Advanced Synthesis & Catalysis

Accepted Article

Title: Oxygen-Substituted Isocyanates: Blocked (Masked) Isocyanates Enable Controlled Reactivity

Authors: Ryan Ivanovich, Dilan Polat, and André Beauchemin

To be cited as: *Adv. Synth. Catal.* 10.1002/adsc.201701046

Link to VoR: http://dx.doi.org/10.1002/adsc.201701046

10.1002/adsc.201701046

COMMUNICATION

DOI: 10.1002/adsc.201((will be filled in by the editorial staff))

Oxygen-Substituted Isocyanates: Blocked (Masked) Isocyanates Enable Controlled Reactivity

Ryan A. Ivanovich, Dilan E. Polat, André M. Beauchemin*[a]

[a] Centre for Catalysis Research and Innovation, Department of Chemistry and Biomolecular Sciences, University of Ottawa, 10 Marie Curie, Ottawa, Ontario, K1N 6N5, Canada
e-mail: andre.beauchemin@uottawa.ca

Received: ((will be filled in by the editorial staff))

Supporting information for this article is available on the WWW under http://dx.doi.org/10.1002/adsc.201######.((Please delete if not appropriate))

Abstract. Oxygen-substituted isocyanates (*O*-isocyanates) are rare isocyanates with a reported propensity to trimerize, a side-reaction that severely limited their use in synthesis. Herein, the development of blocked (masked) *O*-isocyanate precursors that form this reactive intermediate *in situ* provide controlled reactivity, allowing the first examples of cascade reactions involving *O*-isocyanates. Complex hydroxylamine-derived hydantoins and dihydrouracil compounds can be rapidly assembled from α- and β-amino esters, illustrating the convenience of masked *O*-isocyanates as hydroxylamine derived building blocks. Evidence for the intermediacy of an *O*-isocyanate intermediate is provided.

Keywords: cascade reactions; hydantoins; isocyanates; synthetic methods; hydroxylamine derivatives

Isocyanates are important reagents with a rich history that dates back to the inception of synthetic organic chemistry. Today, isocyanates have a wide range of applications (>100,000 publications & patents) and yearly global sales over 10 billion €. While carbon-substituted isocyanates are ubiquitous, *O*-isocyanates are rare, despite interest in their reactivity for over a century.[1] Initial studies were aimed at the study of the hypothetical acid HO-N=C=O, which has yet to be isolated. The synthesis and isolation of *O*-isocyanates has been a longstanding challenge, with documented unsuccessful attempts.[2] In contrast, solid evidence of these rare reactive intermediates has been obtained from spectroscopic data, for example via the thermolysis of *N*-methoxycarbonyl-*O*-methylhydroxylamine and the photolysis of methyl azidoformate.[3-5] However, the rare reactions[6] of *O*-isocyanates were most frequently encountered during unanticipated Lossen-rearrangements of *O*-activated-hydroxylamines.[7] Unfortunately, once formed *O*-isocyanates often promptly engage in homotrimerization to the corresponding aromatic isocyanurate.[8] This competing reaction has severely hampered potential applications of these reactive intermediates.

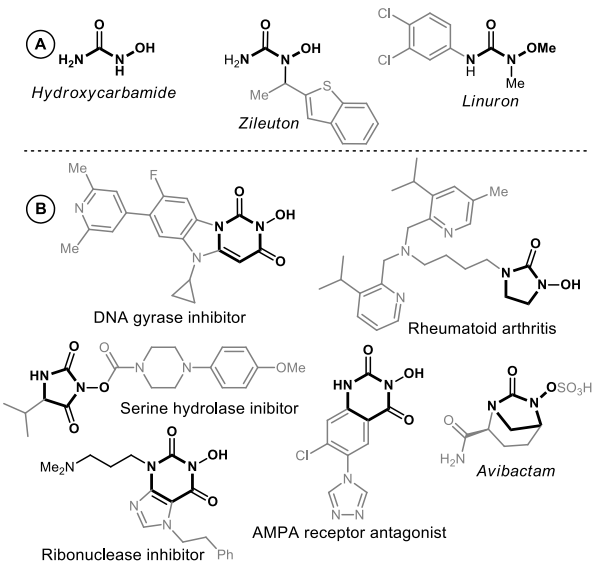


Figure 1. A: Selected examples of acyclic oxyaminoureas in pharmaceuticals and agrochemicals. B: Selected examples of hydroxylamine containing heterocycles in bioactive lead compounds.

