OL | Organic Letters

Letter

Cite This: Org. Lett. XXXX, XXX, XXX−XXX

pubs.acs.org/OrgLett

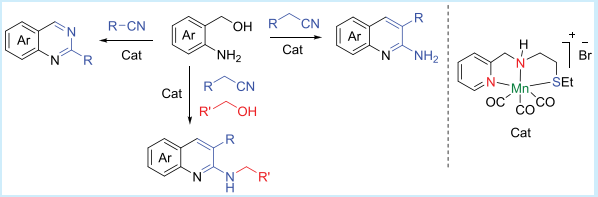
Sustainable Synthesis of Quinazoline and 2-Aminoquinoline via Dehydrogenative Coupling of 2-Aminobenzyl Alcohol and Nitrile Catalyzed by Phosphine-Free Manganese Pincer Complex

Kalicharan Das, Avijit Mondal, Debjyoti Pal, and Dipankar Srimani*

Department of Chemistry, Indian Institute of Technology-Guwahati, Kamrup, Assam 781039, India

Supporting Information

ABSTRACT: A sustainable synthesis of quinazoline and 2-aminoquinoline via acceptorless dehydrogenative annulation is presented. The reaction is catalyzed by earth-abundant well-defined manganese complexes bearing NNS ligands. Furthermore, a one-pot synthetic strategy for the synthesis of 2-alkylaminoquinolines through sequential dehydrogenative annulation and N-alkylation reaction has also been demonstrated.



The use of global resources in a sustainable manner is a challenge of the utmost urgency. For chemistry, the development of useful building blocks from renewable starting materials is highly desirable.[1] Alcohols can be obtained renewably from biomass, lignocellulose via fermentation, or catalytic conversion.[2] Thus, the selective conversion of alcohols to different valuable classes of chemical compounds offers a useful contribution toward the conservation of the finite fossil carbon resources.[3] In this regard, acceptorless dehydrogenative coupling (ADC) reaction[4] became a useful tool for the sustainable synthesis of valuable organic molecules, as this does not require any hydrogen acceptors, oxidant, or prefunctionalization of substrates.

The construction of N-containing compounds has attracted much attention of the pharmaceutical and agrochemical industries due to the important interaction of these types of compounds with the living organisms. Among them, aromatic N-heterocyclic compounds are particularly important, as found in many natural product and bioactive molecules.[5] Moreover, N-heterocyclic compounds are of great importance due to their wide range of applications as drugs,[6] agrochemicals,[7] dyes,[8] vitamins,[9] and flavors.[10] Therefore, there is a high demand for new atom-economical and sustainable synthetic protocols that allow the preparation of diversely functionalized N-heterocycles. Indeed, in recent times, an explosive growth in the noble metal-catalyzed dehydrogenative synthesis of N-heteroaromatic molecules has been observed.[11]

The replacement of expensive noble metal catalysts by earth-abundant, nontoxic first-row transition metals is extremely advantageous with regard to cost effectiveness and sustainability. In addition, the 3d metal-based catalysts could introduce a new selectivity pattern, which enables significant enhancement of the general applicability of these reactions. Despite of the significant progress in de(hydrogenative) reactions by 3d transition metals[12] in recent years, the synthesis of N-heterocycles is still in the nascent stage.[13] Manganese is the third most abundant transition metal in the earth's crust, but surprisingly, its applicability toward acceptorless dehydrogenation and hydrogenation reaction was unexplored until 2016.[14] The pioneering work by the groups of Milstein,[14a] Beller,[14b,d] Kempe,[14c] and Kirchner[14e] triggered rapid growth in the area of manganese-catalyzed ADC reactions.[15] However, the N-heterocycle synthesis via the Mn-catalyzed ADC reaction is in the budding phase.[14c,e,16] Herein, we report the first Mn-catalyzed (Figure 1) synthesis of quinazoline and 2-aminoquinoline through the dehydrogenative condensation of 2-aminobenzyl alcohol and nitriles. In addition, synthesis of 2-alkylaminoquinolines has also been demonstrated via ADC reaction followed by N-alkylation process.

