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Monodentate Transient Directing Group Assisted Ruthenium(II)-Catalyzed Direct *ortho*-C−H Imidation of Benzaldehydes for Diverse Synthesis of Quinazoline and Fused Isoindolinone

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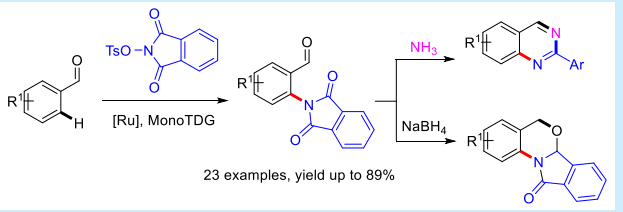
ABSTRACT: 2-Fluoro-5-(trifluoromethyl)aniline was found to be a suitable monodentate transient directing group (MonoTDG) to enable Ru(II)-catalyzed intermolecular direct *ortho*-C(sp^2)−H imidation of benzaldehydes. *N*-Tosyloxyphthalimide was used as an alternative azide-free amidation reagent to achieve high efficiency and good functional group tolerance. Moreover, the reaction could be enlarged to gram scale, and the amidated product could be readily converted into useful quinazoline and fused isoindolinone scaffolds by one-step derivatization.



Quinazoline and fused isoindolinone skeletons stand as two kinds of important nitrogen-containing heterocycles. They have wide existence in natural products and pharmaceutical molecules which exert a remarkably wide variety of biological and pharmacological activities, such as antimalarial, antimicrobial, antiviral, antihypertensive, antituberculosis, antipsychotic, and anticancer activities, etc. (Figure 1).[1,2]

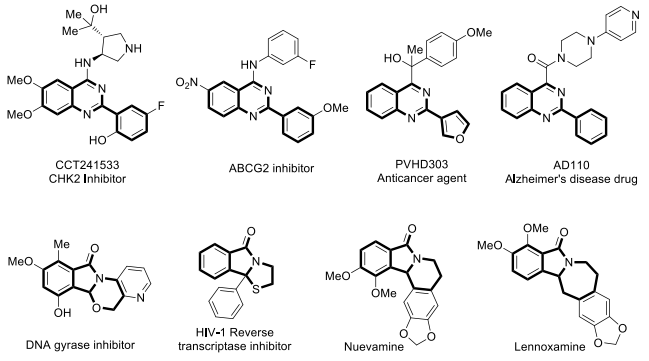


Figure 1. Selected examples of 2-aryl-substituted quinazolines and fused isoindolinones.

Due to their importance and broad applications, great efforts have been devoted to the development of efficient preparation protocols of such useful scaffolds, and several synthetic strategies have been established.[3,4] Although significant advances have already been achieved, there still existed some limitations for these reported procedures. For instance, many prefunctionalized starting precursors were not commercially available. In most cases, stoichiometric amounts of strong oxidants were required, and accompanying waste was generated. Therefore, it is urgent to develop novel environmentally benign atom-economic construction methods for quinazoline and isoindolinone compounds from stable and easily accessible substrates.

For the last two decades, the transition-metal-catalyzed inert C−H bond activation has become an essential tool for the direct and efficient formation of a C−C bond and C−hetero bond.[5] Moreover, a vast number of directing groups have been successfully utilized to enable various transition metal catalysts for the direct C(sp^2)−H amination and amidation of arenes (Scheme 1a).[6] Taking advantage of the assistance of the transient directing group (TDG),[7] the aldehyde compounds have also rendered step-economic C−H amidation via an in situ formed imine intermediate.[8,9] Shi, Yu, and other groups independently reported iridium-catalyzed *ortho*-C−H amidation of benzaldehydes by using organic azide (TsN_3) as amidating reagents (Scheme 1b).[8] Later, dioxazolone as another suitable amino source was employed to fulfill similar transformations by using Rh and Co catalysts (Scheme 1b).[9] Besides, Ackermann and Zhang's group demonstrated that aldehyde and ketone could act as a weakly coordinating directing group for C−H imidation of ketone and amidation of

