OL Organic Letters

pubs.acs.org/OrgLett Letter

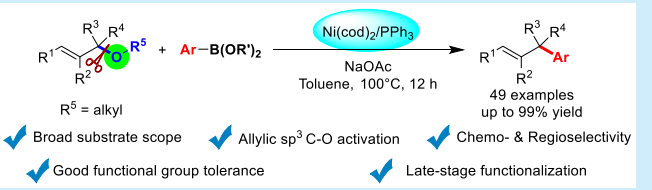
Nickel-Catalyzed Arylation of C(sp^3)−O Bonds in Allylic Alkyl Ethers with Organoboron Compounds

Xiaowei Li,[§] Yuxiu Li,[§] Zhong Zhang, Xiaolin Shi, Ruihua Liu, Zemin Wang, Xiangqian Li, and Dayong Shi*

Cite This: https://doi.org/10.1021/acs.orglett.1c01879 Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: A nickel-catalyzed cross-coupling of allylic alkyl ethers with organoboron compounds through the cleavage of the inert C(sp^3)-O(alkyl) bonds is described. Several types of allylic alkyl ethers can be coupled with various boronic acids or their derivatives to give the corresponding products in good to excellent yields with wide functional group tolerance and excellent regioselectivity. The gram-scale reaction and late-stage modification of biologically active compounds further prove the practicality of this synthetic method.



Transition-metal-catalyzed cross-coupling reactions have emerged as a powerful tool in the formation of C−C and C−heteroatom bonds for decades.[1] Organohalides as good electrophilic cross-coupling partners have been widely studied and applied.[2] With the development of high-efficiency catalytic systems, oxygen-based electrophiles have been shown to be a viable alternative to organohalides considering their natural abundance, ready availability, low toxicity, and excellent economic profile (Figure 1a).[3] Based on their high reactivity, sulfonates[4] and phosphates[5] were first used to construct C−C bonds in cross-coupling reactions, while moisture instability and high cost hindered their application. In recent years, considerable efforts have been made to explore some more stable and readily available C−O electrophiles, such as esters,[6] ethers,[7] and alcohols.[8] In comparison with esters and alcohols, ethers usually act as solvents and protecting groups in organic synthesis owing to their higher chemical stability, and it is more challenging to utilize ethers as electrophiles in transition-metal-catalyzed cross-coupling reactions. The key challenges are related to the high activation energy required for the cleavage of the very electron-rich C(sp^3)−O(alkyl) bonds and the low propensity of alkoxy residues to act as leaving groups. Thus, it is strategically important for C−O bond cleavage from allylic alkyl ethers to construct C−C bonds.

Over the last decades, some efforts to investigate the arylation of allyl alkyl ethers with nucleophilic coupling partners via transition-metal catalysis have been made (Figure 1b). In 2005, Kobayashi and co-workers reported an example of palladium-catalyzed allyl−aryl coupling between allyl methyl ether and phenylboronic acid.[9] Then, Oshima and co-workers developed a phenylation reaction of allylic ethers with phenylmagnesium bromide (PhMgBr) catalyzed by cobalt.[10] An example of iron-catalyzed phenylation of allyl methyl ether has also been shown by Li and co-workers with a low yield.[11] Recently, nickel-based catalysts have been attracting consid-

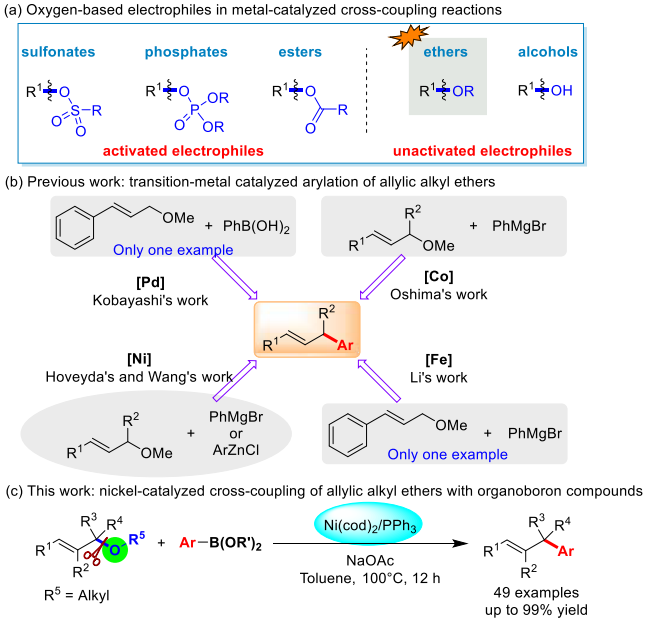


Figure 1. Transition-metal-catalyzed arylation of allylic ethers.

