ORGANIC LETTERS

2007
Vol. 9, No. 7
1175−1178

Room Temperature Zinc Chloride-Catalyzed Cycloisomerization of Alk-3-yn-1-ones: Synthesis of Substituted Furans

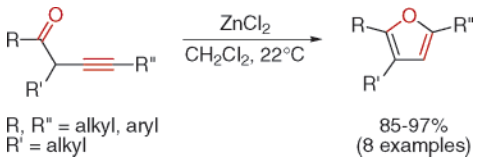
Adam Sniady,[†] Audrey Durham,[†] Marco S. Morreale,[†] Kraig A. Wheeler,[‡] and Roman Dembinski*,[†]

Department of Chemistry, Oakland University, 2200 North Squirrel Road, Rochester, Michigan 48309-4477, and Department of Chemistry, Eastern Illinois University, 600 Lincoln Avenue, Charleston, Illinois 61920-3099

dembinsk@oakland.edu

Received October 15, 2006

ABSTRACT



5-*Endo-dig* cycloisomerization of 1,4-di- and 1,2,4-trisubstituted but-3-yn-1-ones in the presence of a catalytic amount of zinc chloride (10 mol %) in dichloromethane at room temperature (22 °C) provides 2,5-di- and 2,3,5-trisubstituted furans in high yields (85–97%).

Attracting interest for well over a century, the field of furan syntheses is continuously and rapidly developing.[1,2] In general, substituted furans are accessed via ring derivatization or cyclization of acyclic precursors.[1−3] Among the variety of compounds that can be subjected to cyclization, unsaturated alcohols or ketones are substrates of major interest.[1,3]

Intramolecular cycloisomerization reactions that involve an acetylenic functionality are reportedly in the frontiers of the synthesis, in part due to perfect atom economy. Oxygen-containing internal nucleophiles have been used in this regard.[4] Most works in this area report elevated temperatures up to refluxing solvents, although some, mostly gold-catalyzed reactions can be carried out at room temperature.

Base- and acid-catalyzed reactions of alkynyl ketones have been reported to yield furans.[5,6] These approaches are rather incongruous with sensitive functional groups. Relevant reactions have also been reported with the aid of transition-metal catalysts.[7] In general, gold, mainly as $AuCl_3$, is the

[†] Oakland University.
[‡] Eastern Illinois University.

(1) (a) Kirsch, S. F. *Org. Biomol. Chem.* **2006**, *4*, 2076−2080. (b) Brown, R. C. D. *Angew. Chem., Int. Ed.* **2005**, *44*, 850−852.

(2) Selected recent examples: (a) Kawai, H.; Oi, S.; Inoue, Y. *Heterocycles* **2006**, *67*, 101−105. (b) Ma, S.; Gu, Z.; Yu, Z. *J. Org. Chem.* **2005**, *70*, 6291−6294. (c) Duan, X.-h.; Liu, X.-y.; Guo, L.-n.; Liao, M.-c.; Liu, W.-M.; Liang, Y.-m. *J. Org. Chem.* **2005**, *70*, 6980−6983. (d) Suhre, M. H.; Reif, M.; Kirsch, S. F. *Org. Lett.* **2005**, *7*, 3925−3927. (e) Casey, C. P.; Strotman, N. A. *J. Org. Chem.* **2005**, *70*, 2576−2581. (f) Sromek, A. W.; Rubina, M.; Gevorgyan, V. *J. Am. Chem. Soc.* **2005**, *127*, 10500−10501. (g) Aurrecoechea, J. M.; Pérez, E. *Tetrahedron* **2004**, *60*, 4139−4149. (h) Jung, C.-K.; Wang, J.-C.; Krische, M. J. *J. Am. Chem. Soc.* **2004**, *126*, 4118−4119. (i) Nishibayashi, Y.; Yoshikawa, M.; Inada, Y.; Milton, M. D.; Hidai, M.; Uemura, S. *Angew. Chem., Int. Ed.* **2003**, *42*, 2681−2684. (j) Kel'in, A. V.; Gevorgyan, V. *J. Org. Chem.* **2002**, *67*, 95−98.

