OL | Organic Letters

pubs.acs.org/OrgLett

Letter

Cu-catalyzed *N*-3-Arylation of Hydantoins Using Diaryliodonium Salts

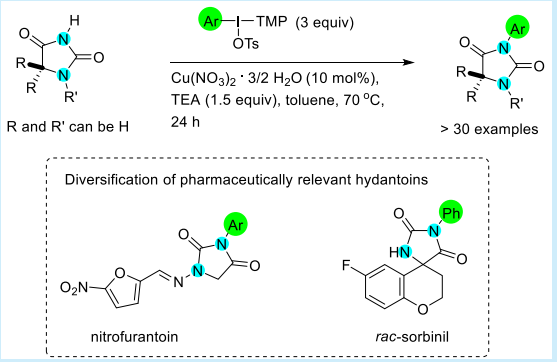
Linn Neerbye Berntsen, Ainara Nova, David S. Wragg, and Alexander H. Sandtorv*

Cite This: *Org. Lett.* 2020, 22, 2687–2691

Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: A general Cu-catalyzed, regioselective method for the *N*-3-arylation of hydantoins is described. The protocol utilizes aryl(trimethoxyphenyl)iodonium tosylate as the arylating agent in the presence of triethylamine and a catalytic amount of a simple Cu-salt. The method is compatible with structurally diverse hydantoins and operates well with neutral aryl groups or aryl groups bearing weakly donating/withdrawing elements. It is also applicable for the rapid diversification of pharmaceutically relevant hydantoins.



Hydantoin is a heterocyclic scaffold with numerous application areas.[1] The structure has an impressive range of biological activities,[2] likely due to its high density of intermolecular interaction points.[3] It is encountered in several drugs, such as nilutamide, sorbinil, and nitrofurantoin, and constitutes a key molecular component of various agrochemicals.[4] The nucleus also has synthetic versatility,[5] for example, in the preparation of amino acids.[6] Of particular interest are *N*-arylated hydantoins due to their important biological applications (Figure 1).[7]

The primary access point to *N*-arylhydantoins (and other substituted hydantoins) is through *de novo* cyclization reactions from linear precursors (Scheme 1).[8] A plethora of such transformations is known,[9] and each method has advantages and limitations. The direct functionalization of the hydantoin nucleus offers a complementary approach where

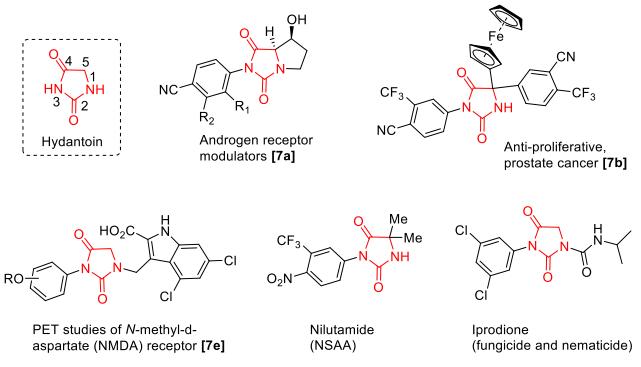
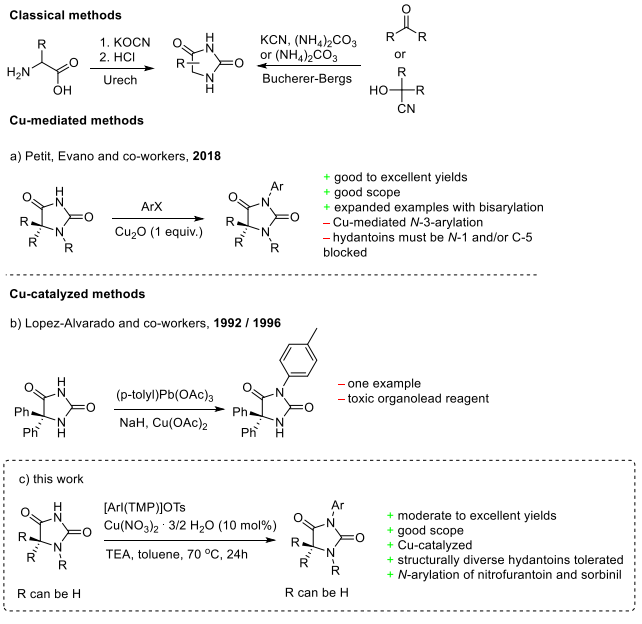


Figure 1. Some *N*-3-arylhydantoins with biological properties.