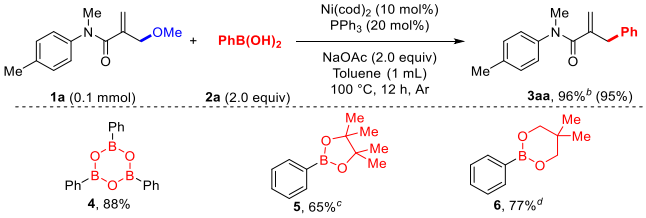
Received: June 6, 2021

erable attention in the transformations of C(sp^3)−O bonds because of their low cost, wide availability, and unique reaction properties. Under nickel-catalyzed conditions, Hoveyda and Wang et al. employed PhMgBr or arylzinc chlorides (ArZnCl) as the nucleophiles to couple with allyl ethers, respectively.[12] However, to the best of our knowledge, nickel-catalyzed allyl−aryl cross-coupling between allylic alkyl ethers and organoboron compounds was still unknown.

Compared with organozinc or Grignard reagents, organoboron compounds have emerged as more attractive nucleophilic coupling partners because of their advantages, such as commercial availability, stability to air and moisture, and low toxicity.[13] Herein, we develop a highly efficient protocol for the direct cross-coupling between allylic alkyl ethers and organoboron compounds (Figure 1c). In the presence of an inexpensive nickel/triphenylphosphine (PPh_3) catalytic system and sodium acetate (NaOAc), a series of coupling products were generated though C(sp^3)−O bond activation and C(sp^3)−C(sp^2) bond formation in good to excellent yields.

Initially, 2-(methoxymethyl)-*N*-methyl-*N*-(*p*-tolyl)-acrylamide (**1a**) and phenylboronic acid (**2a**) were chosen as the model substrates, and a series of experiments aimed at identifying optimal conditions for selective arylation were conducted (see the Supporting Information). To our delight, we found that in the presence of bis(1,5-cyclooctadiene)nickel ($Ni(cod)_2$) (10 mol %), triphenylphosphine (20 mol %), and sodium acetate (2.0 equiv) the desired product **3aa** could be obtained in 95% yield in 1 mL of toluene at 100 °C (Scheme 1). In addition, under these conditions, by using 2,4,6-

Scheme 1. Optimized Conditions[a] and Scope of Organoboron Compounds

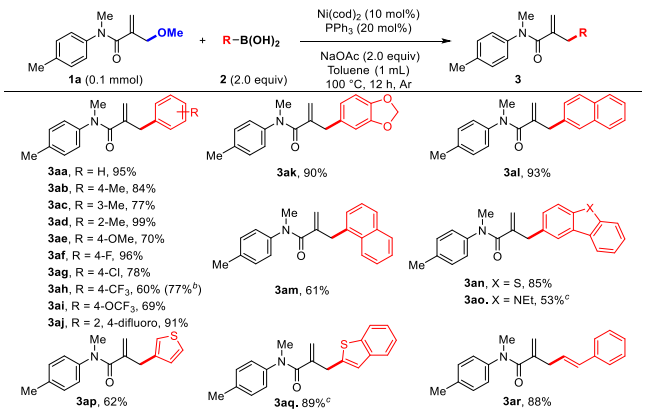


[a]Isolated yield. [b]GC yield with adamantane as the internal standard. [c](p-OMe-C_6H_5)$_3$P (20 mol %) was used instead of PPh_3 for 24 h. [d]Reaction performed at 120 °C for 24 h.

triphenylboroxin **4** and phenylboronic acid esters **5** and **6** instead of **2a**, the product **3aa** could also be generated in high isolated yields (65−88%).