Intrigued by the sustainable synthesis of pyrimidines from amidine and alcohol reported by the group of Kirchner[14e] and Kempe,[14c] we envisioned that quinazoline could be synthesized by the dehydrogenation and condensation reaction between 2-aminobenzyl alcohols and nitriles via an amidine (Figure 2) type intermediate.[17] Thus, initially we investigated the scope of the reaction by our NNS−Mn(I) complexes[16c,d] (Figure 1) using 2-aminobenzyl alcohol and benzonitrile as model substrates. Therefore, when a xylene solution containing an equimolar mixture 2-aminobenzyl alcohol and benzonitrile was refluxed in the presence of 5 mol % of cat. **1** and 0.5 mmol of tBuOK, 68% desired quinazoline was isolated (Table 1, entry 1). The yield was further improved to 86% just by increasing the ratio of 2-aminobenzyl alcohol and benzonitrile (Table 1, entry 2). An investigation on the influence of base showed that tBuOK was more effective than KOH or Cs_2CO_3, whereas K_3PO_4 showed comparable activity (Table 1, entries 9−11). The reaction either in the absence of a catalyst or in the absence of base gave no detectable conversion (Table 1, entries 15 and 16). Thus, the presence of both is essential for

Received: March 16, 2019

DOI: 10.1021/acs.orglett.9b00939
Org. Lett. XXXX, XXX, XXX−XXX

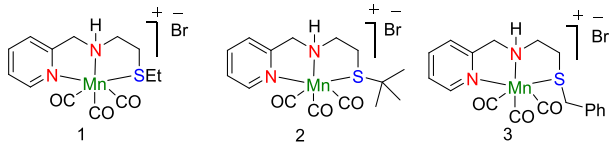


Figure 1. Tridentate ligand derived NNS−Mn(I) complexes.

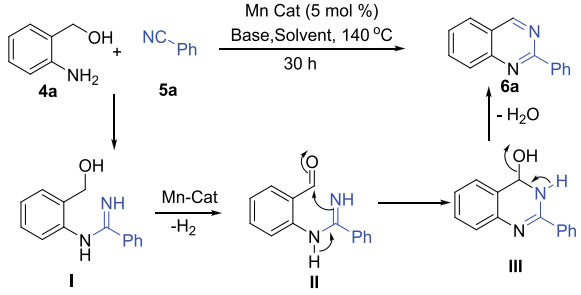
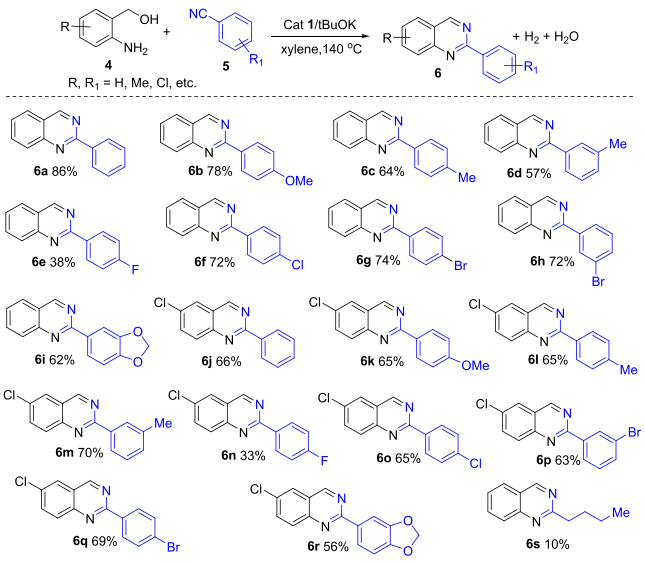


Figure 2. Proposed mechanism.

this protocol. $MnBr(CO)_5$ gave only 14% yield of **6a** under similar reaction conditions.