Scheme 1. Prior Work



Received: February 18, 2020
Published: March 23, 2020

https://dx.doi.org/10.1021/acs.orglett.0c00642
Org. Lett. 2020, 22, 2687–2691

the substituent(s) of interest are chemo- and regioselectively forged onto the ring itself. This scenario allows divergent modifications of hydantoins as well as potentially quicker and cheaper access to such structures. Direct functionalization remains underdeveloped, perhaps due to its challenging nature.[7c,10]

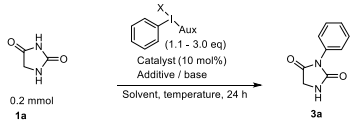
For example, the direct *N*-3-phenylation of unsubstituted hydantoin has, to the best of our knowledge, not been described in the literature.

Recently, a breakthrough was achieved by Petit, Evano, and coworkers (Scheme 1a), who divulged a Cu-mediated *N*-arylation protocol.[11] The method exhibited a good reaction scope and mostly good yields. However, it suffered from two disadvantages: (i) the use of stoichiometric Cu and (ii) clear structural limitations of the hydantoin starting material. Whereas 5,5-disubstituted hydantoins were regioselectively arylated at the *N*-3 position, removing one or both of the C-5 substituents led to significant competing arylation at *N*-1, limiting the substrate scope. The Cu-catalyzed *N*-arylation of hydantoins is largely unexplored, and only sparse and highly specialized examples are reported in the literature (Scheme 1b).[7c,12] Herein we describe a general Cu-catalyzed process for *N*-3-arylation of hydantoins, a complementary method to the current Cu-mediated protocol (Scheme 1).

Diaryliodonium salts[13] have received increasing attention over the past decade,[14] partially due to their ability to transfer aryl groups to nucleophiles.[15] Our reaction discovery process led to the revelation that unsymmetrical iodonium salts regioselectively arylated the *N*-3-position of hydantoin in the presence of a simple copper salt and tertiary amine under mild conditions. In contrast, phenyl iodide was an inefficient arylating agent under Cu-catalyzed conditions and did not successfully couple to the hydantoin nucleus.

An overview of the optimization studies is provided in Scheme 2. The best conditions (entry 1) involved the use of excess aryl(trimethoxyphenyl)iodonium tosylate in the presence of copper(II)nitrate sesquihydrate and triethylamine in toluene at 70 °C for 24 h. Under these conditions, trace amounts (<5%) of the *N*-1-regioisomer were typically observed as well as small amounts of the corresponding *N*,*N*′-bisarylated product (3−10%). The process was also efficient and regioselective when the excesses of phenyl-(trimethoxyphenyl)iodonium tosylate was reduced to 1.5 or 1.1 equiv (entries 2 and 3), although the desired target was produced in slightly reduced yield. If a small reduction in yield is tolerable, then the process can therefore be performed with improved atom efficiency. The scope and limitations of the process are shown in Scheme 3.

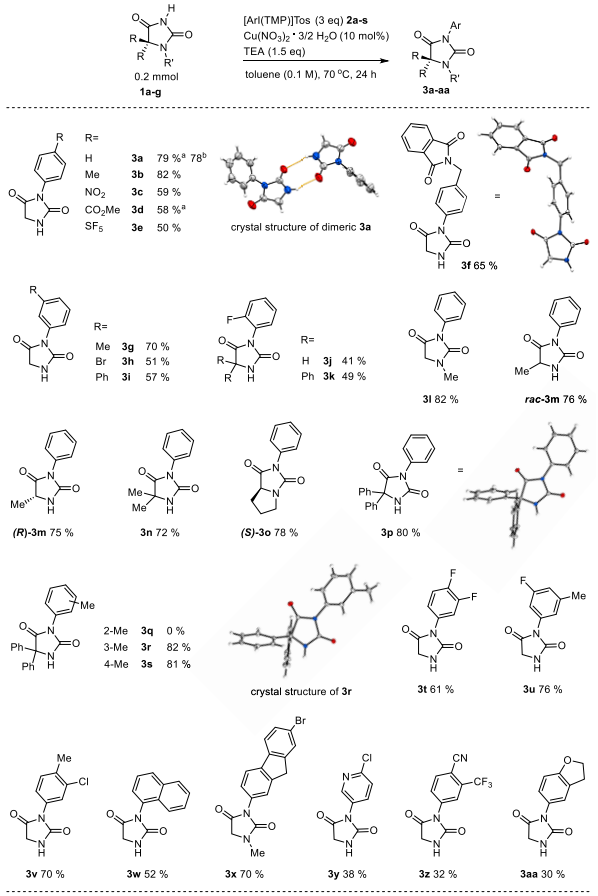
Scheme 2. Key Controls and Optimization Data for the Reaction



