# Regioselective 1,2-Carbosulfenylation of Unactivated Alkenes via Directed Nickel Catalysis

**Lin Zhu**
Tianjin Normal University
**Xiao Meng**
Tianjin Normal University
**Leipeng Xie**
Tianjin Normal University
**Qiuyang Shen**
Tianjin Normal University
**Wenyi Li**
Hengyang Normal University
**Lanlan Zhang**
Tianjin Normal University https://orcid.org/0000-0002-6218-7865
**Chao Wang** ( chwang@tjnu.edu.cn )
Tianjin Normal University https://orcid.org/0000-0001-6979-8506

**Article**

**Keywords:**

**Posted Date:** February 14th, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1339425/v1

# Abstract

A bidentate directing group-assisted Ni-catalyzed three component 1,2-carbosulfenylation of unactivated alkenes with aryl/alkenyloronic acids and disulfide electrophiles is reported. The reaction affords the desired products with high levels of chemo- and regioselectivity. A wide range of aryl groups and sulfur moieties can be simultaneously installed in both internal and terminal homoallylic amines with excellent functional group tolerance. Notably, the alkene substrates with a chiral center at α-position furnish α,γ-dibranched thiolamines with high diastereoselectivity and enantioselectivity that would otherwise be difficult to synthesize. The generality and scability could make this method attractive for preparing complex organosulfur compounds.


# Introduction

Organosulfur compounds are essential to life and widely found in pharmaceuticals,[1-3] natural products,[4] and functional materials[5-6]. In addition, organosulfides can be readily transformed into the corresponding sulfoxides and sulfones, which often act as versatile building blocks for organic synthesis.[7-9] The synthetic approaches for the efficient construction of C-S bonds include Michael addition, $S_N2$-type alkylation, cross-coupling,[10-13] and C-H functionalization[14-16]. One powerful and more attractive protocol for their construction is through the carbosulfenylation of alkenes, because this leads to the simultaneous introduction of a carbogenic and a thiol group across a C=C bond to prepare complex, value-added organosulfur products in a single step. Few examples have been reported for the intermolecular carbosulfenylation with dimethyl(methylthio)sulfonium salts involving the formation of episulfonium ion intermediates and subsequent nucleophilic addition (Fig. 1a).[17-19] However, to achieve excellent regioselectivity, this strategy is usually limited to symmetrical internal alkenes or electronically biased alkenes, such as styrenes. Another limitations pertaining to functional group compatibility hamper the generality and synthetic utility of this strategy, due to the fact that a wide range of functionalities are sensitive toward episulfonium ion intermediates. An alternative approach through carbosulfonylation of activated alkenes via photoredox/nickel catalysis was developed by Nevado group,[20-21] considering the facile interconversion between the thiol and sulfonyl group (Fig. 1b).

Directing group strategy offers an attractive approach to achieve alkene difunctionalization, especially for the less activated alkyl-substituted alkenes and unsymmetrical internal alkenes.[22-28] While significant progress has been made in recent years, most of these transformations are largely focused on alkene dicarbofunctionalization.[29-39] Carboheterofunctionalizations with concomitant formation of C-N,[40-43] C-O,[44-45] C-B,[46-48] and C-Si[48] have been explored, directed olefin carbosulfenylation remains untouched.[49] Recently, our group described a method for Ni(II)-catalyzed dicarbofunctionalization[37] and carboamination[43] of unactivated alkenes bearing picolinamide (PA) directing group via a Ni(I)/Ni(III) cycle rather than a Ni(0)/Ni(II) cycle, thus resulting in reversed regioselectivity that incorporate nucleophiles distal to the directing group. This method was initiated by transmetalation with arylboronic acids, yielding the Ni(I)-alkyl intermediate followed by olefin migratory insertion (Fig. 1c). As a

consequence, we speculated that if the Ni(I)-alkyl species could be intercepted by an electrophilic thiolation reagent via a oxidative addition/reductive elimination sequence,[50] then a modular method for the intermolecular carbosulfenylation would be achieved. However, several challenges need to be addressed: (1) undesired competitive cross-coupling between arylboron and electrophilic thiolation reagents,[51] (2) competitive *β*-H elimination from the alkylnickel species, (3) catalyst deactivation caused by sulfur coordination.[52]

Herein, we report a Ni-catalyzed regioselective 1,2-carbosulfenylation of homoallylic amines with arylboronic acids and aryl disulfides under the assistance of bidentate PA auxiliary. This new protocol exhibits excellent functional group tolerance and is compatible with *α*-substituted terminal alkenes and internal alkenes. Moreover, both the nucleophiles and the electrophiles are stable and commercially available without extra preparation, indicating the practicability of this methodology.

# Results

**Evaluation of reaction conditions**. We began this investigation with PA-protected homoallylic amine **1a** as the model substrate, phenylboronic acid and phenyl disulfide as coupling partners (Table 1). After systematic manipulation of the reaction parameters, the reaction in the presence of 20 mol% of $NiBr_2$·DME and 3 equiv. $K_3PO_4$ at 100 °C afforded the desired three-component conjunctive cross-coupling product **2a** with excellent regioselectivity in 87% isolated yield (entry 1). Using other nickel sources ($Ni(COD)_2$ or $NiBr_2$) led to diminished yield (entries 2, 3). Slightly lower conversion was observed when the catalyst loading was reduced to 15 mol% (entry 4). Phenylboronic esters were regularly used in alkene difunctionalization (entry 5), but $PhB(OH)_2$ was more effective in our reaction system. Screening of the bases revealed that $K_3PO_4$ was optimal for this reaction (entries 6, 7). Replacement of the solvent, a mixture of DMF and methanol with a single solvent led to a substantial decrease in the yield (entries 8, 9). Use of *tert*-butanol as the solvent also resulted in decreased yield and with 15% hydroarylation byproduct (entry 10). Inferior results were obtained when conducting the reaction at 80 °C (entry 11).