After the reaction conditions were optimized, we tried to explore the generality and the limitations of this protocol (Scheme 1). At first, 2-aminobenzyl alcohol was reacted with the nitriles bearing electron-withdrawing and electron-donating functionalities in the aromatic nucleus. In most of the cases, good yields of the desired quinazoline **6a−i** were isolated. Chloro-substituted 2-aminobenzyl alcohol also reacted well with various nitriles to afford the desired quinazoline in good yield. It is worth mentioning that the halo-substituted quinazolines were obtained in good yield, which could be further used for functionalization. Surprisingly, 4-fluorobenzonitrile gave only 38% yield of the desired product **6e**. The reaction with aliphatic nitrile such as valeronitrile gave a

Scheme 1. Synthesis of Quinazoline from 2-Aminobenzyl Alcohol and Nitrile[a,b]

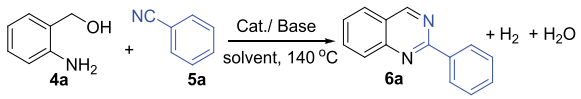


[a]Reaction conditions: 2-aminobenzyl alcohol (0.5 mmol), benzonitrile (0.75 mmol), tBuOK (0.5 mmol), cat. **1** (5 mol %), under argon in xylene (1 mL) at 140 °C (oil bath temp), for 30 h. [b]Isolated yield.

complicated mixture from which only 10% of the desired quinazoline was isolated. It is important to note that all the obtained quinazolines molecules offer the potential for C−H functionalization to synthesize complex building blocks.[18] The evolved H_2 via dehydrogenation reaction has been utilized to convert styrene to ethylbenzene through Pd/C-catalyzed hydrogenation (see the SI).

2-Aminoquinoline derivatives have received much attention due to their important pharmacological properties and wide application in medicinal chemistry.[19] Therefore, development

Table 1. Optimization of the Reaction Conditions for the Synthesis of Quinazoline[a]

