CHEMISTRY
A European Journal

A Journal of
ChemPubSoc Europe

Accepted Article

Title: Divergent Regio- and Stereoselective Gold-catalyzed Synthesis of α-Fluorosulfones and β-Fluorovinylsulfones from Alkynylsulfones

Authors: Gerald Hammond, bo xu, xiaojun zeng, and shiwen liu

To be cited as: *Chem. Eur. J.* 10.1002/chem.201703179

Link to VoR: http://dx.doi.org/10.1002/chem.201703179

Supported by
ACES

WILEY-VCH

10.1002/chem.201703179

COMMUNICATION

WILEY-VCH

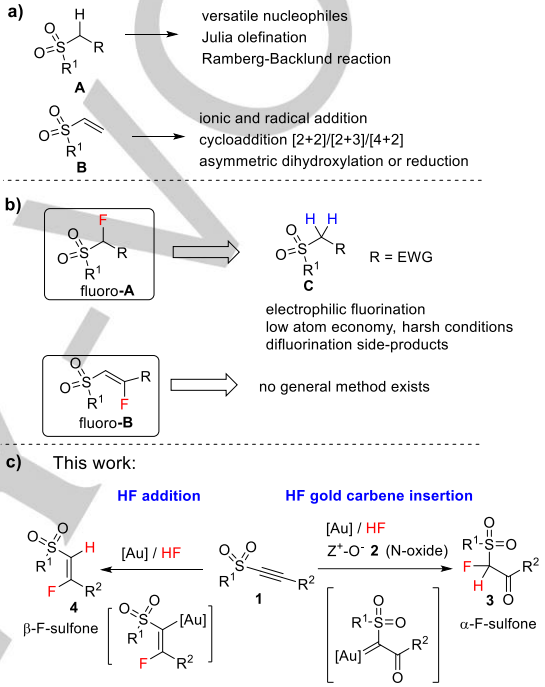
Divergent Regio- and Stereoselective Gold-catalyzed Synthesis of α-Fluorosulfones and β-Fluorovinylsulfones from Alkynylsulfones

Xiaojun Zeng,[a] Shiwen Liu, [a] Gerald B. Hammond[b], * and Bo Xu[a], *

Abstract: We developed a widely applicable, highly efficient synthesis of α-fluorosulfone and β-fluorovinylsulfone catalyzed by gold. Starting with alkynyl sulfone **1**, an [Au]/HF/N-oxide system gives α-fluorosulfone **3** *via* a gold carbene intermediate, and, if no N-oxide is used, direct addition of HF to **1** gives vinyl sulfone **4** *via* a vinylfluoro gold intermediate. Both methods have good functional group tolerance and the reactions can be conducted in ambient atmosphere.

Sulfones are important biological targets[1] and versatile synthetic building blocks.[2] In this regard, the sulfonyl group is one of the strongest electron withdrawing groups, and, as such, it can greatly increase the acidity of an α-proton. Certainly, a sulfone with an α-proton has been widely used as a nucleophile in several C-C bond forming reactions, such as the Julia olefination[3] and the Ramberg-Bäcklund reaction (Scheme 1a).[4] Vinyl sulfones, on the other hand, are among the most electron deficient/reactive alkenes and have been widely used as partners in ionic, radical additions and cycloadditions, [2b, 5] or in the total synthesis of natural products (Scheme 1a).[6] Their importance is underlined by a recent literature review that stated that over 42 new syntheses of vinyl sulfones have been reported in the last 5 years alone.[5a] Given fluorine's preeminence in medicinal chemistry[7] and the sulfonyl group's importance as an organic building block, their juxtaposition on a vinyl or carbonyl template (fluoro-**A** or fluoro-**B** in Scheme 1) should lead to desirable motifs in medicinal or synthetic chemistry but their syntheses are quite challenging. For examples, Hu[8] and Prakash[9] have demonstrated the fluoro-**A** type compounds were versatile fluorinated building blocks. In fact, the synthesis of fluoro-**A** type compounds has only been reported *via* the electrophilic fluorination of precursor **C,** using expensive, low-atom economic reagents and harsh conditions that often give rise to difluorination byproducts.[8] The other reported alternatives are to utilize sophisticated fluorinated synthons.[10] Fluorinated vinyl sulfones (fluoro-**B**) are even harder to prepare; indeed, only perfluorinated vinyl sulfones are hitherto known (Scheme 1b).[11]