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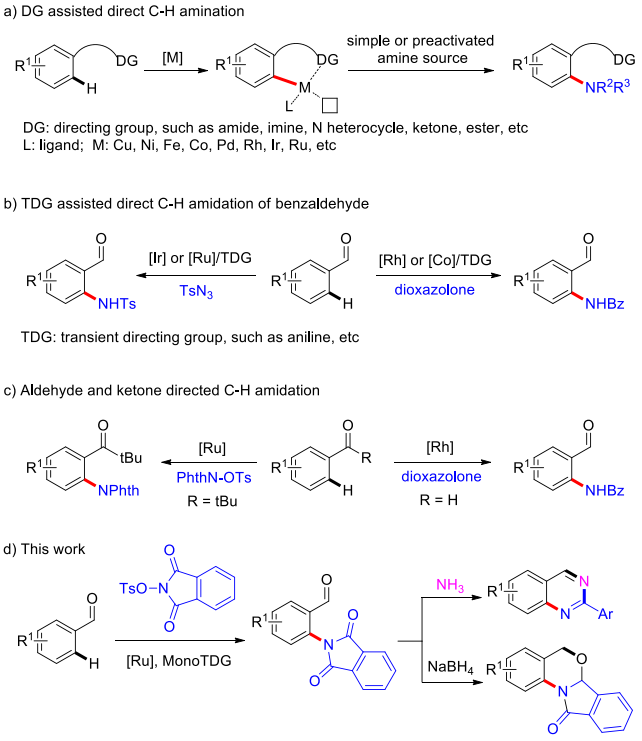
Scheme 1. Transition-Metal-Catalyzed C−H Amidation

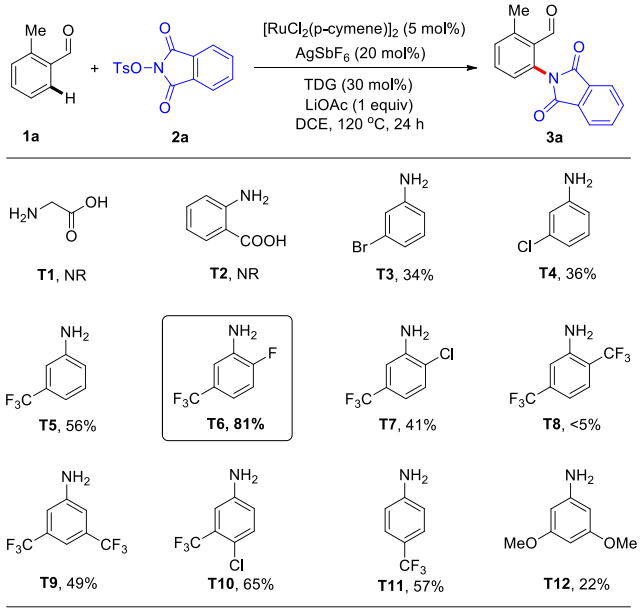


benzaldehyde, respectively (Scheme 1c).[10] However, the direct C−H imidation of benzaldehydes remains an unexplored area. We envisioned that the newly emerged TDG strategy could provide a new alternative opportunity for catalytic C−H imidation of benzaldehyde. Herein, we disclose the first ruthenium(II)-catalyzed intermolecular direct *ortho*-C−H imidation of benzaldehydes. Furthermore, by the treatment of ammonia and sodium borohydride, 2-aryl quinazoline and a fused isoindolinone framework would be readily constructed, respectively (Scheme 1d).

