (**L11**)*. To a solution of 4-methoxybenzenethiol (200 mg, 1.43 mmol, 1.0 eq.) in DMF (6 mL) were added K_2CO_3 (395 mg, 2.0 eq.) and cyclohexyl bromide (350 mg, 1.5 eq.). After the resulting mixture was stirred at 100 ℃ (silicone oil bath) for 24 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 20 : 1) to afford the title compound (228 mg, 72% yield) as colorless oil. IR (KBr) 2929, 2852, 1591, 1492, 1448, 1284, 1243, 1171, 1032, 827, 748, 641, 529 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.38 (2H, d, J = 6.6 Hz), 6.83 (2H, d, J = 6.6 Hz), 3.80 (3H, s), 2.89 (1H, m), 1.96-1.90 (2H, m), 1.76-1.71 (2H, m), 1.62-1.57 (1H, m), 1.40-1.21 (5H, m); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.3, 135.6, 125.0, 114.2, 55.3, 47.9, 33.3, 26.1, 25.7; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{13}H_{18}OS$ 222.1078; Found 222.1080.

Procedure for the Synthesis of L12. *4-chlorophenyl cyclohexyl sulfane (**L12**)*. To a solution of 4-chlorobenzenthiol (200 mg, 1.38 mmol, 1.0 eq.) in DMF (4 mL) were added K_2CO_3 (381 mg, 2.0 eq.) and cyclohexyl bromide (338 mg, 1.5 eq.). After the resulting mixture was stirred at 100 ℃ (silicone oil bath) for 24 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the title compound (283 mg, 91% yield) as colorless oil. IR (KBr) 2930, 2852, 1475, 1448, 1388, 1263, 1201, 1094, 1012, 997, 886, 819, 746, 550, 495 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.31 (2H, d, J = 8.7 Hz), δ 7.24 (2H, d, J = 8.7 Hz), 3.08 (1H, m), δ 2.00-1.90 (2H, m), δ 1.80-1.70 (2H, m), δ 1.65-1.55 (1H, m), δ 1.38-1.30 (5H, m); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 133.6, 133.2, 132.7, 128.9, 46.9, 33.2, 26.0, 25.7; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{12}H_{15}ClS$ 226.0583; Found 226.0580.

Procedure for the Synthesis of L13. *Cyclohexyl-4-trifluoromethylphenyl sulfane (**L13**)*. To a solution of 4-trifluoromethylbenzenethiol (200 mg, 1.12 mmol, 1.0 eq.) in DMF (3 mL) were added K_2CO_3 (310 mg, 2.0 eq.) and cyclohexyl bromide (274 mg, 1.5 eq.). After the resulting mixture was stirred at 100 ℃ (silicone oil bath) for 24 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the title compound (258 mg, 88% yield) as colorless oil. IR (KBr) 2933, 2855, 1606, 1449, 1401, 1325, 1263, 1163, 1124, 1095, 1063, 1013, 824, 749 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.51 (2H, d, J = 8.1 Hz), 7.41 (2H, d, J = 8.1 Hz), 3.26 (1H, m), 2.10-1.98 (2H, m), 1.81-1.77 (2H, m), 1.67-1.63 (1H, m), 1.50-1.30 (5H, m); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 141.2, 129.7, 125.6, 125.5, 45.6, 33.1, 25.9, 25.7; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{13}H_{15}F_3S$ 260.0847; Found 260.0844.

Procedure for the Synthesis of L14. *1-chloro-4-(cyclohexylsulfinyl)benzene (**L14**)*. To a solution of (4-chlorophenyl)(cyclohexyl)sulfane (100 mg, 0.44 mmol) in CH_2Cl_2 (4.5 mL) was added *m*CPBA (76 mg, 1.0 eq.) at 0 ℃. After the resulting mixture was stirred at 0 ℃ for 15 min, the reaction was quenched with saturated $NaHCO_3$ aq. The aqueous layer was extracted with $CHCl_3$ and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 1 : 1) to afford the title compound (97 mg, 91% yield) as white solid. mp 94-96 ℃; IR (KBr) 3463, 2932, 2855, 1644, 1474, 1450, 1390, 1275, 1078, 1041, 1010, 825, 749, 527 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.50 (4H, m), 2.55 (1H, m), 1.90-1.76 (4H, m), 1.70-1.60 (1H, m), 1.50-1.17 (5H, m); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 140.4, 137.0, 129.2, 126.3, 63.2, 26.2, 25.5, 25.3, 23.8; HRMS (EI-quadrupole) m/z: $[M]^+$ Calcd for $C_{12}H_{15}ClOS$ 242.0532; Found 242.0536.

Procedure for the Synthesis of 1b and 1u. *3-(4-methoxybenzyl)but-3-en-2-one O-methyl oxime (**1b, 1u**)*. To a solution of 3-(4-methoxybenzyl)but-3-en-2-one (120 mg, 0.63 mmol, 1.0 eq.) in MeOH (3 mL) and H_2O (0.3 mL) were added *O*-methyl hydroxylamine hydrochloride (68 mg, 1.3 eq.) and NaOAc (52 mg, 1.0 eq.). After the reaction mixture was stirred at 80 ℃ (silicone oil bath) for 30 min, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) to afford the title compound (**1b**, colorless oil, 121 mg, 87% yield) with a small amount of *Z*-isomer (**1u,** colorless oil, 16 mg, 12%). **1b**: IR (KBr) 2936, 2833, 1611, 1584, 1510, 1463, 1440, 1299, 1246, 1176, 1125, 1051, 900, 820, 749, 641, 522 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.14 (2H, d, J = 8.7 Hz), 6.81 (2H, d, J = 8.7 Hz), 5.40 (1H, s), 5.08 (1H, s), 3.91 (3H, s), 3.78 (3H, s), 3.62 (2H, s), 1.95 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.8, 154.5, 145.6, 132.3, 130.3, 117.0, 113.5, 61.8, 55.2, 37.3, 10.8; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{13}H_{17}NO_2$ 219.1259; Found 219.1251. **1u**: IR (KBr) 2952, 1606, 1505, 1248, 1105, 997, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.09 (2H, d, J = 8.7 Hz), 6.82 (2H, d, J = 8.7 Hz), 5.09 (1H, s), 5.03 (1H, s), 3.84 (3H, s), 3.79 (3H, s), 3.57 (2H, s), 1.78 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.2, 156.2, 145.7, 130.6, 130.0, 115.1, 113.7, 61.5, 55.2, 40.1, 21.7; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{13}H_{17}NO_2$ 219.1259; Found 219.1251.

Procedure for the Synthesis of 1h. *(E)-3-(4-methoxybenzyl)but-3-en-2-one O-pivaloyl oxime (**1h**)*. To a solution of (*E*)-3-(4-methoxybenzyl)but-3-en-2-one oxime (40 mg, 0.16 mmol, 1.0 eq.) in CH_2Cl_2 (3.2 mL) were added PivCl (25 mg, 1.3 eq.) and NEt_3 (32 mg, 2.0 eq.). After the reaction mixture was stirred at 0 ℃ for 30 min, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 10/1) to afford the title compound (32 mg, 69%) as colorless oil. IR (KBr) 2968, 1758, 1511, 1275, 1105, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.19 (2H, d, J = 8.7 Hz), 6.83 (2H, d, J = 8.7 Hz), 5.62 (1H, s), 5.26 (1H, s), 3.78 (3H, s), 3.72 (2H, s), 2.12 (3H, s), 1.31 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 174.9, 162.6, 158.0, 145.3, 131.2, 130.6, 120.7, 113.6, 55.1, 38.8, 37.3, 27.2, 12.6; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{17}H_{23}NO_3$ 289.1678; Found 289.1682.

General Procedure for the Synthesis of *O*-substituted *α,β*-unsaturated oximes 1a,c-g. To a solution of *α,β*-unsaturated oxime (1.0 eq.) in DMF (1.0 M) were added NaH (63% dispersion in mineral oil, 1.5 eq.) and alkyl halide (1.3 eq.). After the reaction mixture was stirred at room temperature for 1 h, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel to afford the desired *O*-substituted *α,β*-unsaturated oxime ether.

*(E)-3-methylbut-3-en-2-one O-butyl oxime (**1a**)*. The compound was prepared according to the general procedure for the synthesis of *O*-substituted *α,β*-unsaturated oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the title compound (577 mg, 31% yield) as colorless oil. IR (KBr) 2991, 1275, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.30 (1H, s), δ 5.20 (1H, s), δ 4.11 (2H, t, J = 6.6 Hz), δ 1.98 (3H, s), δ 1.94 (3H, s), δ 1.65 (2H, m), δ 1.41 (2H, m), δ 0.94 (3H, t, J = 7.2 Hz); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 155.2, 141.7, 115.9, 73.8, 31.3, 19.2, 19.1, 13.9, 10.4; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_9H_{17}NO$ 155.1310; Found 155.1302.

*(E)-3-(4-methoxybenzyl)but-3-en-2-one O-butyl oxime (**1c or 4aa**)*. The compound was prepared according to the general procedure for the synthesis of *O*-substituted *α,β*-unsaturated oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 20 :1) to afford the title compound (124 mg, 98% yield) as colorless oil.IR (KBr) 2957, 1612, 1510, 1463, 1246, 1176, 1039, 901, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.13 (2H, d, J = 8.7 Hz), 6.81 (2H, d, J = 8.7 Hz), 5.39 (1H, s), 5.09 (1H, s), 4.10 (2H, t, J = 6.6 Hz), 3.77 (3H, s), 3.62 (2H, s), 1.96 (3H, s), 1.62 (2H, m), 1.36 (2H, m), 0.92 (3H, t, J = 7.2 Hz); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.8, 154.0, 145.8, 132.4, 130.2, 116.6, 113.5, 73.9, 55.2, 37.4, 31.3, 19.2, 13.9, 10.9; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{16}H_{23}NO_2$ 261.1729; Found 261.1715.