With the optimized conditions in hand, the substrate scope of boronic acids was explored (Scheme 2). Both electron-rich and electron-poor arylboronic acids could react with **1a** to afford the corresponding products **3aa**−**ak** in good to excellent yields with excellent regioselectivities (60−99%). A wide range of functional groups, such as methyl (**3ab**−**ad**), methoxyl (**3ae**), fluoro (**3af** and **3aj**), chloro (**3ag**), trifluoromethyl (**3ah**), trifluoromethoxyl (**3ai**), and even acetal (**3ak**), were all well tolerated. Notably, the steric hindrance did not affect the high efficiency of this method, and *p*-, *m*-, and *o*-tolylboronic acids were converted to their desired products with comparable reactivities (**3ab**−**ad**, 77−99% yields). Both 2- and 1-naphthylboronic acids could serve as the nucleophiles to give the corresponding **3al** and **3am** in 93% and 61% yield, respectively. Furthermore, some (hetero)arylboronic acids

Scheme 2. Scope of Boronic Acids[a]

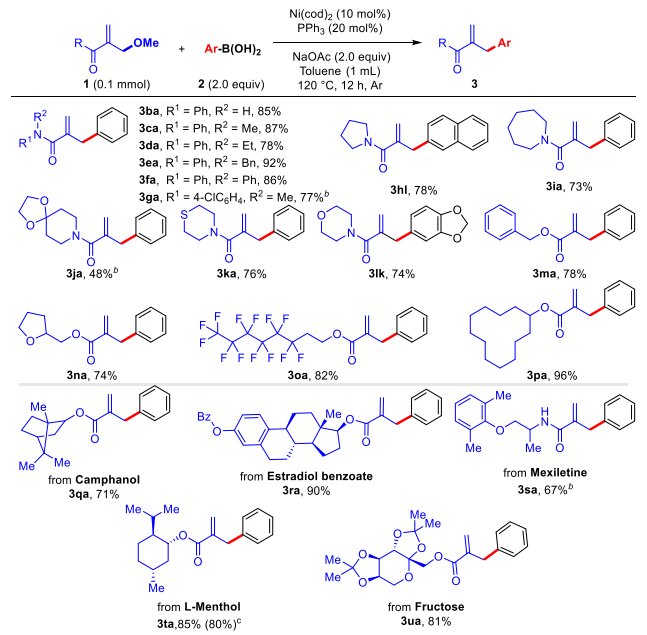


[a]Isolated yield. [b](p-OMe-C_6H_5)$_3$P (20 mol %) was used for 24 h. [c]Reaction performed at 120 °C for 24 h.

bearing dibenzothiophene, carbazole heterocycles, thiophene, and benzothiophene groups could also be successfully applied in this process, manufacturing **3an**−**aq** in 53−89% yields. These results further expanded the scope of boronic acids. The *trans*-*β*-styreneboronic acid **2u** also proved to be a suitable substrate, to afford the desired product **3ar** in good yield (88%).

Next, the broad scope of this protocol with respect to various allylic ethers was observed (Scheme 3). By employing

Scheme 3. Scope of Allylic Ethers[a]



[a]Isolated yield. [b](p-OMe-C_6H_5)$_3$P (20 mol %) was used for 24 h. [c]Reaction was carried out at the 1 mmol scale.

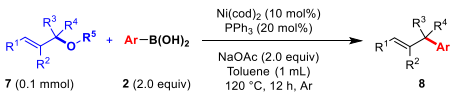
arylboronic acid **2a** as the nucleophilic coupling partner, acrylamide substrate **1b** with an unprotected *N*-H group was efficiently transformed into the desired product **3ba** in 85% yield. Notably, a series of 2-(methoxymethyl)acrylamides with alkyl and aryl groups located at the nitrogen core could be readily applied in this reaction, generating the corresponding products **3ca**−**ga** in good to excellent yields (77−92%). In addition, the substrate scope toward heterocyclic unsaturated

