Organic LETTERS

Letter

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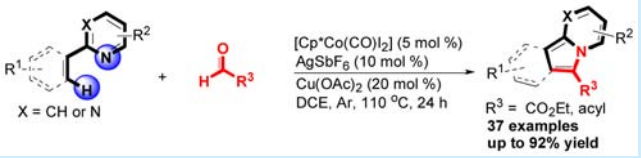
# A [4 + 1] Cyclative Capture Access to Indolizines via Cobalt(III)-Catalyzed Csp$^2$−H Bond Functionalization

Xun Chen, Xinwei Hu, Yuanfu Deng, Huanfeng Jiang, and Wei Zeng*

Key Laboratory of Functional Molecular Engineering of Guangdong Province, School of Chemistry and Chemical Engineering, South China University of Technology, Guangzhou 510641, China

Supporting Information

**ABSTRACT:** A Co(III)-catalyzed [4 + 1] cycloaddition of 2-arylpyridines or 2-alkenylpyridines with aldehydes through Csp$^2$−H bond activation has been developed. This protocol provides a facile approach to structurally diverse indolizines including benzoindolizines with a broad range of functional group tolerance.

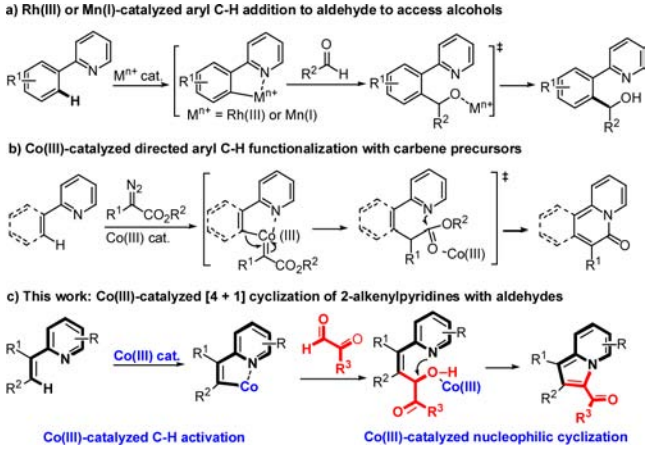



Indolizines and benzoindolizines are pervasive in natural products, pharmaceuticals, and functional materials (Figure 1).[1] In particular, 3-acylindolizines such as Rosabulin (STA-5312) exert a potential cytotoxic effect against multiple cancer cell lines.[1c] Accordingly, substantial interest has been directed toward developing concise methods for the synthesis of diverse 3-acylindolizine skeletons.[2] Among the various methods, bromohydrocarbons and silylaryl triflates have been successively employed to construct indolizine heterocycles via photocyclization,[2d] a multicomponent reaction,[2e,f] and an aryne annulation process,[2i] but these methods are only limited to furnishing benzoindolizines. Therefore, developing efficient synthetic approaches to 3-substituted indolizines is desirable.[3]


**Figure 1.** Selected examples of bioactive indolizines.

Recent, chelation-assisted C−H bond functionalizations provide an innovative strategy for direct Csp$^2$−H addition to aldehydes.[4] The pioneering report by Shi first described that a Rh(III)-catalyzed aryl C−H addition to aldehydes could produce diarylmethanols by using pyridine as a directing group (Scheme 1a).[4b] More recently, employing the earth-abundant first-row metals such as manganese[5] and cobalt[6] catalysts to realize the C−H functionalization has aroused concerns due to their availability and low cost. In this regard, Wang took advantage of the directing character of the pyridine group to enable the manganese-catalyzed Grignard-type nucleophilic addition of Csp$^2$−H bonds to aldehydes, but the corresponding alcohols could not undergo a subsequent intramolecular cyclization (Scheme 1a).[4e] In contrast, Glorius found that a pyridine-directed aryl C−H coupling with diazo compounds could occur in the presence of Co(III) salts, in which Co(III) salts also played the role of Lewis acid catalyst to enhance the nucleophilic attack of pyridyl nitrogen on the carbonyl acceptor and resulted in furnishing polycyclic hydrocarbons (Scheme 1b).[7] These results and our previous work[8] encouraged us to speculate that pyridine-directed Csp$^2$−H addition to aldehydes could also possibly occur to form alcohols by employing a Co(III) catalyst, and then a Co(III) species could activate the resulting hydroxymethylene group, leading to the formation of 3-substituted indolizines through a nucleophilic cyclization process (Scheme 1c).