*(E)-3-(4-methoxybenzyl)but-3-en-2-one O-methoxymethyl oxime (**1d**)*. The compound was prepared according to the general procedure for the synthesis of *O*-substituted *α,β*-unsaturated oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 10 :1) to afford the title compound (84 mg, 69% yield) as colorless oil. IR (KBr) 2937, 1510, 1246, 1158, 1001, 891, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.13 (2H, d, J = 8.7 Hz), 6.81 (2H, d, J = 8.7 Hz), 5.47 (1H, s), 5.15 (2H, s), 5.13 (1H, s), 3.77 (3H, s), 3.64 (2H, s), 3.40 (3H, s), 2.03 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.8, 156.1, 145.4, 132.0, 130.2, 117.8, 113.5, 98.7, 56.5, 55.2, 37.3, 11.2; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{14}H_{19}NO_3$ 249.1365; Found 249.1361.

*(E)-3-(4-methoxybenzyl)but-3-en-2-one O-((trimethylsilyl)methyl) oxime (**1e**)*. The compound was prepared according to the general procedure for the synthesis of *O*-substituted *α,β*-unsaturated oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 20 :1) to afford the title compound (138 mg, 96% yield) as colorless oil. IR (KBr) 2955, 1612, 1510, 1437, 1246, 1176, 1037, 932, 859, 763, 701 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.14 (2H, d, J = 8.7 Hz), 6.82 (2H, d, J = 8.7 Hz), 5.39 (1H, s), 5.03 (1H, s), 3.89 (2H, s), 3.78 (3H, s), 3.62 (2H, s), 1.96 (3H, s), 0.09 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.8, 154.3, 145.7, 132.3, 130.3, 116.6, 113.5, 68.3, 55.2, 37.2, 10.7, -2.75; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{16}H_{25}NO_2Si$ 291.1655; Found 291.1648.

*(E)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1f**)*. The compound was prepared according to the general procedure for the synthesis of *O*-substituted *α,β*-unsaturated oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 20 :1) to afford the title compound (430 mg, 94% yield) as colorless oil. IR (KBr) 2952, 1612, 1510, 1463, 1246, 1176, 1105, 1038, 999, 893, 857, 835, 751 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.14 (2H, d, J = 8.7 Hz), 6.82 (2H, d, J = 8.7 Hz), 5.46 (1H, s), 5.22 (2H, s), 5.12 (1H, s), 3.78 (3H, s), 3.70 (2H, m), 3.65 (2H, s), 2.02 (3H, s), 0.95 (2H, m), 0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.8, 155.7, 145.5, 132.1, 130.2, 117.6, 113.5, 97.2, 66.4, 55.1, 37.3, 18.1, 11.2, -1.44; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{18}H_{29}NO_3Si$ 335.1917; Found 335.1911.

*(E)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-methoxyethoxy)methyl) oxime (**1g**)*. The compound was prepared according to the general procedure for the synthesis of *O*-substituted *α,β*-unsaturated oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 5 :1) to afford the title compound (72 mg, 83% yield) as colorless oil. IR (KBr) 2930, 1661, 1510, 1462, 1246, 1175, 1107, 1000, 893, 851, 750, 515 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.12 (2H, d, J = 8.7 Hz), 6.80 (2H, d, J = 8.7 Hz), 5.47 (1H, s), 5.25 (2H, s), 5.17 (1H, s), 3.78 (3H, s), 3.66 (2H, m), 3.48 (2H, m), 3.37 (3H, s), 2.02 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.8, 155.8, 145.2, 132.1, 130.0, 118.0, 113.5, 97.9, 71.7, 68.4, 59.0, 55.1, 37.5, 11.2; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{16}H_{23}NO_4$ 293.1627; Found 293.1624.

General Procedure for the Synthesis of *α,β*-unsaturated *O*-SEM oximes 1i-t. To a solution of *α,β*-unsaturated oxime (1.0 eq.) in DMF (1.0 M) were added NaH (63% dispersion in mineral oil, 1.5 eq.) and SEMCl (1.3 eq.). After the reaction mixture was stirred at room temperature for 30 min, the reaction was quenched with water. The aqueous layer was extracted with AcOEt and the combined organic layers were washed with brine, dried over Na_2SO_4, filtered and concentrated in *vacuo*. The crude product was purified by flash column chromatography on silica gel to afford the desired *α,β*-unsaturated oxime SEM ethers.

*(E)-3-methylbut-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1i**)*. The compound was prepared according to the general procedure for the synthesis of *α,β*-unsaturated *O*-SEM oximes, purified by flash column chromatography on silica gel (hexane : AcOEt = 20 : 1) to afford the title compound (848 mg, 3.70 mmol, 62% yield) as colorless oil. IR (KBr) 2984, 1275, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.34 (1H, s), δ 5.24 (1H, m), δ 5.21 (2H, s), δ 3.73 (2H, m), δ 2.01 (3H, s), δ 1.94 (3H, s), δ 0.95 (2H, m), δ 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.7, 141.4, 116.8, 97.1, 66.5, 19.1, 18.1, 10.7, -1.48; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{11}H_{23}NNaO_2Si$ 252.1396; Found 252.1393.

*(E)-2-(4-methoxybenzyl)-5-(4-methoxyphenyl)pent-1-en-3-oneO-((2-(trimethylsilyl) ethoxy) methyl) oxime (**1j**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-2-(4-methoxybenzyl)-5-(4-methoxyphenyl)pent-1-en-3-one oxime (65 mg, 0.20 mmol) was converted to the title compound (colorless oil, 90 mg, quant.), and purified by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1). IR (KBr) 2951, 1612, 1511, 1246, 1176, 1105, 1037, 997, 835, 750, 518 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.12 (2H, d, J = 8.7 Hz), 7.09 (2H, d, J = 9.0 Hz), 6.81 (2H, d, J = 8.7 Hz), 6.80 (2H, d, J = 9.0 Hz), 5.45 (1H, s), 5.21 (2H, s), 5.13 (1H, s), 3.79 (6H, s), 3.69 (2H, m), 3.62 (2H, s), 2.81-2.65 (4H, m), 0.96 (2H, m), 0.01 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8, 157.9, 157.8, 144.4, 133.7, 132.1, 130.3, 129.2, 117.6, 113.8, 113.5, 97.3, 66.4, 55.3, 55.2, 37.5, 31.9, 27.8, 18.1, -1.40; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{26}H_{37}NNaO_4Si$ 478.2389; Found 478.2377.

*(E)-3-benzylbut-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1k**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-benzylbut-3-en-2-one oxime (50 mg, 0.29 mmol) was converted to the title compound (colorless oil, 85 mg, 97% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1). IR (KBr) 2988, 2956, 1275, 1105, 1005, 862, 837, 750, 702, 408 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.28-7.16 (5H, m), 5.47 (1H, s), 5.19 (2H, s), 5.12 (1H, s), 3.69 (2H, s), 3.67 (2H, m), 2.01 (3H, s), 0.93 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 155.7, 145.2, 140.1, 129.3, 128.1, 125.8, 117.9, 97.2, 66.4, 38.2, 18.1, 11.2, -1.42; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{17}H_{27}NO_2Si$ 305.1811; Found 305.1806.

*(E)-3-methyleneheptan-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1l**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-methyleneheptan-2-one oxime (165 mg, 1.17 mmol) was converted to the title compound (colorless oil, 257 mg, 81% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1). IR (KBr) 2955, 1260, 1105, 1001, 835, 750, 442, 417 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.35 (1H, s), 5.22 (1H, s), 5.21 (2H, s), 3.72 (2H, m), 2.35 (2H, td, J = 7.2 Hz, 0.9 Hz), 2.00 (3H, s), 1.44 (2H, m), 1.32 (2H, m), 0.98 (2H, m), 0.95 (3H, t, J = 8.4 Hz), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.1, 146.0, 115.8, 97.1, 66.6, 32.0, 30.9, 22.5, 18.2, 14.0, 11.2, -1.46; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{14}H_{29}NNaO_2Si$ 294.1865; Found 294.1857.

*(E)-5-(benzyloxy)-3-methylenepentan-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1m**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-5-(benzyloxy)-3-methylenepentan-2-one oxime (30 mg, 0.14 mmol) was converted to the title compound (colorless oil, 40 mg, 79% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1). IR (KBr) 2953, 1722, 1275, 1107, 994, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.33-7.24 (5H, m), 5.45 (1H, s), 5.34 (1H, s), 5.18 (2H, s), 4.51 (2H, s), 3.69 (2H, m), 3.63 (2H, t, J = 6.9 Hz), 2.71 (2H, td, J = 6.9 Hz, 0.9 Hz), 2.00 (3H, s), 0.93 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 155.8, 142.3, 138.6, 128.3, 127.5, 127.4, 117.9, 97.2, 72.6, 69.3, 66.5, 32.8, 18.1, 11.0, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{19}H_{31}NNaO_3Si$ 372.1971; Found 372.1969.

*(E)-4-methyl-3-methylenepentan-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1n**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-4-methyl-3-methylenepentan-2-one oxime (50 mg, 0.39 mmol) was converted to the title compound (colorless oil, 82 mg, 82% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1). IR (KBr) 2957, 1260, 1104, 1000, 898, 836, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.33 (1H, s), 5.22 (1H, s), 5.21 (2H, s), 3.72 (2H, m), 3.02 (1H, m), 2.01 (3H, s), 1.07 (6H, d, J = 6.6 Hz), 0.95 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.1, 152.4, 113.1, 97.1, 66.5, 28.6, 22.3, 18.2, 11.9, -1.47; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{13}H_{27}NO_2Si$ 257.1811; Found 257.1820.

*(E)-2-methylenecycloheptan-1-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1o**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-2-methylenecycloheptan-1-one oxime (130 mg, 0.93 mmol) was converted to the title compound (colorless oil, 183 mg, 73% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1). IR (KBr) 2926, 1451,1248, 1142, 1101, 1001, 890, 859, 835, 750, 420 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 5.31 (1H, s), 5.18 (2H, s), 4.93 (1H, s), 3.71 (2H, m), 2.58 (2H, m), 2.34 (2H, m), 1.61 (6H, m), 0.95 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 163.8, 146.0, 114.5, 96.8,

66.2, 35.3, 31.0, 29.8, 27.7, 25.6, 18.1, -1.45; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{14}H_{27}NNaO_2Si$ 292.1708; Found 292.1699.