Based on our previous work in TDG-enabled *ortho*-C−H functionalization of benzaldehydes,[11] it was supposed that the TDGs play a pivotal role for the successful transformation. Thus, the effect of a variety of TDGs on the model reaction of 2-methylbenzaldehyde **1a** with *N*-tosyloxyphthalimide **2a** was initially investigated (Scheme 2). Disappointedly, amino acids **T1** and **T2**, as the mostly widely used bidentate transient directing groups, failed to facilitate the transformation, and no desired product was detected. Subsequently, we moved onto the investigation of a library of substituted anilines as monoTDGs (**T3**−**T12**). Fortunately, this time, expected product **3a** was isolated in moderate to good yields. It was worthy to note that the electronic property and position of the substituents on the anilines influenced the reaction significantly. After extensive TDG screening, **T6** turned out to be the optimal one for the direct C−H imidation of benzaldehyde, which generated the highest yield of 81%. Meanwhile, the control experiment showed that no expected imination product was noticed in the absence of **T6**. The base additive, solvent, and reaction temperature also exhibited evident influence on the reaction (for detailed optimization information, see SI).

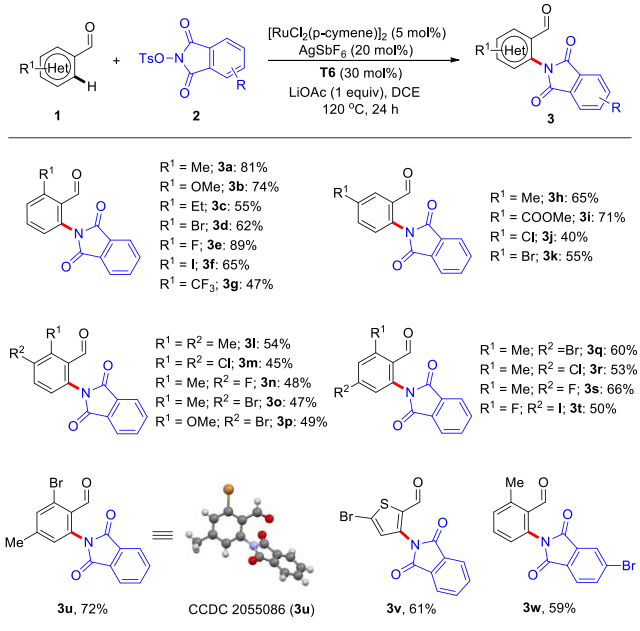
With the optimized reaction conditions in hand, the substrate scope of the benzaldehydes was explored (Scheme 3). In general, both electron-donating groups and electron-withdrawing groups at the *ortho* position of benzaldehydes

Scheme 2. TDG Screening for *ortho*-C−H Imidation of Benzaldehyde[a]



[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), [$RuCl_2$(p-cymene)]$_2$ (5 mol %), $AgSbF_6$ (20 mol %), TDG (30 mol %), and LiOAc (0.2 mmol) in DCE (2 mL) at 120 °C for 24 h. Isolated yields. NR means no reaction.

Scheme 3. Substrate Scope Exploration[a]



[a]Reaction conditions: **1** (0.2 mmol), **2** (0.4 mmol), [$RuCl_2$(p-cymene)]$_2$ (5 mol %), $AgSbF_6$ (20 mol %), **T6** (30 mol %), and LiOAc (0.2 mmol) in DCE (2 mL) at 120 °C for 24 h. Isolated yields.

were well tolerated to provide the desired products **3a**−**3g** in good yields. Importantly, a group of halogen atoms, including F, Cl, Br, and I (**3d**−**3f**, **3j**−**3k**, **3m**−**3v**), were all compatible for this direct C−H imidation, and no side reaction on these sites was detected. In the case of *meta*-substituted benzaldehydes (**1h**−**1k**), it was reasonable to notice the imidation selectively occurred at the less hindered position due to the

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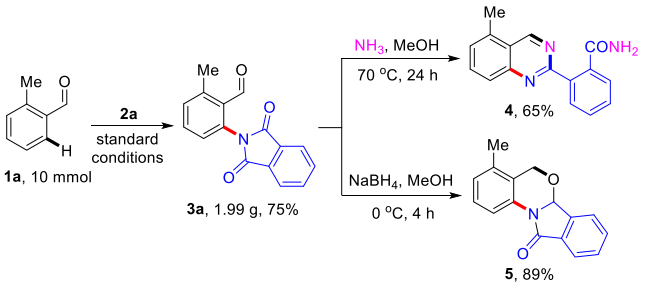
steric constraint. Furthermore, a series of disubstituted benzaldehydes were also probed, and all the tested substrates could deliver imination products in moderate to good yields (**3l**−**3u**). The structure of product **3u** was unambiguously characterized by X-ray crystallographic diffraction. The heterocyclic substrate, such as 5-bromothiophene-2-carbaldehyde (**1v**), was also examined, and a moderate yield was obtained. Eventually, another imidating reagent **2b** was tested, and it showed similar reactivity to generate good yield for **3w**.