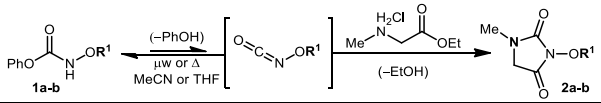
However from a synthetic perspective, *O*-isocyanates could be versatile reagents for the synthesis of hydroxamic acids, hydroxamates, and hydroxylamines. Hydroxamic acids and their derivatives are valuable synthetic intermediates: for example as chiral ligands,[9] or directing groups,[10] and are present in potent bioactive molecules displaying high affinity for various enzymatic receptors (Figure 1).[11] Unfortunately such derivatives can be difficult to synthesize due to their weak N-O bond, and in general routes using hydroxylamines are often preferred if this precursor is readily available. Based on recent work on nitrogen-substituted isocyanates in which the use of blocked isocyanate precursors enabled new reactivity by preventing competing side reactions,[12] we speculated that controlled reactivity of *O*-isocyanates is also possible. Indeed, blocked isocyanate precursors could provide control over the temperature and concentration

10.1002/adsc.201701046

during *in situ* formation of these reactive intermediates. Herein, we report that the use of suitable masked *O*-isocyanates enables controlled reactivity and prevents trimerization, as illustrated in efficient cascade reactions affording hydroxylamine-containing heterocyclic systems.

Strategically, hydroxylamine-containing heterocyclic systems were targeted due to the possibility to rapidly assemble complex architectures through cascade reactions of *O*-isocyanates. As shown in Figure 1B, several interesting biological activities have been reported for such heterocycles,[13] which possess the ability to form unique hydrogen-bonding motifs[14] and strong chelates with metalloproteins.[15] Cascade reactions are also an ideal testing ground to develop *O*-isocyanate reactivity, since high control is inherently required in multistep reaction sequences occurring under the same reaction conditions. In addition, hydantoins continue to be an important scaffold, with a recent review unveiling the scarcity of *N*-hydroxy derivatives.[16] To explore this opportunity and allow comparison with reactions of blocked *N*-isocyanates,[17] optimization began with the reaction of sarcosine ethyl ester hydrochloride and two masked *O*-isocyanates possessing phenol as a blocking group (Table 1).

Table 1. Optimization of *O*-isocyanate cascade reaction.[a]



Entry[a]	R^1	Temp (°C)	Time (h)	Yield (%)
1	H[b]	120 (μw)	6	60
2	H[b]	120 (μw)	2	60
3	**H**[b]	**70** (oil bath)	**16**	**91**
4	Me[c]	90 (oil bath)	16	54
5	Me[c]	90 (oil bath)	30	99
6	Me[c]	120 (μw)	6	99
7	**Me**[c]	**120** (μw)	**2**	**99**
8	Me[c]	120 (μw)	0.5	90

