C–H Activation

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Rhodium-Catalyzed *meta*-C–H Functionalization of Arenes

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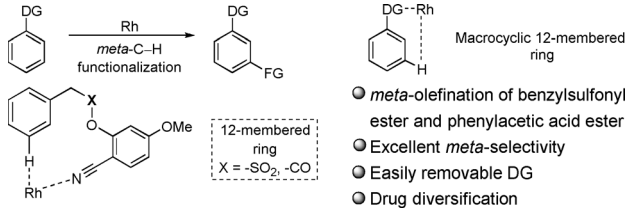
Abstract: *Rhodium-catalyzed ortho-C–H functionalization is well known in the literature. Described herein is the Xphos-supported rhodium catalysis of meta-C–H olefination of benzylsulfonic acid and phenyl acetic acid frameworks with the assistance of a para-methoxy-substituted cyano phenol as the directing group. Complete mono-selectivity is observed for both scaffolds. A wide range of olefins and functional groups attached to arene are tolerated in this protocol.*

Directing-group-assisted functionalization of unreactive C–H bonds has been a vibrant research area in synthetic organic chemistry during the past two decades. This process delivers the selective C–H functionalization products in a step- and atom-economical fashion. Several transition metals can effectively catalyze selective C–H functionalization reactions with the assistance of directing groups (DGs).[1] In all these cases, DGs have been identified as the crucial component for *ortho*-C–H activation and predictable transformation relies on formation of either a five or six membered metallacycle intermediate. In stark contrast, only a limited number of methods are available for selective *meta*-functionalization of arenes.[2] A directing-group-based approach for selective remote *meta*-C–H functionalizations has been pioneered by the group of Yu[3] and subsequently extended by the groups of Tan and Li, as well as our group.[4] In these cases, a nitrile-containing template assists the palladium center to activate remote *meta*-C–H bonds (≥ 10 bonds away) of a tethered arene by formation of a cyclophane-like pre-transition state through linear end-on coordination of the nitrile to metal center.[3,4]

Analogous to the Pd^{II}/Pd^{0} pathways, the Rh^{III}/Rh^{I} cycles are commonly present in oxidative coupling reactions. In addition, a few similar aspects have been observed for both palladium- and rhodium-catalyzed oxidative coupling reactions:[5] 1) C–H activation is well known for $C(sp^2)$–H bonds, 2) formation of M–C bonds by C–H activation are generated through chelation assistance, 3) scope with respect to the coupling partners is limited to unsaturated molecules such as alkenes and alkynes. However, rhodium-catalyzed oxidative C–H functionalizations have been less explored in contrast to palladium-catalyzed reactions. Rhodium catalysis would be highly desirable if it can provide better reaction scope and selectivity. Indeed, *ortho*-selective functionalization of arene C–H bonds have been successfully explored with rhodium.[6] Nevertheless, development of selective distal arene *meta*-C–H functionalizations by rhodium catalysis remain challenging. Herein, we disclose a rhodium-catalyzed *meta*-C–H olefination of benzylsulfonyl and phenyl acetic acid scaffolds using a nitrile-based template (Scheme 1).



Scheme 1. Overview of present work.

The initial reaction of 2-cyanophenol-derived benzylsulfonyl ester **1** (for structure see Scheme 2) with ethyl acrylate in the presence of 5 mol% of $[\{Rh(COD)Cl\}_2]$, 10 mol% of Ac-Gly-OH as a ligand, and Ag_2CO_3 as an oxidant was unsuccessful. However, a trace amount of the desired product was observed when the reaction was performed with $CuCl_2$ as the oxidant in 1,2-dichloroethane (DCE) as the solvent. Furthermore, a systematic study of temperature dependence and solvent indicated that 120 °C and DCE increased the yield up to 12%. Next, modified the DG by introducing an electron-donating group, such as methoxy, at the *para* position to the cyano substituent. Such electron donation through the aromatic ring to the cyano substituent is expected to enhance the mode of rhodium–nitrile linear coordination. To our delight, a slightly higher yield of the olefination product (17%) with complete mono-selectivity was observed. In addition, a wide variety of oxidants was tested and copper trifluoroacetate was found to be best (46%).[7] Use of V_2O_5 as a co-oxidant further improved the yield to 51%. We have subsequently tested this *meta*-C–H olefination reaction with other rhodium salts. Rhodium(II) salts such as $[Rh_2(OAc)_4]$ and $[\{Rh(TFA)_2\}_2]$ were completely inactive, however rhodium(III) salts such as $[\{Rh(Cp^*)Cl_2\}_2]$ provided the desired *meta*-C–H olefination in comparable yield and selectivity.[7] Another catalytic condition was developed by further optimization of the reaction with $[\{Rh(COD)Cl\}_2]$, $CuCl_2$ as oxidant, and trifluoroacetic acid (TFA) as an additive (60%; 49% mono and 11% di). A number of mono- and bidentate phosphine ligands were evaluated for both reaction protocols (Scheme 2). After studying various ligands, we found the Rh/XPhos[8] combination to be most promising as it provided the mono-olefinated product in 69% (reaction conditions A) and 72% (reaction conditions B)