(3) (a) Eicher, T.; Hauptmann, S.; Speicher, A. *The Chemistry of Heterocycles*, 2nd ed.; Wiley-VCH: Weinheim, Germany, 2003; pp 57−62. (b) Jeevanandam, A.; Ghule, A.; Ling, Y.-C. *Curr. Org. Chem.* **2002**, *6*, 841−864. (c) Cacchi, S.; Fabrizi, G.; Goggiomani, A. *Heterocycles* **2002**, *56*, 613−632. (d) König, B. Furan. In *Hetarenes and Related Ring Systems*; *Science of Synthesis*; Maas, G., Ed.; George Thieme Verlag: Stuttgart, Germany, 2001; Category 2, Vol. 9, pp 183−285. (e) Hou, X. L.; Cheung, H. Y.; Hon, T. Y.; Kwan, P. L.; Lo, T. H.; Tong, S. Y.; Wong, H. N. C. *Tetrahedron* **1998**, *54*, 1955−2020. (f) Eberbach, W. Furan. In *Houben-Weyl*; George Thieme Verlag: Stuttgart, Germany, 1994; E6a, Teil I, pp 16−185d. (g) Hou, X. L.; Yang, Z.; Wong, H. N. C. Furans and benzofurans. In *Progress in Heterocyclic Chemistry*; Gribble, G. W., Gilchrist, T. L., Eds.; Pergamon Press: Oxford, UK, 2003; Vol. 15, pp 167−205. (h) Friedrichsen, W. Furans and Benzo Derivatives: Synthesis. In *Comprehensive Heterocyclic Chemistry II*; Katritzky, A. R., Rees, C. W., Scriven, E. F. V., Eds.; Pergamon Press: Oxford, UK, 1996; Vol. 2, pp 351−394.

10.1021/ol062539t CCC: $37.00
Published on Web 03/01/2007

most effective catalyst for cycloisomerizations leading to furans.[8−13] Figure 1 schematically illustrates representative

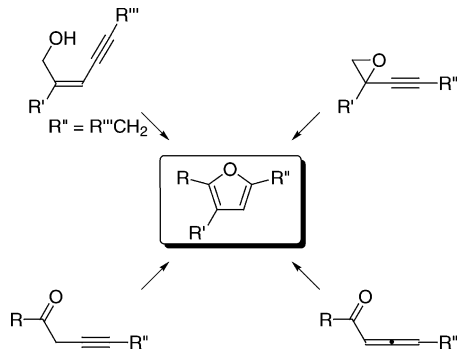


Figure 1. Representative gold-catalyzed cycloisomerizations leading to furans.

examples of gold-catalyzed cycloisomerizations of oxoalkynyl compounds: (*Z*)-alk-2-en-4-yn-1-ols,[8] alkynyloxiranes,[9] alka-2,3-dien-1-ones,[10,11] and alk-3-yn-1-ones,[10,12,13] that lead to substituted furans. Among the starting materials above, homopropargylic ketones are favored due to availability. Analysis of catalysts that have been examined for cycloisomerization of alk-3-yn-1-ones revealed, in addition to Au, derivatives of metals such as Pd[14,15] and Cu.[16] Recently, the list was expanded to include a mercury(II) derivative, $Hg(OTf)_2$·(tetramethylurea)$_2$.[17] The reported yields are sometimes moderate,[15a] elevated reaction temperatures are required,[15,16] or rather expensive catalysts.[10,12,13] Although most reported gold-catalyzed reactions are carried out under mild conditions (room temperature) and with a low catalyst load (usually 1−5 mol %), we were drawn to the investigation of a less expensive and readily available metal derivative that would provide parallel catalytic behavior to that of gold.