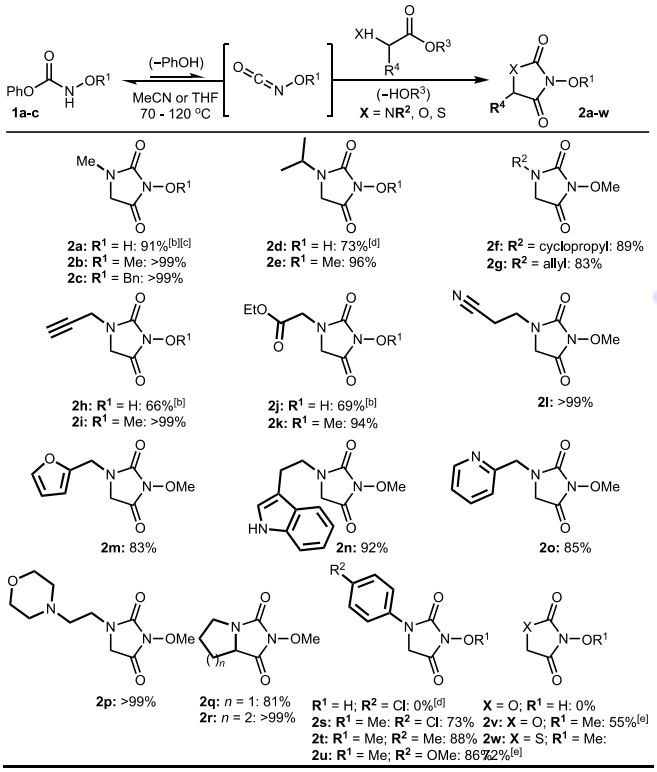
[a] Reaction conditions: Carbamate (1 equiv), sarcosine ethyl ester•HCl (1 equiv), *i*-Pr_2NEt (1.1 equiv), solvent (0.3 M), Temp, Time. Isolated yields are shown. μw: microwave heating.

[b] In THF.

[c] In MeCN.

Encouragingly, formation of the desired heterocycles were observed with both *O*-isocyanate precursors (Table 1), even if it rapidly became apparent that N-OH reagent **1a** was more sensitive than **1b** under microwave heating conditions (entry 1-2 vs 6-7). Changing to milder conventional heating resulted in a significant improvement for the cascade reaction with **1a** (entry 3). In contrast, conventional heating of **1b** required a longer reaction time to form product **2b** efficiently (entry 4-5). This reaction was thus performed using microwave irradiation, allowing to reach completion within 2 hours at 120 °C (entry 7-8).

Table 2. A cascade for the synthesis of hydantoins and their derivatives.[a]



[a] Reaction conditions: Carbamate (1 equiv), α-amino ester (1 equiv), *i*-Pr_2NEt (0.1 equiv or 1.1 equiv if the α-amino ester is an HCl salt), MeCN (0.3 M, 120 °C, 2 h, microwave reactor) unless noted otherwise. Isolated yields are shown.

[b] See [a] but in THF, at 70 °C (oil bath), 16 h.

[c] Gram scale reaction.

[d] See [b] but at 90°C.

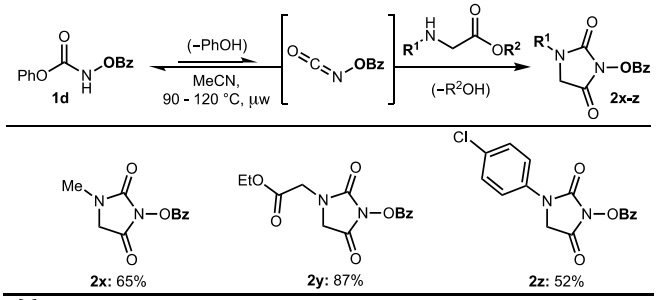
[e] See [a] but using 5 mol% DBU.

With optimized conditions in hand for both *O*-isocyanate reagents, the scope of the reaction could be evaluated (Table 2). Small (**2a-c**) and hindered (**2d-e**) *N*-substituted α-aminoesters reacted in high yields to form the corresponding hydantoins. Functional group tolerance also proved excellent, with substrates possessing cyclopropyl (**2f**), allyl (**2g**), propargyl (**2h-i**), ester (**2j-k**) and cyano (**2l**) groups, or aromatic (**2m-o**) and saturated lewis basic (**2p**) heterocycles cyclizing efficiently. Cyclic α-amino-esters also cyclized to afford bicyclic derivatives (**2q-r**). Anilines readily participate in this cascade with **1b**, providing the *N*-aryl hydantoins (**2s-u**) in good yield. In contrast, aniline derivatives proved unreactive with reagent **1a**. Primary amino aminoesters also failed to cyclize even at higher temperatures, likely due to the strong conformational bias for the *s*-cis urea intermediate, which cannot cyclize. Encouragingly however, methyl glycolate and thioglycolate engaged in this cascade, providing oxygen

