OL Organic Letters

pubs.acs.org/OrgLett Letter

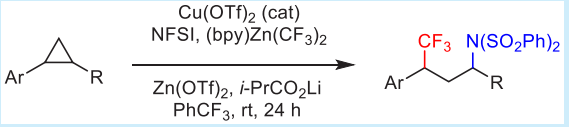
Copper-Catalyzed Ring-Opening 1,3-Aminotrifluoromethylation of Arylcyclopropanes

Huan Zhang, Haiwen Xiao, Feng Jiang, Yewen Fang,* Lin Zhu,* and Chaozhong Li*

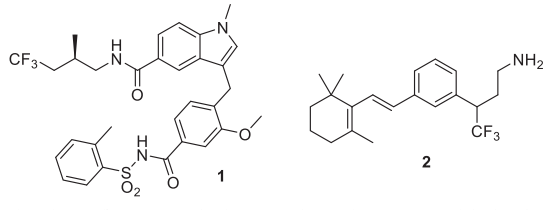
Cite This: *Org. Lett.* 2021, 23, 2268–2272 Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: The copper-catalyzed reaction of arylcyclopropanes, *N*-fluorobis(arenesulfonyl)imides, and (bpy)Zn$(CF_3)_2$ (bpy = 2,2′-bipyridine) at room temperature affords the corresponding ring-opening 1,3-aminotrifluoromethylation products in satisfactory yields. The protocol is highly regioselective, providing a convenient entry to γ-trifluoromethylated amines. A mechanism involving the trifluoromethylation of benzyl radicals is proposed.

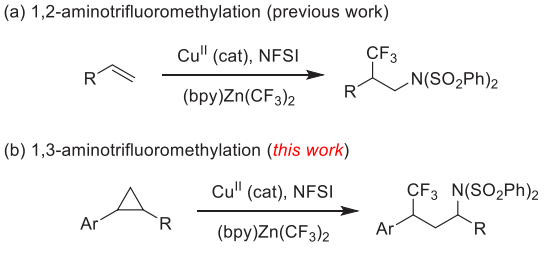


Trifluoromethyl groups have been demonstrated to be important structural motifs in pharmaceuticals and agrochemicals owing to their profound effect on properties such as lipophilicity, permeability, and metabolic stability. In this context, γ-trifluoromethylated amines are a unique class of compounds of important biological activities. For example, γ-CF_3-substituted amine Zeneca ZD 3523 (**1**) is a potent, orally active antagonist of leukotrienes D_4 and E_4 discovered by the Zeneca Pharmaceutical Co.[1] Another example is that 3-(trifluoromethyl)-3-arylpropylamine **2** has been identified as a powerful inhibitor of retinol dehydrogenases for treating ophthalmic diseases and disorders.[2] However, there have been no reports to date of general methods for the synthesis of γ-trifluoromethylated amines despite recent advances in the introduction of CF_3 groups into organic molecules, in particular, C(sp^3)-trifluoromethylation.[3]



Radical trifluoromethylation has been established as a versatile tool in the synthesis of trifluoromethylated compounds, enabling the successful implementation of a number of useful transformations such as C(sp^3)−H trifluoromethylation, decarboxylative trifluoromethylation of aliphatic carboxylic acids, and trifluoromethylation of alkyl (or aryl) halides, as developed by the groups of MacMillan,[4] Liu,[5] Cook,[6] and our group[7] in the past few years. Based on the strategy, the copper-catalyzed 1,2-aminotrifluoromethylation of alkenes has also been accomplished by us, providing a convenient entry to β-trifluoromethylated amines (Scheme 1a).[7g] Given that arylcyclopropanes are a unique class of structurally constrained molecules[8] prone to ring-opening 1,3-difunctionalization upon single-electron oxidation,[9,10] we speculate that they might be used as the starting materials for the concomitant introduction of a CF_3 motif and a protected amino group. Herein, we report the copper-catalyzed ring-opening 1,3-aminotrifluoromethylation of arylcyclopropanes, providing a convenient synthesis of γ-trifluoromethylated amines in a highly regioselective manner (Scheme 1b).