**Substrate scope.** With the optimal conditions in hand, we proceeded to examine the scope of the nucleophilic coupling partners (Fig 2a). Arylboronic acids bearing electron-donating substituents in the *ortho*, *meta*, and *para* positions are found to perform well, furnishing the corresponding products in high yields (**2b**-**2g**). On the other hand, arylboronic acids bearing electron-withdrawing substituents showed relatively lower reactivity, but still resulted in moderate yields (**2h**-**2m**). The reaction showed excellent functional group tolerance and a range of reactive groups, such as bromo (**2k**), aldehyde (**2n**), ketone (**2o**), alkenyl (**2p**), free hydroxyl (**2q**), and phenolic hydroxyl (**2r**), were well tolerated under optimized conditions. It merits mention that heterocycles frequently found in medicinally relevant molecules, such as furan (**2s**) and thiophene (**2t**), were also compatible with the current protocol. In addition, alkenylboronic acid worked well to deliver the alkenylthiolation product in 61% yield without isomerization of the alkene geometry.

Subsequently, we studied the electrophile scope with respect to disulfides under the standard conditions (Fig 2b). To our delight, both electron-rich and electron-deficient diaryl disulfides reacted well to give the corresponding thioethers in good to excellent yields and regioselectivities. Notably, sterically hindered *ortho*-substituted substrates are also excellent reaction partners (**2x** and **2ab**). A series of potential coupling motifs, including bromo (**2af**), ester (**2ah**), secondary amide (**2ai**), cyano (**2aj**) and allyloxy (**2ak**) remain intact, showing both the excellent chemoselectivity of this protocol and the opportunity for further derivatization. Additionally, heteroaryl disulfides showed attenuated reactivity (**2al**-**2am**), giving products in a lower yield with large amounts of unreacted starting materials.

Unfortunately, alkyl disulfides were ineffective under the reaction conditions. On the other hand, as analogues of disulfides, diphenyl diselenide was successfully converted into the desired arylselenolation product (**2an**) in 65% yield.

Next, we explored the scope of alkene substrates (Fig 2c). The terminal homoallylic amines containing $\alpha$-branching were first tested under the standard conditions. The alkenes bearing alkyl- or aryl-substitution proceeded readily to afford the $\alpha,\gamma$-dibranched amines in moderate yields with high diastereoselectivities (**2ao**-**2ar**). The *trans*-stereochemistry of substrates bearing two skipped stereocenters was confirmed by X-ray crystallography of the sulfone derived from the oxidation of **2ap**. This stereochemical outcome arises from formation of the more *trans*-nickelacycle upon C-S bond reductive elimination and is similar to results from our previously reported analogous alkene difunctionalizations.[37,43] Notably, arylboronic acid derived from estrone effectively underwent arylthiolation to give corresponding product (**2ar**) with diastereocontrol, which demonstrates the robustness of this protocol. We then explored challenging internal alkene substrates, *Z* or *E* isomers furnished the corresponding products in nearly 1:1 diastereomeric ratios. We hypothesize that reversible sulfur-Ni(III) homolysis/recombination process or observed partial stereoisomerization of the internal alkenes ablated the diastereoseletivity. In addition, isobutyl-, phenyl-, benzyl-, and thioether-substituted internal alkenes were competent substrates in this reaction.

**Synthetic potential.** This methodology is amenable to gram-scale operation, affording product **2a** in 85% yield on a 5 mmol scale (Fig. 3). The PA directing group could be readily removed under basic conditions, giving the functionalized primary amine **3a** in nearly quantitative yield after extraction without extensive purification by column chromatography. The PA auxiliary could also be easily modified from the products through C-H functionalization. For example, a Rh-catalyzed C-H olefination/cyclization of **2a** yielded the pyrido pyrrolone derivative **3b** with *E*-stereoisomer.[53] Furthermore, the synthetic utility of the sulfide functionality was explored. Controlled oxidation of **2a** with $H_2O_2$ and *m*-CPBA furnished corresponding sulfoxide **3c** and sulfone **3d** in 55% and 64% yields, respectively. Treatment of **2a** with (diacetoxyiodo)benzene and ammonium carbonate led to the synthesis of the corresponding sulfoximine **3e** in 76% yield.[54]

**Mechanistic consideration.** To elucidate the mechanism, we first conducted a radical scavenger experiment (Fig. 5a). As it turned out, the reaction efficiency was not affected by the addition of TEMPO or BHT, indicating that the carbosulfenylation likely did not involve a radical pathway or, alternatively, radical formation followed by a fast recombination with Ni within the solvent cage. Furthermore, a control experiment with *in-situ* prepared Ni(I) intermediate **A**43 was carried out. The intermediate **A** reacted with diphenyl disulfide at 80 °C for 6 h afforded **2a** in 69% yield along with 30% hydroarylation product **5** (Fig. 5b). This result demonstrated that the Ni(I) species could be intercepted by diaryl disulfide to form the desired product.

A proposed NiI/NiIII catalytic cycle for the carbosulfenylation of unactivated alkenes was depicted in Fig. 6. Initially, the NiI species (**I**) was formed from a NiII precursor with a catalytic amount of arylboronic acid. It then underwent transmetalation with arylboronic acid to generate a nickel-aryl intermediate (**II**), followed by olefin migratory insertion to form the nickel-alkyl species (**III**). This 5,5-membered nickeladicycle stabilized by bidentate PA directing group preferentially underwent oxidative addition with the diaryl disulfide rather than undesired β-hydride elimination or protonation with the methanol, leading to the formation of NiIII species (**IV**). Finally, reductive elimination from the reactive high-valent nickel adduct and subsequent ligand exchange delivered the carbosulfenylation product and regenerated the active catalyst **I**.