*(E)-3-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1p**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-(4-methoxyphenyl)but-3-en-2-one oxime (90 mg, 0.51 mmol) was converted to the title compound (colorless oil, 128 mg, 78% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 20 : 1). IR (KBr) 2952, 1608, 1510, 1248, 1176, 1102, 998, 902, 834, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25 (2H, d, *J* = 8.7Hz), 6.83 (2H, d, *J* = 8.7Hz), 5.44 (1H, s), 5.38 (1H, s), 5.20 (2H, s), 3.79 (3H, s), 3.69 (2H, m), 2.02 (3H, s), 0.94 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.3, 157.7, 145.8, 131.0, 129.2, 116.1, 113.4, 97.1, 66.5, 55.2, 18.2, 13.8, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{27}NNaO_3Si$ 344.1658; Found 344.1653.

*(E)-3-(4-fluorophenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1q**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-(4-fluorophenyl)but-3-en-2-one oxime (80 mg, 0.45 mmol) was converted to the title compound (colorless oil, 142 mg, quant.), and purified by flash column chromatography on silica gel (hexane : AcOEt = 20 : 1). IR (KBr) 2953, 1509, 1260, 1104, 997, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.29 (2H, dd, *J* = 8.7 Hz, 5.4Hz), 6.98 (2H, dd, *J* = 9.0 Hz, 8.7Hz,), 5.54 (1H, s), 5.42 (1H, s), 5.18 (2H, s), 3.68 (2H, m), 2.05 (3H, s,), 0.94 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 164.1, 160.8, 157.1, 145.5, 134.8, 129.9, 117.8, 115.0, 114.7, 97.2, 66.6, 18.1, 13.3, -1.46; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{24}FNNaO_2Si$ 332.1458; Found 332.1448.

*(E)-3-(4-chlorophenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1r**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-(4-chlorophenyl)but-3-en-2-one oxime (300 mg, 1.53 mmol) was converted to the title compound (colorless oil, 425 mg, 85% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1). IR (KBr) 2952, 1490, 1248, 1094, 997, 907, 833, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.27-7.25 (4H, m), 5.57 (1H, s), 5.44 (1H, s), 5.18 (2H, s), 3.67 (2H, m), 2.05 (3H, s,), 0.93 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.8, 145.5, 137.3, 133.6, 129.6, 128.1, 118.2, 97.2, 66.7, 18.1, 13.2, -1.46; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{24}ClNNaO_2Si$ 348.1163; Found 348.1150.

*(E)-3-(4-bromophenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1s**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-(4-bromophenyl)but-3-en-2-one oxime (100 mg, 0.42 mmol) was converted to the title compound (colorless oil, 153 mg, 98% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1). IR (KBr) 2953, 1487, 1377, 1248, 1105, 996, 938, 859, 834, 750, 693 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.44 (2H, d, *J* = 8.7 Hz), δ 7.20 (2H, d, *J* = 8.7 Hz), 5.58 (1H, s), 5.46 (1H, s), 5.18 (2H, s), 3.67 (2H, m), 2.06 (3H, s,), 0.94 (2H, m), 0.01 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.8, 145.5, 137.8, 131.1, 130.0, 121.8, 118.3, 97.2, 91.5, 66.7, 18.2, 13.2, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{16}H_{24}BrNNaO_2Si$ 392.0657, 394.0637; Found 392.0645, 394.0618.

*(E)-3-(3-(trifluoromethyl)phenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**1t**)*. Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-(3-(trifluoromethyl)phenyl)but-3-en-2-one oxime (150 mg, 0.65 mmol) was converted to the title compound (colorless oil, 220 mg, 94% yield), and purified by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1). IR (KBr) 2954, 1671, 1437, 1329, 1275, 1250, 1167, 1128, 1073, 996, 912, 859, 935, 801, 749, 700, 417 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.61-7.40 (4H, m), 5.68 (1H, s), 5.53 (1H, s), 5.18 (2H, s), 3.67 (2H, m), 2.11 (3H, s,), 0.94 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 156.4, 145.5, 139.8, 131.8, 130.5, 130.1, 128.3, 125.4, 124.3, 119.2, 97.3, 66.7, 18.1, 12.8, -1.50; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{17}H_{24}F_3NNaO_2Si$ 382.1426; Found 382.1410.

General Procedure for Pd-catalyzed *β*-Arylation of *α,β*-unsaturated oximes. General Procedure A: To a solution of *α,β*-unsaturated oxime **1** (0.1 mmol), arylboronic acid **2** (3.0 eq.), Ag_2CO_3 (2.0 eq.), AgTFA (0.4 eq.), $Na_2HPO_4 \cdot 12\ H_2O$ (1.5 eq.), **L12** (30 mol%), 2,6-dimethyl-1,4-benzoquinone (30 mol%) in dioxane (2.0 mL) was added $Pd(OAc)_2$ (10 mol%). After stirring at 90 ℃ (silicone oil bath) for 2 h, the reaction mixture was diluted with AcOEt and filtered through a Celite® pad (rinsed with AcOEt). The filtrate was concentrated in *vacuo*, and the crude product was purified by flash column chromatography on silica gel. **General Procedure B**: To a solution of *α,β*-unsaturated oxime **1** (0.1 mmol), arylboronic acid **2** (3.0 eq.), Ag_2CO_3 (2.0 eq.), $Na_2HPO_4 \cdot 12\ H_2O$ (1.5 eq.), **L12** (30 mol%), 2,6-dimethyl-1,4-benzoquinone (30 mol%) in dioxane (2.0 mL) was added $Pd(TFA)_2$ (10 mol%). After stirring at 90 ℃ (silicone oil bath) for 1 h, the reaction mixture was diluted with AcOEt and filtered through a Celite® pad (rinsed with AcOEt). The filtrate was concentrated in *vacuo*, and the crude product was purified by flash column chromatography on silica gel.

Representative Procedure for Ligand Optimization using *α,β*-unsaturated oxime 1a. *(2E,3E)-4-(4-methoxyphenyl)-3-methylbut-3-en-2-one O-butyl oxime (**3aa**)*. To a solution of (*E*)-3-methylbut-3-en-2-one *O*-butyl oxime **1a** (31 mg, 0.2 mmol, 1.0 eq.), 4-methoxyphenyl boronic acid **2a** (0.6 mmol. 3.0 eq.), Ag_2CO_3 (0.4 mmol. 2.0 eq.), AgTFA (0.08 mmol, 0.4 eq.), $Na_2HPO_4 \cdot 12H_2O$ (0.3 mmol, 1.5 eq.), 2,6-dimethyl-1,4-benzoquinone (0.2 mmol, 1.0 eq.), **L12** (0.06 mmol, 30 mol%) in dioxane 2 mL was added $Pd(OAc)_2$ (0.02 mmol, 10 mol%) at room temperature. After resulting mixture was stirred at 90 °C (silicone oil bath) for 2 h, the reaction mixture was filtered through a Celite® pad (rinsed with AcOEt) and the filtrate was concentrated in *vacuo*. The crude product was purified by column chromatography on silica gel (hexane : AcOEt = 30 : 1) to afford the desired arylated compounds **3aa** (14.1 mg, 27%), **4aa** (21.4 mg, 41%), and **5aa** (11.8 mg, 16%). **3aa**: Colorless oil. IR (KBr) 2958, 1606, 1509, 1275, 1258, 1037, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.27 (2H, d, *J* = 8.7 Hz), 6.90 (2H, d, *J* = 8.7 Hz), 6.78 (1H, s), 4.14 (2H, t, *J* = 6.6 Hz), 3.83 (3H, s), 2.09 (3H, s), 2.08 (3H, s), 1.69 (2H, m), 1.42 (2H, m), 0.96 (3H, t, *J* = 7.2 Hz); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.5, 156.7, 133.8, 130.7, 130.1, 129.5, 113.6, 73.9, 55.3, 31.4, 19.3, 14.3, 14.0, 10.9; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{16}H_{22}NO_2$ 260.1651; Found 260.1655.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-methyl oxime (**3ba**)*. Following the general

procedure A on 0.14 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded the title compound **3ba** (colorless oil, 32 mg, 70% yield) with a small amount of *Z*-isomer **3ua** (*E*/*Z* isomer ratio was 2.6:1). **3ba**: IR (KBr) 3466, 2358, 1608, 1509, 1275, 1259, 1176, 1044, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.24 (2H, d, *J* = 8.4 Hz), 7.10 (2H, d, *J* = 8.7 Hz), 6.98 (1H, s), 6.83 (2H, d, *J* = 8.4 Hz), 6.81 (2H, d, *J* = 8.4 Hz), 3.94 (2H, s), 3.83 (3H, s), 3.78 (3H, s), 3.77 (3H, s), 2.07 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8, 157.6, 155.7, 135.9, 132.7, 131.2, 130.2, 129.4, 129.1, 113.8, 113.6, 61.8, 55.20, 55.16, 32.2, 11.3; HRMS (EI-quadrupole) *m*/*z*: $[M]^+$ Calcd for $C_{20}H_{23}NO_3$ 325.1678; Found 325.1679.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-butyl oxime (**3ca or 5aa**)*. Following the general procedure A on 0.11 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded the title compound (colorless oil, 32 mg, 79% yield). IR (KBr) 2956, 1606, 1509, 1247, 1176, 1035, 750, 420 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.24 (2H, d, *J* = 8.7 Hz), 7.09 (2H, d, *J* = 9.0 Hz), 6.97 (1H, s), 6.84 (2H, d, *J* = 8.7 Hz), 6.80 (2H, d, *J* = 9.0 Hz), 4.02 (2H, t, *J* = 6.6 Hz), 3.93 (2H, s), 3.79 (3H, s), 3.78 (3H, s), 2.08 (3H, s), 1.50 (2H, m), 1.28 (2H, m), 0.86 (3H, t, *J* = 7.2 Hz); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8, 157.5, 155.2, 136.3, 133.0, 131.0, 130.2, 129.6, 129.1, 113.8, 113.6, 73.8, 55.24, 55.22, 32.3, 31.3, 19.1, 13.9, 11.3; HRMS (EI-quadrupole) *m*/*z*: $[M]^+$ Calcd for $C_{23}H_{29}NO_3$ 367.2147; Found 367.2144.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-methoxymethyl oxime (**3da**)*. Following the general procedure A on 0.12 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded the title compound (colorless oil, 19.5 mg, 48% yield). IR (KBr) 2932, 1606, 1509, 1462, 1246,1177, 1154, 1086, 1033, 999, 892, 749, 535 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25 (2H, d, *J* = 6.6 Hz), 7.09 (2H, d, *J* = 8.7 Hz), 7.04 (1H, s), 6.84 (2H, d, *J* = 8.7 Hz), 6.79 (2H, d, *J* = 8.7 Hz), 5.08 (2H, s), 3.95 (2H, s), 3.79 (3H, s), 3.77 (3H, s), 3.27 (3H, s), 2.14 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.0, 157.6, 157.1, 135.6, 132.6, 132.1, 130.3, 129.3, 129.0, 113.8, 113.7, 98.8, 56.7, 55.3, 55.2, 32.3, 11.7; HRMS (EI-quadrupole) *m*/*z*: $[M]^+$ Calcd for $C_{21}H_{25}NO_4$ 355.1784; Found 355.1775.