Scheme 1. Aminotrifluoromethylation via Trifluoromethylation of Alkyl Radicals

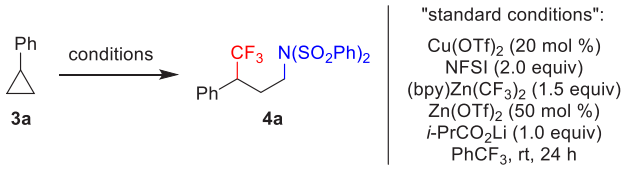


As a start, we chose phenylcyclopropane (**3a**) as the model substrate to test our idea. After an extensive screening of reaction parameters (Table 1, also see Tables S1−S4 for details), we were pleased to find that, with Cu$(OTf)_2$ as the catalyst, *N*-fluorobis(benzenesulfonyl)imide (NFSI)[11] and (bpy)Zn$(CF_3)_2$ (bpy = 2,2′-bipyridine)[12] as the reagents, and Zn$(OTf)_2$ and *i*-$PrCO_2Li$ as the additives, the reaction of **3a** in $PhCF_3$ at room temperature (rt) furnished the desired product **4a** in almost quantitative yield (entry 1, Table 1). Switching the catalyst to Cu$(MeCN)_4BF_4$ also led to the formation of **4a** in a high yield (entry 2, Table 1). However, the use of other copper salts such as CuCN, $CuCl_2$, or Cu_2O in place of Cu$(OTf)_2$ showed a poor performance (entries 3−5,

Received: February 1, 2021
Published: March 9, 2021

https://dx.doi.org/10.1021/acs.orglett.1c00390
Org. Lett. 2021, 23, 2268–2272

Table 1. Optimization of Reaction Conditions



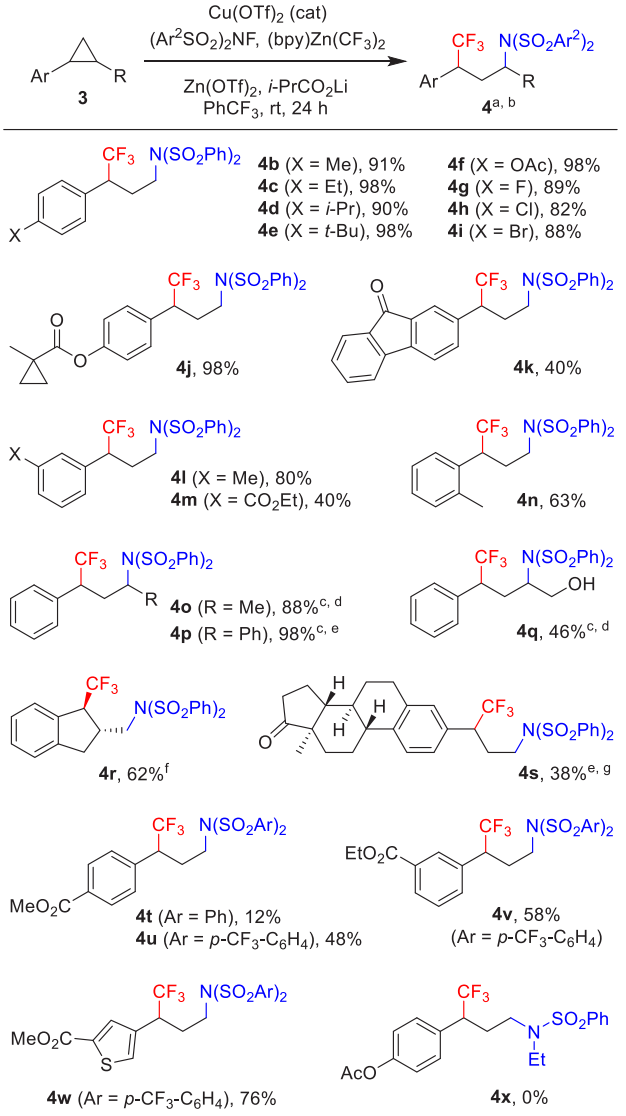
entry[a]	variation from the "standard conditions"	yield[b] (%)
1	none	98
2	$Cu(MeCN)_4BF_4$ in place of $Cu(OTf)_2$	96
3	CuCN in place of $Cu(OTf)_2$	67
4	$CuCl_2$ in place of $Cu(OTf)_2$	46
5	Cu_2O in place of $Cu(OTf)_2$	9
6	less amount (10 mol %) of $Cu(OTf)_2$ used	60
7	without $Cu(OTf)_2$	0
8	$TMSCF_3$ in place of $(bpy)Zn(CF_3)_2$	0
9	LiOAc in place of i-$PrCO_2Li$	88
10	without i-$PrCO_2Li$	4
11	without $Zn(OTf)_2$	14
12	without i-$PrCO_2Li$ and $Zn(OTf)_2$	0
13	DCM in place of $PhCF_3$	51
14	MeCN in place of $PhCF_3$	trace

[a]The reaction was carried out on 0.10 mmol scale in $PhCF_3$ (2.0 mL). [b]Isolated yield based on **3a**.