# Discussion

In conclusion, we have demonstrated a new methodology for the chemo- and regioselective 1,2-carbosulfenylation of unactivated alkenes with commercially available reagents and earth-abundant nickel catalysts. The removable PA auxiliary facilitated formation of 5-membered nickelacycles and enabled the carbosulfenylation of both terminal and internal homoallylic amines, leading the concomitant introduction of important aryl/alkenyl and thiol groups into the C=C bonds with excellent functional group compatibility. To our delight, the alkene substrates with an *α*-chiral center furnished *trans*-isomeric *α*,γ-dibranched thiolamines with high diastereoselectivity and enantioselectivity that would otherwise be difficult to synthesize. Finally, the gram-scale reaction and applications toward the synthesis of diverse sulfur-containing compounds illustrate the synthetic utility of this directed alkene 1,2-carbosulfenylation. Exploratory works seeking to expand the three-component olefin carboheterofunctionalization are currently ongoing in our lab.

# Methods

**General Procedure for the Ni-Catalyzed Arylamination of Alkenyl Amines.** In an argon-filled glovebox, $NiBr_2$•DME (0.04 mmol, 20 mol%), $K_3PO_4$ (0.6 mmol, 3.0 eq), alkene substrate (0.2 mmol, 1.0 eq), appropriate arylboronic acid (0.3 mmol, 1.5 eq), appropriate phenyl disulfide (0.5 mmol, 2.5 eq), DMF/MeOH (1 mL /0.5 mL) were added to a 10 mL schlenk flask. The reaction mixture was stirred at 100 °C for 18 h. After the reaction time, the vessel was allowed to silica gel column chromatography. The crude product was purified by column chromatography on silica gel with a mixture of ethyl acetate and petroleum ether as eluent. The conditions for flash chromatography and data for characterization of the products are listed below.

Data availability

X-ray crystallographic data for compound **2ap'** (CCDC 2143338) is freely available from the Cambridge Crystallographic Data Centre. Copies of the data can be obtained free of charge via https://www.ccdc.cam.ac.uk/structures/. All other data in support of the findings of this study are available within the article and its Supplementary Information or from the corresponding author upon reasonable request.

# Declarations

### Competing interests

The authors declare no competing interests.

# Author contributions

L. Z., X. M. and L.X. planned and conducted most of the experiments; Q. S., W. L and L. Z. prepared substrates for the reaction scope evaluation; C.W. directed the projects and wrote the manuscript. All authors contributed to the discussion.

# Acknowledgement

This work was supported by the National Natural Science Foundation of China (21901185, 22002037) and funds provided by Tianjin Normal University.

## References

1. Evano, G., Theunissen, C. & Pradal, A. Impact of Copper-catalyzed Cross-coupling Reactions in Natural Product Synthesis: the Emergence of New Retrosynthetic Paradigms. Nat. Prod. Rep. **30**, 1467–1489 (2013).
2. Naowarojna, N. et al. Mini-Review: Ergothioneine and Ovothiol Biosyntheses, an Unprecedented Trans-Sulfur Strategy in Natural Product Biosynthesis. Biochemistry **57**, 3309–3325 (2018).
3. Scott, K. A., Njardarson, J. T. Analysis of US FDA-Approved Drugs Containing Sulfur Atoms. Top. Curr. Chem. **376**, 5 (2018).
4. Lee, C. F., Liu, Y. C. & Badsara, S. S. Transition-Metal-Catalyzed C-S Bond Coupling Reaction. Chem. Asian J. **9**, 706–722 (2014).
5. Hoyle, C. E., Lowe, A. B. & Bowman, C. N. Thiol-click Chemistry: a Multifaceted Toolbox for Small Molecule and Polymer Synthesis. Chem. Soc. Rev. **39**, 1355–1387 (2010).
6. Takimiya, K. et al. Organic Semiconductors Based on [1]Benzothieno[3,2–b][1]benzothiophene Substructure. Acc. Chem. Res. **47**, 1493–1502 (2014).
7. Varma, R. S., Naicker, K. P. The Urea–Hydrogen Peroxide Complex: Solid-State Oxidative Protocols for Hydroxylated Aldehydes and Ketones (Dakin Reaction), Nitriles, Sulfides, and Nitrogen Heterocycles. Org. Lett. **1**, 189–192 (1999).
8. Modha, S. G., Mehta, V. P. & van der Eycken, E. V. Transition Metal-catalyzed C–C Bond ForMation via C–S Bond Cleavage: an Overview. Chem. Soc. Rev. **42**, 5042–5055 (2013).
9. Voutyritsa, E., Triandafillidi, I. & Kokotos, C. G. Green Organocatalytic Oxidation of Sulfides to Sulfoxides and Sulfones. *Synthesis* **49**, 917–924 (2017).
10. Mann, G. et al. Carbon–Sulfur Bond-Forming Reductive Elimination Involving sp-, sp2-, and sp3-Hybridized Carbon. Mechanism, Steric Effects, and Electronic Effects on Sulfide Formation. J. Am. Chem. Soc. **120**, 9205–9219 (1998).
11. Lian, Z. et al. Palladium-Catalyzed Carbon-Sulfur or Carbon-Phosphorus Bond Metathesis by Reversible Arylation. Science **356**, 1059–1063 (2017).