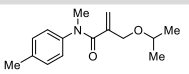
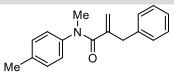
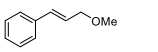
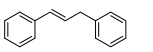
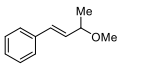
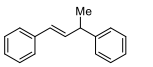
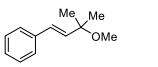
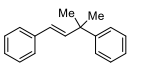
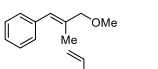
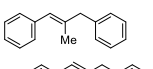
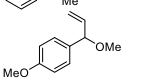
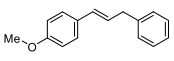
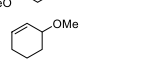
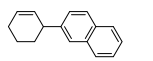
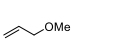
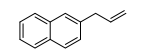
https://doi.org/10.1021/acs.orglett.1c01879
Org. Lett. XXXX, XXX, XXX−XXX

dialkylamides was also screened under the optimized conditions. The formation of **3hl**, **3ia**–**ka**, and **3lk** indicated that these substrates containing five-, six-, and seven-membered heterocycles could be effectively transformed to their desired products with satisfactory results (48–78% yields). Subsequently, various 2-(methoxymethyl)acrylates were tested. Benzyl 2-(methoxymethyl)acrylamide **1m** and (tetrahydrofuran-2-yl)methyl 2-(methoxymethyl)acrylate **1n** were well-tolerated in our conditions, producing the arylation products in high yields. Substrates with a bulky group were compatible reaction partners and could generate coupling products **3oa** and **3pa** in 82% and 96% yield, respectively. To demonstrate the potential utility of this coupling reaction, we evaluated the method in the late-stage modification of complex and/or biologically active compounds, including the derivatives of camphanol, estradiol benzoate, mexiletine, L-menthol, and fructose. The results showed that these substrates were transformed into the target molecules successfully with good yields (**3qa**–**ua**, 67–90%). Moreover, this transformation was scaled up to 1 mmol to generate **3ta** in 80% yield without sacrificing yield.

To broaden the generality of the method, we turned our attention to other C–O electrophiles. As shown in Table 1,

Table 1. Scope of Other C–O Electrophiles[a]



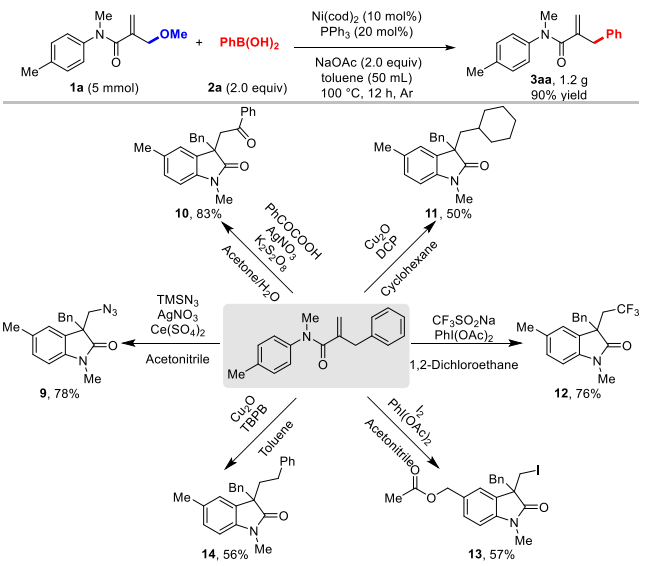
Substrate		Product		Yield
	7a		3aa	76%
	7b		8a	28%
	7c		8b	78%[b]
	7d		8c	83%
	7e		8d	47%
	7f		8e	35%
	7g		8f	70%
	7h		8g	72%

[a]Isolated yield. [b]**2a** (3.0 equiv) and (p-OMe-C_6H_5)$_3$P (20 mol %) were used for 24 h.

various allylic substrates were tested with arylboronic acid **2** under the optimized reaction conditions. We were pleased to find that allylic isopropyl ether **7a** was well applicable for the current transformation, delivering **3aa** in 76% yield. Moreover, a range of cinnamyl methyl ethers were also suitable substrates for this transformation (**7b**–**e**). In contrast to primary ether, methyl-substituted secondary and tertiary ethers reacted more efficiently with **2a**, affording the corresponding products (**8b** and **8c**) in 78% and 83% yield, respectively. In addition, when there is a methyl substituent on the alkene of the cinnamyl methyl ether, moderate yield was obtained (**8d**). It is noted that a branched allylic ether substrate **7f** coupling with **2a** was found to produce the linear product **8e**, albeit with somewhat low yield. Alkyl-substituted allylic ethers could also react with arylboronic acid, yielding the desired products **8f** and **8g** in good yields.