Table 1). Lowering the amount of $Cu(OTf)_2$ from 20 to 10 mol % resulted in a decreased product yield (entry 6, Table 1), and its role as the catalyst was further demonstrated by the control experiment (entry 7, Table 1). The zinc complex $(bpy)Zn(CF_3)_2$ proved to be superior over other trifluoromethylating agents such as the Ruppert–Prakash reagent ($TMSCF_3$)[13] (entry 8, Table 1, also see Table S2 for details). In the meantime, the additives had a dramatic influence on the transformation. Among various additives screened (also see Table S3 for details), the combination of $Zn(OTf)_2$ and i-$PrCO_2Li$ offered the best result. Replacing i-$PrCO_2Li$ by other salts such as LiOAc caused a slight decrease in product yield (entry 9, Table 1). Interestingly, a low yield of **4a** was observed with the use of only one additive, while no expected product was observed without any additive at all (entries 10–12, Table 1). Similar phenomena were also observed in our previous investigations.[7g] While the detailed reason remains unclear for the synergistic effect of additives, it might be possible that the use of the two salts helps to have a better control over the rate of transmetalation of the CF_3 group from zinc to copper (vide infra). Finally, $PhCF_3$ turned out to be a solvent better than dichloromethane (DCM) or acetonitrile (entries 13 and 14, Table 1).

With the optimized conditions, we set out to examine the scope of the method. As summarized in Scheme 2, arylcyclopropanes with *p*-alkyl, acyloxy, or halogen substitution all underwent the condensation with NFSI and $(bpy)Zn(CF_3)_2$ at rt, producing the corresponding 1,3-aminotrifluoromethylation products **4b**–**4j** in excellent yields. Note that the aryl bromide function in **4i** makes possible further elaboration of the product into more complex molecules (see below). The reaction of *meta*- and *ortho*-substituted arylcyclopropanes also proceeded smoothly to afford the expected products **4k**–**4n** in acceptable yields. The protocol was also applicable to 1,2-disubstituted cyclopropanes, as exemplified by the efficient synthesis of **4o** and **4p**. Sensitive functional groups such as free hydroxyl group were well tolerated by the oxidative process, as

Scheme 2. 1,3-Aminotrifluoromethylation



[a]Conditions: **3** (0.10 mmol), $Cu(OTf)_2$ (0.02 mmol), $(Ar_2O_2)_2NF$ (0.20 mmol), $(bpy)Zn(CF_3)_2$ (0.15 mmol), $Zn(OTf)_2$ (0.05 mmol), i-$PrCO_2Li$ (0.10 mmol), $PhCF_3$ (2.0 mL), rt, 24 h. [b]Isolated yield based on **3**. [c]The substrate was in 1,2-*trans* configuration. [d]dr = 45:55 determined by ^{19}F NMR. [e]dr = 50:50 determined by ^{19}F NMR. [f]*trans*/*cis* = 92:8 determined by ^{19}F NMR. [g]Reaction time: 48 h.

evidenced by the generation of **4q**. In another case, the reaction of tetrahydrocyclopropa[*a*]indene (**3r**) delivered 2,3-disubstituted indene **4r** in a highly stereoselective (92:8) manner in favor of the *trans* configuration. Interestingly the ring-opening of **3r** was highly chemoselective in that no ring expansion product (i.e., 1,3-disubstituted tetrahydronaphthalene) could be detected. Furthermore, the use of cyclopropylestrone furnished γ-CF_3-amine **4s**, indicating that the method was suitable for late-stage modification of complex molecules.