(2*E*,3*E*)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one *O*-((trimethylsilyl)methyl) oxime (**3ea**). Following the general procedure A on 0.10 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded the title compound (colorless oil, 18.2 mg, 46% yield). IR (KBr) 3453, 2360, 1607, 1509, 1275, 1260, 1035, 859, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.23 (2H, d, *J* = 8.7 Hz), 7.11 (2H, d, *J* = 8.7 Hz), 6.97 (1H, s), 6.83 (2H, d, *J* = 8.7 Hz), 6.81 (2H, d, *J* = 8.7 Hz), 3.94 (2H, s), 3.82 (2H, s), 3.790 (3H, s), 3.788 (3H, s), 2.07 (3H, s), 0.03 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8, 157.5, 155.4, 135.9, 132.7, 131.0, 130.2, 129.6, 129.1, 113.7, 113.6, 68.2, 55.2, 32.1, 11.2, -2.77; HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{23}H_{31}NNaO_3Si$ 420.1971; Found 420.1965.

(2*E*,3*E*)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one *O*-((2-(trimethylsilyl) ethoxy) methyl) oxime (**3fa**). Following the **general procedure A** on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded the title compound (colorless oil, 38 mg, 97% yield). Following the **general procedure B** on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded the title compound (colorless oil, 36.3 mg, 92% yield). IR (KBr) 2951, 1607, 1509, 1463, 1247, 1176, 1105, 1035, 997, 894, 858, 835, 750, 539 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, 3) δ 7.24 (2H, d, *J* = 8.7 Hz), 7.10 (2H, d, *J* = 8.7 Hz), 7.03 (1H, s), 6.85 (2H, d, *J* = 8.7 Hz), 6.80 (2H, d, *J* = 8.7 Hz), 5.14 (2H, s), 3.96 (2H, s), 3.79 (3H, s), 3.78 (3H, s), 3.59 (2H, m), 2.14 (2H, s), 0.88 (2H, m), -0.01 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 158.9, 157.6, 156.8, 135.7, 132.6, 131.9, 130.2, 129.3, 129.1, 113.8, 113.7, 97.2, 66.5, 55.2, 55.1, 32.2, 18.1, 11.6, -1.43; HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{25}H_{35}NNaO_4Si$ 464.2233; Found 464.2211.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-methoxyethoxy)methyl) oxime (**3ga**)*. Following the general procedure A on 0.10 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 3 : 1) afforded the title compound (colorless oil, 21.7 mg, 56% yield). IR (KBr) 2930, 1606, 1509, 1462, 1247, 1176, 1107, 1032, 998, 894, 750, 536 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.26 (2H, d, *J* = 8.7 Hz), 7.10 (1H, s), 7.06 (2H, d, *J* = 6.3 Hz), 6.84 (2H, d, *J* = 8.7 Hz), 6.79 (2H, d, *J* = 6.3 Hz), 5.17 (2H, s), 3.94 (2H, s), 3.79 (3H, s), 3.77 (3H, s), 3.45 (2H, m), 3.36-3.33 (2H, m), 3.33 (3H, s), 2.14 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 159.0, 157.6, 156.7, 135.4, 132.7, 132.3, 130.2, 129.2, 129.0, 113.8, 113.6, 97.9, 71.7, 68.5, 58.9, 55.3, 55.2, 32.3, 11.6 ; HRMS (EI-quadrupole) *m*/*z*: $[M]^+$ Calcd for $C_{23}H_{29}NO_5$ 399.2046; Found 399.2046.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-pivaloyl oxime (**3ha**)*. Following the general procedure A on 0.07 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded the title compound (colorless oil, 4.3 mg, 14% yield). IR (KBr) 2917, 1752, 1604, 1509, 1245, 1176, 1105, 1028, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.28 (2H, d, *J* = 9.0 Hz), 7.18 (1H, s), 7.15 (2H, d, *J* = 8.7 Hz), 6.86 (2H, d, *J* = 8.7 Hz), 6.82 (2H, d, *J* = 9.0 Hz), 4.00 (2H, s), 3.80 (3H, s), 3.77 (3H, s), 2.16 (3H, s), 1.28 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 174.9, 164.7, 159.3, 157.8, 134.8, 134.5, 131.5, 130.5, 130.4, 129.4, 128.7, 113.9, 113.8, 55.2, 38.8, 32.5, 29.7, 27.3, 13.4; HRMS (EI-quadrupole) *m*/*z*: $[M]^+$ Calcd for $C_{24}H_{29}NO_4$ 395.2097; Found 395.2096.

*(2E,3E)-4-(4-methoxyphenyl)-3-methylbut-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3ia**)*. Following the general procedure B on 0.13 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3ia** (colorless oil, 11.7 mg, 27% yield), **4ia** (colorless oil, 14.3 mg, 32% yield) and **3fa** (colorless oil, 17 mg, 29% yield). **3ia**: IR (KBr) 2953, 1607, 1509, 1466, 1250, 1178, 1104, 998, 893, 859, 835, 750, 531 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.26 (2H, d, *J* = 9.0 Hz), 6.88 (2H, d, *J* = 9.0 Hz), 6.81 (1H, s), 5.23 (2H, s), 3.80 (3H, s), 3.74 (2H, m), 2.11 (3H, s), 2.08 (3H, s), 0.96 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.6, 158.2, 133.4, 130.7, 130.3, 129.8, 113.6, 97.0, 66.5, 55.2, 18.1, 14.3, 11.2, -1.45; HRMS (ESI-TOF) *m*/*z*: $[M + Na]^+$ Calcd for $C_{18}H_{29}NNaO_3Si$ 358.1814; Found 358.1810.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3ja**)*. Following the general procedure B on 0.07 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded **3ja** (colorless oil, 39.6 mg, 96% yield). IR (KBr) 2952, 1607, 1509, 1463, 1246, 1177, 1105, 1035, 997, 834, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.26-7.12 (6H, m), 6.97 (1H, s), 6.88-6.80 (6H, m), 5.16 (2H, s), 3.94 (2H, s), 3.81 (6H, s), 3.79 (3H, s), 3.62 (2H, m), 2.91-2.87 (2H, m), 2.81-2.77 (2H, m), 0.90 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 159.8, 158.9, 158.0, 157.6, 134.6, 133.7, 132.6, 132.0, 130.6, 130.3, 129.9, 129.3, 129.1, 129.0, 113.8, 113.6, 97.3, 66.4, 55.25, 55.22, 55.1, 32.2, 32.0, 27.8, 18.1, -1.40; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{33}H_{43}NNaO_5Si$ 584.2808; Found 584.2790.

*(2E,3E)-3-benzyl-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3ka** or **4fd**), (2E,3E)-3-(4-methoxybenzyl)-4-phenylbut-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**4ka** or **3fd**)*. Following the general procedure B on 0.10 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3ka** (colorless oil, 18.9 mg, 46% yield) and **4ka** (colorless oil, 20.7 mg, 50% yield) as inseparable mixture.

*(E)-3-((E)-4-methoxybenzylidene)heptan-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3la**), (2E,3E)-3-(4-methoxybenzyl)hept-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**4la**)*. Following the general procedure B on 0.15 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3la** (colorless oil, 27.1 mg, 48% yield) and **4la** (colorless oil, 2.7 mg, 5% yield). **3la**: IR (KBr) 2956, 2363, 1509, 1250, 1176, 1105, 1000, 834, 749, 671, 428 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25 (2H, d, *J* = 8.7 Hz), 6.90 (2H, d, *J* = 8.7 Hz), 6.75 (1H, s), 5.25 (2H, s), 3.83 (3H, s), 3.75 (2H, m), 2.55 (2H, m), 2.11 (3H, s), 1.53 (2H, m), 1.36 (2H, m), 0.98 (2H, m), 0.94 (3H, t, *J* = 5.7 Hz), 0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.6, 157.4, 138.7, 130.2, 129.9, 129.8, 113.7, 97.2, 66.5, 55.2, 31.5, 27.2, 23.0, 18.2, 13.9, 11.7, -1.41; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{35}NNaO_3Si$ 400.2284; Found 400.2275. **4la**: IR (KBr) 2955, 2360, 1638, 1509, 1259, 1105, 998, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.11 (2H, d, *J* = 8.7 Hz), 6.76 (2H, d, *J* = 8.7 Hz), 5.99 (1H, t, *J* = 7.2 Hz), 5.15 (2H, s), 3.76 (3H, s), 3.72 (2H, s), 3.63 (2H, m), 2.23 (2H, m), 1.99 (3H, s), 1.44 (2H, m), 0.95-0.87 (5H, m), -0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.5, 156.6, 136.3, 133.9, 133.0, 129.2, 113.5, 97.1, 66.3, 55.2, 31.3, 30.8, 22.6, 18.1, 13.9, 11.4, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{35}NNaO_3Si$ 400.2284; Found 400.2294.