**Scheme 1. Dual Activation Strategy for Transition-Metal-Catalyzed Cascade Csp$^2$−H Functionalization**




To achieve this transformation, we made the starting material 2-phenylpyridine (**1a**) and investigated the effect of various cobalt catalysts (5 mol %) on the aryl C−H addition to ethyl oxoacetate (**2a**) in the presence of $AgSbF_6$ (10 mol %) and NaOAc (20 mol %) using 1,2-dichloroethane (DCE) as solvent at 80 °C for 12 h (Table 1, entries 1−4), and we soon found that the [Cp*Co(CO)$I_2$] catalyst provided the desired 3-

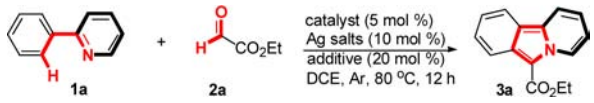
**Received:** August 12, 2016
**Published:** September 1, 2016





DOI: 10.1021/acs.orglett.6b02421
Org. Lett. 2016, 18, 4742−4745

**Table 1. Optimization of the Reaction Parameters**[a]



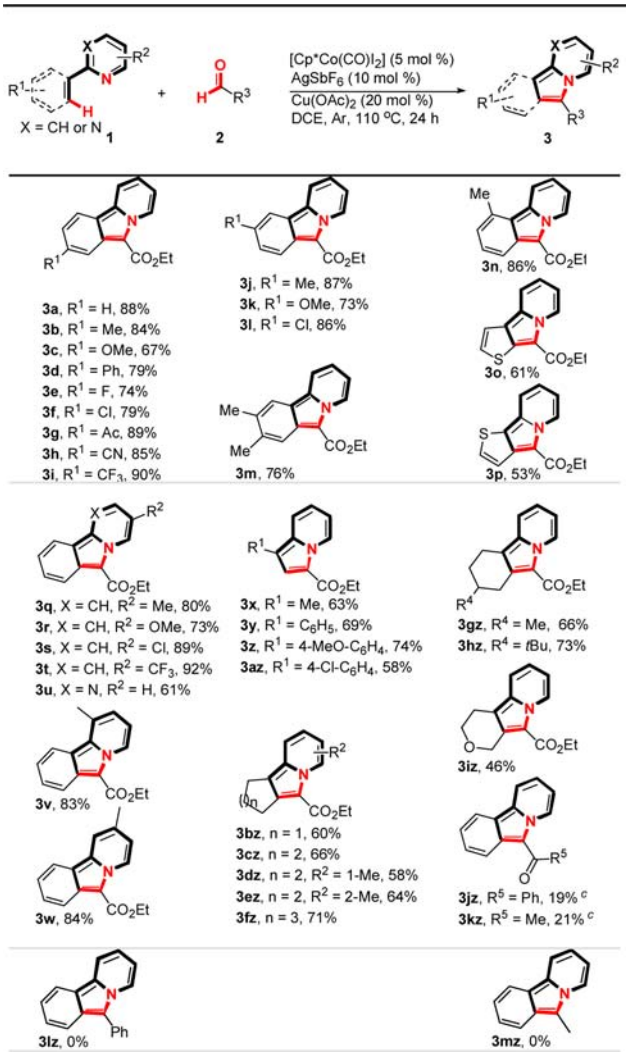

| entry | catalysts | Ag salts | additives | yield (%)[b] |
|---|---|---|---|---|
| 1 | $Co(acac)_3$ | $AgSbF_6$ | NaOAc | 0 |
| 2 | $CoCl_3$ | $AgSbF_6$ | NaOAc | 0 |
| 3 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | NaOAc | 28 |
| 4 | **A**[c] | – | NaOAc | 21 |
| 5 | $[Cp^*Co(CO)I_2]$ | $AgBF_4$ | NaOAc | 19 |
| 6 | $[Cp^*Co(CO)I_2]$ | AgOAc | NaOAc | 14 |
| 7 | $[Cp^*Co(CO)I_2]$ | $AgNTf_2$ | NaOAc | 25 |
| 8 | $[Cp^*Co(CO)I_2]$ | $AgClO_4$ | NaOAc | 0 |
| 9 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | CsOAc | 24 |
| 10 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | AcOH | 18 |
| 11 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | PivOH | 22 |
| 12 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | AgOAc | 16 |
| 13 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | $Cu(OAc)_2$ | 47 |
| 14 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | $Cu(OAc)_2$ | 36[d] |
| 15 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | $Cu(OAc)_2$ | 18[e] |
| 16 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | $Cu(OAc)_2$ | 0[f] |
| 17 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | $Cu(OAc)_2$ | 71[g,h] |
| 18 | $[Cp^*Co(CO)I_2]$ | $AgSbF_6$ | $Cu(OAc)_2$ | 88[g,h,i] |