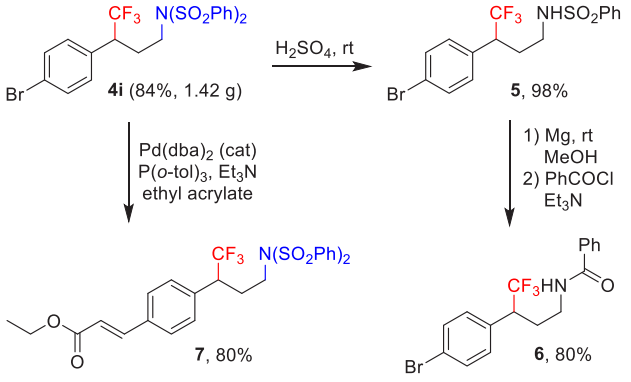
While γ-trifluoromethylated amine **4l** having a *meta*-methyl substitution on the aromatic ring was achieved in 80% yield, the *meta*-ethoxycarbonyl-substituted analogue (**4m**) was obtained in a lower (40%) yield. As a comparison, *p*-methoxycarbonyl-substituted product **4t** was isolated in only 12% yield. The electron-withdrawing substitution on the

https://dx.doi.org/10.1021/acs.orglett.1c00390
Org. Lett. 2021, 23, 2268–2272

aromatic ring had a negative impact on the reaction probably by making the arylcyclopropanes more difficult to oxidize. To overcome this limitation, we switched NFSI to its *p*-trifluoromethylated derivative.[14] We were delighted to find that the same substrate **3t** now delivered the desired products **4u** in a much higher (48%) yield in comparison with **4t** (12% yield). Similarly, the reaction of (*m*-methoxycarbonylphenyl)-cyclopropane (**3m**) with $(p\text{-}CF_3\text{-}C_6H_4SO_2)_2NF$ provided **4v** in a higher (58%) yield compared to its reaction with NFSI (to give **4m** in 40% yield). The protocol could be further extended to heteroarylcyclopropanes. For example, thiophenylcyclopropane **3w** furnished the expected product **4w** in 76% yield on reaction with $(p\text{-}CF_3\text{-}C_6H_4SO_2)_2NF$. The above experiments clearly demonstrated that the *p*-CF_3 substitution increased the reaction efficiency. Presumably, the *p*-CF_3-substitution renders the N−F reagent a stronger oxidant than NFSI, thus facilitating the oxidative ring opening of electron-deficient arylcyclopropanes. This assumption was further supported by our observation that a much weaker oxidant, $(PhSO_2)EtN\text{-}F$, failed to give the desired product **4x**.

In addition to being general, the 1,3-aminotrifluoromethylation was highly regioselective in that the trifluoromethyl group was always attached to the benzylic carbon. Moreover, the reaction could be easily scaled up without an obvious decrease in product yield, as exemplified by the gram-scale synthesis of **4i** (Scheme 3). One of the sulfonyl groups in **4i**

Scheme 3. Gram-Scale Synthesis and Derivatization of 4i



was readily removed by acid hydrolysis at rt to give sulfonamide **5** in almost quantitative yield. Further treatment of **5** with Mg/MeOH at rt furnished the corresponding free amines under mild conditions, which could be easily converted to amides such as **6** according to the conventional methods. In another case, the palladium-catalyzed Heck coupling of **4i** with ethyl acrylate led to the easy synthesis of alkene **7**. These experiments further demonstrated the potential of 1,3-aminotrifluoromethylation products in the synthesis of structurally complex trifluoromethylated compounds.

A mechanism involving the trifluoromethylation of benzyl radicals could be inferred from the above experiments. Indeed, the reaction was completely inhibited by the addition of a stoichiometric amount of TEMPO (2,2,6,6-tetramethylpiperidin-*N*-oxyl) or BHT (2,6-di-*tert*-butyl-4-methylphenol), thus providing additional evidence for the radical intermediacy.

A plausible mechanism can thus be proposed based on the above results and literature reports, as depicted in Figure 1. Transmetalation of CF_3 anion from $(bpy)Zn(CF_3)_2$ to Cu^I forms the $Cu^I\text{−}CF_3$ species that is then captured by NFSI to

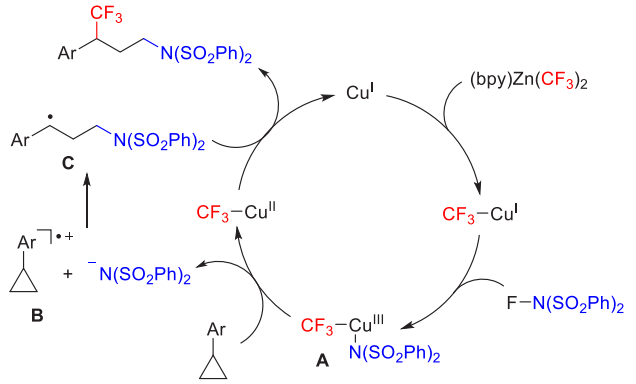


Figure 1. Proposed mechanism.