10.1002/adsc.201701046

(**2v**) and sulfur (**2w**) heterocyclic analogues in modest yields. Alternative conditions were required for these substrates, and the use of DBU at higher temperatures emerged as suitable cyclization conditions. Interestingly, attempts under the conditions optimized for α-aminoesters or at lower temperatures with DBU were plagued by competing formation of the *O*-isocyanate trimer.

Table 3. Formation of *O*-isocyanate precedes Lossen rearrangement with *O*-benzoyl carbamates.[a]

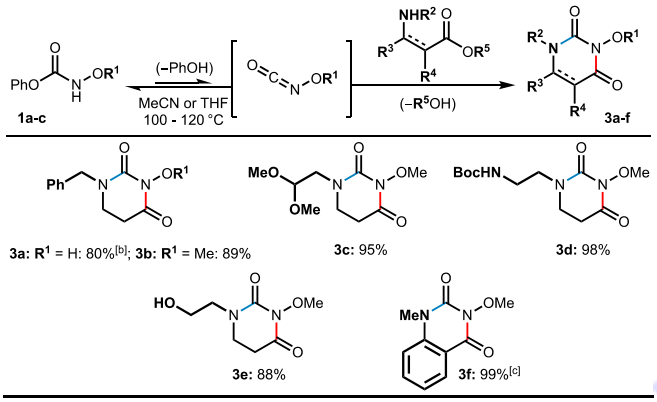


[a] Reaction conditions: Carbamate (1 equiv), α-amino ester (1 equiv), *i*-Pr_2NEt (0.1 equiv or 1.1 equiv if the α-amino ester is an HCl salt), MeCN [0.3 M, 90 (**2x**, **2y**) or 120 °C (**2z**), 2 h, microwave reactor]. Isolated yields are shown.

Controlled cascade reactions also occurred with benzoyl-*O*-isocyanate precursor **1d** (Table 3). Gratifyingly, this process proceeded *without competition* from a Lossen rearrangement that could arise from N-O bond cleavage and extrusion of benzoate anion, a common reaction reported for similar reagents under basic conditions.[18] This unprecedented level of control was achieved in the presence of excess base to yield **2x** in good yield. Pleasingly, under conditions where base catalysis could be used, an excellent yield of the cascade was obtained (**2y**), and even an electron-deficient aniline could participate in this reaction (**2z**).

Studies then shifted to examine the use of β-aminoesters as substrates (Table 4). Encouragingly, using ethyl 3-(benzylamino)propionate under standard conditions produced the 6-membered products **3a** and **3b** in high yields. From reagent **1a**, the hydroxy-dihydrouracil **3a** could be formed on gram-scale in identical yield to the 0.8 mmol reaction. Functional group tolerance was again briefly evaluated, and an acetal (**3c**), a Boc-carbamate (**3d**), and an alcohol (**3e**) proved compatible. Methyl *N*-methyl-anthranilate could also participate in the reaction cascade, affording the aromatic cycle **3f** in near-quantitative yield but required a large excess of the anthranilate, and a longer reaction time, likely due to a reversible addition on the *O*-isocyanate.

Table 4. A cascade for the synthesis of dihydrouracils and their derivatives.[a]

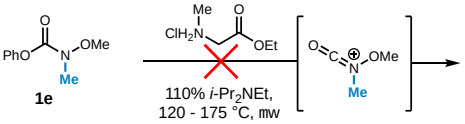


[a] Reaction conditions: Carbamate (1 equiv), β-amino ester (1 equiv), *i*-Pr_2NEt (0.1 equiv or 1.1 equiv if the α-amino ester is an HCl salt), MeCN (0.3 M, 120 °C, 4 h, microwave reactor) unless noted otherwise. Isolated yields are shown.