[a]Unless otherwise noted, all the reactions were carried out using 2-phenylpyridine (**1a**) (0.20 mmol) and ethyl glyoxylate (**2a**) (0.20 mmol) with catalysts (5 mol %) in the presence of silver salts (10 mol %) and additives (20 mol %) in solvent (2.0 mL) at 80 °C for 12 h under Ar in a sealed reaction tube. Followed by flash chromatography on $SiO_2$. [b]Isolated yield. [c]**A** refers to $[Cp^*Co(MeCN)_3(SbF_6)_2]$. [d]THF was used as solvent. [e]Toluene was used as solvent. [f]DMF was used as solvent. [g]The reaction time is 24 h. [h]The reaction temperature is 110 °C. [i]The ratio of **1a**/**2a** is 1:2.

ethoxycarbonylbenzoindolizine **3a** in 28% yield (entry 3). The $[Cp^*Co(MeCN)_3(SbF_6)_2]$ catalyst also gave a 21% yield of **3a** (entry 4). It is worth noting that the further silver salt screening could not improve the reaction conversion (compare entries 5−8 with entry 3). However, after various additives including CsOAc, AcOH, PivOH, AgOAc, and $Cu(OAc)_2$ were evaluated for this transformation, the yield of product **3a** was moderately increased from 28% to 47% using $Cu(OAc)_2$ as an additive (compare entry 3 with 13). Meanwhile, the solvent screening also demonstrated that DCE was the optimal solvent (compare entries 14−16 with 13). Gratifyingly, extending the reaction time, increasing the reaction temperature, and changing the ratio of **1a**/**2a** to 1:2 could significantly improve the reaction yield to 71% and 88%, respectively (entry 17 vs 18).

With the optimized catalytic system in hand, we then turned our attention toward exploring the scope and limitation of the cobalt-catalyzed [4 + 1] cycloaddition of various 2-arylpyridines (**1**) with ethyl oxoacetate (**2a**). As shown in Scheme 2, this reaction protocol could smoothly convert 2-(4-substituted phenyl)-pyridines to the desired 3-ethoxycarbonyl-benzoindolizines with good to excellent yields (67−90%), regardless of whether electron-deficient or -rich substituents were introduced into the phenyl rings (**3a**−**3i**). For example, 2-(4-methylphenyl)pyridine (**1b**) and 2-(4-trifluoro-methylphenyl) pyridine (**1i**) could afford the desired 3-acylbenzoindolizines **3b** and **3i** in 84% and 90% yields, respectively. Moreover, 3- or 2-substitution on the benzene ring with an electron-donating group (Me, MeO) or electron-deficient group (Cl) could also give excellent yields of