give the Cu^{III} intermediate **A**.[15] The oxidation of arylcyclopropanes by **A** generates arylcyclopropanes radical cation **B**, $(PhSO_2)_2N^-$ anion, and $Cu^{II}\text{−}CF_3$ complex. The interaction of $(PhSO_2)_2N^-$ anion with radical cation **B** results in the ring-opening of the latter, and the corresponding benzyl radical **C** is produced. Finally, the CF_3 group transfer from the $Cu^{II}\text{−}CF_3$ complex to radical **C** furnishes the 1,3-aminotrifluoromethylation product and regenerates the Cu^I catalyst.

In conclusion, we have successfully developed the unprecedented protocol for the 1,3-aminotrifluoromethylation of arylcyclopropanes, providing a convenient entry to γ-trifluoromethylated amines. As the procedure is catalytic in copper, broad in scope, and operationally simple, the method should find important applications in the synthesis of trifluoromethylated molecules of biological interests.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.orglett.1c00390.

Full experimental details, characterizations of new compounds, and copies of ^1H, ^{13}C, and ^{19}F NMR spectra (PDF)

■ AUTHOR INFORMATION

Corresponding Authors

Yewen Fang − *School of Materials and Chemical Engineering, Ningbo University of Technology, Ningbo 315211, China;* orcid.org/0000-0002-8911-7330; Email: fang@nbut.edu.cn

Lin Zhu − *Key Laboratory of Organofluorine Chemistry, Center for Excellence in Molecular Synthesis, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Shanghai 200032, China*; Email: zhulin@mail.ustc.edu.cn

Chaozhong Li − *School of Physical Science and Technology, ShanghaiTech University, Shanghai 201210, China; Key Laboratory of Organofluorine Chemistry, Center for Excellence in Molecular Synthesis, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Shanghai 200032, China; School of Materials and Chemical Engineering, Ningbo University of Technology, Ningbo 315211, China;* orcid.org/0000-0002-5135-9115; Email: clig@mail.sioc.ac.cn

https://dx.doi.org/10.1021/acs.orglett.1c00390
Org. Lett. 2021, 23, 2268−2272

Authors

Huan Zhang − *School of Physical Science and Technology, ShanghaiTech University, Shanghai 201210, China*

Haiwen Xiao − *Key Laboratory of Organofluorine Chemistry, Center for Excellence in Molecular Synthesis, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Shanghai 200032, China*

Feng Jiang − *Key Laboratory of Organofluorine Chemistry, Center for Excellence in Molecular Synthesis, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Shanghai 200032, China*

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.orglett.1c00390

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

This project was supported by the National Natural Science Foundation of China (Grant Nos. 21532008, 21871285, and 21971253), by the Chinese Academy of Sciences (Grant Nos. XDB20020000 and ZDBS-LY-SLH026), and by the Zhejiang Provincial Natural Science Foundation of China (Grant No.LY20B020008).

■ DEDICATION

This paper is dedicated to Professor Ilhyong Ryu, a pioneer in free radical chemistry, on the occasion of his 70th birthday.

■ REFERENCES

(1) Jacobs, R. T.; Bernstein, P. R.; Cronk, L. A.; Vacek, E. P.; Newcomb, L. F.; Aharony, D.; Buckner, C. K.; Kusner, E. J. Synthesis, structure-activity relationships, and pharmacological evaluation of a series of fluorinated 3-benzyl-5-indolecarboxamides: identification of 4-[[5-[((2*R*)-2-methyl-4,4,4-trifluorobutyl)carbamoyl]-1-methylindol-3-yl]methyl]-3-methoxy-*N*-[(2-methylphenyl)sulfonyl]-benzamide, a potent, orally active antagonist of leukotrienes D_4 and E_4. *J. Med. Chem.* **1994**, *37*, 1282−1297.

(2) Acucela, Inc. Styrenyl derivative compounds for treating ophthalmic diseases and disorders. WO 2008/131368, 2008.