Coordinative flexibility combined with soft Lewis acidity makes the zinc center useful for catalysis. Participation of zinc bromide in synthesis is known and was summarized recently.[18] However, the formation of ring systems with the use of zinc halides has not been extensively reported.[18−22] Few cyclizations, leading to other than furan heterocycles, were pursued with the aid of $ZnCl_2$.[23]

We have reported electrophilic cyclizations leading to a family of 3-halofurans[24] and furopyrimidine nucleosides[25] with the aid of *N*-bromo- and *N*-iodosuccinimide. Presently, in pursuit of an inexpensive, mild, and efficient synthesis of 2,5-di- and 2,3,5-trisubstituted furans, we have selected the furan acyclic precursor core (but-3-yn-1-one) with various groups that remain as ring substituents of its furan derivative. The alkyl (propyl), cycloalkyl (cyclopropyl, fused cyclohexyl), ether (methoxymethyl), and aryl (phenyl, *p*-alkylphenyls, *p*-halophenyls) groups were elected.

To prepare starting materials, respective alk-3-yn-1-ols (**1a**−**h**), available by alkynylation of oxiranes,[24,26] were treated with Dess−Martin reagent[27] (1.2 equiv) in dichloromethane at room temperature or, except for **1g**, with Jones reagent[24b,28−30] (3.0 M) in acetone at 0 °C, to yield but-3-yn-1-ones (**2a**-**h**) (Scheme 1).[24]

(4) Selected recent examples: (a) Liu, B.; De Brabander, J. K. *Org. Lett.* **2006**, *8*, 4907−4910. (b) Belting, V.; Krause, N. *Org. Lett.* **2006**, *8*, 4489−4492. (c) Lo, C.-Y.; Lin, C.-C.; Cheng, H.-M.; Liu, R.-S. *Org. Lett.* **2006**, *8*, 3153−3156. (d) Genin, E.; Toullec, P. Y.; Antoniotti, S.; Brancour, C.; Genêt, J.-P.; Michelet, V. *J. Am. Chem. Soc.* **2006**, *128*, 3112−3113. (e) Buzas, A.; Istrate, F.; Gagosz, F. *Org. Lett.* **2006**, *8*, 1957−1959. (f) Kim, N.; Kim, Y.; Park, W.; Sung, D.; Gupta, A. K.; Oh, C. H. *Org. Lett.* **2005**, *7*, 5289−5291. (g) Alcázar, E.; Pletcher, J. M.; McDonald, F. E. *Org. Lett.* **2004**, *6*, 3877−3880. (h) Trost, B. M.; Rudd, M. T.; Costa, M. G.; Lee, P. I.; Pomerantz, A. E. *Org. Lett.* **2004**, *6*, 4235−4238.

(5) (a) Vieser, R.; Eberbach, W. *Tetrahedron Lett.* **1995**, *36*, 4405−4408. (b) Arcadi, A.; Marinelli, F.; Pini, E.; Rossi, E. *Tetrahedron Lett.* **1996**, *37*, 3387−3390. (c) Arcadi, A.; Rossi, E. *Tetrahedron* **1998**, *54*, 15253−15272.

(6) Brown, C. D.; Chong, J. M.; Shen, L. *Tetrahedron* **1999**, *55*, 14233−14242.

(7) Reviews: (a) Zeni, G.; Larock, R. C. *Chem. Rev.* **2006**, *106*, 4644−4680. (b) Alonso, F.; Beletskaya, I. P.; Yus, M. *Chem. Rev.* **2004**, *104*, 3079−3159. (c) Zeni, G.; Larock, R. C. *Chem. Rev.* **2004**, *104*, 2285−2309. (d) Nakamura, I.; Yamamoto, Y. *Chem. Rev.* **2004**, *104*, 2127−2198. (e) Kirsch, G.; Hesse, S.; Comel, A. *Curr. Org. Synth.* **2004**, *1*, 47−63. (f) Balme, G.; Bouyssi, D.; Lomberget, T.; Monteiro, N. *Synthesis* **2003**, 2115−2134. (g) Cacchi, S. *J. Organomet. Chem.* **1999**, *576*, 42−64.

(8) Liu, Y.; Song, F.; Song, Z.; Liu, M.; Yan, B. *Org. Lett.* **2005**, *7*, 5409−5412.