#	X	Aux	Amount of salt (eq.)	Catalyst	Additive / base (eq.)	Solvent	Temp (°C)	Yield (%)[a]
1	OTs	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	Toluene	70	79
2	OTs	TMP	1.5	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	Toluene	70	72
3	OTs	TMP	1.1	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	Toluene	70	66
4	OTS	TMP	1.1	$Cu(NO_3)\cdot 3/2\ H_2O$	NaH (1.1) and TEA (0.2)	Toluene	70	67
5	OTf	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	Toluene	70	nd
6	OTs	TMP	3.0	-	-	Toluene	70	nd
7	OTs	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	-	Toluene	70	nd
8	OTs	TMP	3.0	-	TEA (1.5)	Toluene	70	nd
9	OTs	TMP	3.0	-	NaH (1.0)	Toluene	70	nd
10	OTs	TMP	3.0	-	NaH (2.0)	Toluene	70	nd
11	OTs	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	NaH (1.0)	Toluene	70	nd
12	OTs	TMP	3.0	CuI	TEA (1.5)	Toluene	70	47
13	OTs	TMP	3.0	Cu_2O	TEA (1.5)	Toluene	70	41
14	Br	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	Toluene	70	7
15	OTs	Mes	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	Toluene	70	60
16	OTs	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	TEA (1.5)	DMSO	70	74
17	OTs	TMP	3.0	-	-	Toluene	110	nd
18	OTs	TMP	3.0	$Cu(NO_3)\cdot 3/2\ H_2O$	DMEDA(1.5)	Toluene	70	64
19	OTs	TMP	3.0	CuI	DMEDA(1.5)	Toluene	70	trace

[a]Yield measured using mesitylene as an internal standard in the ^{1}H NMR analysis of the crude reaction mixture.

Scheme 3. Scope and Limitations of the Catalytic *N*-3-Arylation Process[c]



[a]5 mol % of catalyst employed. [b]Reaction performed using 1 mmol of diaryl iodonium salt and extended reaction time (31 h). [c]Conditions: Hydantoin **1a−g** (0.2 mmol, 1.0 equiv), [ArI(TMP)]Tos **2a−s** (0.6 mmol, 3.0 equiv), $Cu(NO_3)_2{\cdot}3/2\ H_2O$ (0.02 mmol, 0.1 equiv), triethylamine (TEA) (0.3 mmol, 1.5 equiv), and toluene (2 mL).

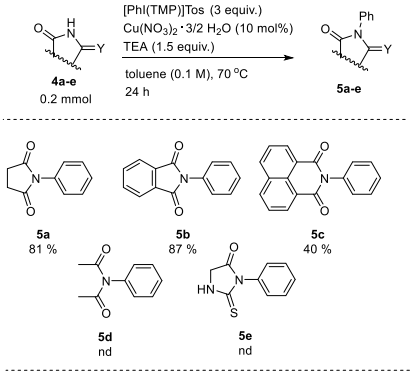
Pleasingly, the *N*-3 arylation proceeded smoothly with structurally diverse hydantoins, including structures lacking substituents on C-5 or N-1.[11] Aryl rings bearing neutral or weakly electron-donating/withdrawing groups were efficiently transferred to the *N*-3-position on the hydantoin ring. This trend was also observed for disubstituted aryl rings. The method was sensitive to iodonium salts bearing aryl groups congested at the *o*-position, likely due to steric crowding around the Cu-center in the catalytic process. The relatively small fluoride atom was tolerated, providing the corresponding hydantoins **3j** and **3k** in moderate yields. The more demanding *o*-methyl group was not tolerated under our conditions, and the coupled product **3q** was not observed in the post reaction