(3) (a) Umemoto, T. Electrophilic perfluoroalkylating agents. *Chem. Rev.* **1996**, *96*, 1757−1777. (b) Schlosser, M. CF_3-bearing aromatic and heterocyclic building blocks. *Angew. Chem., Int. Ed.* **2006**, *45*, 5432−5446. (c) Shibata, N.; Matsnev, A.; Cahard, D. Shelf-stable electrophilic trifluoromethylating reagents: a brief historical perspective. *Beilstein J. Org. Chem.* **2010**, *6*, 65. (d) Nie, J.; Guo, H.-C.; Cahard, D.; Ma, J.-A. Asymmetric construction of stereogenic carbon centers featuring a trifluoromethyl group from prochiral trifluoromethylated substrates. *Chem. Rev.* **2011**, *111*, 455−529. (e) Studer, A. A. "renaissance" in radical trifluoromethylation. *Angew. Chem., Int. Ed.* **2012**, *51*, 8950−8958. (f) Liang, T.; Neumann, C. N.; Ritter, T. Introduction of fluorine and fluorine-containing functional groups. *Angew. Chem., Int. Ed.* **2013**, *52*, 8214−8264. (g) Merino, E.; Nevado, C. Addition of CF_3 across unsaturated moieties: a powerful functionalization tool. *Chem. Soc. Rev.* **2014**, *43*, 6598−6608. (h) Koike, T.; Akita, M. Trifluoromethylation by visible-light-driven photoredox catalysis. *Top. Catal.* **2014**, *57*, 967−974. (i) Egami, H.; Sodeoka, M. Trifluoromethylation of alkenes with concomitant introduction of additional functional groups. *Angew. Chem., Int. Ed.* **2014**, *53*, 8294−8308. (j) Alonso, C.; de Marigorta, E. M.; Rubiales, G.; Palacios, F. Carbon trifluoromethylation reactions of hydrocarbon derivatives and heteroarenes. *Chem. Rev.* **2015**, *115*, 1847−1935. (k) Charpentier, J.; Fruh, N.; Togni, A. Electrophilic trifluoromethylation by use of hypervalent iodine reagents. *Chem. Rev.* **2015**, *115*, 650−682. (l) Koike, T.; Akita, M. Fine design of photoredox systems for catalytic fluoromethylation of carbon-carbon multiple bonds. *Acc. Chem. Res.* **2016**, *49*, 1937−1945.

(4) (a) Kautzky, J. A.; Wang, T.; Evans, R. W.; MacMillan, D. W. C. Decarboxylative trifluoromethylation of aliphatic carboxylic acids. *J. Am. Chem. Soc.* **2018**, *140*, 6522−6526. (b) Kornfilt, D. J. P.; MacMillan, D. W. C. Copper-catalyzed trifluoromethylation of alkyl bromides. *J. Am. Chem. Soc.* **2019**, *141*, 6853−6858. (c) Sarver, P. J.; Bacauanu, V.; Schultz, D. M.; DiRocco, D. A.; Lam, Y.-h.; Sherer, E. C.; MacMillan, D. W. C. The merger of decatungstate and copper catalysis to enable aliphatic C(sp^3)-H trifluoromethylation. *Nat. Chem.* **2020**, *12*, 459−467.

(5) (a) Paeth, M.; Carson, W.; Luo, J.-H.; Tierney, D.; Cao, Z.; Cheng, M.-J.; Liu, W. Copper-mediated trifluoromethylation of benzylic Csp^3−H bonds. *Chem. - Eur. J.* **2018**, *24*, 11559−11563. (b) Jiang, C.; Wang, L.; Zhang, H.; Chen, P.; Guo, Y.-L.; Liu, G. Enantioselective copper-catalyzed trifluoromethylation of benzylic radicals via ring opening of cyclopropanols. *Chem.* **2020**, *6*, 2407−2419.

(6) (a) Guo, S.; AbuSalim, D. I.; Cook, S. P. Aqueous benzylic C−H trifluoromethylation for late-stage functionalization. *J. Am. Chem. Soc.* **2018**, *140*, 12378−12382. (b) Guo, S.; AbuSalim, D. I.; Cook, S. P. 1,2-(Bis)trifluoromethylation of alkynes: a one-step reaction to install an underutilized functional group. *Angew. Chem., Int. Ed.* **2019**, *58*, 11704−11708. (c) He, J.; Nguyen, T. N.; Guo, S.; Cook, S. P. Csp^3−H trifluoromethylation of unactivated aliphatic systems. *Org. Lett.* **2021**, 23. (d) Liu, Z.-Y.; Cook, S. P. Interrupting the Barton−McCombie reaction: aqueous deoxygenative trifluoromethylation of *O*-alkyl thiocarbonates. *Org. Lett.* **2021**, 23.