(9) Hashmi, A. S. K.; Sinha, P. *Adv. Synth. Catal.* **2004**, *346*, 432−438.

(10) Hashmi, A. S. K.; Schwarz, L.; Choi, J.-H.; Frost, T. M. *Angew. Chem., Int. Ed.* **2000**, *39*, 2285−2288.

(11) Zhou, C.-Y.; Chan, P. W. H.; Che, C.-M. *Org. Lett.* **2006**, *8*, 325−328.

(12) Zhang, J.; Schmalz, H.-G. *Angew. Chem., Int. Ed.* **2006**, *45*, 6704−6707.

(13) For 2-(1-alkynyl)-2-alken-1-ones see: (a) Yao, T.; Zhang, X.; Larock, R. C. *J. Org. Chem.* **2005**, *70*, 7679−7685. (b) Yao, T.; Zhang, X.; Larock, R. C. *J. Am. Chem. Soc.* **2004**, *126*, 11164−11165. (c) Liu, X.; Pan, Z.; Shu, X.; Duan, X.; Liang, Y. *Synlett* **2006**, 1962−1964.

(14) Utimoto, K. *Pure Appl. Chem.* **1983**, *55*, 1845−1852.

(15) (a) Sheng, H.; Lin, S.; Huang, Y. *Synthesis* **1987**, 1022−1023. (b) Fukuda, Y.; Shiragami, H.; Utimoto, K.; Nozaki, H. *J. Org. Chem.* **1991**, *56*, 5816−5819.

(16) For 2-(1-alkynyl)-2-alken-1-ones see: Patil, N. T.; Wu, H.; Yamamoto, Y. *J. Org. Chem.* **2005**, *70*, 4531−4534.

(17) Ménard D.; Vidal, A.; Barthomeuf, C.; Lebreton, J.; Gosselin, P. *Synlett* **2006**, 57−60.

(18) Gossage, R. A. *Curr. Org. Chem.* **2006**, *10*, 923−936.

(19) (a) Jacobi von Wangelin, A.: Frederiksen, M. U. Zinc-Mediated Reactions. In *Transition Metals for Organic Synthesis*; Beller, M., Bolm, C., Eds.; Wiley-VCH: Weinheim, Germany, 2003; Chapter 3.7, pp 519−551. (b) Frantz, D. E.; Fässler, R.; Tomooka, C. S.; Carreira, E. M. *Acc. Chem. Res.* **2000**, *33*, 373−381.

(20) Aschwanden, P.; Frantz, D. E.; Carreira, E. M. *Org. Lett.* **2000**, *2*, 2331−2333.

(21) For synthesis of furans from alk-2-yn-1-ones with the use of $ZnBr_2$ and *i*-Pr_2NEt (MeCN, 40−50 °C, 24 h) see: Lee, K. Y.; Lee, M. J.; Kim, J. N. *Tetrahedron* **2005**, *61*, 8705−8710.

(22) Anastasia, L.; Xu, C.; Negishi, E. *Tetrahedron Lett.* **2002**, *43*, 5673−5676.

(23) (a) Görlitzer, K.; Trittmacher, J.; Jones, P. G. *Pharmazie* **2005**, *60*, 494−497. (b) Choi, H.-D.; Seo, P.-J.; Son, B.-W.; Kang, B. W. *Arch. Pharm. Res.* **2004**, *27*, 19−24. (c) For *n*-BuLi/$ZnCl_2$ cyclization of 2-alkynylphenols to benzofurans at reflux in toluene see: Nakamura, M.; Ilies, L.; Otsubo, S.; Nakamura, E. *Org. Lett.* **2006**, *8*, 2803−2805.

(24) (a) Sniady, A.; Wheeler, K. A.; Dembinski, R. *Org. Lett.* **2005**, *7*, 1769−1722. (b) Sniady, A.; Morreale, M. S.; Dembinski, R. *Org. Synth.* **2007**, *84*, 199−208.