After completion of substrate scope exploration, a gram-scale enlarged reaction and the chemo divergent derivatization were performed to reveal the synthetic application of this new strategy. As illustrated in Scheme 4, a 10 mmol scale model

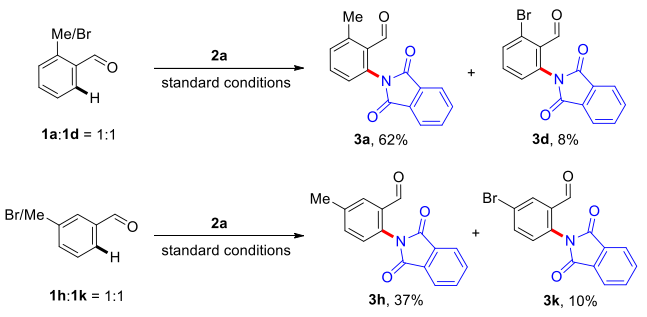
Scheme 4. Synthetic Applicability



reaction of **1a** afforded 1.99 g of product **3a** in 75% yield. It was noteworthy to indicate that the efficacy did not diminish evidently for the enlarged reaction under standard conditions. Further treatment with ammonia in methanol **3a** was readily converted into quinazoline **4** in 65% yield. On the other hand, partial reduction of **3a** using $NaBH_4$ delivered fused isoindolinones **5** in 89% yield.

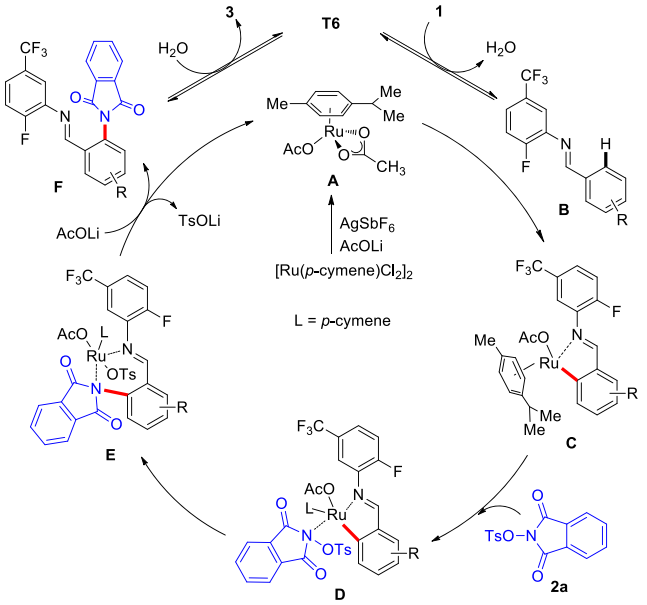
To gain more information about the reaction mechanism, a series of intermolecular competition experiments between differently substituted benzaldehydes were performed. The results in Scheme 5 indicated that electron-rich benzaldehydes reacted preferentially compared with electron-poor ones.

Scheme 5. Intermolecular Competition Experiments



Based on previous reports[8−12] and the above mechanistic findings, a plausible catalytic cycle was proposed in Scheme 6. With silver salt taking the counter chloride anion, and following anion exchange with acetate, the ruthenium dimer catalyst precursor releases the mono active species **A**. In situ condensation between benzaldehyde **1** and TDG **T6** yields imine **B**. Then the imine group directed *ortho*-C−H activation leads to the formation of the five-membered cycloruthenium intermediate **C**. Subsequent coordination with imidating reagent **2a** gives complex **D**. The following N−O bond

Scheme 6. Proposed Reaction Mechanism



cleavage delivers the complex **E**, which subsequently regenerates the active catalyst **A**, thereby liberating the *ortho*-imidated imine **F**. The eventual hydrolysis step provided the desired product **3** and **T6** for the next catalytic cycle.

