ACES Asian Chemical Editorial Society

DOI: 10.1002/asia.202001175

CHEMISTRY AN ASIAN JOURNAL Communication

Fluorocyclization of Vinyl Azides for the Formation of 3-Azido Heterocycles

Diangang Bai[+],[a] Linxuan Li[+],[b] Xiaomeng Li[+],[b] Ying Lu,[b] Yong Wu,*[b] Bhoomireddy Rajendra Prasad Redd,[b] and Yongquan Ning*[a, b]

Abstract: 3-Azido saturated heterocycles are important for therapeutic-development but challenging to prepare. Disclosed herein is a novel synthetic strategy for 3-azido heterocycles via fluorocyclization of the easily available vinyl azides. This transfor-mation proceeded under mild conditions and provided a wide range of 3-azido heterocycles in good to excellent yields. Notably, the azido group plays an indispensable role to promote rapid and regioselective fluorocyclization. Moreover, the protocol was highlighted by gram-scale synthesis and further synthetic transformations.

Functionalized saturated heterocycles are ubiquitous structural elements in many natural products, bioactive compounds, and pharmaceuticals.[1] Among these, 3-azido variants are more attractive as the azido group is a useful linker in bioorthogonal chemistry,[2] and are also frequently found in many biologically active molecules (Figure 1).[3] Moreover, they have also been used as key intermediates in the development of new pharmaceuticals,[4] for instance, Fondaparinux sodium (Figure 1).[3c] These immense biological properties motivate chemists to develop efficient synthetic methods to access 3-azido heterocycles. Typical access of these scaffolds relies on post functionalization of parent heterocycles. For example, Lu and co-workers developed a polarity-reversed addition cascade of 2,3-dihydrofuran with imine, and $TMSN_3$ (Figure 2a).[5] On the other hand, Bian et al. established a multi-step procedure for the synthesis of 3-azido pyrrolidines starting from 2,5-dihydropyrroles (Figure 2a).[6] However, these post functionalization strategies are not practical due to nasty side reactions of sensitive functional groups, thus limiting its broad applications. Therefore, the discovery of new methods to construct 3-azido heterocycles that might not rely on parent heterocycles are especially attractive and also highly desirable. Vinyl azides are a class of structurally unique and synthetically useful functionalized alkenes and have been widely explored in organic synthesis.[7] Recently, López, and Xu groups independently

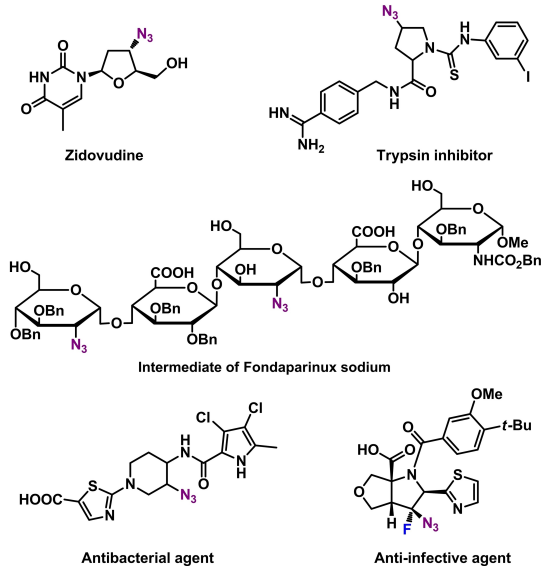


Figure 1. Bioactive molecules containing 3-azido heterocycles.

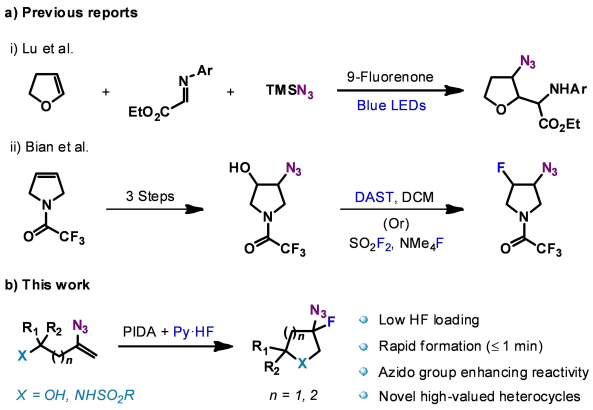


Figure 2. Strategies for the synthesis of 3-azido hereocycles.

utilized vinyl azides as key precursors for the synthesis of azidocycloalkenes[8] and 2-azido-3,4-dihydropyrans,[9] respectively. However, the synthesis of 3-azido saturated heterocycles from vinyl azides remains unknown to date and therefore the development of an efficient method for their synthesis is greatly desirable.