12. Bie, F. et al. Pd-Catalyzed Double-Decarbonylative Aryl Sulfide Synthesis through Aryl Exchange between Amides and Thioesters. Org. Lett. **23**, 8098–8103 (2021).
13. Liu, C., Szostak, M. Decarbonylative Sulfide Synthesis from Carboxylic Acids and Thioesters via Cross-Over C–S Activation and Acyl Capture. Org. Chem. Front. **8**, 4805–4813 (2021).
14. Shen, C. et al. Recent Advances in C–S Bond Formation via C–H Bond Functionalization and Decarboxylation. Chem. Soc. Rev. **44**, 291–314 (2015).
15. Kang, Y.-S. et al. Ligand-Promoted RhIII-Catalyzed Thiolation of Benzamides with a Broad Disulfide Scope. Angew. Chem. Int. Ed. **58**, 9099–9103 (2019).
16. Wang, D. et al. Rhodium(iii)-Catalyzed Carboxylate-Directed Ortho-Selective Thiolation of Benzoic Acids. Org. Chem. Front. **7**, 3229–3233 (2020).
17. Trost, B. M., Shibata, T. & Martin, S. J. Nucleophilic Attack on Olefins Initiated by Dimethylmethylthiosulfonium Fluoroborate (DMTSF). Cyanosulfenylation and Oxy- and Oxosulfenylation. J. Am. Chem. Soc. **104**, 3228–3230 (1982).
18. Trost, B. M., Martin, S. J. Alkynyl Sulfenylation. A Direct Approach for Nucleophilic Addition and Substitution of Olefins by Carbanions. J. Am. Chem. Soc. **106**, 4263–4265 (1984).
19. Tang, M. et al. Carbosulfenylation of Alkenes with Organozinc Reagents and Dimethyl(methylthio)sulfonium Trifluoromethanesulfonate. Org. Lett. **22**, 9729–9734 (2020).
20. Garcia-Dominguez, A., Mondal, R. & Nevado, C. Dual Photoredox/Nickel-Catalyzed Three-Component Carbofunctionalization of Alkenes. Angew. Chem. Int. Ed. **58**, 12286–12290 (2019).
21. Garcia-Dominguez, A., Muller, S. & Nevado, C. Nickel-Catalyzed Intermolecular Carbosulfonylation of Alkynes via Sulfonyl Radicals. Angew. Chem. Int. Ed. **56**, 9949–9952 (2017).
22. Dhungana, R. K. et al. Transition Metal-Catalyzed Dicarbofunctionalization of Unactivated Olefins. Chem. Rec. **18**, 1314–1340 (2018).
23. Derosa, J. et al. Recent Developments in Nickel-Catalyzed Intermolecular Dicarbofunctionalization of Alkenes. Chem. Sci. **11**, 4287–4296 (2020).
24. Tu, H.-Y. et al. Recent Advances in Nickel-Catalyzed Three-Component Difunctionalization of Unactivated Alkenes. Synthesis **52**, 1346–1356 (2020).
25. Qi, X., Diao, T. Nickel-Catalyzed Dicarbofunctionalization of Alkenes. ACS Catal. **10**, 8542–8556 (2020).
26. Luo, Y.-C., Xu, C. & Zhang, X. Nickel-Catalyzed Dicarbofunctionalization of Alkenes. Chin. J. Chem. **38**, 1371–1394 (2020).
27. Badir, S. O., Molander, G. A. Developments in Photoredox/Nickel Dual-Catalyzed 1,2-Difunctionalizations. Chem **6**, 1327–1339 (2020).
28. Wickham, L. M., Giri, R. Transition Metal (Ni, Cu, Pd)-Catalyzed Alkene Dicarbofunctionalization Reactions. Acc. Chem. Res. **54**, 3415–3437 (2021).
29. Gu, J.-W. et al. Tandem Difluoroalkylation-Arylation of Enamides Catalyzed by Nickel. Angew. Chem. Int. Ed. **55**, 12270–12274 (2016).

30. Derosa, J. et al. Nickel-Catalyzed 1,2-Diarylation of Simple Alkenyl Amides. J. Am. Chem. Soc. **140**, 17878–17883 (2018).
31. Li, W., Boon, J. K. & Zhao, Y. Nickel-Catalyzed Difunctionalization of Allyl Moieties Using Organoboronic Acids and Halides with Divergent Regioselectivities. Chem. Sci. **9**, 600–607 (2018).
32. Zhang, Y., Chen, G. & Zhao, D. Three-Component Vicinal-Diarylation of Alkenes via Direct Transmetalation of Arylboronic Acids. Chem. Sci. **10**, 7952–7957 (2019).
33. Tu, H.-Y. et al. Enantioselective Three-Component Fluoroalkylarylation of Unactivated Olefins through Nickel-Catalyzed Cross-Electrophile Coupling. J. Am. Chem. Soc. **142**, 9604–9611 (2020).
34. Guo, L et al. General Method for Enantioselective Three-Component Carboarylation of Alkenes Enabled by Visible-Light Dual Photoredox/Nickel Catalysis. J. Am. Chem. Soc. **142**, 20390–20399 (2020).
35. Yang, T. et al. Broadly Applicable Directed Catalytic Reductive Difunctionalization of Alkenyl Carbonyl Compounds. Chem **6**, 738–751 (2020).
36. Yang, T. et al. Chemoselective Union of Olefins, Organohalides, and Redox-Active Esters Enables Regioselective Alkene Dialkylation. J. Am. Chem. Soc. **142**, 21410–21419 (2020).
37. Wang, S. et al. Regioselective Nickel-Catalyzed Dicarbofunctionalization of Unactivated Alkenes Enabled by Picolinamide Auxiliary. Cell Rep. Phys. Sci. **2**, 100574 (2021).
38. Zhao, L. et al. Directed Nickel-Catalyzed Diastereoselective Reductive Difunctionalization of Alkenyl Amines. Org. Lett. **23**, 8516–8521 (2021).
39. Dhungana, R. K. et al. Nickel-Catalyzed Regioselective Alkenylarylation of γ,δ-AlkenylKetones via Carbonyl Coordination. Angew. Chem. Int. Ed. **60**, 19092–19096 (2021).
40. Liu, Z. et al. Catalytic Intermolecular Carboamination of Unactivated Alkenes via Directed Aminopalladation. J. Am. Chem. Soc. **139**, 11261–11270 (2017).
41. Puyl, V. A., Derosa, J. & Engle, K. M. Directed, Nickel-Catalyzed Umpolung 1,2-Carboamination of Alkenyl Carbonyl Compounds. ACS Catal. **9**, 224–229 (2019).
42. Kang, T. et al. Nickel-Catalyzed 1,2-Carboamination of Alkenyl Alcohols. J. Am. Chem. Soc. **143**, 13962–1397 (2021).
43. Xie, L. et al. Directed Nickel-Catalyzed Regio- and Diastereoselective Arylamination of Unactivated Alkenes. Nat. Commun. **12**, 6280 (2021).
44. Ni, H.-Q. et al. Anti-Selective [3+2] (Hetero)annulation of Non-Conjugated Alkenes via Directed Nucleopalladation. Nat. Commun. **11**, 6432 (2020).
45. Ni, H.-Q. et al. Mapping Ambiphile Reactivity Trends in the Anti-(Hetero)annulation of Non-Conjugated Alkenes via Pd(II)/Pd(IV) Catalysis. Angew. Chem. Int. Ed. https://doi.org/10.1002/anie.202114346 (2022).
46. Liu, Z. et al. Catalytic Carbo- and Aminoboration of Alkenyl Carbonyl Compounds via Five- and Six-Membered Palladacycles. J. Am. Chem. Soc. **140**, 3223–3227 (2018).