*(E)-5-(benzyloxy)-3-((E)-4-methoxybenzylidene)pentan-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3ma**), (2E,3E)-5-(benzyloxy)-3-(4-methoxybenzyl)pent-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**4ma**)*. Following the general procedure B on 0.086 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded **3ma** and **4ma** (colorless oil, 34 mg, **3ma** : **4ma** = 93 : 7, 87% yield) as inseparable mixture. **3ma**, **4ma**: IR (KBr) 2952, 1606, 1509, 1251, 1178, 1100, 998, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, detectable signals from **4ma** are marked with an asterisk.) δ 7.37-7.32 (7H, m), 7.07* (2H, d, *J* = 8.7 Hz), 6.89 (1H, s), 6.88 (2H, d, *J* = 8.7 Hz), 6.77* (2H, d, *J* = 8.7 Hz), 6.16* (1H, m), 5.22 (2H, s), 5.17* (2H, s), 4.52 (2H, s), 4.27* (1H, d, *J* = 6.0 Hz), 3.83 (3H, s), 3.76-3.69 (4H, m), 2.96 (2H, t, *J* = 7.2 Hz), 2.11 (3H, s), 2.01* (3H, s), 0.96 (2H, m), 0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8, 157.1, 138.8, 134.3, 132.3, 130.5, 129.3, 128.3, 127.5, 127.4, 113.7, 97.3, 72.6, 69.3, 66.5, 55.3, 28.0, 18.2, 11.4, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{26}H_{37}NNaO_4Si$ 478.2390; Found 478.2375.

*(E)-3-((Z)-4-methoxybenzylidene)-4-methylpentan-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3na**)*. Following the general procedure B on 0.12 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded **3na** (colorless oil, 10.5 mg, 25% yield). IR (KBr) 2957, 1607, 1509, 1254, 1177, 1103, 1002, 858, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.21 (2H, d, *J* = 8.4 Hz), 6.80 (2H, d, *J* = 8.4 Hz), 6.33 (1H, s), 5.24 (2H, s), 3.79 (3H, s), 3.73 (2H, m), 2.69 (1H, m), 1.84 (3H, s), 1.14 (6H, d, *J* = 6.9 Hz), 0.96 (2H, m), 0.01 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.4, 158.6, 143.6, 129.8, 129.6, 125.6, 113.6, 96.8, 66.1, 55.2, 35.7, 21.5, 18.2, 16.9, -1.43; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{20}H_{33}NNaO_3Si$ 386.2127; Found 386.2123.

*(E)-2-((E)-4-methoxybenzylidene)cycloheptan-1-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3oa**)*. Following the general procedure B on 0.11 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded **3oa** (colorless oil, 16 mg, 39% yield). IR (KBr) 2925, 1509, 1275, 1259, 1001, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.29 (2H, d, *J* = 8.7 Hz), 6.87 (2H, d, *J* = 8.7 Hz), 6.72 (1H, s), 5.23 (2H, s), 3.81 (3H, s), 3.75 (2H, m), 2.66-2.50 (4H, m), 1.70-1.60 (6H, m), 0.99 (2H, m), 0.01 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 165.7, 158.5, 137.2, 130.4, 129.7, 127.9, 113.7, 113.6, 96.8, 66.2, 55.2, 30.5, 29.9, 28.3, 27.7, 25.0, 18.1, -1.39; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{33}NNaO_3Si$ 398.2127; Found 398.2121.

*(2E,3E)-3,4-bis(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (E-**3pa**), (2E,3Z)-3,4-bis(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (Z-**3pa**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded (*E*)-**3pa** (colorless oil, 19.2 mg, 50% yield) and (*Z*)-**3pa** (colorless oil, 15.3 mg, 40% yield). (*E*)-**3pa**: IR (KBr) 2952, 1606, 1511, 1462, 1248,1177, 1099, 1034, 998, 833, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.09 (2H, d, *J* = 8.7 Hz), 6.93 (2H, d, *J* = 8.7 Hz), 6.86 (1H, s), 6.85 (2H, d, *J* = 8.7 Hz), 6.66 (2H, d, *J* = 8.7 Hz), 5.21 (2H, s), 3.82 (3H, s), 3.74 (3H, s), 3.69 (2H, m), 1.98 (3H, s), 0.96 (2H, m), 0.03 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.5, 158.8, 158.7, 136.4, 131.3, 131.1, 129.8, 129.0, 114.0, 113.4, 97.1, 66.6, 55.13, 55.10, 18.2, 13.3, -1.39; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{33}NNaO_4Si$ 450.2077; Found 450.2060. (*Z*)-**3pa**: IR (KBr) 2954, 1602, 1509, 1275, 1259, 1172, 1105, 1037, 999, 834, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.38 (2H, d, *J* = 8.7 Hz), 7.35 (2H, d, *J* = 8.7 Hz), 6.88 (2H, d, *J* = 8.7 Hz), 6.86 (1H, s), 6.84 (2H, d, *J* = 8.7 Hz), 5.25 (2H, s), 3.82 (3H, s), 3.81 (3H, s), 3.69 (2H, m), 2.02 (3H, s), 0.96 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.3, 158.9, 157.8, 135.5, 132.3, 130.2, 129.3, 128.0, 127.8, 113.9, 113.8, 97.0, 66.2, 55.3, 55.2, 18.2, 16.4, -1.42;

HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{24}H_{33}NNaO_4Si$ 450.2077; Found 450.2057.

*(2E,3E)-3-(4-fluorophenyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (E-**3qa**), (2E,3Z)-3-(4-fluorophenyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (Z-**3qa**)*. Following the general procedure B on 0.10 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded (*E*)-**3qa** (colorless oil, 21.5 mg, 53% yield) and (*Z*)-**3qa** (colorless oil, 13.1 mg, 32% yield). (*E*)-**3qa**: IR (KBr) 2952, 1603, 1509, 1253, 1101, 997, 834, 750 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.15 (2H, dd, *J* = 8.7 Hz, 5.7 Hz), 7.02 (2H, dd, *J* = 8.7 Hz, 8.7 Hz), 6.93 (1H, s), 6.88 (2H, d, *J* = 8.7 Hz), 6.66 (2H, d, *J* = 8.7 Hz), 5.17 (2H, s), 3.74 (3H, s), 3.65 (2H, m), 2.03 (3H, s), 0.92 (2H, m), 0.01 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 163.7, 160.4, 158.95, 158.89, 135.9, 133.6, 131.7, 131.6, 131.3, 130.8, 128.6, 115.6, 115.4, 113.5, 97.2, 66.7, 55.1, 18.2, 12.8, -1.41; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{23}H_{30}FNNaO_3Si$ 438.1877; Found 438.1864. (*Z*)-**3qa**: IR (KBr) 2953, 1603, 1509, 1275, 1258, 1179, 1102, 997, 834, 750 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41 (2H, dd, *J* = 9.0 Hz, 5.7 Hz), 7.35 (2H, d, *J* = 8.4 Hz), 7.03 (2H, dd, *J* = 8.7 Hz, 8.7 Hz), 6.86 (2H, d, *J* = 9.0 Hz), 6.83 (1H, s), 5.24 (2H, s), 3.81 (3H, s), 3.68 (2H, m), 2.01 (3H, s), 0.95 (2H, m), 0.00 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 164.1, 160.8, 159.2, 157.6, 136.0, 135.0, 130.3, 129.6, 128.9, 128.3, 128.2, 115.5, 115.2, 113.8, 97.0, 66.3, 55.2, 18.2, 16.3, -1.43; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{23}H_{30}FNNaO_3Si$ 438.1877; Found 438.1857.

*(2E,3E)-3-(4-chlorophenyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (E-**3ra**), (2E,3Z)-3-(4-chlorophenyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (Z-**3ra**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded (*E*)-**3ra** (colorless oil, 23.1 mg, 59% yield) and (*Z*)-**3ra** (colorless oil, 11.4 mg, 29% yield). (*E*)-**3ra**: IR (KBr) 2953, 1605, 1509, 1489, 1301, 1249, 1174, 1093, 997, 859, 833, 749 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.26 (2H, d, *J* = 8.7 Hz), 7.09 (2H, d, *J* = 8.7 Hz), 6.91 (2H, d, *J* = 8.7 Hz), 6.86 (1H, s), 6.66 (2H, d, *J* = 8.7 Hz), 5.15 (2H, s), 3.73 (3H, s), 3.63 (2H, m), 2.02 (3H, s), 0.92 (2H, m), 0.00 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 159.0, 158.7, 136.3, 135.8, 133.1, 131.5, 131.3, 130.9, 128.7, 128.4, 113.5, 97.2, 66.8, 55.1, 18.2, 12.8, -1.41; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{23}H_{30}ClNNaO_3Si$ 454.1581; Found 454.1561. (*Z*)-**3ra**: IR (KBr) 2952, 1605, 1509,1249, 1174, 1093, 997, 833, 749 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *E*-isomer.) δ 7.40-7.28 (6H, m), 6.87 (1H, s), 6.86 (2H, d, *J* = 8.7 Hz), 5.24 (2H, s), 3.81 (3H, s), 3.68 (2H, m), 2.01 (3H, s), 0.95 (2H, m), 0.00 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$, contains a small amount of *E*-isomer.) δ 159.3, 157.5, 138.4, 134.8, 133.5, 130.4, 130.1, 128.8, 128.6, 127.9, 113.8, 97.0, 66.3, 55.2, 18.2, 16.3, -1.43; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{23}H_{30}ClNNaO_3Si$ 454.1581; Found 454.1559.

*(2E,3E)-3-(4-bromophenyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (E-**3sa**), (2E,3Z)-3-(4-bromophenyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (Z-**3sa**)*. Following the general procedure B on 0.11 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded (*E*)-**3sa** (colorless oil, 25.4 mg, 48% yield) and (*Z*)-**3sa** (colorless oil, 12.4 mg, 24% yield). (*E*)-**3sa**: IR (KBr) 2952, 1605, 1509, 1275, 1257, 1178, 1102, 997, 828, 750 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.44 (2H, d, *J* = 8.4 Hz), 7.04 (2H, d, *J* = 8.4 Hz), 6.93 (1H, s), 6.89 (2H, d, *J* = 8.7 Hz), 6.67 (2H, d, *J* = 8.7 Hz), 5.16 (2H, s), 3.75 (3H, s), 3.65 (2H, m), 2.03 (3H, s), 0.93 (2H, m), 0.01 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 159.0, 158.6, 136.8, 135.8, 131.8, 131.7, 131.3, 130.9, 128.4, 121.3, 113.5, 97.2, 66.8, 55.2, 18.2, 12.8, -1.40; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{23}H_{30}BrNNaO_3Si$ 498.1076; Found 498.1054. (*Z*)-**3sa**: IR (KBr) 2952, 1605, 1509, 1275, 1259, 1174, 1102, 997, 831, 750, 474 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *E*-isomer.) δ 7.44 (2H, d, *J* = 8.4 Hz), 7.35 (2H, d, *J* = 8.4 Hz), 7.32 (2H, d, *J* = 8.4 Hz), 6.87 (1H, s), 6.86 (2H, d, *J* = 8.7 Hz), 5.24 (2H, s), 3.82 (3H, s), 3.68 (2H, m), 2.01 (3H, s), 0.95 (2H, m), 0.01 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$, contains a small amount of *E*-isomer.) δ 159.3, 157.4, 138.9, 134.9, 131.6, 130.5, 130.2, 128.8, 128.2, 121.6, 113.9, 97.0, 66.3, 55.2, 18.2, 16.3, -1.43; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{23}H_{30}BrNNaO_3Si$ 498.1076; Found 498.1065.