In recent years, the fluorocyclization of alkenes has continued to attract increasing attention for the validation of saturated fluorinated heterocycles.[10] In line with our continued efforts in the chemistry of vinyl azides,[11] we wondered whether vinyl azides with appropriately positioned *O*/*N*-nucleophiles are

[a] *D. Bai,[+] Y. Ning*
School of Chemistry and School of Chemistry and Life Science, Anshan Normal University, Anshan, 114005 (P. R. China)

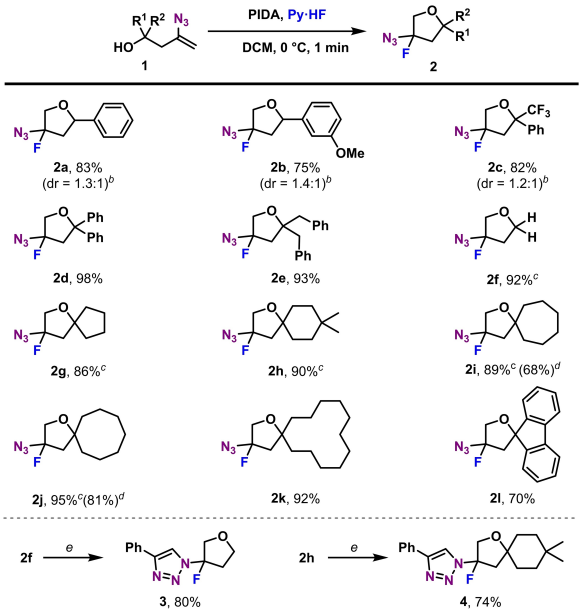
[b] *L. Li,[+] X. Li,[+] Y. Lu, Y. Wu, B. Rajendra Prasad Redd, Y. Ning*
Department of Chemistry, Northeast Normal University, Changchun 130024 (P. R. China)
E-mail: wuy651@nenu.edu.cn
ningyq508@nenu.edu.cn

[+] *D. Bai, L. Li and X. Li are equal to this work.*

involved in fluorocyclization to build 3-azido saturated heterocycles. Herein, we disclose the first successful process that delivers 3-azido saturated heterocycles upon fluorocyclization of vinyl azides (Figure 2b). In this event, the azido group serves not only as a useful functional group but also plays an indispensable role by developing a charge difference in C=C to enhance the reactivity of electrophilic addition that led to promote 5-*endo*-cyclization. The azido group with many possibilities for further modification[7] and the potency of a fluorine atom to modulate the chemical/biological properties of molecules;[12] such derivatives would constitute a new chemical space for exploration in drug discovery.

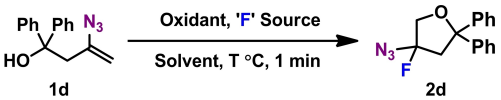
To test the proposed strategy, we began our investigation by studying the oxyfluorination reaction of **1d** (Table 1). After intensive examination, we found that the desired 3-azido heterocycle **2d** was obtained in 98% yield when using iodobenzene diacetate (PIDA, 1.5 equiv) as oxidant and pyridine·HF complex (Py·HF, 2.0 equiv) as fluorine source in dichloromethane (DCM) at 0 °C (entry 1).[13] Replacing PIDA with iodosobenzene bis(trifluoroacetate) (PIFA) or iodosylbenzene (PhIO) resulted in lower yields (entries 2, 3). The use of oxidants other than hypervalent iodines led to no reaction (entries 4 and 5). The desired product was not observed when using inorganic fluorinating agents (AgF and CsF) and Selectfluor, although a trace amount of **2d** was obtained with $Et_3N·HF$ (entries 6–8). Switching the solvent from DCM to chlorobenzene or acetonitrile gave the product in a slightly lower yield, while the reaction was shutdown in DMF (entries 9–11). The reaction also proceeded equally at either room temperature or below 0 °C, albeit produced **2d** in somewhat reduced yields (entries 12–14).

Having developed the optimum conditions for the oxyfluorination of vinyl azides, the scope of the reaction evaluated first with a range of linear homoallylic alcohols (Scheme 1). The oxyfluorination of mono- or different substituents at the β-carbon of alkene affords the diastereomeric mixture of products in overall high yields (**2a**–**2c**, 75–83% yields, 1.2:1–1.4:1). Vinyl azides bearing diphenyl or dibenzyl groups at the β-carbon of alkene dispense the corresponding products in excellent yields (**2d**, **2e**). Unsubstituted homoallylic alcohol (**1f**) also participated well. Similarly, cyclic homopropargylic alco-hols were also equally undergone effective fluorocyclization, giving the desired spiro-products **2g**–**2l** in 70–95% yield. However, the compounds **2f**–**2l** were not enough stable to isolate, and the formation of these compounds was confirmed by derivatization of **2f** and **2h**.