In conclusion, the first direct *ortho*-C−H imidization of benzaldehydes with *N*-tosyloxyphthalimide was successfully rendered. A novel monotransient directing group assisted Ru(II) catalytic strategy was developed to achieve high efficacy and broad functional group tolerance. Synthetically useful yield was obtained for a gram-scale enlarged model reaction, and important 2-aryl quinazoline and fused isoindolinone skeletons were facilely constructed by simple one-step late-stage derivatization.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.orglett.1c01083.

Experimental details and spectra for important compounds including NMR spectra and X-ray structure of **3u** (PDF)

Accession Codes

CCDC 2055086 contains 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.

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#Y.W. and N.L. contributed equally to this work.

Notes

The authors declare no competing financial interest.

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■ REFERENCES

(1) (a) Shang, X.; Morris-Natschke, S. L.; Liu, Y.; Guo, X.; Xu, X.; Goto, M.; Li, J.; Yang, G.; Lee, K. Biologically active quinoline and quinazoline alkaloids part I. *Med. Res. Rev.* **2018**, *38*, 775−828. (b) Alagarsamy, V.; Chitra, K.; Saravanan, G.; Solomon, V. R.; Sulthana, M. T.; Narendhar, B. An overview of quinazolines: Pharmacological significance and recent developments. *Eur. J. Med. Chem.* **2018**, *151*, 628−685. (c) Anderson, V. E.; Walton, M. I.; Eve, P. D.; Boxall, K. J.; Antoni, L.; Caldwell, J. J.; Aherne, W.; Pearl, L. H.; Oliver, A. W.; Collins, I.; Garrett, M. D. CCT241533 Is a Potent and Selective Inhibitor of CHK2 that Potentiates the Cytotoxicity of PARP Inhibitors. *Cancer Res.* **2011**, *71*, 463−472. (d) Krapf, M. K.; Gallus, J.; Namasivayam, V.; Wiese, M. 2,4,6-Substituted Quinazolines with Extraordinary Inhibitory Potency toward ABCG2. *J. Med. Chem.* **2018**, *61*, 7952−7976. (e) Suzuki, Y.; Otake, A.; Ueno, S.; Hayashi, K.; Ishii, H.; Miyoshi, N.; Kuroiwa, K.; Tachikawa, M.; Fujimaki, Y.; Nishiyama, K.; Manabe, K.; Yamazaki, R.; Asai, A. Discovery of a Potent Anticancer Agent PVHD303 with in Vivo Activity. *ACS Med. Chem. Lett.* **2020**, *11*, 1287−1291. (f) Sun, P.; Zhou, W.; Yue, H.; Zhang, C.; Ou, Y.; Yang, Z.; Hu, W. Compound AD110 Acts as Therapeutic Management for Alzheimer's Disease and Stroke in Mouse and Rat Models. *ACS Chem. Neurosci.* **2020**, *11*, 929−938.

(2) (a) Lübbers, T.; Angehrn, P.; Gmünder, H.; Herzig, S. Design, synthesis, and structure-activity relationship studies of new phenolic DNA gyrase inhibitors. *Bioorg. Med. Chem. Lett.* **2007**, *17*, 4708−4714. (b) Schäfer, W.; Friebe, W.; Leinert, H.; Mertens, A.; Poll, T.; von der Saal, W.; Zilch, H.; Nuber, B.; Ziegler, M. L. Non-nucleoside inhibitors of HIV-1 reverse transcriptase: molecular modeling and x-ray structure investigations. *J. Med. Chem.* **1993**, *36*, 726−732. (c) Valencia, E.; Freyer, A. J.; Shamma, M.; Fajardo, V. (±)-Nuevamine, an isoindoloisoquinoline alkaloid, and (±)-lennoxamine, an isoindolobenzazepine. *Tetrahedron Lett.* **1984**, *25*, 599−602.