https://dx.doi.org/10.1021/acs.orglett.0c00642
Org. Lett. 2020, 22, 2687−2691

mixture. The mild conditions did not cause epimerization at the C-5-position of the hydantoin ring. The coupled chiral hydantoin products (*R*)-**3m** and (*S*)-**3o** were obtained in good yield with stereoretention, as indicated by polarimetric analysis. Strongly electron-poor and electron-rich aryl groups were less efficient substrates (**3c**,**d**, **e**), and *N*-3-arylated hydantoins **3y**, **3z**, and **3aa** were isolated in modest yield.

To our delight, the method was also applicable to a small selection of cyclic imide-type structures[16] (Scheme 4) such as

Scheme 4. *N*-Arylation of Other N−H Bonds[a]

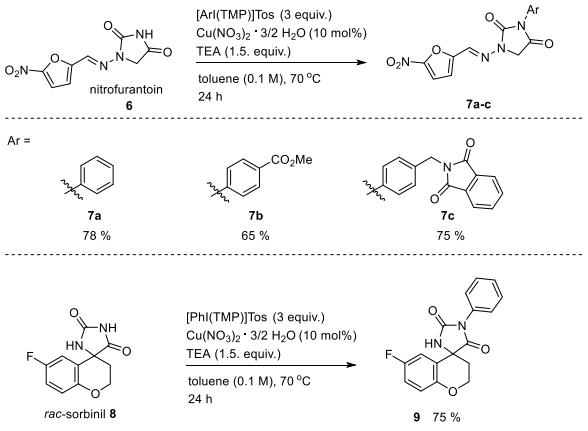


[a]Conditions: Imide **4a**−**d** (0.2 mmol, 1.0 equiv), [ArI(TMP)]Tos **2a** (0.6 mmol, 3.0 equiv), $Cu(NO_3)_2{\cdot}3/2\ H_2O$ (0.02 mmol, 0.1 equiv), triethylamine (TEA) (0.3 mmol, 1.5 equiv), and toluene (2 mL).

succinimide **4a** and phtalamide **4b**, exemplifying the usefulness of the method in an expanded structural space. The linear imide **4d** did not produce the desired product **5d**, indicating that the method is not applicable to linear imides, likely due to their less constrained confirmation compared with cyclic imides. Thiohydantoin **4e** did not react under our conditions.

To illustrate the practicality of the method, the well-known antibiotic drug nitrofurantoin **6**[17] was *N*-3-arylated in good yield, providing a small library of nitrofurantoin derivatives **7a**−**c** (Scheme 5). The racemate of the aldose reductase inhibitor sorbinil **8**[18] was also *N*-3-arylated in good yield.

Scheme 5. Regioselective *N*-Arylation of Pharmaceutically Relevant Agents[a]

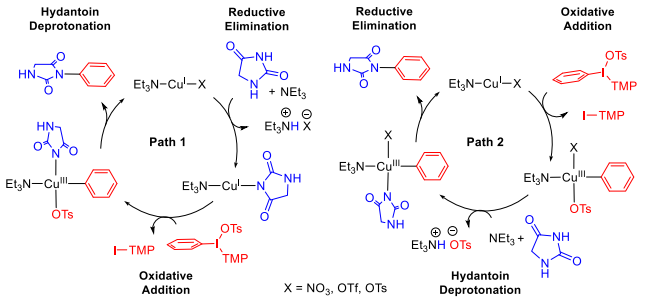


[a]Conditions: hydantoin **6** or **8** (0.2 mmol, 1.0 equiv), [ArI(TMP)]-Tos (0.6 mmol, 3.0 equiv), $Cu(NO_3)_2{\cdot}3/2H_2O$ (0.02 mmol, 0.1 equiv), triethylamine (TEA) (0.3 mmol, 1.5 equiv), and toluene (2 mL).

These examples illustrate the potential methods for the rapid diversification of pharmaceutically relevant agents and highlight the advantage of direct functionalization.

Two different mechanisms involving the Cu(I)/Cu(III) species could be envisaged for this process (Scheme 6).