Scheme 1. Oxyfluorination.[a] [a] Reaction conditions: **1** (0.2 mmol), PIDA (0.3 mmol, 1.5 equiv), and Py·HF (0.4 mmol, 2.0 equiv) in 2 mL of DCM at 0 °C for 1 min. [b] Inseparable mixture. [c] Yields refer to 1H-NMR with respect to the $PhCF_3$ standard, not isolated due to the volatile nature of compounds. [d] Isolated yield is less owing to low boiling points. [e] **1f** or **1h** (0.5 mmol), PIDA (0.75 mmol, 1.5 equiv), and Py·HF (1.0 mmol, 2.0 equiv) in 2 mL of DCM at 0 °C for 1 min; after simple handling without isolation, added phenylacetylene (1.2 equiv), and CuI (10 mol%) in 2 mL of DMSO at rt for 6 h.

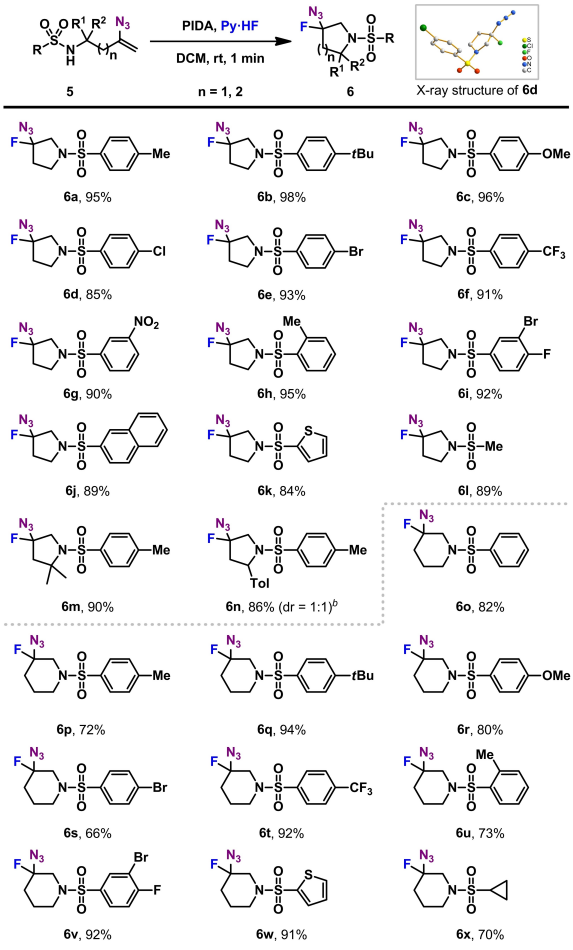
Table 1. Optimization of the reaction conditions.[a]



Entry	oxidant	'F' source	solvent	*T* [°C]	yield of **2d** [%][b]
1	PIDA	Py·HF	DCM	0	98
2	PIFA	Py·HF	DCM	0	23
3	PhIO	Py·HF	DCM	0	48
4	H_2O_2	Py·HF	DCM	0	0
5	$K_2S_2O_8$	Py·HF	DCM	0	0
6	PIDA	Et_3·HF	DCM	0	trace
7	PIDA	AgF/CsF	DCM	0	0
8	PIDA	Selectfluor	DCM	0	0
9	PIDA	Py·HF	PhCl	0	82
10	PIDA	Py·HF	CH_3CN	0	70
11	PIDA	Py·HF	DMF	0	0
12	PIDA	Py·HF	DCM	25	79
13	PIDA	Py·HF	DCM	−20	81
14	PIDA	Py·HF	DCM	−45	80

[a] Reaction conditions: **1d** (0.2 mmol), oxidant (0.3 mmol, 1.5 equiv), and 'F' source (0.4 mmol, 2.0 equiv) in 2 mL of solvent for 1 min. [b] Isolated yield.