47. Liu, Z. et al. Directed, Palladium(II)-Catalyzed Enantioselective Anti-Carboboration of Alkenyl Carbonyl Compounds. ACS Catal. **9**, 3260–3265 (2019).
48. Liu, Z. et al. Palladium(0)-Catalyzed Directed Syn-1,2-CarboboRation and -Silylation: Alkene Scope, Applications in Dearomatization, and Stereocontrol by a Chiral Auxiliary. Angew. Chem. Int. Ed. **58**, 17068–17073 (2019).
49. Li, Z.-Q. et al. Electrophilic Sulfur Reagent Design Enables Catalytic Syn-Carbosulfenylation of Unactivated Alkenes. ChemRxiv https://doi.org/10.26434/chemrxiv-2021-bj205 (2021).
50. Zhang, Y., Xu, X. & Zhu, S. Nickel-Catalysed Selective Migratory Hydrothiolation of Alkenes and Alkynes with Thiols. Nat. Commun. **10**, 1752 (2019).
51. Taniguchi, N. Convenient Synthesis of Unsymmetrical Organochalcogenides Using Organoboronic Acids with Dichalcogenides via Cleavage of the S–S, Se–Se, or Te–Te Bond by a Copper Catalyst. J. Org. Chem. **72**, 1241–1245 (2007).
52. Du, B. et al. Thioether-Directed NiH-Catalyzed Remote γ-C(sp3)–H Hydroamidation of Alkenes by 1,4,2-Dioxazol-5-Ones. J. Am. Chem. Soc. **143**, 14962–14968 (2021).
53. Cai, S. et al. Rh(III)-Catalyzed Cascade Oxidative Olefination/Cyclization of Picolinamides and Alkenes via C–H Activation. Org. Lett. **16**, 3142–3145 (2014).
54. Xie, Y. et al. Sulfimine-Promoted Fast O Transfer: One–Step Synthesis of Sulfoximine from Sulfide. ChemistrySelect **2**, 1620–1624 (2017).

# Table 1

Table 1 is available in the supplementary files section.