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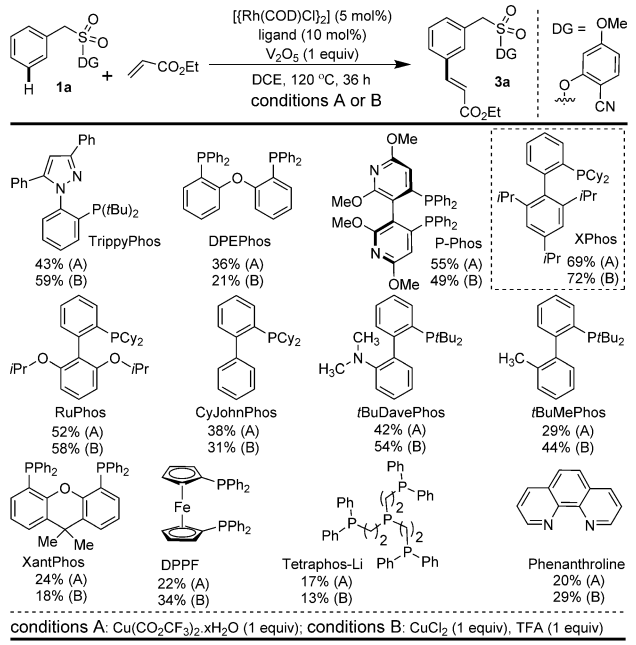
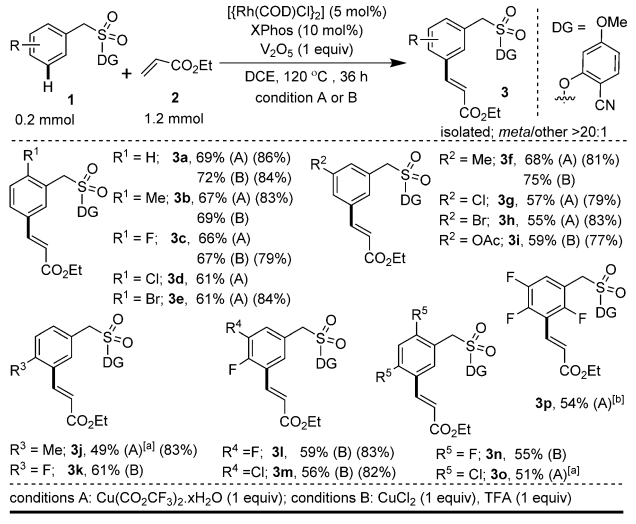


Scheme 2. Ligand optimization for rhodium-catalyzed *meta*-olefination. Yields are based on ^{1}H NMR spectroscopy of the crude reaction mixture with trimethoxybenzene as an internal standard.

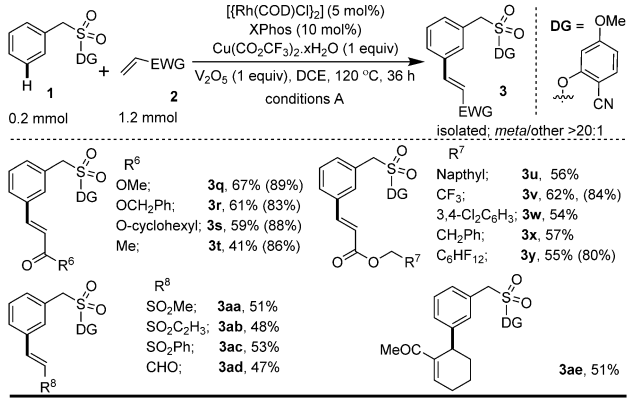
yields. In a similar way, various rhodium(I) complexes were tested under the standard reaction conditions A.

With these optimized reaction conditions A and B, we examined the scope of the protocol for benzylsulfonate esters with different olefins. Both electron-donating and electron-withdrawing functional groups at the *ortho*-, *meta*-, and *para*-position of the arene ring of benzylsulfonyl esters were well adapted in this reaction (**3a**–**p**; Scheme 3). Reactivity decreased slightly with a *para*-methyl-substituted compound (**3j**) as a result of steric hindrance.