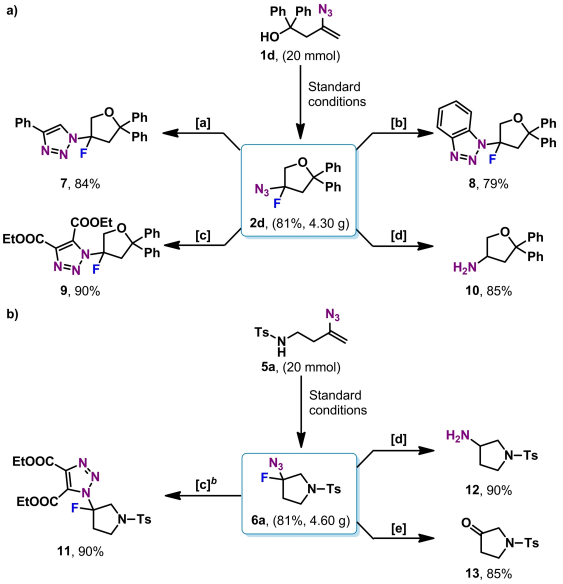
Encouraged by the above results, we next applied this strategy to homoallylic sulfonamides that enable the amino-fluorination (Scheme 2). However, the high temperature (typi-cally room temperature) required to afford the best efficiency. The influence of having a substitution pattern of the aryl sulfonyl protecting group on the nitrogen atom was firstly examined (**6a**–**6i**). The electronic nature and position of substituents on the benzene ring did not influence the amino-fluorination pro-cess, and all were delivered the azaheterocycles in excellent yields (**6a**–**6i**). The formation of pyrrolidine structure was confirmed by single-crystal X-ray diffraction analysis of 6d (CCDC: 1978654). Similarly, amines bearing naphthyl-, heteroaryl-, and methyl sulfonyl groups were also smoothly participated in the cyclization (**6j**–**6l**). Moreover, amine tethered on secondary or tertiary carbon has also proceeded well and afforded the desired products in ex-cellent yields (**6m** and **6n**). Subsequently, we studied the possibility of extending the aminofluorination reaction to the synthesis of piperidine derivatives. Under the standard conditions, a range of piperidine derivatives (**6o**–**6x**) has also been framed well without difficulty.



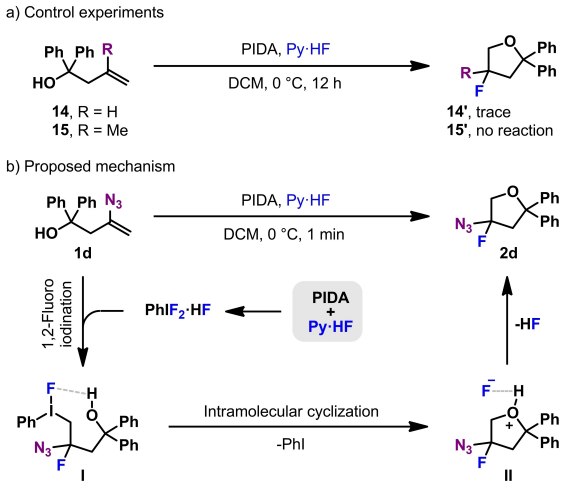
Scheme 2. Aminofluorination.[a] [a] Reaction conditions: **5** (0.2 mmol), PIDA (0.3 mmol, 1.5 equiv), and Py·HF (0.4 mmol, 2.0 equiv) in 2 mL of DCM at rt for 1 min. [b] Inseparable mixture. Yields are of isolated products.

The practicability and effectiveness of this strategy were demonstrated by the gram-scale synthesis of **2d** and **6a** (Scheme 3). To further prove the utilities of these com-pounds, we performed a series of synthetic manipulations. For example, the azido group in the products **2d** and **6a** were easily transformed to 1,2,3-triazoles (**7**–**9**, **11**) through base-mediated 1,3-dipolar cycloaddition with alkynes.[14–16] Meanwhile, the representative products **2d** and **6a** are readily converted to the respective amines (**10**, **12**) by reduction with $LiAlH_4$.[17] Further, pyrrolidine **6a** was effectively converted to 3-pyrrolidone **13** simply treated by HCl (1.0 M).

To determine the role of the azido group in fluorocyclization, we performed the control experiments with homoallylic alcohols lacking an azido group (Scheme 4a). No desired product **15′** was observed under standard conditions, even if the reaction time was extended to 12 h, albeit trace amount of **14′** was detected. The reason behind the higher activity of vinyl azides may be due to the fact that the azido group acts as an electron-donating group which is capable of polarizing the C=C double bond and then readily attacted by electrophilic species.[7] Based on these experimental results and literature precedents,[18] the possible reaction pathway is proposed (Scheme 4b). Initially, $PhIF_2 \cdot HF$ is generated in situ from the reaction of PIDA and Py·HF. Then, the regioselective vicinal iodofluorination of vinyl azide **1d** with $PhIF_2 \cdot HF$ occurs to form the intermediate **I**. Subsequently, the intramolecular nucleo-philic attack of the C–I bond of **I** by the tethered O/N-nucleophile results in the formation of a tetrahydrofuranium