*(2E,3E)-4-(4-methoxyphenyl)-3-(3-(trifluoromethyl)phenyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (E-**3ta**), (2E,3Z)-4-(4-methoxyphenyl)-3-(3-(trifluoromethyl)phenyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (Z-**3ta**)*. Following the general procedure B on 0.10 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 20 : 1) afforded (*E*)-**3ta** (colorless oil, 25.4 mg, 47% yield) and (*Z*)-**3ta** (colorless oil, 11.5 mg, 25% yield). (*E*)-**3ta**: IR (KBr) 2954, 1605, 1509, 1325, 1275, 1257, 1163, 1127, 994, 835, 750 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *Z*-isomer.) δ 7.54 (1H, d, *J* = 7.8 Hz), 7.46-7.33 (3H, m), 6.99 (1H, s), 6.83 (2H, d, *J* = 7.8 Hz), 6.65 (2H, d, *J* = 7.8 Hz), 5.14 (2H, s), 3.74 (3H, s), 3.62 (2H, m), 2.08 (3H, s), 0.91 (2H, m), 0.00 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$, contains a small amount of *Z*-isomer**.**) δ 159.2, 158.3, 138.7, 135.6, 133.6, 131.6, 131.3,128.8, 128.1, 127.1, 124.0, 113.6, 97.3, 66.8, 55.2, 18.1, 12.6, -1.43; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{24}H_{30}F_3NNaO_3Si$ 488.1845; Found 488.1868. (*Z*)-**3ta**: IR (KBr) 2952, 1602, 1509, 1330, 1259, 1168, 1127, 997, 835, 750 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$, contains a small amount of *E*-isomer.) δ 7.70 (1H, s), 7.64-7.40 (3H, m), 7.37 (2H, d, *J* = 8.7 Hz), 6.93 (1H, s), 6.87 (2H, d, *J* = 8.7 Hz), 5.25 (2H, s), 3.83 (3H, s), 3.70 (2H, m), 2.03 (3H, s), 0.96 (2H, m), 0.00 (9H, s); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$, contains a small amount of *E*-isomer**.**) δ 159.5, 157.3, 140.8, 134.7, 131.3, 130.6, 129.9, 128.9, 128.6, 124.2, 123.3, 113.9, 97.0, 66.3, 55.2, 18.2, 16.4, -1.47; HRMS (ESI-TOF) *m/z*: [M + Na]$^+$ Calcd for $C_{24}H_{30}F_3NNaO_3Si$ 488.1845; Found 488.1847.

*(2E,3E)-3-(4-methoxybenzyl)-4-(3,4,5-trimethoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (**3fb**), (2E,3E)-4-(4-methoxyphenyl)-3-(3,4,5-trimethoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (**4fb**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 3 : 1) afforded **3fb** (colorless oil, 16.1

mg, 36% yield) and **4fb** (colorless oil, 19.4 mg, 43% yield). **3fb**: IR (KBr) 1579, 1509, 1275, 1128, 999, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains a small amount of inseparable isomer **4fb**.) δ 7.09 (2H, d, *J* = 8.7 Hz), 7.03 (1H, s), 6.79 (2H, d, *J* = 8.7 Hz), 6.50 (2H, s), 5.15 (2H, s), 3.99 (2H, s), 3.83 (3H, s), 3.76 (3H, s), 3.63 (6H, s), 3.60 (2H, m), 2.17 (3H, s), 0.87 (2H, m), -0.03 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains a small amount of inseparable isomer **4fd**.) δ 157.6, 156.7, 152.9, 137.4, 136.7, 132.6, 132.34, 132.25, 130.3, 128.9, 113.7, 106.1, 97.3, 66.6, 60.9, 55.8, 55.2, 32.5, 18.1, 11.6, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{27}H_{39}NNaO_6Si$ 524.2444; Found 524.2420. **4fb**: IR (KBr) 2952, 1605, 1588, 1509, 1455, 1420, 1328, 1249, 1179, 1128, 999, 894, 835, 750, 529 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains a small amount of inseparable isomer **3fb**.) δ 7.28 (2H, d, *J* = 9.0 Hz), 7.06 (1H, s), 6.88 (2H, d, *J* = 9.0 Hz), 6.42 (2H, s), 5.18 (2H, s), 3.96 (2H, s), 3.82 (3H, s), 3.81 (3H, s), 3.80 (6H, s), 3.65 (2H, m), 2.16 (2H, s), 0.90 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.0, 157.0, 153.0, 136.3, 135.9, 135.6, 132.2, 130.2, 129.3, 113.8, 105.1, 97.2, 66.4, 60.8, 55.9, 55.3, 33.2, 18.0, 11.7, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{27}H_{39}NNaO_6Si$ 524.2444; Found 524.2421.

*(2E,3E)-3-(4-methoxybenzyl)-4-(p-tolyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3fc**), (2E,3E)-4-(4-methoxyphenyl)-3-(4-methylbenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**4fc**).* Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3fc** (colorless oil, 17.6 mg, 46% yield) and **4fc** (colorless oil, 17.6 mg, 46% yield). **3fc**: IR (KBr) 1509, 1275, 1105, 998, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.21 (2H, d, *J* = 8.1 Hz), 7.12 (2H, d, *J* = 8.1 Hz), 7.10 (1H, s), 7.06 (2H, d, *J* = 8.7 Hz), 6.79 (2H, d, *J* = 8.7 Hz), 5.13 (2H, s), 3.94 (2H, s), 3.77 (3H, s), 3.59 (2H, m), 2.33 (3H, s), 2.13 (3H, s), 0.87 (2H, m), -0.02 (9H, s) ; $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.5, 156.8, 137.2, 136.7, 133.9, 132.7, 132.2, 129.08, 129.07, 128.8, 113.6, 97.2, 66.5, 55.1, 32.3, 21.2, 18.1, 11.7, -1.41; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{25}H_{35}NNaO_3Si$ 448.2284; Found 448.2270. **4fc**: IR (KBr) 2952, 1606, 1509, 1275, 1257, 1178, 1104, 998, 895, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25 (2H, d, *J* = 8.7 Hz), δ 7.06 (4H, s), 7.04 (1H, s), 6.84 (2H, d, *J* = 8.7 Hz), 5.12 (2H, s), 3.98 (2H, s), 3.79 (3H, s), 3.57 (2H, m), 2.30 (3H, s), 2.13 (3H, s), 0.85 (2H, m), -0.02 (9H, s) ; $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.9, 156.8, 137.5, 135.6, 134.9, 131.9, 130.2, 129.4, 129.0, 128.0, 113.8, 97.2, 66.5, 55.2, 32.7, 21.0, 18.1, 11.7, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{25}H_{35}NNaO_3Si$ 448.2284; Found 448.2273.

*(2E,3E)-3-(4-methoxybenzyl)-4-phenylbut-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3fd**), (2E,3E)-3-benzyl-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**4fd**).* Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3fd** (colorless oil, 13.1 mg, 35% yield) and **4fd** (colorless oil, 16.1 mg, 43% yield) as inseparable mixture. **3fd (4ka)**: IR (KBr) 1605, 1509, 1275, 1259, 1178, 1103, 997, 835, 764, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains inseparable isomer **4fd**.) δ 7.30-7.08 (7H, m), 7.09 (1H, s), 6.81 (2H, d, *J* = 9.0 Hz), 5.16 (2H, s), 3.96 (2H, s), 3.79 (3H, s), 3.60 (2H, m), 2.15 (3H, s), 0.89 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains inseparable isomer **4fd**.) δ 157.6, 156.7, 137.5, 136.9, 132.6, 132.2, 129.1, 128.8, 128.3, 127.4, 113.6, 97.2, 66.5, 55.1, 32.2, 18.1, 11.7, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{33}NNaO_3Si$ 434.2127; Found 434.2115. **4fd (3ka)**: IR (KBr) 1606, 1509, 1248, 1105, 997, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.26-7.10 (7H, m), 7.06 (1H, s), 6.84 (2H, d, *J* = 9.0 Hz), 5.11 (2H, s), 4.02 (2H, s), 3.79 (3H, s), 3.55 (2H, m), 2.14 (3H, s), 0.85 (2H, m), 0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.9, 156.8, 140.7, 135.4, 132.1, 130.2, 129.3, 128.2, 128.1, 125.6, 113.8, 97.2, 66.5, 55.2, 33.2, 18.1, 11.6, -1.40; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{33}NNaO_3Si$ 434.2127; Found 434.2115.