Scheme 6. Two Mechanistic Proposals for the Cu-Catalyzed *N*-Arylation Process



Pathway 1 corresponds to the mechanism proposed for Ullman-type C−N bond coupling reactions using aryl iodides.[19] In this process, a Cu(I) species would deprotonate the hydantoin prior to the oxidative addition of the iodonium tosylate. In Pathway 2, the first step would consist of an oxidative addition of the iodonium salt followed by the deprotonation of hydantoin. The latter pathway has been proposed in Cu-catalyzed arylation reactions involving diaryliodonium salts.[20] In both pathways, the final product is formed by reductive elimination of the Cu(III) aryl amido intermediate. The use of Cu(II) precatalyst for Cu(I)-mediated reactions is precedented.[21] Both one-electron reduction and disproportionation mechanisms have been proposed for the reduction of Cu.[22] We believe that in the two mechanisms TEA acts as both a Cu ligand and base, driving the deprotonation of hydantoin. This double function was corroborated by using a catalytic amount of TEA and NaH as a base (see entry 4, Scheme 2). The tosylate anion may also play an important role when coordinated to the Cu center, assisting the intramolecular deprotonation of hydantoin at the N-3 position, which is the most acidic.[22] This could account for the lower yield observed when using bromide or the less basic OTf anion (see entries 5 and 14, Scheme 2).

In summary, we have reported the first general Cu-catalyzed method for the regioselective *N*-3-arylation of hydantoins. The method utilizes unsymmetrical iodonium salts, a simple Cu salt, and triethylamine under mild conditions. The method is robust and flexible, operates well, with weakly electron-donating and -withdrawing groups, proceeds without epimerization at C-5 of hydantoin, and smoothly arylates structurally varied hydantoins, including pharmaceutically relevant structures such as nitrofurantoin and *rac*-sorbinil. In-depth mechanistic investigations are currently underway.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.orglett.0c00642.

Detailed experimental procedures and full spectroscopic data for all new compounds (PDF)

https://dx.doi.org/10.1021/acs.orglett.0c00642
Org. Lett. 2020, 22, 2687−2691

Accession Codes

CCDC 1975309, 1975600, 1975603, and 1986195 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

Alexander H. Sandtorv − *Department of Chemistry, University of Oslo, N-0315 Oslo, Norway;* orcid.org/0000-0003-2480-0195; Email: a.h.sandtorv@kjemi.uio.no

Authors

Linn Neerbye Berntsen − *Department of Chemistry, University of Oslo, N-0315 Oslo, Norway*

Ainara Nova − *Hylleraas Centre for Quantum Molecular Sciences, Department of Chemistry, University of Oslo, N-0315 Oslo, Norway;* orcid.org/0000-0003-3368-7702

David S. Wragg − *Department of Chemistry, University of Oslo, N-0315 Oslo, Norway*

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.orglett.0c00642

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

L.N.B. gratefully acknowledges the Department of Chemistry at the University of Oslo for funding her Ph.D. fellowship. Arild X. Hagen (Department of Chemistry, University of Oslo) is acknowledged for technical assistance with the optimization study, and Brian C. Gilmour (Oslo University Hospital, University of Oslo) is acknowledged for technical assistance in the preparation of diaryliodonium salts. The project has received support from UiO: Life Science and was partially supported by the Research Council of Norway through the Norwegian NMR Platform, NNP (226244/F50). A.N. acknowledges the support from the Research Council of Norway (FRINATEK grant no. 250044 and Center of Excellence grant no. 262695). We acknowledge the use of the Norwegian national infrastructure for X-ray diffraction and scattering (RECX, Research Council of Norway project number 208896).

REFERENCES

(1) Konnert, L.; Lamaty, F.; Martinez, J.; Colacino, E. *Chem. Rev.* **2017**, *117*, 13757−13809.