Scheme 3. Gram-scale synthesis and further transfor-mations. [a] Reaction conditions: [a] **2d** (0.5 mmol), phenylacetylene (0.6 mmol, 1.2 equiv), and CuI (0.05 mmol, 10 mol%) in 2 mL of DMSO at rt for 6 h; [b] **2d** (0.5 mmol), 2-(trimethylsilyl)phenyl triflate (0.6 mmol), and CsF (2.0 mmol, 4.0 equiv) in 2 mL of CH_3CN at rt for 24 h; [c] **2d** or **6a** (0.5 mmol), and diethyl acetylenedicarboxylate (0.7 mmol, 1.4 equiv) in neat at 100 °C for 30 min; [d] **2d** or **6a** (0.5 mmol), and $LiAlH_4$ (0.6 mmol, 1.2 equiv) in 10 mL of THF at 25 °C for 3 h; [e] **6a** (0.5 mmol), and 1.0 M HCl (2.0 mmol, 4.0 equiv) in 2 mL of DCM at rt for overnight. [b] 110 °C for 10 min. Yields are of isolated products.



Scheme 4. Control experiments and proposed mechanism.

ion (**II**). Following the proton elimination from **II** in the form of HF produced the final product **2 d**.

In summary, a novel strategy for the synthesis of 3-azido saturated heterocycles via the fluorocyclization of vinyl azides has been developed. This method furnishes a broad range of 3-azido oxa/azaheterocycles that are typically difficult with post functionalization. The protocol is viable for large-scale synthesis, and further synthetic derivatization demonstrates the usefulness of these products. Given the importance of azido and fluoro heterocycles in drug discovery and the rich chemistry of the azido group, the cyclization method described here is expected to have broad applications in medicinal research and organic synthesis methodology can find potential applications in the future.

Experimental Section

General procedure for the synthesis of saturated oxygen rings: In a 15 mL plastic tube (PVC), a solution of 1, PIDA (0.30 mmol, 1.5 equiv) in anhyd DCM (0.1 M) stirred for 5 min at 0 °C. Py·HF (0.40 mmol, 2.0 equiv) was added to the mixture. After 1 min the mixture was quenched with sat. aq $NaHCO_3$ solution and extracted with DCM (3×20 mL). Then combined organic layers dried over Na_2SO_4 and filtered, evacuated under vacuum. The residue was purified by triethylamine-treated (Et_3N/PE = 1:100) silica gel column chromatography (PE) to give saturated oxygen ring compounds 2.

General procedure for the synthesis of saturated nitrogen rings: In a 15 mL plastic tube (PVC), a solution of vinyl azide amine 5 (0.20 mmol, 1.0 equivalent), PIDA (0.30 mmol, 1.5 equiv) in anhydrous DCM (0.1 M) Stir at 25 °C for 5 minutes. Py·HF (0.40 mmol, 2.0 equiv) was added to the mixture. After 1 minute, the mixture was quenched with saturated NaHCO3. It was washed with aqueous $NaHCO_3$ solution and extracted with DCM (3×20 mL). The combined organic layers were then dried over Na_2SO_4 and filtered, and evacuated under vacuum. The residue was purified by basic alumina column chromatography (PE/EA = 20:1) to give saturated nitrogen ring compounds 6.

4-azido-4-fluoro-2,2-diphenyltetrahydrofuran (2 d). Colorless oil; 1H NMR (600 MHz, CDCl3) δ 7.42–7.37 (m, 4H), 7.32 (dt, J = 12.0, 7.2 Hz, 4H), 7.24 (dt, J = 10.8, 7.2 Hz, 2H), 4.22 (dd, J = 16.2, 10.2 Hz, 1H), 3.95 (dd, J = 20.4, 10.8 Hz, 1H), 3.23 (dd, J = 19.8, 14.4 Hz, 1H), 3.05 (dd, J = 17.4, 13.8 Hz, 1H). 13 C NMR (150 MHz, CDCl3) δ 144.2, 144.1, 128.5, 128.4, 127.5, 127.4, 125.7, 125.6, 112.9 (d, J = 224.6 Hz), 88.7 (d, J = 2.1 Hz), 74.0 (d, J = 30.9 Hz), 49.7 (d, J = 25.5 Hz). 19F NMR (470 MHz, CDCl3) δ −110.88–(−111.08) (m). IR (film, cm^{-1}): 2124, 1339, 1260, 1166, 990, 867, 743, 706.