# Figures

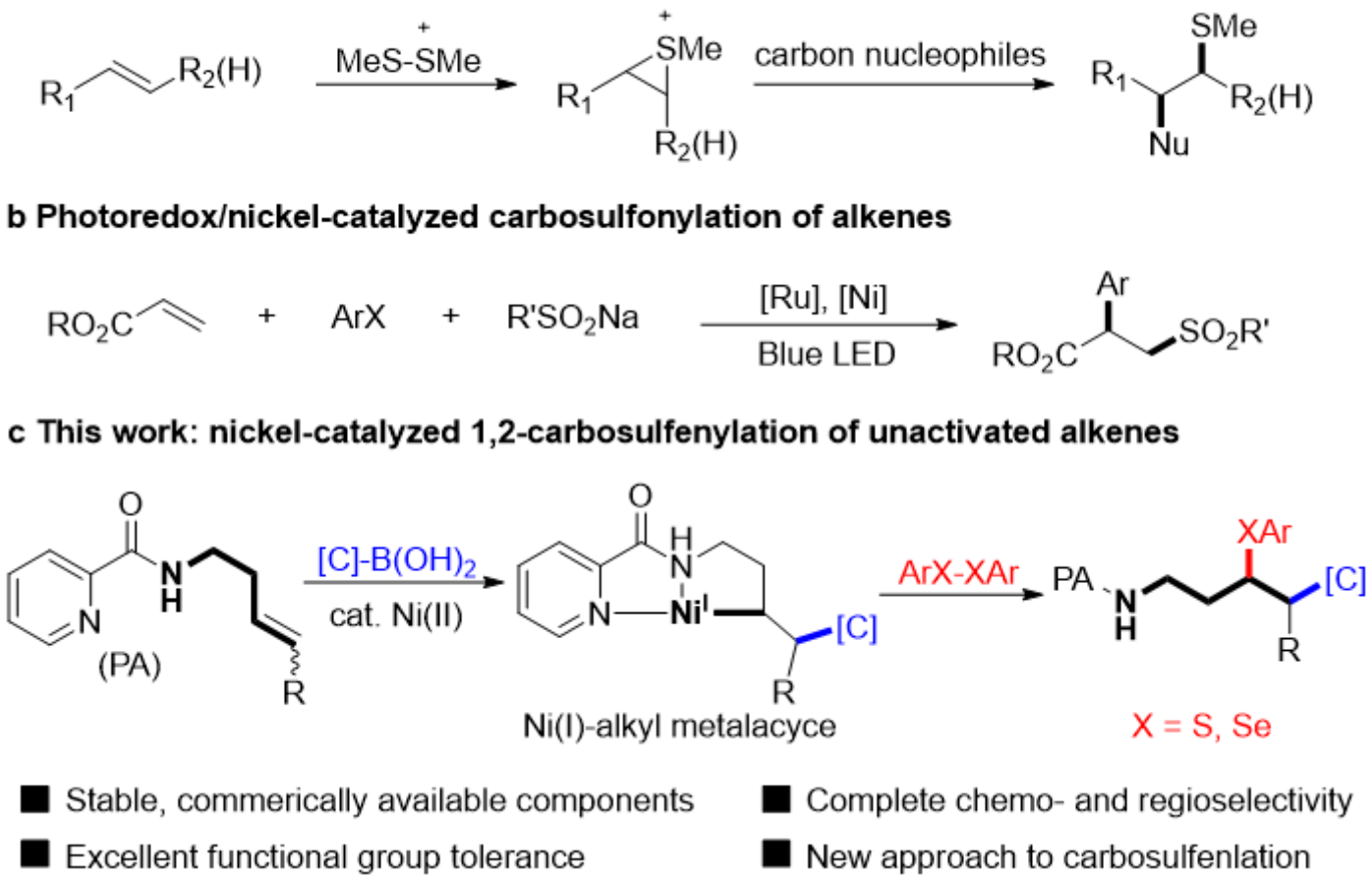
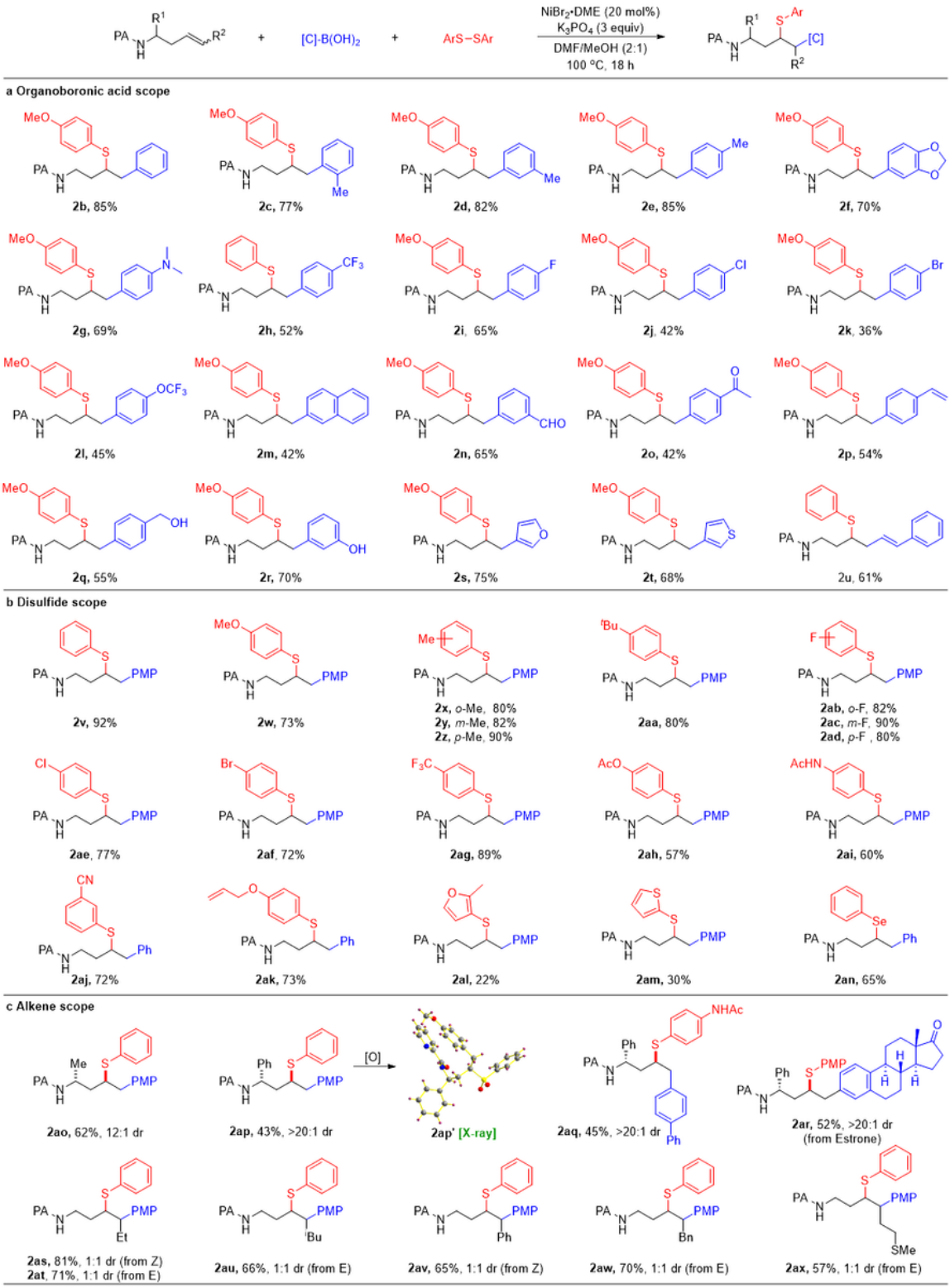



**Figure 1**

**Background and design for carbosulfenylation of unactivated alkenes. a** Episulfonium ion mediated 1,2-carbosulfenylation. **b** Photoredox/nickel-catalyzed carbosulfonylation of alkenes. **c** This work: nickel-catalyzed 1,2-carbosulfenylation of unactivated alkenes.




## Figure 2

**Scope of Ni-catalyzed 1,2-carbosulfenylation of unactivated alkenes.** Reaction conditions: alkene 1 (0.2 mmol), arylboronic acid (0.3 mmol), diaryl sulfide (0.5 mmol), DMF/MeOH (1/0.5 mL); yield of isolated product; dr was determined by NMR or GC-MS analysis of the crude products. PMP: 4-methoxyphenyl.