**Scheme 2. Substrate Scope**[a,b]




[a]All the reactions were carried out using 2-substituted pyridine (**1**) (0.20 mmol) and aldehyde (**2**) (0.40 mmol) with $[Cp^*Co(CO)I_2]$ (5 mol %) in the presence of $AgSbF_6$ (10 mol %) and $Cu(OAc)_2$ (20 mol %) in DCE (2.0 mL) at 110 °C for 24 h under Ar in a sealed tube. Followed by flash chromatography on $SiO_2$. [b]Isolated yield. [c]Anhydrous $MgSO_4$ (100 mg) was added.

multisubstituted benzoindolizines in excellent yields, in which no significant effect of steric hindrance was observed in this transformation (**3i**−**3n**, 73% − 87% yields). Note that, 2-(3-thienyl)pyridine (**1o**) and 2-(2-thienyl)pyridine (**1p**) are also allowed for this transformation to assemble the corresponding 3-substituted thieno[3,2-*α*]indolizine (**3o**) and thieno[2,3-*α*]indolizine (**3p**) in good yields. Meanwhile, the reaction scope with respect to 2-phenyl-3- or 4- or 5-substituted pyridines was further evaluated, and it was found that these substrates with eletron-poor and -rich pyridine moieties were reactive, and could produce the corresponding benzoindolizines in 61−92% yields (**3q**−**3w**). Among them, the structure of **3s** was already unambiguously assigned by single crystal X-ray analysis [see Supporting Information (SI) for more details].

More importantly, the reactions are not limited to 2-arylpyridines. 2-Alkenylpyridines could also smoothly undergo a [4 + 1] cycloaddition with ethyl oxoacetate (**2a**) to furnish 3-ethoxycarbonylindolizines, in which 2-pyridyl substituted



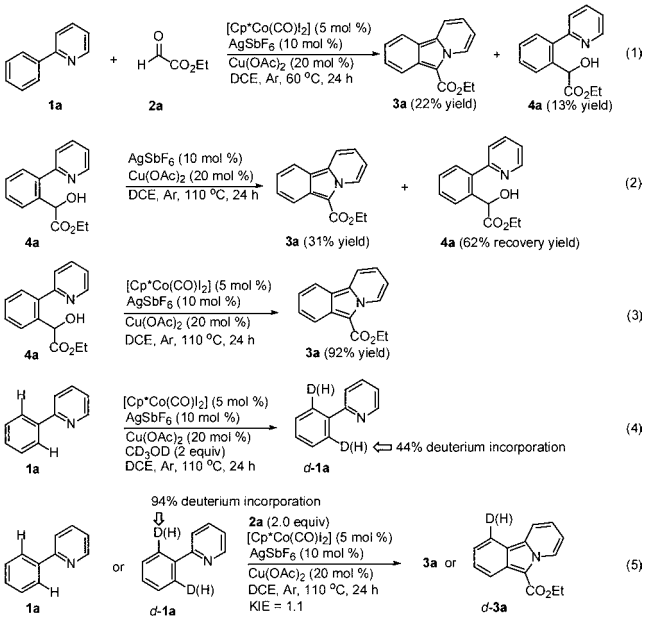
DOI: 10.1021/acs.orglett.6b02421
Org. Lett. 2016, 18, 4742−4745

terminal alkenes and interal akenes are compatible with the reaction conditions, and produce the corresponding structurally diverse indolizines (**3x**–**3iz**) in moderate to good yields (46–74%).

Finally, the reaction scope with respect to aldehydes was further investigated. In addition to ethyl oxoacetate, oxo-aryl-acetaldehyde, and oxo-alkyl-acetaldehyde could give the desired 3-acylindolizines (**3jz** and **3kz**) in accepted yields.[9] In contrast, other aldehydes such as benzaldehyde and acetaldehyde were not allowed for this transformation, and the starting materials were recovered completely.