3-azido-3-fluoro-1-tosylpyrrolidine (6 a). Colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.8 Hz, 2H), 7.35 (d, *J* = 7.8 Hz, 2H), 3.61 (ddd, *J* = 17.4, 12.0, 1.2 Hz, 1H), 3.53 (ddd, *J* = 12.0, 8.4, 3.6 Hz, 1H), 3.47–3.36 (m, 2H), 2.45 (s, 3H), 2.35–2.28 (m, 1H), 2.17–2.08 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 144.2, 133.1, 129.9, 127.6, 110.1 (d, *J* = 223.4 Hz), 55.8 (d, *J* = 30.6 Hz), 46.2, 35.6 (d, *J* = 26.6 Hz), 21.6. ^{19}F NMR (470 MHz, $CDCl_3$) δ −114.68–(−114.84) (m). IR (film, cm^{-1}): 3446, 2963, 2125, 1508, 1339, 1261, 1163, 1094, 826, 626.

Acknowledgements

This work was supported by Postdoctoral Innovation Talent Support Program (BX20200079) and the Fundamental Research Funds for the Central Universities (2412020QD005, 2412020FZ006).

Conflict of Interest

The authors declare no conflict of interest.

Keywords: Vinyl Azides · Fluorocyclization · Metal free · Synthetic Methods · Heterocycles

[1] a) J. Cossy, Synthesis of Saturated Oxygenated Heterocycles I: 5- and 6-Membered Rings; Springer: Paris, 2014; b) J. Cossy, Synthesis of Saturated Oxygenated Heterocycles II: 7-to 16-Membered Rings; Springer: Paris, 2014; c) W.-D. Meng, F.-L. Qing, *Curr. Top. Med. Chem.* **2006**, *6*, 1499; d) E. Vitaku, D. T. Smith, J. T. Njardarson, *J. Med. Chem.* **2014**, *57*, 10257; e) Q. Lu, D. S. Harmalkar, Y. Choi, K. Lee, *Molecules* **2019**, *24*, 3778; f) D. C. Blakemore, L. Castro, I. Churcher, D. C. Rees, A. W. Thomas, D. M. Wilson, A. Wood, *Nat. Chem.* **2018**, *10*, 383; g) M. E. Welsch, S. A. Snyder, B. R. Stockwell, *Curr. Opin. Chem. Biol.* **2010**, *14*, 347; h) R. D. Taylor, M. MacCoss, A. D. G. Lawson, *J. Med. Chem.* **2014**, *57*, 5845; i) T. Y. Zhang, *Adv. Heterocycl. Chem.* **2017**, *121*, 1; j) A. Lorente, J. Lamariano-Merketegi, F. Albericio, M. Álvarez, *Chem. Rev.* **2013**, *113*, 4567; k) C. Molinaro, E. M. Phillips, B. Xiang, E. Milczek, M. Shevlin, J. Balsells, S. Ceglia, J. Chen, L. Chen, Q. Chen, Z. Fei, S. Hoerrner, J. Qi, M. de Lera Ruiz, L. Tan, B. Wan, J. Yin, *J. Org. Chem.* **2019**, *84*, 8006.

[2] a) N. K. Devaraj, *ACS Cent. Sci.* **2018**, *4*, 952; b) L. Li, Z. Zhang, *Molecules* **2016**, *21*, 1393; c) K. L. Kiick, E. Saxon, D. A. Tirrell, C. R. Bertozzi, *Proc. Natl. Acad. Sci. USA* **2002**, *99*, 19; d) X. Zhang, Y. Zhang, *Molecules* **2013**, *18*, 7145; e) N. J. Agard, J. M. Baskin, J. A. Prescher, A. Lo, C. R. Bertozzi, *ACS Chem. Biol.* **2016**, *10*, 644.

[3] a) S. Melkko, Y. Zhang, C. E. Dumelin, J. Scheuermann, D. Neri, *Angew. Chem.* **2007**, *119*, 4755; *Angew. Chem. Int. Ed.* **2007**, *46*, 4671; b) N. U. A. Mohsin, M. Ahmed, M. Irfan, *J. Chil. Chem. Soc.* **2019**, *64*, 4523; c) X. Dai, W. Liu, Q. Zhou, C. Cheng, C. Yang, S. Wang, M. Zhang, P. Tang, H. Song, D. Zhang, Y. Qin, *J. Org. Chem.* **2016**, *81*, 162.

[4] a) M. Zheng, S. Hwang, T. Snyder, J. Aquilina, G. Proni, M. M. Paz, P. Pradhan, S.-Y. Cheng, E. Champeil, *Bioorg. Chem.* **2019**, *92*, 103280; b) M. A. Aga, S. Rayees, A. Rouf, B. Kumar, A. Sharma, P. V. V. S. Nagaraju, G. Singh, S. C. Taneja, *Bioorg. Med. Chem.* **2017**, *25*, 1440; c) C. Held, H. Hübner, R. Kling, Y. A. Nagel, H. Wennemers, P. Gmeiner, *ChemMedChem* **2013**, *8*, 772; d) H.-Q. Liu, C.-C. Song, Y.-H. Niu, T. Li, Q. Li, X. S. Ye, *Org. Biomol. Chem.* **2017**, *15*, 5912.