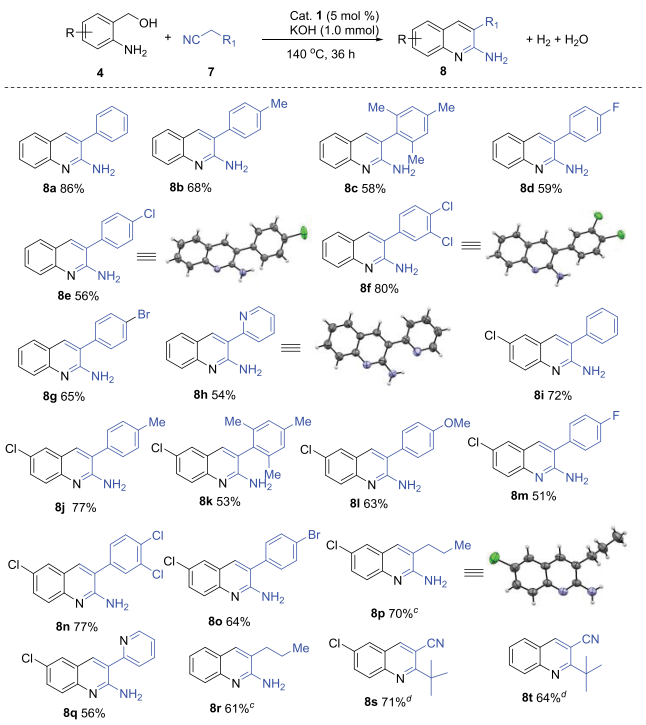


entry	cat.	solvent	base (mmol)	4a/5a	time (h)	yield[b] (%)
1	cat-1	xylene	tBuOK (0.5)	1:1	36	68
2	cat-1	xylene	tBuOK (0.5)	1:1.5	36	86
3	cat-1	xylene	tBuOK (0.5)	1:1.5	30	86
4	cat-1	xylene	tBuOK (0.5)	1:1.2	30	69
5	cat-1	xylene	tBuOK (0.5)	1:1.5	15	38
6	cat-1	toluene	tBuOK (0.5)	1:1.5	30	62
7	cat-1	xylene	tBuOK (0.2)	1:1.5	30	58
8	cat-1	Neat	tBuOK (0.5)	1:1.5	30	65
9	cat-1	xylene	KOH (0.5)	1:1.5	30	72
10	cat-1	xylene	Cs_2CO_3(0.5)	1:1.5	30	52
11	cat-1	xylene	K_3PO_4 (0.5)	1:1.5	30	84
12	cat-1	xylene	tBuOK (0.5)	1:1.5	30	56[c]
13	cat-2	xylene	tBuOK (0.5)	1:1.5	30	70
14	cat-3	xylene	tBuOK (0.5)	1:1.5	30	58
15		xylene	tBuOK (0.5)	1:1.5	30	trace
16	cat-1	xylene		1:1.5	30	trace
17	$MnBr(CO)_5$	xylene	tBuOK (0.5)	1:1.5	30	14

[a]Reaction conditions: 2-aminobenzyl alcohol (0.5 mmol), benzonitrile (0.5−0.75 mmol), base (0.2−0.5 mmol), cat. (5 mol %), under argon. [b]Isolated yield. [c]2 mol % of cat. **1**

DOI: 10.1021/acs.orglett.9b00939
Org. Lett. XXXX, XXX, XXX−XXX

Scheme 2. Synthesis of 2-Aminoquinoline through Acceptorless Dehydrogenative Annulation[a,b]



[a]Reaction conditions: 2-aminobenzyl alcohol (1.0 mmol), nitrile (1.5 mmol), KOH (1.0 mmol), toluene (2 mL), cat. **1** (5 mol %), 140 °C (oil bath temp), pressure tube, 36 h, [b]Isolated yield, [c]48 h, nitrile (2.0 mmol). [d]Pivaloylacetonitrile used (product via Friedländer type pathway).

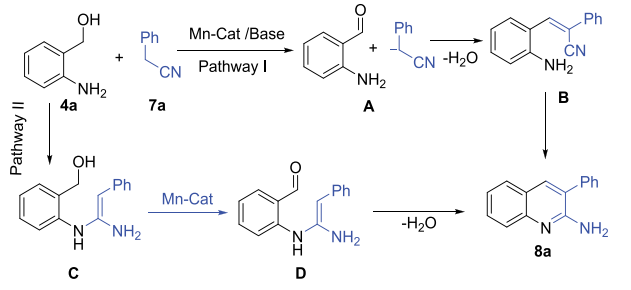
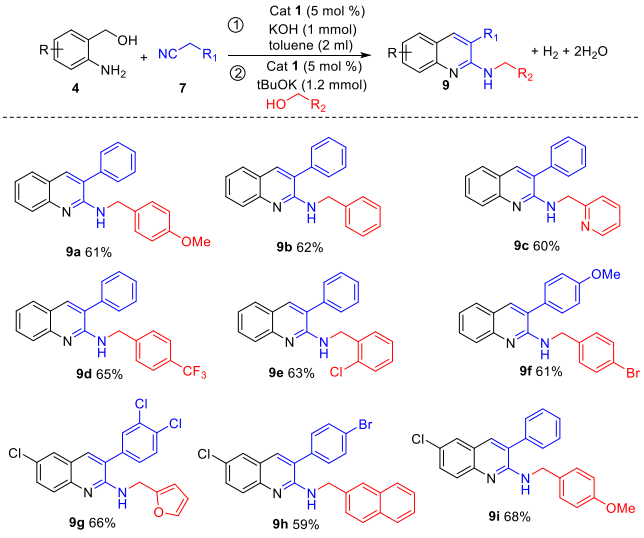


Figure 3. Proposed mechanistic pathways for the formation of 2-aminoquinoline.