[b] Performed on a 5 mmol scale, in THF.

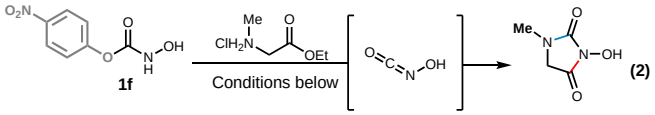
[c] See conditions [a] (except time: 6 h, using 5 equiv. anthranilate), NMR yield using 1,3,5-trimethoxybenzene as internal standard.

To probe the possibility that *O*-isocyanates are intermediates in these cascade reactions, methoxy carbamate **1e** possessing an *N*-methyl substituent was synthesized, and the cascade was attempted with sarcosine ethyl ester (Eq 1). If this reaction was proceeding through formation of a tetrahedral intermediate via nucleophilic attack on the carbamate, then this *N*-methyl group should only have a minimal impact on the efficiency of the reaction. In contrast, the *N*-H group is required to form the *O*-isocyanate through extrusion of phenol. However, using *N*-methyl derivative **1e** there was no observed product, even upon heating at higher temperatures (up to 175 °C): phenol was not formed and both starting materials were recovered (Eq. 1).[19]



To probe the influence of the blocking group used on the reactivity, *p*-nitrophenyl hydroxycarbamate **1f** was synthesized and the cascade was attempted [Eq. (2)]. Surprisingly, in the presence of this better leaving group the yield of the cascade decreased to 40%, with a fast generation of *p*-nitrophenol and unreacted α-aminoester being observed by NMR [Eq. (2a)]. Gratifyingly, addition of phenol (2 equiv) restored the efficiency of the cascade, likely by acting as a blocking group on the *O*-isocyanate (i.e. forming precursor **1a** *in situ*) and ensuring that the concentration remains low enough to ensure an efficient cascade and prevent side-reactions [Eq. (2b)]. Reasoning that this reduced efficiency could

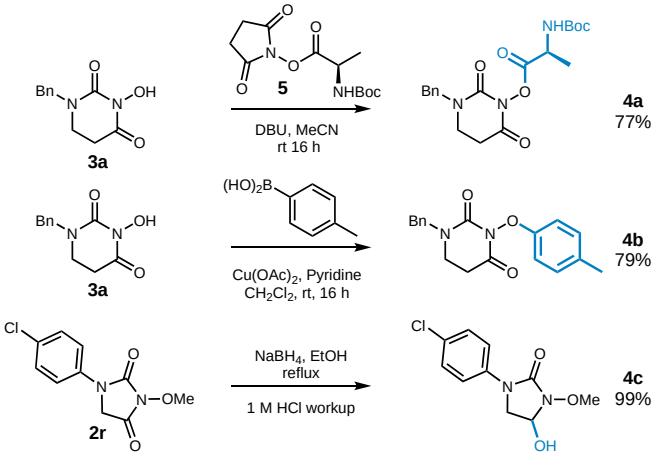
be due to reversible protonation of the α-aminoester by *p*-nitrophenol, the efficiency of the cascade could be restored in the presence of excess base [Eq. (2c)]. Overall, these experiments demonstrate that an *O*-isocyanate precursor that has both a favourable deblocking/blocking profile (equilibrium & rate) and one which releases a "spectator" leaving group is critical for the development of efficient cascade reactions.



Eq. 2a: Optimized conditions for precursor **1a** (1.1 equiv *i*-Pr_2NEt,70 °C): **40%**
Eq. 2b: Same as [Eq. 2a] but 2.0 equiv PhOH added: **95%**
Eq. 2c: Same as [Eq. 2a] but 2.1 equiv *i*-Pr_2NEt used: **80%**

While the products formed via *O*-isocyanates are interesting in themselves (e.g. Figure 1), simple diversification reactions can also broaden their usefulness and lead to complex hydroxylamine derivatives (Scheme 1). Transesterification can be performed with succinate ester **5**, enabling the synthesis of the more complex activated ester (**4a**).[20] Chan-Evans-Lam coupling of the hydroxamic acid **3a** with a boronic acid furnishes the *O*-aryl substituted dihydrouracil **4b** in good yield, providing to our knowledge the first example that couples a hydroxyurea with boronic acid. Reductions also provide a convenient route toward hydroxy imidazolidinones (**4c**), which are useful synthetic intermediates, perhaps most notably as precursors to *N*-acyliminium ions.[21]

Scheme 1. Derivatization of hydantoin/ dihydrouracil products.