To further demonstrate the practicality of this method, a gram-scale reaction of **1a** (5 mmol) with **2a** was carried out under the standard reaction conditions, affording product **3aa** (1.2 g) in 90% yield (Scheme 4, top). Furthermore, several

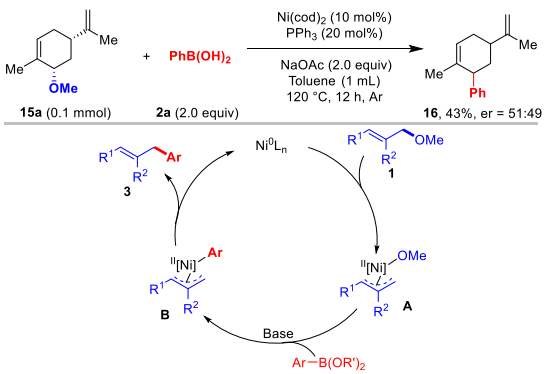
Scheme 4. Gram-Scale Synthesis and Transformation of 3aa



transformations of **3aa** were performed (Scheme 4, bottom). In the presence of various coupling partners and oxidants, the carbocyclization of **3aa** proceeded successfully, providing a series of functionalized 3,3-disubstituted oxindoles **9**–**14** in moderate to good yields. Azido,[14] benzoyl,[15] cyclohexyl,[16] trifluoromethyl,[17] iodo,[18] and benzyl groups[19] were well-tolerated. Notably, when **3aa** was treated with iodine (I_2) and iodobenzene diacetate ($PhI(OAc)_2$) in acetonitrile at room temperature, an unexpected difunctional product **13** was formed in 57% yield.

To gain insights into the reaction mechanism, a control experiment was carried out. Under the standard reaction conditions, chiral allylic alkyl ether **15a** can react with **2a**, yielding racemic products **16** in 43% yield (er = 51:49) (Scheme 5, top). It is very likely that an allylic nickel intermediate was formed. Therefore, according to the previous reports[3c] and the result of our experiments, we proposed a possible mechanism for this reaction (Scheme 5, bottom).

Scheme 5. Mechanistic Study and Proposed Catalytic Cycle



https://doi.org/10.1021/acs.orglett.1c01879
Org. Lett. XXXX, XXX, XXX–XXX

Assisted by the coordination with alkene **1**, a key allylic intermediate **A** is formed by oxidative addition of nickel(0) to a C−O bond. Transmetalation followed by reductive elimination gives the desired product **3**.

In summary, we have established an efficient and practical nickel-catalyzed cross-coupling of allylic alkyl ethers with organoboron compounds through the cleavage of the inert $C(sp^3)$−O bond. This protocol is distinguished by its wide substrate scope, providing the desired products in good to excellent yields with excellent regioselectivity and good functional group compatibility. The application in the late-stage modification of biologically active molecules, gram-scale synthesis, and product transformation proves the synthetic utility of this method.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.orglett.1c01879.

Experimental procedures and characterization of all compounds (PDF)

■ AUTHOR INFORMATION

Corresponding Author

Dayong Shi − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China; Laboratory for Marine Biology and Biotechnology, Pilot National Laboratory for Marine Science and Technology, Qingdao 266237 Shandong, P. R. China;* orcid.org/0000-0002-5807-5633; Email: shidayong@sdu.edu.cn

Authors

Xiaowei Li − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China;* orcid.org/0000-0001-7586-2850

Yuxiu Li − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China;* orcid.org/0000-0002-5185-7501

Zhong Zhang − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China;* orcid.org/0000-0001-7056-0060

Xiaolin Shi − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China*

Ruihua Liu − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China*

Zemin Wang − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China*

Xiangqian Li − *State Key Laboratory of Microbial Technology, Shandong University, Qingdao 266237, P. R. China*

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.orglett.1c01879

Author Contributions

[§]V.B. and V.M. contributed equally to this work.