Scheme 3. Rhodium-catalyzed *meta*-olefination of benzylsulfonyl ester. Yield within parentheses is based on recovered starting material. [a] 10 mol% [{Rh(COD)Cl}$_2$], 20% XPhos. [b] Reaction run up to 48 h.

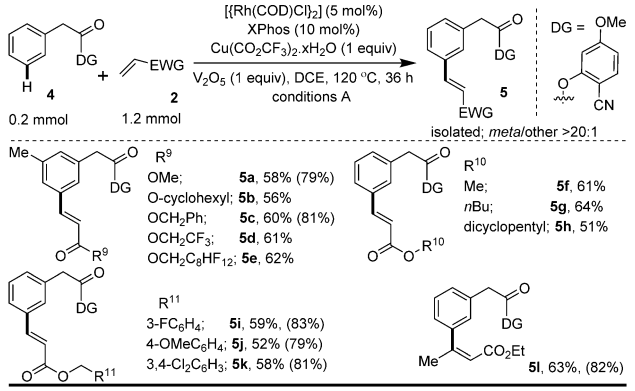
A variety of commonly used α,β-unsaturated esters and ketones were successfully employed (**3q**–**y**; Scheme 4). Olefins with different sulfone moieties (**3aa**–**ac**), acrolein (**3ad**), and methylvinyl ketone (**3t**) resulted in olefinated products with excellent *meta* selectivity. Interestingly, trisubstituted 1-acetyl cyclohexene (**3ae**) was also successfully employed.



Scheme 4. Substrate scope with various olefins. Yield within parentheses is based on recovered starting material.

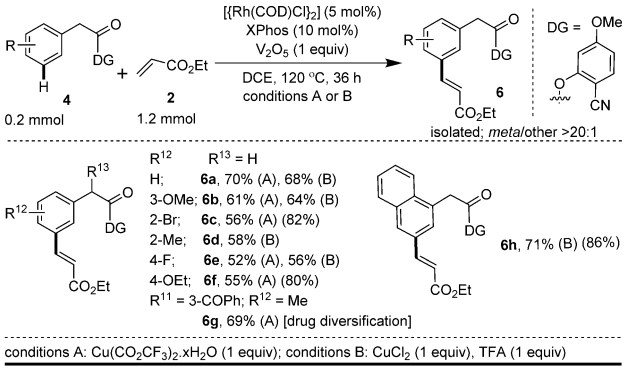
The versatility of the template-based *meta*-olefination approach was extended to a motif derived from phenylacetic acid ester. During our previous efforts on palladium-catalyzed *meta*-olefination with a phenylacetic acid framework,[4a,b] two major limitations, that is, 1) transesterification of the DG with HFIP solvent, and 2) moderate to good *meta* selectivity, were observed. However, in the present study with rhodium catalysis, we overcome these limitations by performing the reaction in DCE. Notably, a rhodium catalyst with a large phosphine ligand is expected to have very different steric effects compared to the palladium catalyst.[9]

Olefination with various acrylates proceeded to give only the mono-*meta*-olefinated arylacetic acid ester in synthetically useful yields (**5a**–**l**; Scheme 5). The efficiency of the present rhodium-catalyzed *meta*-olefination method was tested by synthesizing various substituted arene compounds



Scheme 5. Substrate scope: Olefin variation and different phenylacetic acid esters. Yield within parenthesis is based on recovered starting material.

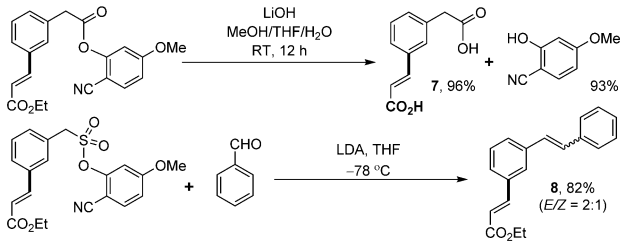
as well (**6a**–**g**; Scheme 6). We have obtained *meta*-olefination with a ketophenyl-substituted arene (**6g**). Although we failed to synthesize methoxy-substituted benzylsulfonyl esters (starting material), *meta*-olefination of methoxy-substituted



Scheme 6. Substrate scope with various arenes. Yield within parenthesis is based on recovered starting material.