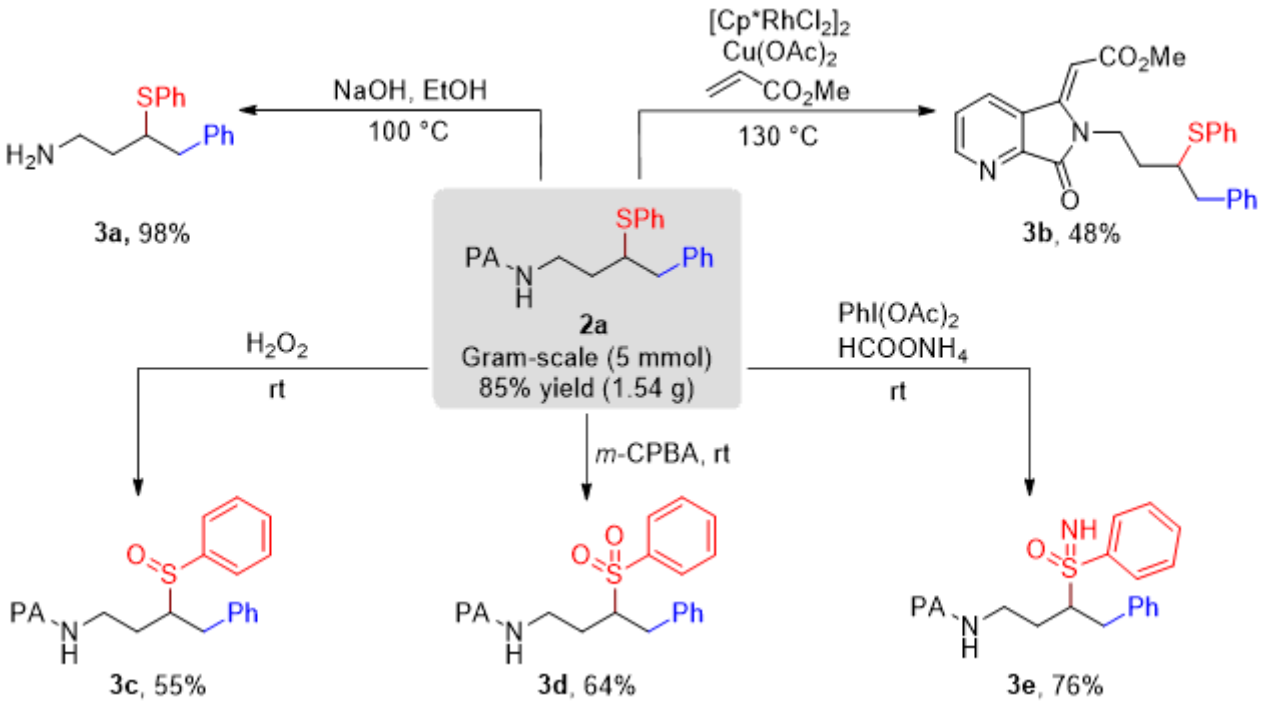



**Figure 3**

Scaling up, auxiliary removal and synthetic applications.

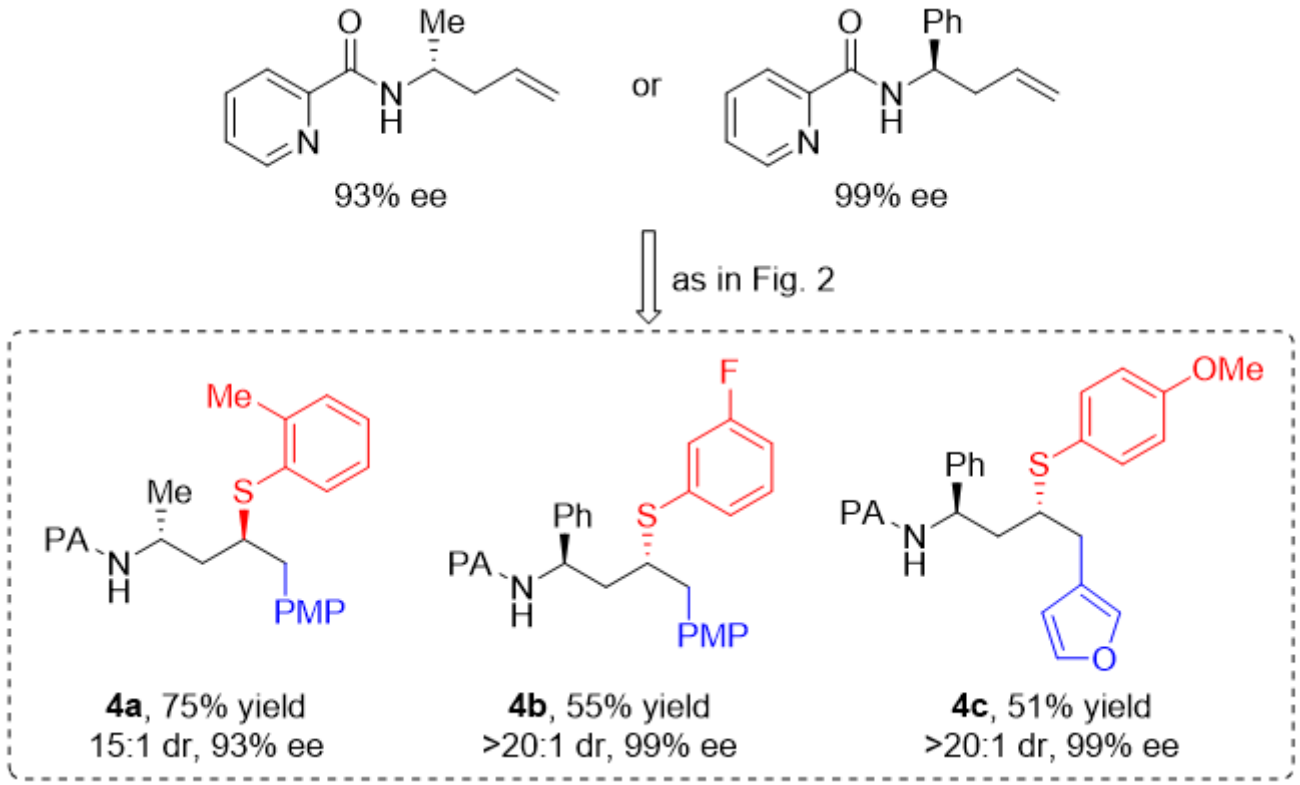



**Figure 4**

Access to enantioenriched α,γ-difunctionalized thiolamines.