Overall, the use of blocked *O*-isocyanates precursors allows controlled reactivity of *O*-isocyanates, and enabled the first cascade reactions using these reactive intermediates. Using phenol as a blocking group, suitable crystalline precursors can conveniently release the desired *O*-isocyanates *in situ*, preventing typical side reactions such as trimerization or Lossen rearrangement. This resulted in rapid assembly of hydroxylamine-derived hydantoins and dihydrouracils from α- and β-amino-esters, yielding useful products that can be further derivatized. Given that few stable hydroxylamine derivatives are available for the synthesis of more complex derivatives, and the rich reactivity of N-O bonds in synthetic transformations, we anticipate that this new building block will prove synthetically useful.

Experimental section

Cascade reactions with *O*-alkyl isocyanates (RO-NCO)

To a 5 mL microwave vial charged with a stir bar was added the corresponding α- or β-aminoester (1.00 equiv) then acetonitrile (0.3 M), to which was added *i*-Pr_2NEt (0.05 equiv, 1.10 equiv for aminoester hydrochlorides), and finally the *N*-alkoxycarbamate (1.00 equiv). The vial was sealed with a microwave cap and heated for 2 h at the temperature specified (80-150 °C) via microwave irradiation. The crude products were then purified by silica gel chromatography to give the corresponding pure alkoxy-hydantoins and dihydrouracils. Experimental details, characterisation data and NMR spectra are provided in the Supporting Information.

Cascade reactions with OH-isocyanate (HO-NCO)

To a 5 mL microwave vial charged with a stir bar was added the corresponding α- or β-aminoester (1.10 equiv) then THF (0.3 M), to which was added *i*-Pr_2NEt (1.20 equiv), and finally the *N*-hydroxy-carbamate (1.00 equiv). The vial was sealed with a microwave cap and heated for 16 h at the temperature specified (70-100 °C) via conventional (oil bath) heating. The crude products were then purified by silica gel chromatography to give the corresponding pure hydroxy-hydantoins and dihydrouracils. Experimental details, characterisation data and NMR spectra are provided in the Supporting Information.

Acknowledgements

We thank the University of Ottawa and NSERC for generous financial support. R.A.I. thanks NSERC for a graduate scholarship.

References

[1] For early studies of *O*-isocyanates see: a) J. U. Nef, *Liebigs Ann. Chem.* **1894**, *280*, 263; b) L. W. Jones, *J. Am. Chem. Soc.* **1898**, *20*, 1; c) L. W. Jones, L. Neuffer, *J. Am. Chem. Soc.* **1917**, *39*, 652.

[2] a) V.D. Sheludyakov, A. B. Dmitrieva, A. D. Kirilin, E. A. Chernyshev, *Zh. Obshch. Khim.* **1983**, *53*, 2051; *J. Gen. Chem. USSR* **1983**, *53*, 1851; b) W. Mormann, G. Leukel, *Synthesis* **1988**, 990.

[3] J. H. Teles, G. Maier, *Chem. Ber.* **1989**, *122*, 745.

[4] Wentrup has also performed computational experiments on *O*-iso*thi*ocyanates: C. Wentrup, J. J. Finnerty, R. Koch, *Curr. Org. Chem.* **2011**, *15*, 1745.

[5] C. S. Jamieson, A. M. Mebel, R. I. Kaiser, *Phys. Chem. Chem. Phys.* **2005**, *7*, 4089.