(2) For some examples, see: (a) Sarges, R.; Goldstein, S. W.; Welch, W. M.; Swindell, A. C.; Siegel, T. W.; Beyer, T. A. *J. Med. Chem.* **1990**, *33*, 1859−1865. (b) Tan, L.; Maji, S.; Mattheis, C.; Zheng, M.; Chen, Y.; Caballero-Díaz, E.; Gil, P. R.; Parak, W. J.; Greiner, A.; Agarwal, S. *Macromol. Biosci.* **2012**, *12*, 1068−1076. (c) Su, M.; Xia, D.; Teng, P.; Nimmagadda, A.; Zhang, C.; Odom, T.; Cao, A.; Hu, Y.; Cai, J. *J. Med. Chem.* **2017**, *60*, 8456−8465. (d) Żesławska, E.; Kincses, A.; Spengler, G.; Nitek, W.; Tejchman, W.; Handzlik, J. *Chem. Biol. Drug Des.* **2019**, *93*, 844−853. (e) Cho, S.; Kim, S.-H.; Shin, D. *Eur. J. Med. Chem.* **2019**, *164*, 517−545. (f) Fetzer, C.; Korotkov, V. S.; Sieber, S. A. *Org. Biomol. Chem.* **2019**, *17*, 7124−7217.

(3) Mendgen, T.; Steuer, C.; Klein, C. D. *J. Med. Chem.* **2012**, *55*, 743−753.

(4) Mizuno, T.; Kino, T.; Ito, T.; Miyata, T. *Synth. Commun.* **2000**, *30*, 1675−1688.

(5) (a) Khazaei, A.; Zolfigol, M. A.; Rostami, A. *Synthesis* **2004**, 2959−2961. (b) Sandtorv, A. H.; Bjørsvik, H.-R. *Adv. Synth. Catal.* **2013**, *355*, 499−507. (c) Leitch, J. A.; Cook, H. P.; Bhonoah, Y.; Frost, C. G. *J. Org. Chem.* **2016**, *81*, 10081−10087. (d) Luo, Z.; Liu, T.; Guo, W.; Wang, Z.; Huang, J.; Zhu, Y.; Zeng, Z. *Org. Process Res. Dev.* **2018**, *22*, 1188−1199.

(6) (a) Burton, S. G.; Dorrington, R. A. *Tetrahedron: Asymmetry* **2004**, *15*, 2737−2741. (b) May, O.; Verseck, S.; Bommarius, A.; Drauz, K. *Org. Process Res. Dev.* **2002**, *6*, 452−457. (c) Fernandez-Nieto, F.; Mas Rosello, J.; Lenoir, S.; Hardy, S.; Clayden, J. *Org. Lett.* **2015**, *17*, 3838−3841. (d) Abas, H.; Mas-Roselló; Amer, M. M.; Durand, D. J.; Groleau, R. R.; Fey, N.; Clayden, J. *Angew. Chem., Int. Ed.* **2019**, *58*, 2418−2422. (e) Amer, M. M.; Abas, H.; Leonard, D. J.; Ward, J. W.; Clayden, J. *J. Org. Chem.* **2019**, *84*, 7199−7206.

(7) For some examples, see: (a) Hamann, L. G.; Manfredi, M. C.; Sun, C.; Krystek, S. R., Jr.; Huang, Y.; Bi, Y.; Augeri, D. J.; Wang, T.; Zou, Y.; Betebenner, D. A.; Fura, A.; Seethala, R.; Golla, R.; Kuhns, J. E.; Lupisella, J. A.; Darienzo, C. J.; Custer, L. L.; Price, J. L.; Johnson, J. M.; Biller, S. A.; Zahler, R.; Ostrowski, J. *Bioorg. Med. Chem. Lett.* **2007**, *17*, 1860−1864. (b) Payen, O.; Top, S.; Vessieres, A.; Brule, E.; Plamont, M.-A.; McGlinchey, M. J.; Muller-Bunz, H.; Jaouen, G. *J. Med. Chem.* **2008**, *51*, 1791−1799. (c) Wang, C.; Zhao, Q.; Vargas, M.; Jones, J. O.; White, K. L.; Shackleford, D. M.; Chen, G.; Saunders, J.; Ng, A. C. F.; Chiu, F. C. K.; Dong, Y.; Charman, S. A.; Keiser, J.; Vennerstrom, J. L. *J. Med. Chem.* **2016**, *59*, 10705−10718. (d) Tamura, T.; Noda, H.; Joyashiki, E.; Hoshino, M.; Watanabe, T.; Kinosaki, M.; Nishimura, Y.; Esaki, T.; Ogawa, K.; Miyake, T.; Arai, S.; Shimizu, M.; Kitamura, H.; Sato, H.; Kawabe, Y. *Nat. Commun.* **2016**, *7*, 13384−13398. (e) Bauman, A.; Piel, M.; Höhnemann, S.; Krauss, A.; Jansen, M.; Solbach, C.; Dannhardt, G.; Rösch, F. *J. Labelled Compd. Radiopharm.* **2011**, *54*, 645−656.