of new synthetic strategies to prepare 2-aminoquinoline derivatives continues to be an important target in organic chemistry.[20] Thus, we are interested in applying our Mn catalysts to synthesize these compounds through acceptorless dehydrogenation and consecutive C−C and C−N bond-forming reactions. Hence, to examine the potential of our catalyst, dehydrogenative annulation of 2-aminobenzyl alcohol and benzyl cyanide was studied. Thus, when a toluene solution containing 2-aminobenzyl alcohol (1 mmol) and benzyl cyanide (1.5 mmol) was refluxed in the presence of 5 mol % of cat. **1** and KOH (1 mmol), 86% 3-phenylquinolin-2-amine was obtained after 36 h (Scheme 2, entry **8a**). Benzyl cyanide having both electron-donating and electron-withdrawing groups in the aromatic ring reacted well to give good yield of the desired 2-aminoquinolines. Not only mono- or disubstituted benzyl cyanide but also 1,3,5-trisubstituted

Scheme 3. One-Pot Synthesis of 2-Alkylaminoquinolines[a,b]



[a]Reaction conditions: 2-aminobenzyl alcohol (1.0 mmol), nitrile (1.5 mmol), cat. **1** (5 mol %), and KOH (1.0 mmol) in toluene (2 mL) at 140 °C (oil bath temp), pressure tube, for 36 h followed by addition of cat. **1** (5 mol %), tBuOK (1.2 mmol), and primary alcohol (1.5 mmol) heated for 24 h. [b]Isolated yield.

benzyl cyanide reacted smoothly to give the corresponding product **8k** in moderate yield. Heterocyclic cyanide worked successfully under the optimized conditions. Interestingly, the reaction with a more challenging aliphatic nitrile was found to be sluggish, and only 35% yield of **8p** was obtained after 36 h, which could be further improved to 70% using longer reaction time (48 h). Next, we were interested in studying the dehydrogenative coupling of (2-amino-5-chlorophenyl)-methanol with pivaloylacetonitrile. There is a possibility of the formation of two different quinoline derivatives: 2-*tert*-butyl-6-chloroquinoline-3-carbonitrile (via Friedländer-type pathway: nucleophilic addition of NH_2 to C═O) and 3-*tert*-butyl-6-chloroquinolin-2-amine (via nucleophilic addition of NH_2 to CN). In this protocol, 2-*tert*-butyl-6-chloroquinoline-3-carbonitrile **8s** was obtained in 71% yield. Interestingly, no 3-*tert*-butyl-6-chloroquinolin-2-amine was observed; hence, it can be concluded that the amine preferred to attack ketone over the nitrile under the reaction conditions.

Two different pathways for the formation of 2-aminoquinoline are proposed (Figure 3). In pathway I, the reaction commences with the dehydrogenation of alcohol and subsequent formation of **B** via condensation at the α-carbon of phenyl acetonitrile. Then the nucleophilic addition of an amino group to the cyano functionality followed by tautomerization led to the formation of 2-aminoquinoline. In pathway II, the reaction began with the formation of **C** via nucleophilic addition of NH_2 to CN followed by tautomerization, which upon dehydrogenation followed by condensation reaction led to the formation of **8a**. The reaction of benzyl alcohol with phenyl acetonitrile under the optimized reaction conditions led to the formation of 2,3-diphenylacrylonitrile via dehydrogenative condensation at α-phenyl acetonitrile, suggesting that the formation 2-aminoquinoline **B** through path I is more likely.

Next, we wanted to investigate the catalytic applicability of our Mn complexes toward the synthesis of 2-(alkylamino)-quinolines through sequential dehydrogenative annulation and

DOI: 10.1021/acs.orglett.9b00939
Org. Lett. XXXX, XXX, XXX−XXX

N- alkylation reaction. Thus, the dehydrogenative annulation between 2-aminobenzyl alcohol and phenylacetonitrile followed by the N-alkylation reaction with benzyl alcohol were examined in the presence of cat. **1**. Gratifyingly, a 61% yield of the desired *N*-(4-methoxybenzyl)-3-phenylquinolin-2-amine was isolated after column chromatography. Next, a wide range of 2-(alkylamino)quinolines **9a**−**9i** were synthesized as summarized in Scheme 3. To the best of our knowledge, the first Mn-catalyzed one-pot sequential dehydrogenative annulation and N-alkylation reaction to synthesize 2-alkylaminoquinolines have been achieved.