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

This work was supported by the Funded by National Program for Support of Top-Notch Young Professionals, Fund of Taishan scholar project, Shandong Provincial Natural Science Foundation for Distinguished Young Scholars (JQ201722), Qingdao Science and Technology Benefit People Demonstration Guide Special Project (20-3-4-20 nsh), and the Fundamental Research Funds of Shandong University (2020GN033). Haiyan Sui and Xiaoju Li from Shandong University Core Facilities for Life and Environmental Sciences are thanked for their help with the NMR.

■ REFERENCES

(1) For selected reviews, see: (a) Negishi, E. Magical Power of Transition Metals: Past, Present, and Future (Nobel Lecture). *Angew. Chem., Int. Ed.* **2011**, *50*, 6738−6764. (b) Cherney, A. H.; Kadunce, N. T.; Reisman, S. E. Enantioselective and Enantiospecific Transition-Metal-Catalyzed Cross-Coupling Reactions of Organometallic Reagents To Construct C−C Bonds. *Chem. Rev.* **2015**, *115*, 9587−9652. (c) Su, B.; Cao, Z.-C.; Shi, Z.-J. Exploration of Earth-Abundant Transition Metals (Fe, Co, and Ni) as Catalysts in Unreactive Chemical Bond Activations. *Acc. Chem. Res.* **2015**, *48*, 886−896. (d) Desnoyer, A. N.; Love, J. A. Recent Advances in Well-defined, Late Transition Metal Complexes That Make and/or Break C-N, C-O and C-S Bonds. *Chem. Soc. Rev.* **2017**, *46*, 197−238.

(2) For selected reviews, see: (a) Schafer, P.; Sidera, M.; Palacin, T.; Fletcher, S. P. Asymmetric Cross-Coupling of Alkyl, Alkenyl and (Hetero)aryl Nucleophiles with Racemic Allyl Halides. *Chem. Commun. (Cambridge, U. K.)* **2017**, *53*, 12499−12511. (b) Korch, K. M.; Watson, D. A. Cross-Coupling of Heteroatomic Electrophiles. *Chem. Rev.* **2019**, *119*, 8192−8228.

(3) For selected reviews on oxygen-based electrophiles, see: (a) Yu, D.-G.; Li, B.-J.; Shi, Z.-J. Exploration of New C-O Electrophiles in CrossCoupling Reactions. *Acc. Chem. Res.* **2010**, *43*, 1486−1495. (b) Rosen, B. M.; Quasdorf, K. W.; Wilson, D. A.; Zhang, N.; Resmerita, A. M.; Garg, N. K.; Percec, V. Nickel-Catalyzed Cross-Couplings Involving Carbon-Oxygen Bonds. *Chem. Rev.* **2011**, *111*, 1346−1416. (c) Butt, N. A.; Zhang, W.-B. Transition Metal-Catalyzed Allylic Substitution Reactions with Unactivated Allylic Substrates. *Chem. Soc. Rev.* **2015**, *44*, 7929−7967. (d) Pamies, O.; Margalef, J.; Canellas, S.; James, J.; Judge, E.; Guiry, P. J.; Moberg, C.; Backvall, J. E.; Pfaltz, A.; Pericas, M. A.; Dieguez, M. Recent Advances in Enantioselective Pd-Catalyzed Allylic Substitution: From Design to Applications. *Chem. Rev.* **2021**, *121*, 4373−4505.

(4) For selected examples, see: (a) Quasdorf, K. W.; Riener, M.; Petrova, K. V.; Garg, N. K. Suzuki-Miyaura Coupling of Aryl Carbamates, Carbonates, and Sulfamates. *J. Am. Chem. Soc.* **2009**, *131*, 17748−17749. (b) Duan, J.-C.; Du, Y.-F.; Pang, X.-B.; Shu, X.-Z. Ni-catalyzed cross-electrophile coupling between vinyl/aryl and alkyl sulfonates: synthesis of cycloalkenes and modification of peptides. *Chem. Sci.* **2019**, *10*, 8706−8712.