Several control experiments were designed to elucidate the possible mechanism of this transformation (Scheme 3). When

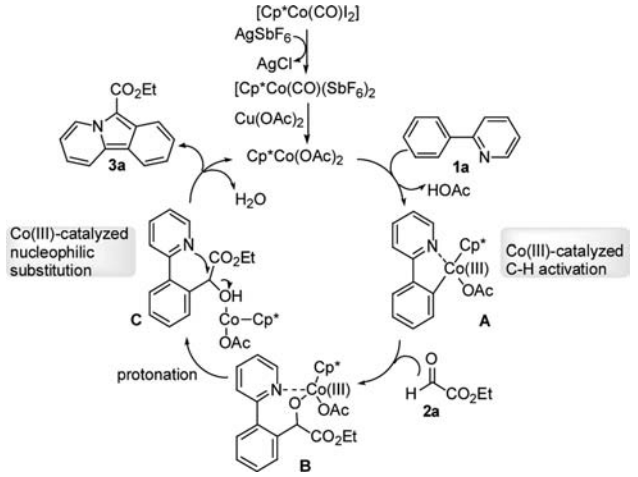
**Scheme 3. Preliminary Mechanistic Studies**




the cobalt-catalyzed [4 + 1] cycloaddition of 2-phenylpyridine (**1a**) with ethyl oxoacetate (**2a**) was conducted in the Co(III)/$Cu(OAc)_2$/$AgSbF_6$ system at 60 °C for 24 h, 3-acylbenzolizine **3a** and alcohol **4a** were produced in 22% and 13% yields, respectively (eq 1). Considering that the alcohol **4a** was the possible intermediate for this cycloaddition, alcohol **4a** was then subjected to the $AgSbF_6$/$Cu(OAc)_2$ system in the absence of a cobalt catalyst at 110 °C for 24 h, and **3a** was formed in 31% yield; the starting material **4a** could be recovered in 62% yield (eq 2). However, treating the alcohol **4a** with the Co(III)/Ag(I)/Cu(II) catalytic system at 110 °C for 24 h afforded a 92% yield of **3a** (eq 3). Moreover, deuterium incorporation at the phenyl C2- and C6-position of 2-pyridylbenzene (**1a**) was also observed in the presence of $CD_3OD$ (eq 4). These results implied that alcohol **4a** belonged to the intermediate for this transformation in which Co(III) salts also played a dual role of transition metal catalyst and Lewis acid. Subsequently, the parallel kinetic experiments from **1a** and *d*-**1a** ($k_H/k_D$ = 1.1) further indicated that aryl C–H bond-breaking was not involved in the rate-limiting step of this transformation (eq 5) (see SI for more details).

Based on the preliminary mechanistic investigations, a plausible mechanism is proposed in Scheme 4. First, [Cp*Co-$(CO)I_2$] catalysts are activated by additives $AgSbF_6$/$Cu(OAc)_2$ to form the Co(III) species $Cp^*Co(OAc)_2$[7,10] which

**Scheme 4. Proposed Mechanism**




coordinate to pyridine "N" of **1a** to form a five-membered cobaltacycle intermediate **A** via a concerted metalation/deprotonation (CMD) process.[11] Subsequently, an insertion of $\alpha$-keto aldehyde **2a** to a Co-carbonyl bond of intermediate **A** forms the seven-membered Co(III) intermediate **B**, and then intermediate **B** undergoes protonation to give alcohol **C** in which the hydroxymethylene group is activated by a Co(III) Lewis acid. Finally, Co(III)-catalyzed nucleophilic attack of the pyridine nitrogen on the hydroxymethene carbon leads to the formation of 3-acylbenzoindolizine (**3a**) with release of the Co(III) catalyst.