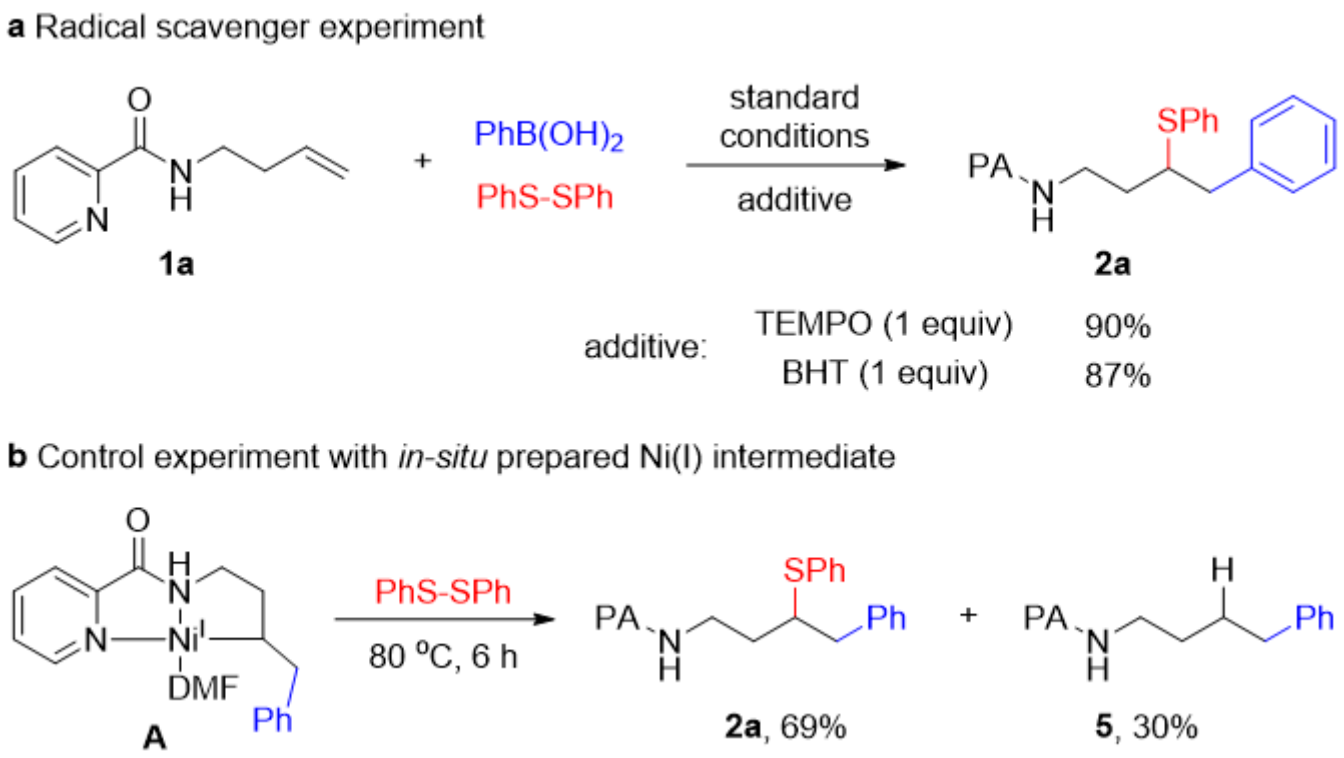



Figure 5

**Preliminary mechanistic studies. a** Radical scavenger experiment. **b** Control experiment with in-situ prepared Ni(I) intermediate.

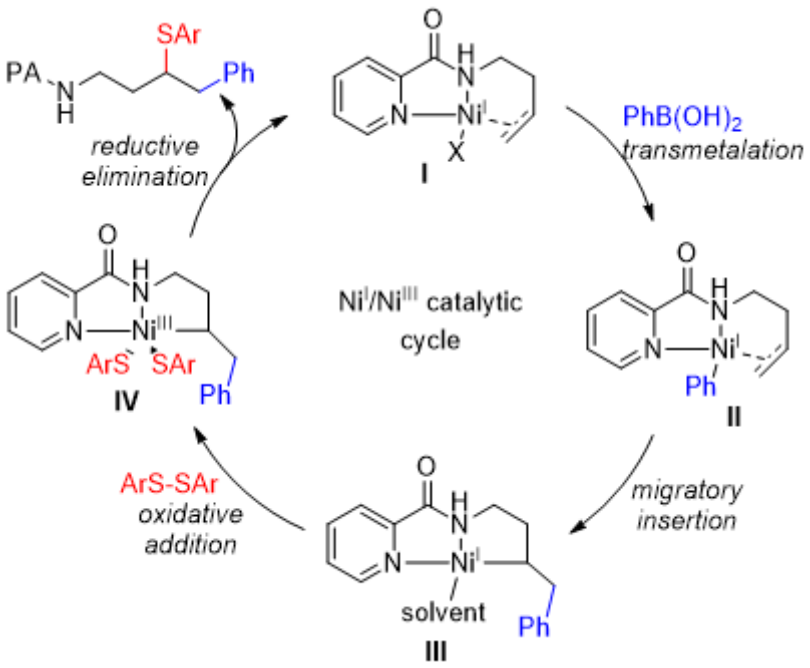



Figure 6

**Proposed mechanism.**

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- A220118A.cif
- SupplementaryInformation.pdf
- Onlinefloatimage2.png
- checkcif.pdf