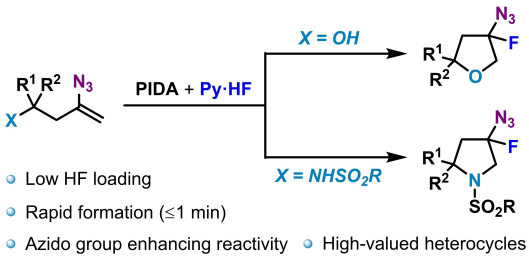
[5] S. Yang, S. Zhu, D. Lu, Y. Gong, *Org. Lett.* **2019**, *21*, 8464.
[6] Z. Fei, X. Xiong, C. Cheung, W. Liu, Q. Shen, J. Zhang, H. Gao, J. Bian, *Synlett* **2019**, *30*, 1228.
[7] For recent reviews, see: a) J. Fu, G. Zanoni, E. A. Anderson, X. Bi, *Chem. Soc. Rev.* **2017**, *46*, 7208; b) H. Hayashi, A. Kaga, S. Chiba, *J. Org. Chem.* **2017**, *82*, 11981; c) B. Hu, S. G. DiMagno, *Org. Biomol. Chem.* **2015**, *13*, 3844; d) N. Jung, S. Bräse, *Angew. Chem.* **2012**, *124*, 12335; *Angew. Chem. Int. Ed.* **2012**, *51*, 12169.
[8] E. López, L. A. López, *Angew. Chem.* **2017**, *129*, 5203; *Angew. Chem. Int. Ed.* **2017**, *56*, 5121.
[9] N. Thirupathi, F. Wei, C.-H. Tung, Z. Xu, *Nat. Commun.* **2019**, *10*, 3158.
[10] a) J. R. Wolstenhulme, V. Gouverneur, *Acc. Chem. Res.* **2014**, *47*, 3560; b) S. R. Chemler, M. T. Bovino, *ACS Catal.* **2013**, *3*, 1076; c) T. Wu, G. Yin, G. Liu, *J. Am. Chem. Soc.* **2009**, *131*, 16354; d) S. C. Wilkinson, O. Lozano, M. Schuler, M. C. Pacheco, R. Salmon, V. Gouverneur, *Angew. Chem.* **2009**, *121*, 7217; *Angew. Chem. Int. Ed.* **2009**, *48*, 7083; e) W. Yuan, K. J. Szabó, *Angew. Chem.* **2015**, *127*, 8653; *Angew. Chem. Int. Ed.* **2015**, *54*, 8533; f) D. Parmar, M. Rueping, *Chem. Commun.* **2014**, *50*, 13928; g) S. Suzuki, T. Kamo, K. Fukushi, T. Hiramatsu, E. Tokunaga, T. Dohi, Y. Kita, N. Shibata, *Chem. Sci.* **2014**, *5*, 2754; h) T. Xu, S. Qiu, G. Liu, *Chin. J. Chem.* **2011**, *29*, 2785; i) L. E. Combettes, O. Lozano, V. Gouverneur, *J. Fluorine Chem.* **2012**, *143*, 167; j) T. Kitamura, A. Miyake, K. Muta, J. Oyamada, *J. Org. Chem.* **2017**, *82*, 11721; k) Q. Wang, W. Zhong, X. Wei, M. Ning, X. Meng, Z. Li, *Org. Biomol. Chem.* **2012**, *10*, 8566; l) J. Cui, Q. Jia, R.-Z. Feng, S.-S. Liu, T. He, C. Zhang, *Org. Lett.* **2014**, *16*, 1442; m) H.-T. Huang, T. C. Lacy, B. Błachut, G. X. Ortiz Jr, Q. Wang, *Org. Lett.* **2013**, *15*, 1818; n) S. Arimitsu, M. Nakasone, E. Gima, *Tetrahedron Lett.* **2018**, *59*, 887; o) L. F. Lourie, Y. A. Serguchev, M. V. Ponomarenko, E. B. Rusanov, M. V. Vovk, N. V. Ignat'ev, *Tetrahedron* **2013**, *69*, 833; p) K. M. Mennie, S. M. Banik, E. C. Reichert, E. N. Jacobsen, *J. Am. Chem. Soc.* **2018**, *140*, 4797.