(3) (a) Khan, I.; Zaib, S.; Batool, S.; Abbas, N.; Ashraf, Z.; Iqbal, J.; Saeed, A. Quinazolines and quinazolinones as ubiquitous structural fragments in medicinal chemistry: An update on the development of synthetic methods and pharmacological diversification. *Bioorg. Med. Chem.* **2016**, *24*, 2361−2381. (b) Khan, I.; Ibrar, A.; Ahmed, W.; Saeed, A. Synthetic approaches, functionalization and therapeutic potential of quinazoline and quinazolinone skeletons: The advances continue. *Eur. J. Med. Chem.* **2015**, *90*, 124−169. (c) Connolly, D. J.; Cusack, D.; O'Sullivan, T. P.; Guiry, P. J. Synthesis of quinazolinones and quinazolines. *Tetrahedron* **2005**, *61*, 10153−10202.

(4) (a) Lalji, R. S. K.; Kumar, P.; Gupta, M.; Parmar, V. S.; Singh, B. K. Palladium-Catalyzed Decarboxylative Synthesis of 5H-Benzo[4,5]-[1,3]oxazino[2,3-a]isoindole-5,11(6a*H*)-Diones using 2-Phenyl-4*H*-Benzo[d][1,3]oxazin-4-Ones and α-Oxo Carboxylic Acids. *Adv. Synth. Catal.* **2020**, *362*, 552−560. (b) Qiao, J.; Jia, X.; Li, P.; Liu, X.; Zhao, J.; Zhou, Y.; Wang, J.; Liu, H.; Zhao, F. Gold-catalyzed Rapid Construction of Nitrogen-containing Heterocyclic Compound Library with Scaffold Diversity and Molecular Complexity. *Adv. Synth. Catal.* **2019**, *361*, 1419−1440. (c) Wang, X.; Gallardo-Donaire, J.; Martin, R. Mild ArI-Catalyzed C(sp^2)-H or C(sp^3)-H Functionalization/C-O Formation: An Intriguing Catalyst-Controlled Selectivity Switch. *Angew. Chem., Int. Ed.* **2014**, *53*, 11084−11087. (d) Natte, K.; Chen, J.; Li, H.; Neumann, H.; Beller, M.; Wu, X. Palladium-Catalyzed Carbonylation of 2-Bromoanilines with 2-Formylbenzoic Acid and 2-Halobenzaldehydes: Efficient Synthesis of Functionalized Isoindolinones. *Chem. - Eur. J.* **2014**, *20*, 14184−14188.

(5) (a) C−H Activation. Yu, J. Q., Shi, Z. J., Eds.; *Topics in Current Chemistry*; Springer: Heidelberg, 2010. (b) Ritleng, V.; Sirlin, C.; Pfeffer, M. Ru-, Rh-, and Pd-Catalyzed C-C Bond Formation Involving C-H Activation and Addition on Unsaturated Substrates: Reactions and Mechanistic Aspects. *Chem. Rev.* **2002**, *102*, 1731−1769. (c) Yan, G.; Wu, X.; Yang, M. Transition-metal-catalyzed additions of C-H bonds to C-X (X = N, O) multiple bonds via C-H bond activation. *Org. Biomol. Chem.* **2013**, *11*, 5558−5578. (d) Chen, Z.; Wang, B.; Zhang, J.; Yu, W.; Liu, Z.; Zhang, Y. Transition metal-catalyzed C-H bond functionalizations by the use of diverse directing groups. *Org. Chem. Front.* **2015**, *2*, 1107−1295.