In conclusion, we report the first sustainable synthesis of quinazoline and 2-aminoquinoline through dehydrogenative annulation of 2-aminobenzyl alcohol with nitriles using a well-defined Mn(I) pincer complex. The reaction proceeds via dehydrogenation and concomitant formation of C−C and C−N bond with high atom economy. Furthermore, the synthesis of 2-(alkylamino)quinolines was achieved through sequential dehydrogenative annulation and N-alkylation reaction with alcohols. The structural importance of the obtained compounds and the use of nontoxic, earth-abundant Mn metals make this approach attractive and sustainable.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.orglett.9b00939.

^{1}H NMR and ^{13}C NMR spectra of all compounds; X-ray crystallographic data for **8e**, **8f**, **8h**, and **8p** (PDF)

Accession Codes

CCDC 1895879−1895882 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, or by emailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: dsrimani@iitg.ac.in.

ORCID

Kalicharan Das: 0000-0003-4347-1390

Dipankar Srimani: 0000-0001-8826-9773

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

We are grateful to SERB, DST (ECR/2016/000108), and DST-INSPIRE (IFA-14-CH-143) for financial support. We acknowledge the Department of Chemistry and the CIF, IIT-Guwahati, for the instrumental support and startup grant. K.D., A.M., and D.P. are thankful to IITG for their fellowships.

■ REFERENCES

(1) Hülsey, M. J.; Yang, H.; Yan, N. *ACS Sustainable Chem. Eng.* **2018**, *6*, 5694−5707.

(2) (a) Barta, K.; Ford, P. C. *Acc. Chem. Res.* **2014**, *47*, 1503−1512. (b) Vispute, T. P.; Zhang, H.; Sanna, A.; Xiao, R.; Huber, G. W. *Science* **2010**, *330*, 1222−1227.

(3) Michlik, S.; Kempe, R. *Nat. Chem.* **2013**, *5*, 140−144.

(4) (a) Crabtree, R. H. *Chem. Rev.* **2017**, *117*, 9228−9246. (b) Huang, F.; Liu, Z.; Yu, Z. *Angew. Chem., Int. Ed.* **2016**, *55*, 862−875. (c) Gunanathan, C.; Milstein, D. *Chem. Rev.* **2014**, *114*, 12024−12087. (d) Obora, Y. *ACS Catal.* **2014**, *4*, 3972−3981. (e) Gunanathan, C.; Ben-David, Y.; Milstein, D. *Science* **2007**, *317*, 790−792. (f) Nielsen, M.; Alberico, E.; Baumann, W.; Drexler, H.-J.; Junge, H.; Gladiali, S.; Beller, M. *Nature* **2013**, *495*, 85. (g) Choi, G.; Hong, S. H. *Angew. Chem.* **2018**, *130*, 6274−6278.

(5) (a) Keller, P. A. *Comprehensive Heterocyclic Chemistry III*; Elsevier, 2008. (b) Michael, J. P. *Nat. Prod. Rep.* **1997**, *14*, 605−618.

(6) Joule, J. A.; Mills, K. *Heterocyclic Chemistry*; Blackwell, 2000.

(7) Tombo, G. R.; Blaser, H.; Brooks, G.; Roberts, T. *Pesticide Chemistry and Bioscience*; RSC: Cambridge, 1999.

(8) Loudet, A.; Burgess, K. *Chem. Rev.* **2007**, *107*, 4891−4932.

(9) Schrauzer, G. N.; Kohnle, J. *Chem. Ber.* **1964**, *97*, 3056−3064.