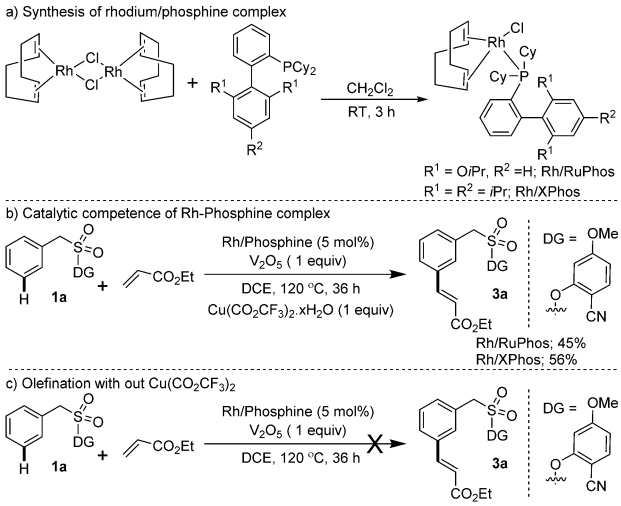
phenylacetic acid ester was successful (**6b**). Similarly, *meta*-olefination of ethoxy-substituted phenylacetic acid ester gave the desired product in excellent *meta* selectivity (**6f**). Unfortunately, we failed to obtain *meta*-olefination of 3-trifluromethyl-substituted benzyl sulfonyl ester. An acetoxy substitution at the 3-position of the arene led to the *meta*-functionalization at the remaining *meta*-position. The broader synthetic applicability of this reaction was further tested using ketoprofen, a drug molecule containing a secondary α-methyl substituent (**6g**).

The 2-hydroxy-4-methoxy benzonitrile template is easily removed by LiOH hydrolysis. Additionally, the SO_2-DG linker of the benzylsulfonyl ester scaffold can be easily cleaved by modified Julia olefination conditions (Scheme 7).



Scheme 7. Removal of directing group.

To gain insight into the reaction mechanism, we synthesized two rhodium/phosphine complexes.[10] Independently synthesized rhodium/phosphine complexes were found to be catalytically competent (Scheme 8). The olefination reaction in the absence of $Cu(CO_2CF_3)_2{\cdot}x\,H_2O$ was ineffective. Further the *meta*-C–H olefination reaction can also be catalyzed effectively by rhodium(III) salts.[7] A UV-visible study of the stoichiometric reaction solution of the Rh/XPhos complex and $Cu(CO_2CF_3)_2{\cdot}x\,H_2O$ suggested formation of a rhodium-(III) intermediate (Figure 1 a).[11] All these results indicated



Scheme 8. Synthesis and catalytic competence of rhodium/phosphine complex.

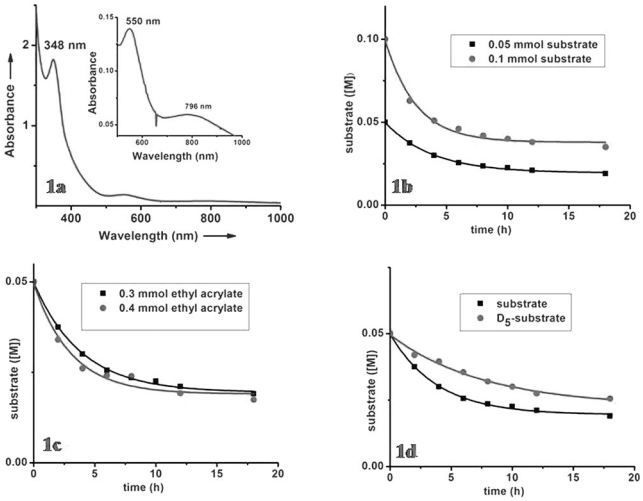
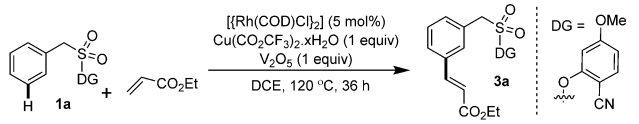


Figure 1. a) UV-visible study of stoichiometric reaction of the Rh/Xphos complex and $Cu(CO_2CF_3)_2{\cdot}x\,H_2O$ for order determination
b) Overlay of reaction profile with 0.05 and 0.1 mmol substrate.
c) Overlay of reaction profile with 0.3 and 0.4 mmol ethyl acrylate.
d) Determination of KIE. Reactions run with the model substrate and [D_5] substrate on a 0.05 mmol scale.

that the *meta*-C–H activation likely involves in situ formation of a rhodium(III) species. We did not observe formation of the XPhos oxide under the standard reaction conditions. Additionally, we performed the reaction in the presence of independently synthesized XPhos oxide, which provided lower yield compared to XPhos (Table 1).[7] These control experiments demonstrate the necessity of the XPhos ligand during this *meta*-C–H functionalization reaction. Furthermore, kinetic studies of the olefination of **1a** revealed a first-order and zero-order rate dependency on **1a** and ethyl acrylate, respectively (Figure 1 b,c). In addition an isotope-labelling experiment and intermolecular competition between [D_5]-**1a** and **1a** showed a large kinetic isotope effect (2.75 k_H/k_D) and product distribution value 3.44

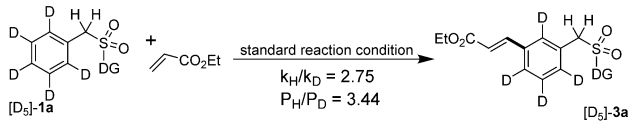
Table 1: Screening with XPhos and XPhos oxide.