(7) (a) Shen, H.; Liu, Z.; Zhang, P.; Tan, X.; Zhang, Z.; Li, C. Trifluoromethylation of alkyl radicals in aqueous solution. *J. Am. Chem. Soc.* **2017**, *139*, 9843−9846. (b) Tan, X.; Liu, Z.; Shen, H.; Zhang, P.; Zhang, Z.; Li, C. Silver-catalyzed decarboxylative trifluoromethylation of aliphatic carboxylic acids. *J. Am. Chem. Soc.* **2017**, *139*, 12430−12433. (c) Zhang, P.; Shen, H.; Zhu, L.; Cao, W.; Li, C. Radical C(sp^2)−H trifluoromethylation of aldehydes in aqueous solution. *Org. Lett.* **2018**, *20*, 7062−7065. (d) Liu, Z.; Xiao, H.; Zhang, B.; Shen, H.; Zhu, L.; Li, C. Copper-catalyzed remote C(sp^3)−H trifluoromethylation of carboxamides and sulfonamides. *Angew. Chem., Int. Ed.* **2019**, *58*, 2510−2513. (e) Xiao, H.; Liu, Z.; Shen, H.; Zhang, B.; Zhu, L.; Li, C. Copper-catalyzed late-stage benzylic C(sp^3)−H trifluoromethylation. *Chem.* **2019**, *5*, 940−949. (f) Zhang, Z.; Zhu, L.; Li, C. Copper-catalyzed carbotrifluoromethylation of unactivated alkenes driven by trifluoromethylation of alkyl radicals. *Chin. J. Chem.* **2019**, *37*, 452−456. (g) Xiao, H.; Shen, H.; Zhu, L.; Li, C. Copper-catalyzed radical aminotrifluoromethylation of alkenes. *J. Am. Chem. Soc.* **2019**, *141*, 11440−11445. (h) Liu, Z.; Shen, H.; Xiao, H.; Wang, Z.; Zhu, L.; Li, C. Copper-catalyzed ring-opening radical trifluoromethylation of cycloalkanone oximes. *Org. Lett.* **2019**, *21*, 5201−5205. (i) Shen, H.; Xiao, H.; Zhu, L.; Li, C. Copper-catalyzed radical bis(trifluoromethylation) of alkynes and 1,3-enynes. *Synlett* **2020**, *31*, 41−44. (j) Zhu, L.; Fang, Y.; Li, C. Trifluoromethylation of alkyl radicals: breakthrough and challenges. *Chin. J. Chem.* **2020**, *38*, 787−789.

(8) (a) de Meijere, A. Bonding properties of cyclopropane and their chemical consequences. *Angew. Chem., Int. Ed. Engl.* **1979**, *18*, 809−886. (b) Reissig, H.-U.; Zimmer, R. Donor-acceptor-substituted cyclopropane derivatives and their application in organic synthesis. *Chem. Rev.* **2003**, *103*, 1151−1196. (c) Schneider, T. F.; Kaschel, J.; Werz, D. B. A new golden age for donor-acceptor cyclopropanes. *Angew. Chem., Int. Ed.* **2014**, *53*, 5504−5523.

(9) (a) Mizuno, K.; Yoshioka, K.; Otsuji, Y. 9,10-Dicyanoanthracene-sensitized two-electron oxidation of phenylcyclopropane and aromatic olefins in the presence of copper(II) ion. *Chem. Lett.* **1983**, *12*, 941−944. (b) Mazzocchi, P. H.; Oda, K. Electron transfer photochemistry of 1,8-naphthalimide and phenylcyclopropane. *Heterocycles* **1988**, *27*, 1105−1107. (c) Takahashi, Y.; Nishioka, N.; Endoh, F.; Ikeda, H.; Miuashi, T. Phenylcyclopropane cation radical revisited: generation, direct observation and determination of the rates of nucleophilic capture. *Tetrahedron Lett.* **1996**, *37*, 1841−1844.