(6) (a) Timsina, Y. N.; Gupton, B. F.; Ellis, K. C. Palladium-Catalyzed C-H Amination of C(sp^2) and C(sp^3)-H Bonds: Mechanism and Scope for N-Based Molecule Synthesis. *ACS Catal.* **2018**, *8*, 5732−5776. (b) Park, Y.; Kim, Y.; Chang, S. Transition Metal-Catalyzed C-H Amination: Scope, Mechanism, and Applications. *Chem. Rev.* **2017**, *117*, 9247−93017. (c) Kim, H.; Chang, S. Transition-Metal-Mediated Direct C-H Amination of Hydrocarbons with Amine Reactants: The Most Desirable but Challenging C-N Bond-Formation Approach. *ACS Catal.* **2016**, *6*, 2341−2351. (d) Zhou, Y.; Yuan, J.; Yang, Q.; Xiao, Q.; Peng, Y. Directing-Group-Assisted Transition-Metal-Catalyzed Direct Intermolecular C-H Amidation and Amination of Arenes. *ChemCatChem* **2016**, *8*, 2178−2192.

(7) (a) Gandeepan, P.; Ackermann, L. Transient Directing Groups for Transformative C-H Activation by Synergistic Metal Catalysis. *Chem.* **2018**, *4*, 199−222. (b) Higham, J. I.; Bull, J. A. Transient imine directing groups for the C-H functionalisation of aldehydes, ketones and amines: an update 2018−2020. *Org. Biomol. Chem.* **2020**, *18*, 7291−7315. (c) Lapuh, M. I.; Mazeh, S.; Besset, T. Chiral Transient Directing Groups in Transition-Metal-Catalyzed Enantioselective C-H Bond Functionalization. *ACS Catal.* **2020**, *10*, 12898−12919. (d) Liao, G.; Zhang, T.; Lin, Z.; Shi, B. Transition Metal-Catalyzed Enantioselective C-H Functionalization via Chiral Transient Directing Group Strategies. *Angew. Chem., Int. Ed.* **2020**, *59*, 19773−19786. (e) Li, G.; Liu, Q.; Vasamsetty, L.; Guo, W.; Wang, J. Ruthenium(II)-Catalyzed Asymmetric Inert C-H Bond Activation Assisted by a

Chiral Transient Directing Group. *Angew. Chem., Int. Ed.* **2020**, *59*, 3475−3479.

(8) (a) Zhang, Y.; Wu, B.; Shi, Z. Ir-Catalyzed C-H Amidation of Aldehydes with Stoichiometric/Catalytic Directing Group. *Chem. - Eur. J.* **2016**, *22*, 17808−17812. (b) Liu, X.; Park, H.; Hu, J.; Hu, Y.; Zhang, Q.; Wang, B.; Sun, B.; Yeung, K.; Zhang, F.; Yu, J. Diverse ortho-C(sp^2)-H Functionalization of Benzaldehydes Using Transient Directing Groups. *J. Am. Chem. Soc.* **2017**, *139*, 888−896. (c) Mu, D.; Wang, X.; Chen, G.; He, G. Iridium-Catalyzed ortho-C(sp^2)-H Amidation of Benzaldehydes with Organic Azides. *J. Org. Chem.* **2017**, *82*, 4497−4503. (d) Hu, J.; Xu, Y.; Liu, D.; Sun, B.; Yi, Y.; Zhang, F. Direct stereoselective construction of cyclopropane α-amino acid with contiguous quaternary centers via [4 + 2] annulation reaction. *RSC Adv.* **2017**, *7*, 38077−38080. (e) Rasheed, O. K. Ruthenium-Catalyzed Ortho C(sp^2)-H Amidation of Benzaldehydes with Organic Azides. *Synlett* **2018**, *29*, 1033−1036.