(10) Mason, M.; Johnson, B.; Hamming, M. *J. Agric. Food Chem.* **1966**, *14*, 454−460.

(11) (a) Nandakumar, A.; Midya, S. P.; Landge, V. G.; Balaraman, E. *Angew. Chem., Int. Ed.* **2015**, *54*, 11022−11034. (b) Yamaguchi, R.; Fujita, K.-i.; Zhu, M. *Heterocycles* **2010**, *81*, 1093−1140.

(12) (a) Irrgang, T.; Kempe, R. *Chem. Rev.* **2019**, *119*, 2524. (b) Kallmeier, F.; Kempe, R. *Angew. Chem., Int. Ed.* **2018**, *57*, 46−60. (c) Mukherjee, A.; Milstein, D. *ACS Catal.* **2018**, *8*, 11435−11469. (d) Powers, I. G.; Uyeda, C. *ACS Catal.* **2017**, *7*, 936−958. (e) Zell, T.; Milstein, D. *Acc. Chem. Res.* **2015**, *48*, 1979−1994. (f) Bauer, I.; Knölker, H.-J. *Chem. Rev.* **2015**, *115*, 3170−3387. (g) Elangovan, S.; Sortais, J. B.; Beller, M.; Darcel, C. *Angew. Chem., Int. Ed.* **2015**, *54*, 14483−14486.

(13) (a) Daw, P.; Chakraborty, S.; Garg, J. A.; Ben-David, Y.; Milstein, D. *Angew. Chem., Int. Ed.* **2016**, *55*, 14373−14377. (b) Daw, P.; Ben-David, Y.; Milstein, D. *ACS Catal.* **2017**, *7*, 7456−7460. (c) Midya, S. P.; Landge, V. G.; Sahoo, M. K.; Rana, J.; Balaraman, E. *Chem. Commun.* **2018**, *54*, 90−93. (d) Shee, S.; Ganguli, K.; Jana, K.; Kundu, S. *Chem. Commun.* **2018**, *54*, 6883−6886. (e) Singh, K.; Vellakkaran, M.; Banerjee, D. *Green Chem.* **2018**, *20*, 2250−2256. (f) Parua, S.; Sikari, R.; Sinha, S.; Chakraborty, G.; Mondal, R.; Paul, N. D. *J. Org. Chem.* **2018**, *83*, 11154−11166.

(14) (a) Mukherjee, A.; Nerush, A.; Leitus, G.; Shimon, L. J.; Ben David, Y.; Espinosa Jalapa, N. A.; Milstein, D. *J. Am. Chem. Soc.* **2016**, *138*, 4298−4301. (b) Elangovan, S.; Neumann, J.; Sortais, J.-B.; Junge, K.; Darcel, C.; Beller, M. *Nat. Commun.* **2016**, *7*, 12641. (c) Deibl, N.; Kempe, R. *Angew. Chem., Int. Ed.* **2017**, *56*, 1663−1666. (d) Peña-López, M.; Piehl, P.; Elangovan, S.; Neumann, H.; Beller, M. *Angew. Chem., Int. Ed.* **2016**, *55*, 14967−14971. (e) Mastalir, M.; Glatz, M.; Pittenauer, E.; Allmaier, G. n.; Kirchner, K. *J. Am. Chem. Soc.* **2016**, *138*, 15543−15546.