(5) For selected examples, see: (a) Takeda, M.; Takatsu, K.; Shintani, R.; Hayashi, T. Synthesis of quaternary carbon stereocenters by copper-catalyzed asymmetric allylic substitution of allyl phosphates with arylboronates. *J. Org. Chem.* **2014**, *79*, 2354−67. (b) Yasuda, Y.; Nagao, K.; Shido, Y.; Mori, S.; Ohmiya, H.; Sawamura, M. Copper-Catalyzed gamma-Selective and Stereospecific Allylic Cross-Coupling with Secondary Alkylboranes. *Chem. - Eur. J.* **2015**, *21*, 9666−70. (c) Xu, G.-X.; Fu, B.; Zhao, H.-Y.; Li, Y.-F.; Zhang, G.; Wang, Y.; Xiong, T.; Zhang, Q. Enantioselective and site-specific copper-catalyzed reductive allyl-allyl cross-coupling of allenes. *Chem. Sci.* **2019**, *10*, 1802−1806.

(6) For selected examples, see: (a) Liu, X. T.; Zhang, Y. Q.; Han, X. Y.; Sun, S. P.; Zhang, Q. W. Ni-Catalyzed Asymmetric Allylation of Secondary Phosphine Oxides. *J. Am. Chem. Soc.* **2019**, *141*, 16584−16589. (b) Takizawa, K.; Sekino, T.; Sato, S.; Yoshino, T.; Kojima, M.; Matsunaga, S. Cobalt-Catalyzed Allylic Alkylation Enabled by Organophotoredox Catalysis. *Angew. Chem., Int. Ed.* **2019**, *58*, 9199−9203. (c) Weng, Y.-Y.; Zhang, C.-H.; Tang, Z.-Q.; Shrestha, M.; Huang, W.-Y.; Qu, J.-P.; Chen, Y.-F. Nickel-Catalyzed Allylic