*(2E,3E)-4-([1,1'-biphenyl]-4-yl)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3fe**), (2E,3E)-3-([1,1'-biphenyl]-4-ylmethyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (**4fe**).* Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded **3fe** (colorless oil, 14.4 mg, 33% yield) and **4fe** (colorless oil, 17.8 mg, 41% yield). **3fe**: IR (KBr) 2951, 1606, 1509, 1486, 1275, 1259, 1104, 997, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains inseparable isomer **4fe**.) δ 7.62-7.24 (9H, m), 7.15-7.07 (3H, m), 6.86 (2H, d, *J* = 8.7 Hz), 5.14 (2H, s), 4.07 (2H, s), 3.64 (3H, s), 3.60 (2H, m), 2.18 (3H, s), 0.88 (2H, m), -0.04 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains inseparable isomer **4fe**.) δ 157.6, 156.7, 140.5, 140.1, 137.5, 135.8, 132.5, 131.8, 129.3, 129.1, 128.8, 127.4, 127.0, 113.4, 97.2, 66.5, 55.1, 32.4, 18.1, 11.7, -1.41; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{30}H_{37}NNaO_3Si$ 510.2440; Found 510.2415. **4fe**: IR (KBr) 1605, 1509, 1487, 1275, 1259, 1178, 1105, 997, 895, 835, 751, 698 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.58 (2H, d, *J* = 8.1 Hz), 7.49 (2H, d, *J* = 8.1 Hz), 7.42 -7.23 (7H, m), 7.08 (1H, s), 6.86 (2H, d, *J* = 9.0 Hz), 5.13 (2H, s), 4.06 (2H, s), 3.80 (3H, s), 3.58 (2H, m), 2.17 (3H, s,), 0.84 (2H, m), -0.05 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.0, 156.7, 141.1, 139.9, 138.4, 135.3, 132.2, 130.3, 129.3, 128.7, 128.5, 126.95, 126.90, 113.9, 97.3, 66.5, 55.3, 32.8, 18.0, 11.6, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{30}H_{37}NNaO_3Si$ 510.2440; Found 510.2422.

*(2E,3E)-4-(4-chlorophenyl)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3ff**), (2E,3E)-3-(4-chlorobenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**4ff**).* Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded **3ff** (colorless oil, 13.0 mg, 32% yield) and **4ff** (colorless oil, 22.0 mg, 55% yield) as inseparable mixture. **3ff**, **4ff**: IR (KBr) 1606, 1509, 1248, 1177, 1095, 997, 896, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, signals from the minor isomer **3ff** are marked with an asterisk.) δ 7.28-7.19* (4H, m), 7.21-7.18 (4H, m), 7.09 (2H, d, *J* = 8.4 Hz), 7.06 (1H, s), 7.05* (2H, d, *J* = 8.7 Hz), 7.00* (1H, s), 6.85 (2H, d, *J* = 8.7 Hz), 6.79* (2H, d, *J* = 8.7 Hz), 5.16* (2H, s), 5.12 (2H, s), 3.99 (2H, s), 3.92* (2H, s), 3.81 (3H, s), 3.79* (3H, s), 3.58* (2H, m), 3.54 (2H, m), 2.16 (3H, s), 2.14* (3H, s), 0.88 (2H, m), 0.87* (2H, m), 0.00 (9H, s), -0.00* (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, inseparable mixture of **3ff** and **4ff**) δ 159.1, 157.7, 156.5, 156.4, 139.3, 138.1, 135.3, 135.0, 133.2, 132.5, 132.2, 131.2, 130.8, 130.2, 130.17, 130.12 129.5, 129.1, 129.0, 128.5, 128.3, 113.9, 113.7, 97.3, 66.49, 66.44, 55.2, 55.1, 32.5, 32.2, 18.0, 11.7, 11.4,-1.43;

HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{32}ClNNaO_3Si$ 468.1738; Found 468.1729.

*(2E,3E)-4-(4-bromophenyl)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3fg**), (2E,3E)-3-(4-bromobenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**4fg**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3fg** (colorless oil, 13.0 mg, 16% yield) and **4fg** (colorless oil, 12.9 mg, 29% yield) as inseparable mixture. **3fg**, **4fg**: IR (KBr) 2951, 1509, 1275, 1259, 1103, 998, 897, 836, 764, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, signals from the minor isomer **3fg** are marked with an asterisk.) δ 7.39* (2H, d, *J* = 8.1 Hz), 7.32 (2H, d, *J* = 8.7 Hz), 7.20 (2H, d, *J* = 9.0 Hz), 7.15* (2H, d, *J* = 8.1 Hz), 7.07 (1H, s), 7.06* (2H, d, *J* = 8.7 Hz), 7.05 (2H, d, *J* = 8.7 Hz), 6.98* (1H, s), 6.84 (2H, d, *J* = 9.0 Hz), 6.79* (2H, d, *J* = 8.7 Hz), 5.14* (2H, s), 5.10 (2H, s), 3.95 (2H, s), 3.90* (2H, s), 3.80 (3H, s), 3.77* (3H, s), 3.56* (2H, m), 3.53 (2H, m), 2.14 (3H, s), 2.12* (3H, s), 0.87* (2H, m), 0.84 (2H, m), -0.00* (9H, s), -0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, inseparable mixture of **3fg** and **4fg**.) δ 159.1, 157.7, 156.5, 156.4, 139.9, 138.2, 135.7, 134.9, 132.5, 132.2, 131.5, 131.3, 130.9, 130.4, 130.2, 129.9, 129.1, 129.0, 121.4, 119.3, 113.9, 113.7, 97.3, 66.50, 66.46, 55.26, 55.16, 32.6, 32.2, 18.0, 11.7, 11.4, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{32}BrNNaO_3Si$ 512.1233; Found 512.1227.

*(2E,3E)-3-(4-methoxybenzyl)-4-(4-(trifluoromethyl)phenyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (**3fh**), (2E,3E)-4-(4-methoxyphenyl)-3-(4-(trifluoromethyl)benzyl)but-3-en-2-one O-((2-(trimethylsilyl) ethoxy)methyl) oxime (**4fh**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3fh** (colorless oil, 9.0 mg, 21% yield) and **4fh** (colorless oil, 18.0 mg, 42% yield). **3fh**: IR (KBr) 2953, 1614, 1509, 1323, 1275,1246, 1165, 1126, 1067, 997, 835, 764, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, contains inseparable isomer **4fh**.) δ 7.56 (2H, d, *J* = 9.0 Hz), 7.38 (2H, d, *J* = 9.0 Hz), 7.07 (1H, s), 7.05 (2H, d, *J* = 8.7 Hz), 6.79 (2H, d, *J* = 8.7 Hz), 5.15 (2H, s), 3.91 (2H, s), 3.77 (3H, s), 3.59 (2H, m), 2.14 (3H, s), 0.88 (2H, m), -0.02 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, contains inseparable isomer **4fh**.) δ 157.7, 156.3, 140.5, 139.4, 132.0, 130.5, 129.03, 128.98, 125.3, 125.2, 113.8, 97.3, 66.5, 55.2, 32.3, 18.1, 11.8, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{25}H_{32}F_3NNaO_3Si$ 502.2001; Found 502.1976. **4fh**: IR (KBr) 2954, 1607, 1509, 1324, 1253, 1161, 1123, 1066, 998, 898, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.50 (2H, d, *J* = 8.1 Hz), 7.28 (2H, d, *J* = 9.0 Hz), 7.20 (2H, d, *J* = 8.7 Hz), 7.10 (1H, s), 6.85 (2H, d, *J* = 9.0 Hz), 5.09 (2H, s), 4.06 (2H, s), 3.80 (3H, s), 3.53 (2H, m), 2.16 (3H, s), 0.82 (2H, m), -0.03 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 159.1, 156.3, 145.2, 134.6, 132.8, 130.1, 129.0, 128.4, 125.2, 125.1, 113.9, 97.3, 66.4, 55.3, 33.1, 18.0, 11.3, -1.47; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{25}H_{32}F_3NNaO_3Si$ 502.2001; Found 502.1976.

*(2E,3E)-4-(2,6-dichlorophenyl)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3fi**), (2E,3E)-3-(2,6-dichlorobenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**4fi**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3fi** (colorless oil, 15.5 mg, 36% yield) and **4fi** (colorless oil, 2.5 mg, 6% yield). **3fi**: IR (KBr) 2952, 1611, 1510, 1428, 1275, 1246, 1176, 1105, 1037, 998, 895, 857, 835, 764, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.34 (2H, d, *J* = 7.8 Hz), 7.18 (1H, m), 6.94 (2H, d, *J* = 8.7 Hz), 6.68 (1H, s), 6.67 (2H, d, *J* = 8.7 Hz), 5.19 (2H, s), 3.72 (3H, s), 3.64 (2H, m), 3.58 (2H, s), 2.12 (3H, s), 0.92 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 157.5, 155.4, 142.0, 135.03, 134.99, 131.9, 129.7, 129.0, 127.9, 125.9, 113.2, 97.3, 66.4, 55.1, 33.4, 18.1, 11.8, -1.41; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{31}Cl_2NNaO_3Si$ 502.1348; found 502.1335. **4fi**: IR (KBr) 2918, 1509, 1435, 1249, 997, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25 (2H, d, *J* = 9.0 Hz), 7.13 (2H, d, *J* = 7.8 Hz), 6.95 (1H, t, *J* = 7.8 Hz), 6.89 (1H, s), 6.86 (2H, d, *J* = 9.0 Hz), 5.04 (2H, s), 4.21 (2H, s), 3.81 (3H, s), 3.55 (2H, m), 2.04 (3H, s), 0.87 (2H, m), 0.00 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.6, 156.7, 136.7, 136.0, 134.7, 131.9, 130.2, 129.5, 128.0, 127.1, 113.6, 97.1, 66.0, 55.3, 31.3, 18.1, 12.3, -1.34; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{24}H_{31}Cl_2NNaO_3Si$ 502.1348; Found 502.1327.

*(2E,3E)-4-(6-chloropyridin-3-yl)-3-(4-methoxybenzyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3fj**), (2E,3E)-3-((6-chloropyridin-3-yl)methyl)-4-(4-methoxyphenyl)but-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**4fj**)*. Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded **3fj** (colorless oil, 2.2 mg, 5% yield) and **4fj** (colorless oil, 7.8 mg, 19% yield) as inseparable mixture. **3fj**, **4fj**: IR (KBr) 2917, 2358, 1606, 1509, 1457, 1275, 1257, 1177, 1105, 997, 896, 835, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, signals from the minor isomer **3fj** are marked with an asterisk.) δ 8.31* (1H, d, *J* = 2.4 Hz), 8.17 (1H, d, *J* = 2.1 Hz), 7.52* (1H, dd, *J* = 8.4, 2.4 Hz), 7.44 (1H, dd, *J* = 8.4, 2.1 Hz), 7.23* (1H, s), 7.18 (1H, s), 7.17 (2H, d, *J* = 8.7 Hz), 7.08 (1H, s), 7.03* (2H, d, *J* = 8.7 Hz), 6.95* (1H, s), 6.88 (2H, d, *J* = 8.7 Hz), 6.78* (2H, d, *J* = 8.7 Hz), 5.15* (2H, s), 5.10 (2H, s), 3.95 (2H, s), 3.90* (2H, s), 3.81 (3H, s), 3.77* (3H, s), 3.60* (2H, m), 3.57 (2H, m), 2.13 (3H, s), 2.13* (3H, s), 0.90* (2H, m), 0.88 (2H, m), -0.01 (9H, s), -0.02* (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, inseparable mixture of **3fj** and **4fj**) δ 159.2, 157.9, 156.2, 156.1, 149.9, 149.7, 148.6, 140.5, 138.6, 138.4, 135.5, 134.4, 133.0, 131.5, 130.0, 128.9, 128.8, 126.8, 123.8, 123.7, 114.0, 113.9, 97.3, 66.4, 55.3, 32.3, 29.7, 18.1, 18.0, 11.7, 11.2, -1.42; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{23}H_{31}FN_2NaO_3Si$ 453.1986; Found 453.1981.