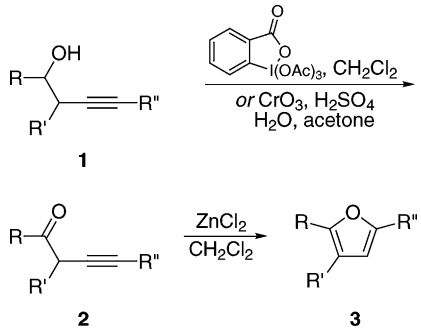
(25) Rao, M. S.; Esho, N.; Sergeant, C.; Dembinski, R. *J. Org. Chem.* **2003**, *68*, 6788−6790.

(26) Brandsma, L. *Preparative Acetylenic Chemistry*, 2nd ed.; Studies in Organic Chemistry 34; Elsevier: Amsterdam, The Netherlands, 1988; p 67.

(27) (a) Boeckman, R. K., Jr.; Shao, P.; Mullins, J. J. *Organic Syntheses*; Wiley: New York, 2004; Collect. Vol. X, pp 696−703 (*Org. Synth.* **2000**, *77*, 141−152). (b) Ireland, R. E.; Liu, L. *J. Org. Chem.* **1993**, *58*, 2899.

(28) Eisenbraun, E. J. *Organic Syntheses*; Wiley: New York, 1973; Collect. Vol. V, pp 310−314 (*Org. Synth.* **1965**, *45*, 28−32).

Scheme 1. Synthesis of Furans **3**[a]



[a] For full structures see Table 1.

When 1-phenyl-4-(*p*-tolyl)butynone **2a** (0.1 mmol) was treated with $ZnCl_2$ (10 mol %) in dichloromethane, complete conversion into **3a** was noticed after 2 h by TLC. To maintain mild conditions, the reaction was carried out at room temperature and in the absence of base. Furan **3a** was isolated, after workup by simple filtration through a silica gel pad, in 97% yield (Table 1, entry 1). Quantitative

Table 1. Preparation of Furans **3** via Cycloisomerization of **2** with the Use of Zinc Chloride

entry	ynone	R	R′	R″	furan	yield (%)[a]
1	**2a**	C_6H_5	H	*p*-$CH_3C_6H_4$	**3a**	97
2	**2b**	C_6H_5	H	*c*-C_3H_5	**3b**	85
3	**2c**	*p*-BrC_6H_4	H	*p*-$CH_3C_6H_4$	**3c**	90
4	**2d**	*p*-BrC_6H_4	H	*p*-*t*-BuC_6H_4	**3d**	96
5	**2e**	*p*-ClC_6H_4	H	*p*-$CH_3C_6H_4$	**3e**	89
6	**2f**	*p*-ClC_6H_4	H	*p*-*t*-BuC_6H_4	**3f**	85
7	**2g**	*p*-ClC_6H_4	H	CH_3OCH_2	**3g**	65[b]
8	**2h**	$(CH_2)_4$		$CH_3(CH_2)_2$	**3h**	89[c]

[a] Reactions were carried out on a 1.0 mmol scale with 10 mol % of $ZnCl_2$, in CH_2Cl_2 at room temperature for 2 h, unless referenced otherwise. Yields >99%, as determined by ^{1}H NMR. [b] 0.18 mol % of $ZnCl_2$, crude **2g** was used as a substrate. [c] 3.2 mmol scale.

formation of **3a** was also observed in an NMR tube when an anhydrous atmosphere was maintaned ($CDCl_3$, $ZnCl_2$ 6 mol %, 10 min). Thus, preparative reactions can likely be carried out with a lower catalyst load.

The effect of the presence of water was also examined for the cycloisomerization of **2a**. The reaction conditions included CH_2Cl_2 and 1.7 equiv of H_2O. While the reaction was sluggish, the furan **3a** can be isolated with a comparable yield at room temperature. However, the presence of water required an additional quantity of $ZnCl_2$. It is known that Zn halides form oxy derivatives when mixed with water.[31] Albeit not catalytically active, their presence did not seem to affect the reaction progress. Although strict anhydrous conditions are not mandatory, the catalyst load can be diminished by using freshly distilled anhydrous CH_2Cl_2 and monitoring the reaction progress. If necessary, an extra amount of $ZnCl_2$ can be added to bring the reaction to completion.