In conclusion, we have developed a novel cobalt-catalyzed [4 + 1] cycloaddition of 2-arylpyridines with aldehydes via a $Csp^2$–H activation process, in which cobalt catalysts play a dual role as a metal catalyst and Lewis acid. A wide range of 2-arylpyridines and 2-alkenylpyridines are allowed for this transformation, and this method provides concise access to 3-acylindolizines. Excellent functional group tolerance from 2-substituted pyridines is observed.

## ■ ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.orglett.6b02421.

Detailed experimental procedures, characterization data, copies of $^1$H NMR and $^{13}$C NMR spectra for all isolated compounds (PDF)

Crystallographic data for **3s** (CIF)

## ■ AUTHOR INFORMATION


### Corresponding Author

*E-mail: zengwei@scut.edu.cn.


### Notes

The authors declare no competing financial interest.

## ■ ACKNOWLEDGMENTS


The authors thank the NSFC (No. 21372085), National Key Research Program of China (No. 2016YFA0602900), and Science and Technology Program of Guangzhou (No. 156300075) for financial support.




DOI: 10.1021/acs.orglett.6b02421
*Org. Lett.* 2016, 18, 4742–4745

## REFERENCES


(1) For selected examples, see: (a) Han, W. B.; Zhang, A. H.; Deng, Z. Z.; Lei, X.; Tan, R. X. *Org. Lett.* **2016**, *18*, 1816. (b) Han, W. B.; Lu, Y. H.; Zhang, G. F.; Mei, Y. N.; Jiang, N.; Lei, X.; Song, Y. C.; Ng, S. W.; Tan, R. X. *Org. Lett.* **2014**, *16*, 5366. (c) Colley, H. E.; Muthana, M.; Danson, S. J.; Jackson, L. V.; Brett, M. L.; Harrison, J.; Coole, S. F.; Mason, D. P.; Jennings, L. R.; Wong, M.; Tulasi, V.; Norman, D.; Lockey, P. M.; Williams, L.; Dossetter, A. G.; Griffen, E. J.; Thompson, M. J. *J. Med. Chem.* **2015**, *58*, 9309. (d) Mitsumori, T.; Bendikov, M.; Dautel, O.; Wudl, F.; Shioya, F.; Sato, H.; Sato, Y. *J. Am. Chem. Soc.* **2004**, *126*, 16793.

(2) For selected examples, see: (a) Zhao, B.; Yu, M.; Liu, H.; Chen, Y.; Yuan, Y.; Xie, X. *Adv. Synth. Catal.* **2014**, *356*, 3295. (b) Kim, C. E.; Baek, Y.; Kim, S. H.; Lee, P. H. *Adv. Synth. Catal.* **2015**, *357*, 2903. (c) Katritzky, A. R.; Qiu, G.; Yang, B.; He, H. Y. *J. Org. Chem.* **1999**, *64*, 7618. (d) Fozard, A.; Bradsher, C. K. *J. Org. Chem.* **1967**, *32*, 2966. (e) Xie, C.; Zhang, Y.; Xu, P. *Synlett* **2008**, *2008*, 3115. (f) Huang, X.; Zhang, T. *Tetrahedron Lett.* **2009**, *50*, 208. (g) Liu, S.; Hu, X.; Li, X.; Cheng, J. *Synlett* **2013**, *24*, 847. (h) Wang, Z.; Li, T. *Org. Lett.* **2015**, *17*, 1348. (i) Rogness, D. C.; Markina, N. A.; Waldo, J. P.; Larock, R. C. *J. Org. Chem.* **2012**, *77*, 2743.

(3) Kel'in, A. V.; Sromek, A. W.; Gevorgyan, V. *J. Am. Chem. Soc.* **2001**, *123*, 2074.