[6] For a single example of *O*-isocyanates in synthesis see: J. L. Romine, S. W. Martin, N. A. Meanwell, J. R. Epperson, *Synthesis* **1994**, 846. For examples that likely go through *O*-isocyanates see: R. E. Beevers, G. M. Buckley, N. Davies, J. L. Fraser, F. C. Galvin, D. R. Hannah, A. F. Haughan, K. Jenkins, S. R. Mack, W. R. Pitt, A. J. Ratcliffe, M. D. Richard, V. Sabin, A. Sharpe, S. C. Williams, *Bioorg. Med. Chem. Lett.* **2006**, *16*, 2539; b) J. F. Berry, D. V. Ferraris, B. Duvall, N. Hin, R. Rais, J. Alt, A. G. Thomas, C. Rojas, K. Hashimoto, B. S. Slusher, T. Tsukamoto, *ACS Med. Chem. Lett.* **2012**, *3*, 839.

[7] For examples of unexpected Lossen rearrangements forming *O*-isocyanates see: a) S. Hanessian, S. Johnstone, *J. Org. Chem.* **1999**, *64*, 5896; b) S. Fioravanti, F. Marchetti, A. Morreale, L. Pellacani, P. A. Tardella, *Org. Lett.* **2003**, *5*, 119; c) J. G. Krause, B. D. Leskiw, M. L. Emery, M. E. McGahan, M. P. McCourt, R. Priefer, *Tetrahedron Lett.* **2010**, *51*, 3568; d) T. Baburaj, S. Thambidurai, *Synlett* **2011**, 1993; e) T. Baburaj, S. Thambidurai, *Tetrahedron Lett.* **2012**, *53*, 2294.

[8] For examples of trimerization of *O*-isocyanate intermediates see: a) A. F. McKay, D. L. Garmaise, G. Y. Paris, S. Gelblum, *Can. J. Chem.* **1960**, *38*, 343; b) H. A. Staab, *Angew. Chem. Int. Ed.* **1962**, *1*, 351; c) M. T. Randolph, T. J. Hendrick, *J. Org. Chem*, **1965**, *30*, 1268; d) U, Heep, *Tetrahedron*, **1975**, *31*, 77.

[9] a) Z. Li, H. Yamamto, *Acc. Chem. Res.* **2013**, *46*, 506; b) K.-J. Xioa, D. W. Lin, M. Miura, R.-Y. Zhu, W. Gong, M. Wasa, J.-Q. Yu, *J. Am. Chem. Soc.* **2014**, *136*, 8138.

[10] For a recent review on hydroxamate directing groups see: R.-Y. Zhu, M. E. Farmer, Y.-Q. Chen, J.-Q. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 10578.

[11] For reviews on the interesting biological properties of hydroxamic acids see: a) P. A. Marks, R. A. Rifkind, V. M. Richon, R. Breslow, T. Miller, W. K. Kelly, *Nat. Rev. Cancer*, **2001**, *1*, 194; b) R. W. Johnstone, *Nat. Rev. Drug. Discov.* **2002**, *1*, 287; c) W. K. Kelly, P. A. Marks, *Nat. Rev. Clin. Oncol.* **2005**, *2*, 150; d) P. A. Marks, R. Breslow, *Nature Biotechnol.* **2007**, *25*, 84; e) C. Harrison, *Nat. Rev. Drug Discov.* **2009**, *8*, 924; f) S. P. Gupta, *Chem. Rev.* **2015**, *115*, 6427.

[12] a) C. Clavette, J.-F. Vincent-Rocan, A. M. Beauchemin, *Angew. Chem. Int. Ed.* **2013**, *52*, 12705; b) R. A. Ivanovich, J.-F. Vincent-Rocan, E. B. Elkaeed, A. M. Beauchemin, *Org. Lett.* **2015**, *17*, 4898; c) J.-F. Vincent-Rocan, J. S. Derasp, A. M. Beauchemin, *Chem. Commun.* **2015**, *51*, 16405; d) J.-F. Vincent-Rocan, R. A. Ivanovich, C. Clavette, K. Leckett, J. Bejjani, A. M. Beauchemin, *Chem. Sci.* **2016**, *7*, 315; e) J. S. Derasp, J.-F. Vincent-Rocan, A. M. Beauchemin, *Org. Lett.* **2016**, *18*, 658. For a review on nitrogen-substituted isocyanates allowing a comparison with other methods to form *N*-isocyanates, see: f) J.-F. Vincent-Rocan, A. M. Beauchemin, *Synthesis* **2016**, *48*, 3625.