Entry	Condition	Yield [%][a]
1	with XPhos	69
2	with XPhos oxide	45
3	with $HPPh_2$	44
4	with $HP(O)Ph_2$	18

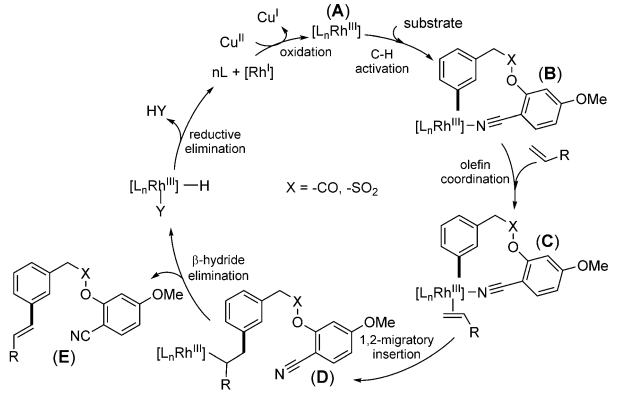
[a] Yield is that of isolated product.

(P_H/P_D; Scheme 9 and Figure 1 d). The observed results likely suggest C–H activation as the rate-determining step and proceeds by the involvement of a rhodium(III) species.[12]



Scheme 9. Kinetic isotope effect experiment.

A mechanistic proposal is presented in Scheme 10. While the rhodium(I) catalyst precursor was used for these reaction, the active catalyst which activates the C–H bond might be the



Scheme 10. Proposed mechanistic cycle.

rhodium(III) species under the oxidative conditions.[13] Linear coordination of the nitrile to rhodium(III) is followed by *meta*-C–H bond activation to generate an 11-membered rhodacyle intermediate (**B**). Subsequent, olefin binding, 1,2-migratory insertion, and β-hydride elimination from **B** produces the desired product **E**. Finally, reductive elimination from the [Rh^{III}-H] intermediate regenerates rhodium(I) and completes the catalytic cycle.

In summary, we have developed a rhodium-catalyzed *meta*-selective olefination[14] of substituted phenylacetic acid esters and benzylsulfonyl esters using a 2-hydroxy-4-methoxy benzonitrile template. Substituents are tolerated at all positions of the arene ring. Synthetic application of this protocol was expanded to drug diversification. Efforts to understand the detailed reaction mechanism is underway in our laboratory.

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Conflict of interest

The authors declare no conflict of interest.

Keywords: C–H activation · reaction kinetics · reaction mechanisms · regioselectivity · rhodium

[1] For elected reviews/examples of metal-catalyzed *ortho* C–H activation, see: a) D. Alberico, M. E. Scott, M. Lautens, *Chem. Rev.* **2007**, *107*, 174; b) I. V. Seregin, V. Gevorgyan, *Chem. Soc. Rev.* **2007**, *36*, 1173; c) I. A. I. Mkhalid, J. H. Barnard, T. B. Marder, J. M. Murphy, J. F. Hartwig, *Chem. Rev.* **2010**, *110*, 890; d) C. S. Yeung, V. M. Dong, *Chem. Rev.* **2011**, *111*, 1215; e) C.-L. Sun, B.-J. Li, Z.-J. Shi, *Chem. Rev.* **2011**, *111*, 1293; f) L. Ackermann, *Chem. Rev.* **2011**, *111*, 1315; g) S. R. Neufeldt, M. S. Sanford, *Acc. Chem. Res.* **2012**, *45*, 936; h) P. B. Arockiam, C. Bruneau, P. H. Dixneuf, *Chem. Rev.* **2012**, *112*, 5879; i) G. Rouquet, N. Chatani, *Angew. Chem. Int. Ed.* **2013**, *52*, 11726; *Angew. Chem.* **2013**, *125*, 11942; j) J. Wencel-Delord, F. Glorius, *Nat. Chem.* **2013**, *5*, 369; k) F. Zhang, D. R. Spring, *Chem. Soc. Rev.* **2014**, *43*, 6906; l) J. Schranck, A. Tlili, M. Beller, *Angew. Chem. Int. Ed.* **2014**, *53*, 9426; *Angew. Chem.* **2014**, *126*, 9580; m) A. Deb, S. Bag, R. Kancherla, D. Maiti, *J. Am. Chem. Soc.* **2014**, *136*, 13602.