Other alkynyl ketones **2b**−**h** (0.1−0.3 mmol) with cycloalkyl/aryl (entry 2), aryl/aryl (entries 3−6), aryl/alkyl ether (entry 7), and alkyl/fused cycloalkyl (entry 8) groups were subjected to the reaction with $ZnCl_2$ at room temperature in a similar manner as **2a**.[32] To maximize the effectiveness of the preparative experiments, we extended the time to 2 h to ensure full completion of the reactions. ^{1}H NMR examination of postreaction mixtures indicated quantitative conversion to the furans **3**. The straightforward workup of the reaction, by a simple filtration through a silica gel pad, allowed separation of the product from the Zn(II) catalyst to render furans with 85−97% yield.[32] The isolation procedure facilitates a complete removal of $ZnCl_2$, which was confirmed based upon a $AgNO_3$ test of the filtrate. The results are summarized in Table 1.

The new furans **3b**−**h** were characterized by ^{1}H and ^{13}C NMR spectroscopy. The characteristic NMR ($CDCl_3$) features for furans[33] **3a**−**g** include the ^{1}H H-3/H-4 signals (AB, 6.00−6.77 ppm) and ^{13}C C-3/C-4 signals (105.7−111.7 ppm). Mass spectra for **3a**−**h** exhibited intense molecular ions. Most of the furans **3** gave highly accurate (±0.1%) elemental analyses without recrystallization.

A molecular structure of a representative furan was confirmed by X-ray crystallography. The crystallization of compound **3d** from ether gave single crystals suitable for X-ray analysis. Figure 2 illustrates the molecular structure of the expected 2,5-disubstituted furan.[34] Excluding the methyl groups of the disordered *tert*-butyl substituent, the entire molecule of **3d** is planar. The maximum atom deviations from the average plane are 0.31(1) and 0.27(1) Å for C10 and C11, respectively.

A relevant cycloisomerization, a ZnI_2-catalyzed formation of 2,3-dihydroisooxazoles from propargylic *N*-hydroxyl-

(29) Padwa, A.; Crumrine, D.; Hartman, R.; Layton, R. *J. Am. Chem. Soc.* **1967**, *89*, 4435−4442.

(30) Due to the presence of a labile propargylic ether function, the ketone **2g** was not purified and was used as crude material for the reaction. However, the furan **3g** is stable.

(31) (a) Duffy, J. A.; Ingram, M. D. *Inorg. Chem.* **1978**, *17*, 2798−2802. (b) See, also: McDaniel, D. H. *Inorg. Chem.* **1979**, *18*, 1412.

(32) Representativeprocedure: **2-(4-methylphenyl)-5-phenylfuran(3a)**.[15a] A round-bottom flask was charged with **2a** (0.234 g, 1.00 mmol) and CH_2Cl_2 (10 mL). Zinc chloride (1.0 M in ether, 0.10 mL, 0.10 mmol) was added dropwise with a syringe. The solution was stirred at room temperature (22 °C) for 2 h. ^{1}H NMR showed complete conversion of substrate. The reaction mixture was passed through a short path silica gel column (2.5 × 15 cm; CH_2Cl_2). The solvent was removed by rotary evaporation and the residue was dried by an oil pump vacuum for 3 h to give **3a** as a white solid (0.227 g, 0.970 mmol, 97%), mp 97−99 °C. Calcd for $C_{17}H_{14}O$: C, 87.15; H, 6.02. Found: C, 87.05; H, 6.03. IR (ν, cm^{-1}, KBr) 1498 m, 1482 m, 821 m, 794 s, 757 s, 691 m. UV−vis (ϵ, M^{-1} cm^{-1}; ether; 4.7 × 10^{-5} M) 227 (11 000), 326 (28 000). MS 234 (M^+, 100%); no other peaks of >20%. NMR ($CDCl_3$): ^{1}H 7.83−7.64 (m, 4H), 7.50−7.20 (m, 5H), 6.77 (d, 1H, J = 3.3 Hz), 6.72 (d, 1H, J = 3.3 Hz), 2.42 (s, 3H); ^{13}C 153.7, 153.1, 137.4, 131.0, 129.5, 128.8, 128.2, 127.3, 123.8, 107.3, 106.6, 21.5.