[13] In order of compounds in Figure 1B (left to right): a) H. Gmunder, K. Kuratli, W. Keck, *Antimicrob. Agents Chemother.* **1995**, *39*, 163; b) G. Bridger, E. J. McEachern, R. Skerlj, D. Schols (Genzyme Corp), US2004/209921 A1, **2004**; Location in patent: Page 72; c) A. B. Cognetta III, M. J. Niphakid, H.-C. Lee, M. L. Martini, J. J. Hulce, B. F. Cravatt, *Chem. Biol.* **2015**, *22*, 928; d) D. Catarzi, V. Colotta, F. Varano, *Med. Res. Rev.* **2007**, *27*, 239; e) G. P. Jadhav, I. Kaur, M. Maryati, B. Airhihen, P. M. Fischer, G. S. Winkler, *Bioorg. Med. Chem. Lett.* **2015**, *25*, 4219; f) D. Y. Wang, M. I. Abboud, M. S. Markoulides, J. Brem, C. J. Schofield, *Future Med. Chem.* **2016**, *8*, 1063.

[14] D. Leung, G. Abbenante, D. P. Fairlie, *J. Med. Chem.* **2000**, *43*, 305.

[15] For reviews on hydroxamates as matrix metalloproteinase inhibitors see: a) M. Whittaker, C. D. Floyd, P. Brown, A. J. H. Gearing, *Chem. Rev.* **1999**, *99*, 2735; b) M. Hidalgo, S. G. Eckhardt, *J. Natl. Cancer Inst.* **2001**, *93*, 178; c) J. W. Skiles, N. C. Gonnella, A. Y. Jeng, *Curr. Med. Chem.* **2004**, *11*, 2911; d) B. Govinda Rao, *Curr. Pharm. Design*, **2005**, *11*, 295; e) G. G. Tu, W. F. Xu, H. M. Huang, S. H. Li, *Curr. Med. Chem.* **2008**, *15*, 1388.

[16] L. Konnert, E. Colacino, *Chem. Rev.* **2017**, ASAP (DOI: 10.1021/acs.chemrev.7b00067).

[17] J.-F. Vincent-Rocan, C. Clavette, K. Leckett, A. M. Beauchemin, *Chem. Eur. J.* **2015**, *21*, 10.

[18] For recent examples demonstrating the propensity of *O*-acyl hydroxylamines to undergo Lossen rearrangements under basic conditions see: a) Y. Hoshino, M. Okuno, E. Kawamura, K. Honda, S. Inoue, *Chem. Commun.* **2009**, *17*, 2281; b) E-S. M. N. AbdelHafez, O. M. Aly, G. E-D A. A. Abuo-Rahma, S. B. King, *Adv. Synth. Catal.* **2014**, *356*, 3456; c) N. Ohtsuka, M. Okuno, Y. Hoshino, K. Honda, *Org. Biomol. Chem.* **2016**, *14*, 9046.

[19] Upon prolonged heating at 175 ºC, sarcosine ethyl ester hydrochloride began to decompose.

[20] See reference 13c and citations therein.

[21] P. Wu, T. E. Nielsen, *Chem. Rev.* **2017**, *117*, 7811.

10.1002/adsc.201701046

Oxygen-Substituted Isocyanates: Blocked (Masked) Isocyanates Enable Controlled Reactivity

Adv. Synth. Catal. **Year**, *Volume*, Page – Page

Ryan A. Ivanovich, Dilan E. Polat, André M. Beauchemin*