[2] For other approaches for *meta*-functionalizations, see: a) J.-Y. Cho, M. K. Tse, D. Holmes, R. E. Maleczka, M. R. Smith, *Science* **2002**, *295*, 305; b) J. M. Murphy, X. Liao, J. F. Hartwig, *J. Am. Chem. Soc.* **2007**, *129*, 15434; c) R. J. Phipps, M. J. Gaunt, *Science* **2009**, *323*, 1593; d) O. Saidi, J. Marafie, A. E. W. Ledger, P. M. Liu, M. F. Mahon, G. Kociok-Köhn, M. K. Whittlesey, C. G. Frost, *J. Am. Chem. Soc.* **2011**, *133*, 19298; e) H. A. Duong, R. E. Gilligan, M. L. Cooke, R. J. Phipps, M. J. Gaunt, *Angew. Chem. Int. Ed.* **2011**, *50*, 463; *Angew. Chem.* **2011**, *123*, 483; f) N. Hofmann, L. Ackermann, *J. Am. Chem. Soc.* **2013**, *135*, 5877; g) C. Cheng, J. F. Hartwig, *Science* **2014**, *343*, 853; h) J. Luo, S. Preciado, I. Larrosa, *J. Am. Chem. Soc.* **2014**, *136*, 4109; i) A. J. Martínez-Martínez, A. R. Kennedy, R. E. Mulvey, C. T. O'Hara, *Science* **2014**, *346*, 834; j) M. Tobisu, N. Chatani, *Science* **2014**, *343*, 850; k) X.-C. Wang, W. Gong, L.-Z. Fang, R.-Y. Zhu, S. Li, K. M. Engle, J.-Q. Yu, *Nature* **2015**, *519*, 334; l) P.-X. Shen, X.-C. Wang, P. Wang, R.-Y. Zhu, J.-Q. Yu, *J. Am. Chem. Soc.* **2015**, *137*, 11574; m) Z. Dong, J. Wang, G. Dong, *J. Am. Chem. Soc.* **2015**, *137*, 5887; n) J. Luo, S. Preciado, I. Larrosa, *Chem. Commun.* **2015**, *51*, 3127; o) C. J. Teskey, A. Y. W. Lui, M. F. Greaney, *Angew. Chem. Int. Ed.* **2015**, *54*, 11677; *Angew. Chem.* **2015**, *127*, 11843; p) A. J. Paterson, S. St John-Campbell, M. F. Mahon, N. J. Press, C. G. Frost, *Chem. Commun.* **2015**, *51*, 12807; q) Y.

Kuninobu, H. Ida, M. Nishi, M. Kanai, *Nat. Chem.* **2015**, *7*, 712; r) L. Ackermann, J. Li, *Nat. Chem.* **2015**, *7*, 686; s) J. Li, S. Warratz, D. Zell, S. De Sarkar, E. E. Ishikawa, L. Ackermann, *J. Am. Chem. Soc.* **2015**, *137*, 13894; t) R. Bisht, B. Chattopadhyay, *J. Am. Chem. Soc.* **2016**, *138*, 84; u) P. Wang, M. E. Farmer, X. Huo, P. Jain, P.-X. Shen, M. Ishoey, J. E. Bradner, S. R. Wisniewski, M. D. Eastgate, J.-Q. Yu, *J. Am. Chem. Soc.* **2016**, *138*, 9269; v) P. Wang, G.-C. Li, P. Jain, M. E. Farmer, J. He, P.-X. Shen, J.-Q. Yu, *J. Am. Chem. Soc.* **2016**, *138*, 14092; w) H. J. Davis, M. T. Mihai, R. J. Phipps, *J. Am. Chem. Soc.* **2016**, *138*, 12759; x) S. Warratz, D. J. Burns, C. Zhu, K. Korvorapun, T. Rogge, J. Scholz, C. Jooss, D. Gelman, L. Ackermann, *Angew. Chem. Int. Ed.* **2017**, *56*, 1557 – 1560; *Angew. Chem.* **2017**, *129*, 1579 – 1582.