(d) Pitts, C. R.; Ling, B.; Snyder, J. A.; Bragg, A. E.; Lectka, T. Aminofluorination of cyclopropanes: a multifold approach through a common, catalytically generated intermediate. *J. Am. Chem. Soc.* **2016**, *138*, 6598−6609. (e) Yang, S.; Wang, L.; Zhang, H.; Liu, C.; Zhang, L.; Wang, X.; Zhang, G.; Li, Y.; Zhang, Q. Copper-Catalyzed Asymmetric Aminocyanation of Arylcyclopropanes for Synthesis of γ-Amino Nitriles. *ACS Catal.* **2019**, *9*, 716−721. (f) Wang, L.; Wang, X.; Zhang, G.; Yang, S.; Li, Y.; Zhang, Q. Copper-catalyzed 1,3-aminoazidation of arylcyclopropanes: a facile access to 1,3-diamine derivatives. *Org. Chem. Front.* **2019**, *6*, 2934−2938. (g) Ge, L.; Wang, D.-X.; Xing, R.; Ma, D.; Walsh, P. J.; Feng, C. Photoredox-catalyzed oxo-amination of aryl cyclopropanes. *Nat. Commun.* **2019**, *10*, 4367.

(10) (a) Garve, L. K. B.; Barkawitz, P.; Jones, P. G.; Werz, D. B. Ring-opening 1,3-dichlorination of donor-acceptor cyclopropanes by iodobenzene dichloride. *Org. Lett.* **2014**, *16*, 5804. (b) Wallbaum, J.; Garve, L. K. B.; Jones, P. G.; Werz, D. B. Ring-opening region-, diastereo- and Enantioselective 1,3-chlorochalcogenation of cyclopropyl carbaldehydes. *Chem. - Eur. J.* **2016**, *22*, 18756. (c) Wallbaum, J.; Garve, L. K. B.; Jones, P. G.; Werz, D. B. Ring-opening 1,3-halochalcogenation of cyclopropane dicarboxylates. *Org. Lett.* **2017**, *19*, 98. (d) Das, S.; Daniliuc, C. G.; Studer, A. Stereospecific 1,3-aminobromination of donor-acceptor cyclopropanes. *Angew. Chem., Int. Ed.* **2017**, *56*, 11554. (e) Ilchenko, N. O.; Hedberg, M.; Szabó, K. J. Fluorinative ring-opening of cyclopropanes by hypervalent iodine reagents. An efficient method for 1,3-oxyfluorination and 1,3-difluorination. *Chem. Sci.* **2017**, *8*, 1056. (f) Guin, A.; Rathod, T.; Gaykar, R. N.; Roy, T.; Biju, A. T. Lewis acid catalyzed ring-opening 1,3-aminothiolation of donor-acceptor cyclopropanes using sulfonamides. *Org. Lett.* **2020**, *22*, 2276.

(11) Differding, E.; Ofner, H. *N*-Fluorobenzenesulfonimide: a practical reagent for electrophilic fluorination. *Synlett* **1991**, *1991*, 187−189.

(12) Aikawa, K.; Nakamura, Y.; Yokota, Y.; Toya, W.; Mikami, K. Stable but reactive perfluoroalkylzinc reagents: Application in ligand-free copper-catalyzed perfluoroalkylation of aryl iodides. *Chem. - Eur. J.* **2015**, *21*, 96.

(13) (a) Ruppert, I.; Schlich, K.; Volbach, W. Die ersten CF_3-substituierten organyl(chlor)silane. *Tetrahedron Lett.* **1984**, *25*, 2195−2198. (b) Prakash, G. K. S.; Krishnamurti, R.; Olah, G. A. Synthetic methods and reactions. 141. Fluoride-induced trifluoromethylation of carbonyl compounds with trifluoromethyltrimethylsilane (TMS-CF_3). A trifluoromethide equivalent. *J. Am. Chem. Soc.* **1989**, *111*, 393−395. (c) Shibata, N.; Mizuta, S.; Kawai, H. Recent advances in enantioselective trifluoromethylation reactions. *Tetrahedron: Asymmetry* **2008**, *19*, 2633−2644.

(14) Chen, G.; Chen, F.; Zhang, Y.; Yang, X.; Yuan, X.; Wu, F.; Yang, X. The investigation of fluorination reaction of p-substituted benzenesulfonimides with fluorine-nitrogen mixed gas to synthesize NFSI analogues. *J. Fluorine Chem.* **2012**, *133*, 155−159.

(15) Zhang, H.; Song, Y.; Zhao, J.; Zhang, J.; Zhang, Q. Regioselective radical aminofluorination of styrenes. *Angew. Chem., Int. Ed.* **2014**, *53*, 11079−11083.

https://dx.doi.org/10.1021/acs.orglett.1c00390
Org. Lett. 2021, 23, 2268−2272