(4) For selected examples, see: (a) Jeong, T.; Han, S. H.; Han, S.; Sharma, S.; Park, J.; Lee, J. S.; Kwak, J. H.; Jung, Y. H.; Kin, I. S. *Org. Lett.* **2016**, *18*, 232. (b) Li, Y.; Zhang, X. S.; Chen, K.; He, K. H.; Pan, F.; Li, B. J.; Shi, Z. J. *Org. Lett.* **2012**, *14*, 636. (c) Lian, Y.; Bergman, R. G.; Lavis, L. D.; Ellman, J. A. *J. Am. Chem. Soc.* **2013**, *135*, 7122. (d) Lian, Y.; Bergman, R. G.; Ellman, J. A. *Chem. Sci.* **2012**, *3*, 3088. (e) Zhou, B.; Hu, Y.; Wang, C. *Angew. Chem., Int. Ed.* **2015**, *54*, 13659. (f) Lian, Y.; Huber, T.; Hesp, K. D.; Bergman, R. G.; Ellman, J. A. *Angew. Chem., Int. Ed.* **2013**, *52*, 629. (g) Hummel, J. R.; Ellman, J. A. *J. Am. Chem. Soc.* **2015**, *137*, 490. (h) Yang, L.; Correia, C. A.; Li, C.-J. *Adv. Synth. Catal.* **2011**, *353*, 1269.

(5) (a) Wang, C. *Synlett* **2013**, *24*, 1606. (b) Kuninobu, Y.; Asanoma, D.; Takai, Y. *Synlett* **2010**, *2010*, 2883. (c) Kuninobu, Y.; Nishina, Y.; Takeuchi, T.; Takai, K. *Angew. Chem., Int. Ed.* **2007**, *46*, 6518. (d) Liu, W.; Zell, D.; John, M.; Ackermann, L. *Angew. Chem., Int. Ed.* **2015**, *54*, 4092. (e) Zhou, B.; Chen, H.; Wang, C. *J. Am. Chem. Soc.* **2013**, *135*, 1264. (f) Shi, L.; Zhong, X.; She, H.; Lei, Z.; Li, F. *Chem. Commun.* **2015**, *51*, 7136.

(6) For recent reviews of Co-catalyzed C−H functionalization, see: (a) Gao, K.; Yoshikai, N. *Acc. Chem. Res.* **2014**, *47*, 1208. (b) Tilly, D.; Dayaker, G.; Bachu, P. *Catal. Sci. Technol.* **2014**, *4*, 2756. (c) Moselage, M.; Li, J.; Ackermann, L. *ACS Catal.* **2016**, *6*, 498. For examples about Co-catalyzed C−H functionalization, see: (c1) Kim, J. H.; Greßies, S.; Glorius, F. *Angew. Chem., Int. Ed.* **2016**, *55*, 5577. (d) Lerchen, A.; Vasquez-Cespedes, S.; Glorius, F. *Angew. Chem., Int. Ed.* **2016**, *55*, 3208. (e) Li, J.; Tang, M.; Zang, L.; Zhang, X.; Zhang, Z.; Ackermann, L. *Org. Lett.* **2016**, *18*, 2742. (f) Prakash, S.; Muralirajan, K.; Cheng, C.-H. *Angew. Chem., Int. Ed.* **2016**, *55*, 1844. (g) Zhang, Z.-Z.; Liu, B.; Xu, J.-W.; Yan, S.-Y.; Shi, B.-F. *Org. Lett.* **2016**, *18*, 1776. (h) Wang, F.; Wang, H.; Wang, Q.; Yu, S.; Li, X. *Org. Lett.* **2016**, *18*, 1306. (i) Liang, Y.; Jiao, N. *Angew. Chem., Int. Ed.* **2016**, *55*, 4035. (j) Grigorjeva, L.; Daugulis, O. *Angew. Chem., Int. Ed.* **2014**, *53*, 10209. (k) Ilies, L.; Chen, Q.; Zeng, X.; Nakamura, E. *J. Am. Chem. Soc.* **2011**, *133*, 5221. (l) Chen, Q.; Ilies, L.; Nakamura, E. *J. Am. Chem. Soc.* **2011**, *133*, 428. (m) Gao, K.; Yoshikai, N. *J. Am. Chem. Soc.* **2011**, *133*, 400. (n) Gao, K.; Lee, P. − S.; Fujita, T.; Yoshikai, N. *J. Am. Chem. Soc.* **2010**, *132*, 12249. (o) Lenges, C. P.; White, P. S.; Brookhart, M. *J. Am. Chem. Soc.* **1998**, *120*, 6965. (p) Lenges, C. P.; Brookhart, M. *J. Am. Chem. Soc.* **1997**, *119*, 3165. (q) Yu, D.-G.; Gensch, T.; de Azambuja, F.; Vásquez-Céspedes, S.; Glorius, F. *J. Am. Chem. Soc.* **2014**, *136*, 17722. (r) Yoshino, T.; Ikemoto, H.; Matsunaga, S.; Kanai, M. *Angew. Chem., Int. Ed.* **2013**, *52*, 2207. (s) Sun, B.; Yoshino, T.; Kanai, M.; Matsunaga, S. *Angew. Chem., Int. Ed.* **2015**, *54*, 12968. (t) Gensch, T.; Klauck, F. J. R.; Glorius, F. *Angew. Chem., Int. Ed.* **2016**, *55*, DOI: 10.1002/anie.201605193.