(2*E*,3*E*)-4-(6-fluoropyridin-3-yl)-3-(4-methoxybenzyl)but-3-en-2-one *O*-((2-(trimethylsilyl)ethoxy) methyl) oxime (**3fk**), (2*E*,3*E*)-3-((6-fluoropyridin-3-yl)methyl)-4-(4-methoxyphenyl)but-3-en-2-one *O*-((2-(trimethylsilyl)ethoxy)methyl) oxime (**4fk**). Following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded **3fk** (colorless oil, 5 mg, 13% yield) and **4fk** (colorless oil, 14.8 mg, 38% yield) as inseparable mixture. **3fk**, **4fk**: IR (KBr) 2917, 1595,1509, 1482, 1395, 1275, 1259, 1178, 1105, 998, 835, 764, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$, signals from the minor isomer **3fk** are marked with an asterisk.) δ 8.13* (1H, d, *J* = 2.1 Hz), 7.98 (1H, d, *J* = 2.1 Hz), 7.66* (1H, dd, *J* = 8.4, 2.1 Hz), 7.56 (1H, dd, *J* = 8.4, 2.1 Hz), 7.19 (2H, d, *J* = 8.7Hz), 7.07 (1H, s), 7.03* (2H, d, *J* = 8.7 Hz), 6.97* (1H, s), 6.87 (2H, d, *J* = 8.7 Hz), 6.89-6.84* (1H, m), 6.79 (1H, d, *J* = 8.4 Hz), 6.78* (2H, d, *J* = 8.7

Hz), 5.15* (2H, s), 5.11 (2H, s), 3.96 (2H, s), 3.89* (2H, s), 3.81 (3H, s), 3.77* (3H, s), 3.58 (2H, m), 3.58* (2H, m), 2.14* (3H, s), 2.13 (3H, s), 0.90* (2H, m), 0.88 (2H, m), -0.01 (9H, s), -0.02* (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$, inseparable mixture of **3fk** and **4fk**) δ 163.6, 160.5, 159.2, 157.8, 156.2, 156.1, 147.9, 147.7, 147.2, 147.0, 141.0, 140.9, 139.8, 134.7, 134.0, 133.9, 132.9, 131.6, 130.1, 128.9, 128.8, 126.9, 114.0, 113.9, 109.4, 109.0, 108.9, 108.5, 97.3, 97.2, 66.5, 66.4, 55.3, 55.2, 32.2 29.7, 29.5, 18.0, 11.7, 11.2, -1.44; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{23}H_{31}FN_2NaO_3Si$ 453.1986; Found 453.1981.

*(2Z,3E)-3-(4-methoxybenzyl)-4-(4-methoxyphenyl)but-3-en-2-one O-methyl oxime (**3ua**).* Following the general procedure B on 0.064 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded **3ua** (colorless oil, 14 mg, 67% yield). IR (KBr) 3500, 2358, 1607, 1509, 1463, 1275, 1256, 1175, 1044, 749 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.18 (2H, d, *J* = 9.0 Hz), 7.15 (2H, d, *J* = 9.0 Hz), 6.84 (2H, d, *J* = 9.0 Hz), 6.81 (2H, d, *J* = 9.0 Hz), 6.35 (1H, s), 3.90 (3H, s), 3.793 (3H, s), 3.787 (3H, s), 3.64 (2H, s), 1.62 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.8, 158.1, 157.5, 137.4, 131.1, 130.2, 129.9, 129.4, 129.2, 113.7, 113.6, 61.6, 55.22, 55.21, 43.6, 15.9; HRMS (EI-quadrupole) *m/z*: $[M]^+$ Calcd for $C_{20}H_{23}NO_3$ 325.1678; Found 325.1684.

1.0 mmol scale synthesis of 3fa. Following the general procedure B on 1.0 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 30 : 1) afforded **3fa** (colorless oil, 355 mg, 80% yield).

Preparation of deuterated *α,β*-unsaturated oxime . *(E)-3-(4-methoxybenzyl)but-3-en-2-one-1,1,1,4,4-d_5 O-((2-(trimethylsilyl) ethoxy)methyl) oxime-1,1,1,4,4-d_5 (**1f-d_5**).* Following the general procedure for *α,β*-unsaturated oxime SEM ether synthesis, (*E*)-3-(4-methoxybenzyl)but-3-en-2-one-4,4-d_2 oxime-4,4-d_2 (280 mg, 1.35 mmol) was converted to the title compound (460 mg, quant.) as colorless oil. Purified by flash column chromatography on silica gel (hexane : AcOEt = 20 : 1).

Isotope Labeling Experiment. Isotope labeling experiment was performed following the general procedure B on 0.09 mmol scale. Purification by flash column chromatography on silica gel (hexane : AcOEt = 10 : 1) afforded **3fd-d_4** and **4fd-d_5** (colorless oil, 25.1 mg, 67% yield) as inseparable mixture.

Procedure for the Synthesis of 7. *Benzyl (8E,10E,12E)-2,2,9,10-tetramethyl-5,7-dioxa-8-aza-2-silatetradeca-8,10,12-trien-14-oate (7).* To a solution of *α,β*-unsaturated oxime **1i** (30 mg, 0.13 mmol, 1.0 eq.), benzyl acrylate **6** (0.20 mmol, 1.5 eq.), Ag_2CO_3 (0.26 mmol, 2.0 eq.), AgTFA (0.05 mmol, 0.4 eq.), **L12** (0.04 mmol, 30 mol%), 2,6-dimethyl-1,4-benzoquinone (0.04 mmol, 30 mol%) in dioxane (2.0 mL) was added $Pd(OAc)_2$ (0.013 mmol, 10 mol%). After stirring at 90 °C (silicone oil bath) for 24 h, the reaction mixture was diluted with AcOEt and filtered through a Celite® pad (rinsed with AcOEt). The filtrate was concentrated in *vacuo*, and the crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded azatriene **7** (6.2 mg, 12% yield) as colorless oil. IR (KBr) 2948, 1714, 1621, 1275, 1260, 1139, 993, 835, 763, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.74 (1H, dd, *J* = 15.3 Hz, 11.7Hz), 7.40-7.34 (5H, m), 6.53 (1H, d, *J* = 11.7 Hz), 6.05 (1H, d, *J* = 15.3 Hz), 5.25 (2H, s), 5.22 (2H, s), 3.73 (2H, m), 2.11 (3H, s), 2.06 (3H, s), 0.96 (2H, m), 0.01 (9H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.8, 157.0, 142.6, 140.3, 136.1, 128.6, 128.2, 127.2, 122.5, 97.4, 66.7, 66.3, 18.1, 13.4, 10.9, -1.45; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{21}H_{31}NNaO_4Si$ 412.1920; Found 412.1926.

Conversion of *β*-Arylated *α,β*-unsaturated oximes to Multi-substituted Pyridine.[3a] *4-(4-methoxyphenyl)-2,3-dimethyl-5,6-diphenylpyridine.* To a solution of (2E,3E)-4-(4-methoxyphenyl)-3-methylbut-3-en-2-one O-((2-(trimethylsilyl)ethoxy)methyl) oxime (**3ia**, 0.1 mmol, 1.0 eq.) and diphenylacetylene (1.2 eq.) in toluene was added $RhCl(PPh_3)_3$ (5 mol%) and stirring at reflux (silicone oil bath) for 24 h. After completion, the reaction mixture was diluted with AcOEt and filtered through a Celite® pad (rinsed with AcOEt). The filtrate was concentrated in *vacuo*, and the crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded the title compound (12 mg, 32% yield) as pale yellow solid.

To a solution of (2*E*,3*E*)-4-(4-methoxyphenyl)-3-methylbut-3-en-2-one oxime (0.1 mmol, 1.0 eq.) and diphenylacetylene (1.2 eq.) in toluene was added $RhCl(PPh_3)_3$ (5 mol%) and stirring at reflux (silicone oil bath) for 3 h. After completion, the reaction mixture was diluted with AcOEt and filtered through a Celite® pad (rinsed with AcOEt). The filtrate was concentrated in *vacuo*, and the crude product was purified by flash column chromatography on silica gel (hexane : AcOEt = 5 : 1) afforded the title compound (29 mg, 80% yield) as pale yellow solid. mp 116-118 °C; IR (KBr) 3450, 1636, 1275, 1261, 750 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25-23 (2H, m), 7.15-7.12 (3H, m), 7.00-6.94 (3H, m), 6.86 (2H, d, *J* = 8.7 Hz), 6.84-6.78 (2H, m), 6.73 (2H, d, *J* = 8.7 Hz), 3.75 (3H, s), 2.68 (3H, s), 2.11 (3H, s); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 158.2, 156.0, 154.3, 149.6, 141.1, 138.8, 133.2, 131.2, 131.1, 130.6, 129.9, 128.5, 127.5, 127.2, 126.9, 125.9, 113.2, 55.1, 23.6, 16.8; HRMS (ESI-TOF) *m/z*: $[M + Na]^+$ Calcd for $C_{26}H_{23}NO$ 365.1780; Found 365.1744.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website.

Characterization data for all new compounds, additional experiments and spectral data (PDF)

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Notes

The authors declare no competing financial interest.

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