[3] For DG-assisted *meta*-functionalizations, see: a) D. Leow, G. Li, T.-S. Mei, J.-Q. Yu, *Nature* **2012**, *486*, 518; b) H.-X. Dai, G. Li, X.-G. Zhang, A. F. Stepan, J.-Q. Yu, *J. Am. Chem. Soc.* **2013**, *135*, 7567; c) G.-J. Cheng, Y.-F. Yang, P. Liu, P. Chen, T.-Y. Sun, G. Li, X. Zhang, K. N. Houk, J.-Q. Yu, Y.-D. Wu, *J. Am. Chem. Soc.* **2014**, *136*, 894; d) Y.-F. Yang, G.-J. Cheng, P. Liu, D. Leow, T.-Y. Sun, P. Chen, X. Zhang, J.-Q. Yu, Y.-D. Wu, K. N. Houk, *J. Am. Chem. Soc.* **2014**, *136*, 344; e) Y. Deng, J.-Q. Yu, *Angew. Chem. Int. Ed.* **2015**, *54*, 888; *Angew. Chem.* **2015**, *127*, 902; f) S. Lee, H. Lee, K. L. Tan, *J. Am. Chem. Soc.* **2013**, *135*, 18778; g) R.-Y. Tang, G. Li, J.-Q. Yu, *Nature* **2014**, *507*, 215; h) G. Yang, P. Lindovska, D. Zhu, J. Kim, P. Wang, R.-Y. Tang, M. Movassaghi, J.-Q. Yu, *J. Am. Chem. Soc.* **2014**, *136*, 10807; i) S. Li, H. Ji, L. Cai, G. Li, *Chem. Sci.* **2015**, *6*, 5595; j) L. Chu, M. Shang, K. Tanaka, Q. Chen, N. Pissarnitski, E. Streckfuss, J.-Q. Yu, *ACS Cent. Sci.* **2015**, *1*, 394; k) S. Li, L. Cai, H. Ji, L. Yang, G. Li, *Nat. Commun.* **2016**, *7*, 10443.

[4] For DG-assisted *meta*- and *para*-functionalizations from our group, see: a) M. Bera, A. Modak, T. Patra, A. Maji, D. Maiti, *Org. Lett.* **2014**, *16*, 5760; b) M. Bera, A. Maji, S. K. Sahoo, D. Maiti, *Angew. Chem. Int. Ed.* **2015**, *54*, 8515; *Angew. Chem.* **2015**, *127*, 8635; c) T. Patra, R. Watile, S. Agasti, T. Naveen, D. Maiti, *Chem. Commun.* **2016**, *52*, 2027; d) A. Maji, B. Bhaskararao, S. Singha, R. B. Sunoj, D. Maiti, *Chem. Sci.* **2016**, *7*, 3147; e) M. Bera, S. K. Sahoo, D. Maiti, *ACS Catal.* **2016**, *6*, 3575; f) S. Maity, E. Hoque, U. Dhawa, D. Maiti, *Chem. Commun.* **2016**, *52*, 14003; g) A. Modak, A. Mondal, R. A. Watile, S. Mukherjee, D. Maiti, *Chem. Commun.* **2016**, *52*, 13916; h) S. Bag, T. Patra, A. Modak, A. Deb, S. Maity, U. Dutta, A. Dey, R. Kancherla, A. Maji, A. Hazra, M. Bera, D. Maiti, *J. Am. Chem. Soc.* **2015**, *137*, 11888; i) T. Patra, S. Bag, R. Kancherla, A. Mondal, A. Dey, S. Pimparkar, S. Agasti, A. Modak, D. Maiti, *Angew. Chem. Int. Ed.* **2016**, *55*, 7751; *Angew. Chem.* **2016**, *128*, 7882; j) A. Dey, S. Maity, D. Maiti, *Chem. Commun.* **2016**, *52*, 12398.

[5] a) G. Song, F. Wang, X. Li, *Chem. Soc. Rev.* **2012**, *41*, 3651; b) G. Song, X. Li, *Acc. Chem. Res.* **2015**, *48*, 1007.