(7) Zhao, D.; Kim, J. H.; Stegemann, L.; Strassert, A.; Glorius, F. *Angew. Chem., Int. Ed.* **2015**, *54*, 4508.

(8) For selected examples, see: (a) Xie, Y.; Chen, X.; Liu, X.; Su, S. − J.; Li, J.; Zeng, W. *Chem. Commun.* **2016**, *52*, 5856. (b) Wei, J.; Jiang, J.; Xiao, X.; Lin, D.; Deng, Y.; Ke, Z.; Jiang, H.; Zeng, W. *J. Org. Chem.* **2016**, *81*, 946. (c) Chen, X.; Xie, Y.; Xiao, X.; Li, G.; Deng, Y.; Jiang, H.; Zeng, W. *Chem. Commun.* **2015**, *51*, 15328. (d) Xie, Y.; Chen, T. F.; Fu, S. M.; Jiang, H. F.; Zeng, W. *Chem. Commun.* **2015**, *51*, 9377. (e) Xie, Y.; Chen, T. F.; Fu, S. M.; Li, X. S.; Deng, Y. F.; Jiang, H. F.; Zeng, W. *Chem. Commun.* **2014**, *50*, 10699. (f) Xiao, X. S.; Hou, C.; Zhang, Z. H.; Ke, Z. F.; Lan, J. Y.; Jiang, H. F.; Zeng, W. *Angew. Chem., Int. Ed.* **2016**, *55*, DOI: 10.1002/anie.201606531.

(9) The lower yield of **3jz** was obtained possibly due to the fact that oxo-phenyl-acetaldehyde is more stable than ethyl oxoacetate.

(10) (a) Zhang, J.; Chen, H.; Lin, C.; Liu, Z.; Wang, C.; Zhang, Y. *J. Am. Chem. Soc.* **2015**, *137*, 12990. (b) Ikemoto, H.; Yoshino, F.; Sakata, K.; Matsunaga, S.; Kanai, M. *J. Am. Chem. Soc.* **2014**, *136*, 5424.

(11) (a) Yoshino, T.; Ikemoto, H.; Matsunaga, S.; Kanai, M. *Angew. Chem., Int. Ed.* **2013**, *52*, 2207. (b) Landge, V. G.; Jaiswal, G.; Balaraman, E. *Org. Lett.* **2016**, *18*, 812. (c) Kong, L.; Yu, S.; Zhou, X.; Li, X. *Org. Lett.* **2016**, *18*, 588.




DOI: 10.1021/acs.orglett.6b02421
*Org. Lett.* 2016, 18, 4742−4745