Carbonylative Coupling of Alkyl Zinc Reagents with Tert-Butyl Isocyanide. *Nat. Commun.* **2020**, *11*, 392−400.
(7) For selected examples, see: (a) Cornella, J.; Zarate, C.; Martin, R. Metal-Catalyzed Activation of Ethers via C−O Bond Cleavage: a New Strategy for Molecular Diversity. *Chem. Soc. Rev.* **2014**, *43*, 8081−8097. (b) Cao, Z.-C.; Shi, Z.-J. Deoxygenation of Ethers to Form Carbon-Carbon Bonds via Nickel Catalysis. *J. Am. Chem. Soc.* **2017**, *139*, 6546−6549. (c) Lyu, H.; Kevlishvili, I.; Yu, X.; Liu, P.; Dong, G.-B. Boron Insertion Into Alkyl Ether Bonds via Zinc/Nickel Tandem Catalysis. *Science* **2021**, *372*, 175−182.
(8) For selected examples, see: (a) Sundararaju, B.; Achard, M.; Bruneau, C. Transition metal catalyzed nucleophilic allylic substitution: activation of allylic alcohols via pi-allylic species. *Chem. Soc. Rev.* **2012**, *41*, 4467−4483. (b) Kita, Y.; Kavthe, R. D.; Oda, H.; Mashima, K. Asymmetric Allylic Alkylation of beta-Ketoesters with Allylic Alcohols by a Nickel/Diphosphine Catalyst. *Angew. Chem., Int. Ed.* **2016**, *55*, 1098−1101. (c) Mitra, S.; Mukherjee, S. Iridium-Catalyzed Asymmetric Allylic Alkylation of Deconjugated Butyrolactams. *Org. Lett.* **2021**, *23*, 3021−3026.
(9) Manabe, K.; Nakada, K.; Aoyama, N.; Kobayashi, S. Cross-Coupling Reactions of Allylic Alcohols in Water. *Adv. Synth. Catal.* **2005**, *347*, 1499−1503.
(10) Yasui, H.; Mizutani, K.; Yorimitsu, H.; Oshima, K. Cobalt- and Rhodium-Catalyzed Cross-Coupling Reaction of Allylic Ethers and Halides with Organometallic Reagents. *Tetrahedron* **2006**, *62*, 1410−1415.
(11) Qi, L.-Y.; Ma, E.-L.; Jia, F.; Li, Z.-P. Iron-catalyzed allylic substitution reactions of allylic ethers with Grignard reagents. *Tetrahedron Lett.* **2016**, *57*, 2211−2214.
(12) (a) Didiuk, M. T.; Morken, J. P.; Hoveyda, A. H. Directed Regio- and Stereoselective Nickel-Catalyzed Addition of Alkyl Grignard Reagents to Allylic Ethers. *J. Am. Chem. Soc.* **1995**, *117*, 7273−7274. (b) Didiuk, M. T.; Morken, J. P.; Hoveyda, A. H. Phosphine-Directed Stereo- & Regioselective Ni-Catalyzed Reactions of Grignard reagents with Allylic Ethers. *Tetrahedron* **1998**, *54*, 1117−1130. (c) Tao, J.-L.; Yang, B.; Wang, Z.-X. Pincer-Nickel-Catalyzed Allyl-Aryl Coupling between Allyl Methyl Ethers and Arylzinc Chlorides. *J. Org. Chem.* **2015**, *80*, 12627−12634.
(13) For selected reviews, see: (a) Miyaura, N.; Suzuki, A. Palladium-Catalyzed Cross-Coupling Reactions of Organoboron Compounds. *Chem. Rev.* **1995**, *95*, 2457−2483. (b) Partyka, D. V. Transmetalation of Unsaturated Carbon Nucleophiles from Boron-Containing Species to the Mid to Late d-Block Metals of Relevance to Catalytic C-X Coupling Reactions (X = C, F, N, O, Pb, S, Se, Te). *Chem. Rev.* **2011**, *111*, 1529−95. (c) Rygus, J. P. G.; Crudden, C. M. Enantiospecific and Iterative Suzuki-Miyaura Cross-Couplings. *J. Am. Chem. Soc.* **2017**, *139*, 18124−18137. (d) Wang, M.; Shi, Z. Methodologies and Strategies for Selective Borylation of C-Het and C-C Bonds. *Chem. Rev.* **2020**, *120*, 7348−7398.
(14) Yuan, Y.-Z.; Shen, T.; Wang, K.; Jiao, N. Ag-Promoted Azido-Carbocyclization of Activated Alkenes via C-H Bond Cleavage. *Chem. - Asian J.* **2013**, *8*, 2932−2935.
(15) Wang, H.; Guo, L.-N.; Duan, X.-H. Silver-Catalyzed Decarboxylative Acylarylation of Acrylamides with α-Oxocarboxylic Acids in Aqueous Media. *Adv. Synth. Catal.* **2013**, *355*, 2222−2226.
(16) Li, Z.-J.; Zhang, Y.; Zhang, L.-Z.; Liu, Z.-Q. Free-Radical Cascade Alkylarylation of Alkenes with Simple Alkanes: Highly Efficient Access to Oxindoles via Selective (sp3)C−H and (sp2)C−H Bond Functionalization. *Org. Lett.* **2014**, *16*, 382−385.
(17) Shi, L.-L.; Yang, X.-B.; Wang, Y.-Y.; Yang, H.-J.; Fu, H. Metal-Free Trifluoromethylation and Arylation of Alkenes: Domino Synthesis of Oxindole Derivatives. *Adv. Synth. Catal.* **2014**, *356*, 1021−1028.
(18) Wei, H.-L.; Piou, T.; Dufour, J.; Neuville, L.; Zhu, J.-P. Iodo-Carbocyclization of ElectronDeficient Alkenes: Synthesis of Oxindoles and Spirooxindoles. *Org. Lett.* **2011**, *13*, 2244−2247.
(19) Zhou, S.-L.; Guo, L.-N.; Wang, H.; Duan, X.-H. Copper-Catalyzed Oxidative Benzylarylation of Acrylamides by Benzylic C-H Bond Functionalization for the Synthesis of Oxindoles. *Chem. - Eur. J.* **2013**, *19*, 12970−12973.

https://doi.org/10.1021/acs.orglett.1c01879
Org. Lett. XXXX, XXX, XXX−XXX