(15) (a) Sklyaruk, J.; Borghs, J. C.; El-Sepelgy, O.; Rueping, M. *Angew. Chem.* **2019**, *131*, 785−789. (b) Papa, V.; Cabrero-Antonino, J. R.; Alberico, E.; Spanneberg, A.; Junge, K.; Junge, H.; Beller, M. *Chem. Sci.* **2017**, *8*, 3576−3585. (c) Fu, S.; Shao, Z.; Wang, Y.; Liu, Q. *J. Am. Chem. Soc.* **2017**, *139*, 11941−11948. (d) Espinosa-Jalapa, N. A.; Kumar, A.; Leitus, G.; Diskin-Posner, Y.; Milstein, D. *J. Am. Chem. Soc.* **2017**, *139*, 11722−1172. (e) Chakraborty, S.; Gellrich, U.; Diskin-Posner, Y.; Leitus, G.; Avram, L.; Milstein, D. *Angew. Chem.* **2017**, *129*, 4293−4297. (f) Chakraborty, S.; Das, U. K.; Ben-David, Y.; Milstein, D. *J. Am. Chem. Soc.* **2017**, *139*, 11710−11713. (g) Zhang, G.; Irrgang, T.; Dietel, T.; Kallmeier, F.; Kempe, R. *Angew. Chem., Int. Ed.* **2018**, *57*, 9131−9134. (h) Nguyen, D. H.; Trivelli, X.; Capet, F. d. r.; Paul, J.-F. o.; Dumeignil, F.; Gauvin, R. g. M. *ACS Catal.* **2017**, *7*, 2022−2032. (i) Dubey, A.; Nencini, L.; Fayzullin, R. R.; Nervi, C.; Khusnutdinova, J. R. *ACS Catal.* **2017**, *7*, 3864−3868. (j) Liu, T.; Wang, L.; Wu, K.; Yu, Z. *ACS Catal.* **2018**, *8*, 7201−7207. (k) Jana, A.; Reddy, C. B.; Maji, B. *ACS Catal.* **2018**, *8*, 9226−9231. (l) Wei, D.; Bruneau-Voisine, A.; Valyaev, D. A.; Lugan, N.; Sortais, J.-B. *Chem. Commun.* **2018**, *54*, 4302−4305.

(16) (a) Kallmeier, F.; Dudziec, B.; Irrgang, T.; Kempe, R. *Angew. Chem., Int. Ed.* **2017**, *56*, 7261−7265. (b) Daw, P.; Kumar, A.; Espinosa-Jalapa, N. A.; Diskin-Posner, Y.; Ben-David, Y.; Milstein, D.

DOI: 10.1021/acs.orglett.9b00939
Org. Lett. XXXX, XXX, XXX−XXX

ACS Catal. **2018**, *8*, 7734−7741. (c) Das, K.; Mondal, A.; Srimani, D. *J. Org. Chem.* **2018**, *83*, 9553−9560. (d) Das, K.; Mondal, A.; Srimani, D. *Chem. Commun.* **2018**, *54*, 10582−10585.
(17) Chen, M.; Zhang, M.; Xiong, B.; Tan, Z.; Lv, W.; Jiang, H. *Org. Lett.* **2014**, *16*, 6028−6031.
(18) (a) Dong, J.; Long, Z.; Song, F.; Wu, N.; Guo, Q.; Lan, J.; You, J. *Angew. Chem.* **2013**, *125*, 608−612. (b) Štefane, B.; Brodnik Žugelj, H.; Grošelj, U.; Kuzman, P.; Svete, J.; Požgan, F. *Eur. J. Org. Chem.* **2017**, *2017*, 1855−1864.
(19) (a) Pfister, J. R. *J. Nat. Prod.* **1988**, *51*, 969−970. (b) Inglis, S. R.; Jones, R. K.; Booker, G. W.; Pyke, S. M. *Bioorg. Med. Chem. Lett.* **2006**, *16*, 387−390.
(20) (a) Cheung, C. W.; Surry, D. S.; Buchwald, S. L. *Org. Lett.* **2013**, *15*, 3734−3737. (b) Zhang, L.; Zheng, L.; Guo, B.; Hua, R. *J. Org. Chem.* **2014**, *79*, 11541−11548. (c) Lv, W.; Xiong, B.; Jiang, H.; Zhang, M. *Adv. Synth. Catal.* **2017**, *359*, 1202−1207.

DOI: 10.1021/acs.orglett.9b00939
Org. Lett. XXXX, XXX, XXX−XXX