(33) Alvarez-Ibarra, C.; Quiroga-Feijóo, M. L.; Toledano, E. *J. Chem. Soc., Perkin Trans. 2* **1998**, 679−689.

(34) Crystallographic data (excluding structural factors) for the structure reported in this paper were also deposited with Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-621939. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, by e-mailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44(0)1223−336033.

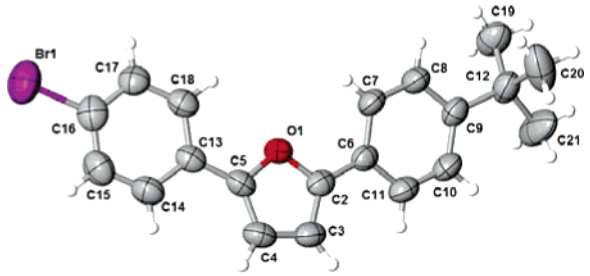


Figure 2. An ORTEP view of the **3d** with the atom-labeling scheme. Thermal ellipsoids at the 50% probability level. Selected interatomic distances (Å): O1−C2 1.376(3); O1−C5 1.370(3); C2−C3 1.358(4); C2−C6 1.442(3); C3−C4 1.392(4); C4−C5 1.361(4); C5−C13 1.450(3). Key angles (deg): C2−O1−C5 107.46(18); O1−C2−C3 108.6(2); C3−C2−C6 133.9(2); O1−C2−C6 117.5(2); C2−C3−C4 107.7(2); C3−C4−C5 107.4(2); O1−C5−C4 108.8(2); O1−C5−C13 117.3(2); C4−C5−C13 133.8(2).

amines (DMAP, CH_2Cl_2, 23 °C), is postulated to proceed via an intramolecular, stepwise mechanism involving an organozinc intermediate.[20] Carreira et al. determined that the process is not proton-catalyzed, the presence of base is essential for completion of the reaction, and suggested that Zn(II) likely coordinates *N*-hydroxylamine.[20]

To gain insight into the mechanism we have carried out two independent experiments of a zinc-catalyzed cyclization of **2a** in the presence of D_2O (1.7 equiv; 35 mol % of $ZnCl_2$) and CD_3OD (30 equiv; 1.7 equiv of $ZnCl_2$). Since no incorporation of deuterium was observed into the essentially quantitatively formed furan **3a**, it may be suggested that the mechanism involves an intramolecular H transfer.

In summary, we have demonstrated that $ZnCl_2$ is an efficient, non-transition metal catalyst for quantitative cycloisomerization of the but-3-yn-1-one unit at room temperature and in the absence of base. Simple isolation protocol facilitates high yields. The relatively short reaction time and an easy-to-handle catalyst provide an appealing alternative to currently available methods. Our approach allows for facile preparation of highly substituted furans. This route, with perfect atom economy, tolerates sensitive functional groups, as illustrated with the labile propargyl ether-containing example. The investigation of an extension of this method toward a preparation of potent antiviral furopyrimidine nucleosides from 5-alkynyl-2′-deoxyuridines is in progress.

Acknowledgment is made to the donors of the Petroleum Research Fund (ACS-PRF#46094), administered by the American Chemical Society, for support of this research. We also thank Oakland University, the Research Excellence Program in Biotechnology for funding. A.S. is grateful for the Provost's Graduate Student Research Award. A.D. was supported by a Dershwitz Summer Fellowship.

Supporting Information Available: ^1H, ^{13}C NMR spectra for all furans (**3a**−**h**) and an X-ray table for **3d**, and a separate CIF file for **3d**. This material is available free of charge via the Internet at http://pubs.acs.org.

OL062539T