[11] a) Y. Ning, P. Sivaguru, G. Zanoni, E. A. Anderson, X. Bi, *Chem.* **2020**, *6*, 486; b) H. Li, B. R. P. Reddy, X. Bi, *Org. Lett.* **2019**, *21*, 9358; c) Y. Ning, A. Mekareeya, K. R. Babu, E. A. Anderson, X. Bi, *ACS Catal.* **2019**, *9*, 4203; d) B. Liu, Y. Ning, M. Virelli, G. Zanoni, E. A. Anderson, X. Bi, *J. Am. Chem. Soc.* **2019**, *141*, 1593; e) Y. Ning, X.-F. Zhao, Y.-B. Wu, X. Bi, *Org. Lett.* **2017**, *19*, 6240; f) J. Tang, P. Sivaguru, Y. Ning, G. Zanoni, X. Bi, *Org. Lett.* **2017**, *19*, 4026; g) Y. Ning, Q. Ji, P. Liao, E. A. Anderson, X. Bi, *Angew. Chem.* **2017**, *129*, 13993; *Angew. Chem. Int. Ed.* **2017**, *56*, 13805; h) L. Zhang, G. Sun, X. Bi, *Chem. Asian J.* **2016**, *11*, 3018; i) Z. Zhang, R. K. Kumar, G. Li, D. Wu, X. Bi, *Org. Lett.* **2015**, *17*, 6190; j) Z. Liu, J. Liu, L. Zhang, P. Liao, J. Song, X. Bi, *Angew. Chem.* **2014**, *126*, 5409; *Angew. Chem. Int. Ed.* **2014**, *53*, 5305; k) Z. Liu, P. Liao, X. Bi, *Org. Lett.* **2014**, *16*, 3668; l) L. Li, S. Cao, F. Lin, P. Liao, Y. Ning, *Eur. J. Org. Chem.* **2020**, *6*, 693.
[12] For recent reviews, see: a) W. K. Hagmann, *J. Med. Chem.* **2008**, *51*, 4359; b) E. P. Gillis, K. J. Eastman, M. D. Hill, D. J. Donnelly, N. A. Meanwell, *J. Med. Chem.* **2015**, *58*, 8315; c) N. A. Meanwell, *J. Med. Chem.* **2011**, *54*, 2529; d) J. Wang, M. Sánchez-Roselló, J. L. Aceña, C. del Pozo, A. E. Sorochinsky, S. Fustero, V. A. Soloshonok, H. Liu, *Chem. Rev.* **2014**, *114*, 2432; e) S. Purser, P. R. Moore, S. Swallow, V. Gouverneur, *Chem. Soc. Rev.* **2008**, *37*, 320; f) C. Isanbor, D. O'Hagan, *J. Fluorine Chem.* **2006**, *127*, 303.
[13] W.-X. Lv, Q. Li, J. -Li Li, Z. Li, E. Lin, D.-H. Tan, Y.-H. Cai, W.-X. Fan, H. Wang, *Angew. Chem.* **2018**, *130*, 16782; *Angew. Chem. Int. Ed.* **2018**, *57*, 16544.
[14] X. Sun, X. Li, S. Song, Y. Zhu, Y.-F. Liang, N. Jiao, *J. Am. Chem. Soc.* **2015**, *137*, 6059.
[15] F. Shi, J. P. Waldo, Y. Chen, R. C. Larock, *Org. Lett.* **2008**, *10*, 2409.
[16] P. Shanmugavelan, S. Nagarajan, M. Sathishkumar, A. Ponnuswamy, P. Yogeeswari, D. Sriram, *Bioorg. Med. Chem. Lett.* **2011**, *21*, 7273.
[17] K. Kuroda, Y. Hayashi, T. Mukaiyam, *Tetrahedron* **2007**, *63* 6358.
[18] a) B. Zhou, M. K. Haj, E. N. Jacobsen, K. N. Houk, X.-S. Xue, *J. Am. Chem. Soc.* **2018**, *140*, 15206; b) S. Shu, Y. Li, J. Jiang, Z. Ke, Y. Liu, *J. Org. Chem.* **2019**, *84*, 458.

Manuscript received: October 6, 2020
Revised manuscript received: October 22, 2020
Version of record online: ■■, ■■■

ACES Asian Chemical Editorial Society

CHEMISTRY
AN ASIAN JOURNAL
Communication

COMMUNICATION



Synthetic Methods. A novel strategy for the synthesis of 3-azido saturated heterocycles via the fluorocyclization of vinyl azides has been developed. This method furnishes a broad range of 3-azido oxa/azaheterocycles that are typically difficult to attain with post functionalization.