(8) (a) Meusel, M.; Gütschow, M. *Org. Prep. Proced. Int.* **2004**, *36*, 391−443. (b) Konnert, L.; Lamaty, F.; Martinez, J.; Colacino, E. *Chem. Rev.* **2017**, *117* (23), 13757−13809.

(9) For some recent examples, see: (a) Rajic, Z.; Zorc, B.; Raic-Malic, S.; Ester, K.; Kralj, M.; Pavelic, K.; Balzarini, J.; De Clercq, E.; Mintas, M. *Molecules* **2006**, *11*, 837−848. (b) Zhao, B.; Du, H.; Shi, Y. *J. Am. Chem. Soc.* **2008**, *130*, 7220−7221. (c) Gao, M.; Yang, Y.; Wu, Y.-D.; Deng, C.; Shu, W.-M.; Zhang, D.-X.; Cao, L.-P.; She, N.-F.; Wu, A.-X. *Org. Lett.* **2010**, *12*, 4026−4029. (d) Bogolubsky, A. V.; Moroz, Y. S.; Savych, O.; Pipko, S.; Konovets, A.; Platonov, M. O.; Vasylchenko, O. V.; Hurmach, V. V.; Grygorenko, O. O. *ACS Comb. Sci.* **2018**, *20*, 35−43. (e) Saunthwal, R. K.; Cornall, M. T.; Abrams, R.; Ward, J. W.; Clayden, J. *Chem. Sci.* **2019**, *10*, 3408−3412. (f) Declas, N.; Le Vaillant, F.; Waser, J. *Org. Lett.* **2019**, *21*, 524−528. (g) Liu, S. L.; Haung, J.-Y.; Barve, I. J.; Huang, S.-C.; Sun, C.-M. *ACS Comb. Sci.* **2019**, *21* (4), 336−344.

(10) (a) Hugel, H. M.; Rix, C. J.; Fleck, K. *Synlett* **2006**, *2006*, 2290−2292. (b) Bigg, D.; Auvin, S.; Lanco, C.; Prevost, G. Imidazolidine-2,4-dione Derivatives, Their Preparation and Use for Treating Hormone-Dependent Cancer. WO 2010119194 A1, 2010. (c) Cowley, P. M.; McGowan, M. A.; Brown, T. J.; Han, Y.; Liu, K.; Pu, Q.; Wise, A.; Zhang, H.; Zhou, H. Novel Substituted Imidazopyridine Compounds as Inhibitors of indoleamine 2,3-Dioxygenase and/or Tryptophan-2,3-dioxygenase. WO 2017189386 A1, 2017. (d) Qin, X.; Fang, L.; Zhao, J.; Gou, S. *Inorg. Chem.* **2018**, *57*, 5019−5029.

(11) Thilmany, P.; Gerard, P.; Vanoost, A.; Deldaele, C.; Petit, L.; Evano, G. *J. Org. Chem.* **2019**, *84*, 392−400.

(12) Preliminary communication: (a) Lopez-Alvarado, P.; Avendano, C.; Carlos Menendez, J. *Tetrahedron Lett.* **1992**, *33*, 6875−6878. Full report: (b) Lopez-Alvarado, P.; Avendano, C.; Menendez, J. C. *J. Org. Chem.* **1996**, *61*, 5865−5870. (c) Suresh, M.; Ravi, S.; Sudhakar, K. Synthesis of Nilutamide and Development of C-N Bond Formation by Reusable Green Catalyst. IN 201741010702, 2017. (d) Pierce, J. M.; Hale, J. J.; Miao, S.; Vachal, P. Substituted-1,3,8-triazaspiro[4.5]decane-2,4-diones. WO2010147776 A1, 2010.