(9) (a) Wang, X.; Song, S.; Jiao, N. Rh-catalyzed Transient Directing Group Promoted C-H Amidation of Benzaldehydes Utilizing Dioxazolones. *Chin. J. Chem.* **2018**, *36*, 213−216. (b) Liu, C.; Liu, M.; Sun, J.; Li, C.; Dong, L. Synthesis of 2-aminobenzaldehydes by rhodium(III)-catalyzed C-H amidation of aldehydes with dioxazolones. *Org. Chem. Front.* **2018**, *5*, 2115−2119. (c) Hande, A. E.; Ramesh, V. B.; Prabhu, K. R. Rh(III)-Catalyzed ortho-C-(sp^2)-H amidation of ketones and aldehydes under synergistic ligand-accelerated catalysis. *Chem. Commun.* **2018**, *54*, 12113−12116. (d) Huang, J.; Ding, J.; Ding, T.; Zhang, S.; Wang, Y.; Sha, F.; Zhang, S.; Wu, X.; Li, Q. Cobalt-Catalyzed Ortho-C(sp^2)-H Amidation of Benzaldehydes with Dioxazolones Using Transient Directing Groups. *Org. Lett.* **2019**, *21*, 7342−7345. (e) Khan, B.; Dwivedi, V.; Sundararaju, B. Cp*Co(III)-Catalyzed o-Amidation of Benzaldehydes with Dioxazolones Using Transient Directing Group Strategy. *Adv. Synth. Catal.* **2020**, *362*, 1195−1200.

(10) (a) Ding, J.; Jiang, W.; Bai, H.; Ding, T.; Gao, D.; Bao, X.; Zhang, S. Experimental and computational studies on H_2O-promoted, Rh-catalyzed transient-ligand-free ortho-C(sp^2)-H amidation of benzaldehydes with dioxazolones. *Chem. Commun.* **2018**, *54*, 8889−8892. (b) Raghuvanshi, K.; Zell, D.; Rauch, K.; Ackermann, L. Ketone-Assisted Ruthenium(II)-Catalyzed C-H Imidation: Access to Primary Aminoketones by Weak Coordination. *ACS Catal.* **2016**, *6*, 3172−3175.

(11) (a) Li, F.; Zhou, Y.; Yang, H.; Liu, D.; Sun, B.; Zhang, F. Assembly of Diverse Spirocyclic Pyrrolidines via Transient Directing Group Enabled Ortho-C(sp^2)-H Alkylation of Benzaldehydes. *Org. Lett.* **2018**, *20*, 146−149. (b) Tang, M.; Yu, Q.; Wang, Z.; Zhang, C.; Sun, B.; Yi, Y.; Zhang, F. Synthesis of Polycyclic Aromatic Hydrocarbons (PAHs) via a Transient Directing Group. *Org. Lett.* **2018**, *20*, 7620−7623. (c) Li, F.; Zhou, Y.; Yang, H.; Wang, Z.; Yu, Q.; Zhang, F. Monodentate Transient Directing Group Enabled Pd-Catalyzed Ortho-C-H Methoxylation and Chlorination of Benzaldehydes. *Org. Lett.* **2019**, *21*, 3692−3695. (d) Qiao, H.; Sun, B.; Yu, Q.; Huang, Y.; Zhou, Y.; Zhang, F. Palladium-Catalyzed Direct Ortho-C-H Selenylation of Benzaldehydes Using Benzidine as a Transient Directing Group. *Org. Lett.* **2019**, *21*, 6914−6918. (e) Wang, Y.; Xu, W.; Sun, B.; Yu, Q.; Li, T.; Zhang, F. Monodentate Transient Directing Group Assisted Pd-Catalyzed Direct Dehydrogenative Cross-Coupling of Benzaldehydes with Arenes toward 9-Fluorenones. *J. Org. Chem.* **2019**, *84*, 13104−13111.

(12) (a) Yu, S.; Wan, B.; Li, X. Rhodium(III)-Catalyzed C-H Activation and Amidation of Arenes Using N-Arenesulfonated Imides as Amidating Reagents. *Org. Lett.* **2013**, *15*, 3706−3709. (b) Yadav, M. R.; Shankar, M.; Ramesh, E.; Ghosh, K.; Sahoo, A. K. Ruthenium-Catalyzed ortho-C-H Mono- and Di-imidation of Arenes with N-Tosyloxyphthalimide. *Org. Lett.* **2015**, *17*, 1886−1889.

https://doi.org/10.1021/acs.orglett.1c01083
Org. Lett. 2021, 23, 3923−3927