[6] For selected examples for rhodium-catalyzed *ortho*-C–H olefination, see: a) F. W. Patureau, F. Glorius, *J. Am. Chem. Soc.* **2010**, *132*, 9982; b) A. S. Tsai, M. Brasse, R. G. Bergman, J. A. Ellman, *Org. Lett.* **2011**, *13*, 540; c) S. Rakshit, C. Grohmann, T. Besset, F. Glorius, *J. Am. Chem. Soc.* **2011**, *133*, 2350; d) T.-J. Gong, B. Xiao, Z.-J. Liu, J. Wan, J. Xu, D.-F. Luo, Y. Fu, L. Liu, *Org. Lett.* **2011**, *13*, 3235; e) S. H. Park, J. Y. Kim, S. Chang, *Org. Lett.* **2011**, *13*, 2372; f) T. K. Hyster, L. Knörr, T. R. Ward, T. Rovis, *Science* **2012**, *338*, 500; g) P. Zhao, F. Wang, K. Han, X. Li, *Org. Lett.* **2012**, *14*, 3400; h) C. Feng, D. Feng, T.-P. Loh, *Org. Lett.* **2013**, *15*, 3670; i) T. Zhang, L. Wu, X. Li, *Org. Lett.* **2013**, *15*, 6294; j) Y. Shen, G. Liu, Z. Zhou, X. Lu, *Org. Lett.* **2013**, *15*, 3366; k) M. Presset, D. Oehlrich, F. Rombouts, G. A. Molander, *Org. Lett.* **2013**, *15*, 1528; l) J. Zhou, B. Li, F. Hu, B.-F. Shi, *Org. Lett.* **2013**, *15*, 3460; m) X.-S. Zhang, Q.-L. Zhu, Y.-F. Zhang, Y.-B. Li, Z.-J. Shi, *Chem. Eur. J.* **2013**, *19*, 11898; n) S. Han, Y. Shin, S. Sharma, N. K. Mishra, J. Park, M. Kim, M. Kim, J. Jang, I. S. Kim, *Org. Lett.* **2014**, *16*, 2494; o) S. Cai, C. Chen, P. Shao, C. Xi, *Org. Lett.* **2014**, *16*, 3142; p) N.-J. Wang, S.-T. Mei, L. Shuai, Y. Yuan, Y. Wei, *Org. Lett.* **2014**, *16*, 3040; q) K. D. Otley, J. A. Ellman, *Org. Lett.* **2015**, *17*, 1332.

[7] See the Supporting Information for details.

[8] a) X. Huang, K. W. Anderson, D. Zim, L. Jiang, A. Klapars, S. L. Buchwald, *J. Am. Chem. Soc.* **2003**, *125*, 6653; b) H. N. Nguyen, X. Huang, S. L. Buchwald, *J. Am. Chem. Soc.* **2003**, *125*, 11818; c) D. S. Surry, S. L. Buchwald, *Angew. Chem. Int. Ed.* **2008**, *47*, 6338; *Angew. Chem.* **2008**, *120*, 6438.

[9] D. A. Colby, R. G. Bergman, J. A. Ellman, *Chem. Rev.* **2010**, *110*, 624.

[10] A. R. O'Connor, W. Kaminsky, D. M. Heinekey, K. I. Goldberg, *Organometallics* **2011**, *30*, 2105.

[11] a) J. Zakzeski, S. Burton, A. Behm, M. Head-Gordon, A. T. Bell, *Phys. Chem. Chem. Phys.* **2009**, *11*, 9903; b) Z. Xue, Y. Wang, J. Mack, S. Mkhize, T. Nyokong, Y. Fang, Z. Ou, K. M. Kadish, *RSC Adv.* **2016**, *6*, 41919.

[12] D. A. Colby, A. S. Tasi, R. G. Bergman, J. A. Ellman, *Acc. Chem. Res.* **2012**, *45*, 814.

[13] a) T. Matsumoto, H. Yoshida, *Chem. Lett.* **2000**, *29*, 1064; b) T. Uto, M. Shimizu, K. Ueura, H. Tsurugi, T. Satoh, M. Miura, *J. Org. Chem.* **2008**, *73*, 298; c) M. Shimizu, H. Tsurugi, T. Satoh, M. Miura, *Chem. Asian J.* **2008**, *3*, 881.

[14] While this manuscript was under review, Yu et al. published the rhodium-catalyzed *meta*-olefination of hydrocinnamic acid, see: H.-J. Xu, Y. Lu, M. E. Farmer, H.-W. Wang, D. Zhao, Y.-S. Kang, W.-Y. Sun, J.-Q. Yu, *J. Am. Chem. Soc.* **2017**, *139*, 2200.

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Communications

C–H Activation

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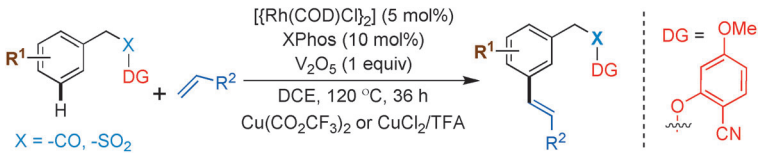
Rhodium-Catalyzed *meta*-C–H Functionalization of Arenes



***Meta* is a must**: *meta*-C–H olefination of benzylsulfonic acid and phenyl acetic acid frameworks with the assistance of a *para*-methoxy-substituted cyano phenol as the directing group is achieved by Xphos-supported rhodium catalysis. Complete mono-selectivity is observed for both scaffolds. COD = 1,5-cyclooctadiene, DCE = 1,2-dichloroethane, TFA = trifluoroacetic acid.