(e) Vachal, P.; Miao, S.; Pierce, J. M.; Guiadeen, D.; Colandrea, V. J.; Wyvratt, M. J.; Salowe, S. P.; Sonatore, L. M.; Milligan, J. A.; Hajdu, R.; Gollapudi, A.; Keohane, C. A.; Lingham, R. B.; Mandala, S. M.; DeMartino, J. A.; Tong, X.; Wolff, M.; Steinhuebel, D.; Kieczykowski, G. R.; Fleitz, F. J.; Chapman, K.; Athanasopoulos, J.; Adam, G.; Akyuz, C. D.; Jena, D. K.; Lusen, J. W.; Meng, J.; Stein, B. D.; Xia, L.; Sherer, E. C.; Hale, J. J. *J. Med. Chem.* **2012**, *55*, 2945−2959.

(13) For some reviews, see, for example: (a) Deprez, N. R.; Sanford, M. S. *Inorg. Chem.* **2007**, *46* (6), 1924−1935. (b) Merritt, E. A.; Olofsson, B. *Angew. Chem., Int. Ed.* **2009**, *48*, 9052−9070. (c) Yusubov, M. S.; Maskaev, A. V.; Zhdankin, V. V. *ARKIVOC* **2011**, *2011*, 370−409. (d) Aradi, K.; Tóth, B. L.; Tolnai, G. L.; Novák, Z. *Synlett* **2016**, *27*, 1456−1485. (e) Olofsson, B. *Top. Curr. Chem.* **2015**, *373*, 135−166.

(14) Stuart, D. R. *Chem. - Eur. J.* **2017**, *23*, 15852−15863.

(15) For some recent examples, see: (a) Jalalian, N.; Ishikawa, E. E.; Silva, L. F.; Olofsson, B. *Org. Lett.* **2011**, *13*, 1552−1555. (b) Phipps, R. J.; McMurray, L.; Ritter, S.; Duong, H. A.; Gaunt, M. J. *J. Am. Chem. Soc.* **2012**, *134*, 10773−10776. (c) Sandtorv, A. H.; Stuart, D. R. *Angew. Chem., Int. Ed.* **2016**, *55*, 15812−15815. (d) Bhattarai, B.; Tay, J.-H.; Nagorny, P. *Chem. Commun.* **2015**, *51*, 5398−5401. (e) Modha, S. G.; Greaney, M. F. *J. Am. Chem. Soc.* **2015**, *137*, 1416−1419. (f) Aradi, K.; Mészáros, Á.; Tóth, B. L.; Vincze, Z.; Novák, Z. *J. Org. Chem.* **2017**, *82*, 11752−11764. (g) Purkait, N.; Kervefors, G.; Linde, E.; Olofsson, B. *Angew. Chem., Int. Ed.* **2018**, *57*, 11427−11431. (h) Wang, L.; Chen, M.; Zhang, J. *Org. Chem. Front.* **2019**, *6*, 32−35.

(16) Metal-free coupling of imides with unsymmetric iodonoum salts is also known: Basu, S.; Sandtorv, A. H.; Stuart, D. R. *Beilstein J. Org. Chem.* **2018**, *14*, 1034−1038.

(17) Wijma, R. A.; Huttner, A.; Koch, B. C. P.; Mouton, J. W.; Muller, A. E. *J. Antimicrob. Chemother.* **2018**, *73*, 2916−2926.

(18) Huang, Q.; Liu, Q.; Ouyang, D. *Med. Chem.* **2019**, *15*, 3−7.

(19) Gurjar, K. K.; Sharma, R. K. *ChemCatChem* **2017**, *9*, 862−869.

(20) (a) Chen, B.; Hou, X.-L.; Li, Y.-X.; Wu, Y.-D. *J. Am. Chem. Soc.* **2011**, *133*, 7668−7671. (b) Ichiishi, N.; Canty, A. J.; Yates, B. F.; Sanford, M. S. *Organometallics* **2014**, *33*, 5525−5534.

(21) Allen, S. E.; Walvoord, R. R.; Padilla-Salinas, R.; Kozlowski, M. C. *Chem. Rev.* **2013**, *113*, 6234−6458.

(22) For similar acetate-assisted deprotonation reactions, see: Davies, D. L.; Macgregor, S. A.; McMullin, C. L. *Chem. Rev.* **2017**, *117*, 8649−8709.

https://dx.doi.org/10.1021/acs.orglett.0c00642
Org. Lett. 2020, 22, 2687−2691