Herein, we report a widely applicable, highly efficient and divergent synthesis of fluoro-**A** and fluoro-**B,** catalyzed by gold (Scheme 1c). The common precursor, alkynylsulfone **1**, is readily accessible, and the fluorinating reagent, hydrogen fluoride (HF), is one of the most atom economical fluorine sources.[7b] Our strategy hinges on the sulfonyl group's dual role of activator and director in the nucleophilic fluorination of an alkyne. Using this approach, alkynyl sulfone **1**, [Au]/HF/N-oxide yields α-fluoro-sulfone **3** *via* a gold carbene intermediate in the presence of N-oxide, and furnishes vinyl sulfone **4** by direct addition of HF via a fluoro vinyl gold intermediate when the N-oxide is absent (1c).



Scheme 1. Background and overview of approach.

In our previous work, we found that HF was highly compatible with cationic gold catalysts, this was demonstrated by the synthesis of α-fluoroketone *via* HF insertion to a gold carbene intermediate[12] or by the synthesis of fluoroalkenes through the addition of HF to a cationic gold activated alkyne.[13] These methods proved efficient for terminal alkynes; internal alkynes showed low or no reactivity, and the regioselectivity depended on steric and electronic biases at either end of the alkyne. Also, there are many progresses in gold catalyzed fluorination of alkynes using electrophilic fluorination reagents.[14]

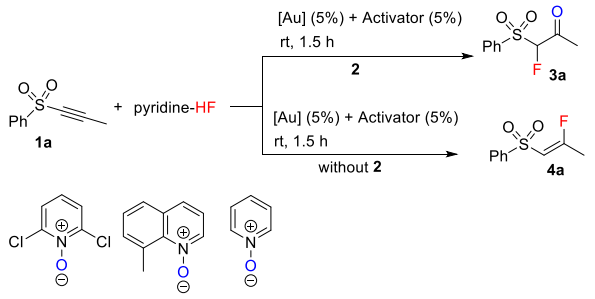
For our HF insertion and addition protocols, we used the fluorination of alkynyl sulfone **1a** as our model reaction (Table 1). The method we used to generate a gold carbene[15] was the gold catalyzed alkyne oxidation by N-oxide.[16] N-oxide is a mild oxidant, so we expected good functional group tolerance. Initially, we chose dichloropyridine N-oxide **2a** as our oxidant and pyridine-HF as our fluorine source. Screening of various silver activators indicated that $AgNTf_2$ was slightly better than AgOTf and $AgSbF_6$ (Table 1, entries 1-3). We proceeded to investigate the effect of the ligand (Table 1, entries 4-7).[17] Buchwald type ligands gave slightly better results, and, among them, JohnPhos gave the best chemical yield (Table 1, entry 6). Recently, we had demonstrated that excess amounts of silver almost always

[a] X. Zeng, S. Liu and Prof. B. Xu
College of Chemistry, Chemical Engineering and Biotechnology
Donghua University, Shanghai 201620 China
Email: bo.xu@dhu.edu.cn
[b] Prof. G. B. Hammond
Department of Chemistry, University of Louisville
Louisville, KY 40292 USA.
E-mail: gb.hammond@louisville.edu

Supporting information for this article is given via a link at the end of the document. ((Please delete this text if not appropriate))

had a deleterious effect on the reactivity of gold catalysts,[18] and that a preformed gold catalyst (e.g., L-Au-NTf_2)[19] rendered better results. Indeed, a preformed JohnPhos-Au-NTf_2 catalyst gave a good result in our reaction (Table 1, entry 8). Among other N-oxides tested, 8-methylquinoline N-oxide **2b** gave poorer yields (Table 1, entry 9) and pyridine N-oxide **2c** could not mediate this reaction at all (Table 1, entry 10). We found that fluoro vinyl sulfone **4a** could be obtained by simply removing N-oxide **2** (Table 1, entry 11). Other solvents (DCM, fluorobenzene) led to poorer yields (Table 1, entries 12-13). No reaction took place in the absence of gold catalyst (Table 1, entry 14).

Table 1.Screening of reaction conditions.[a]

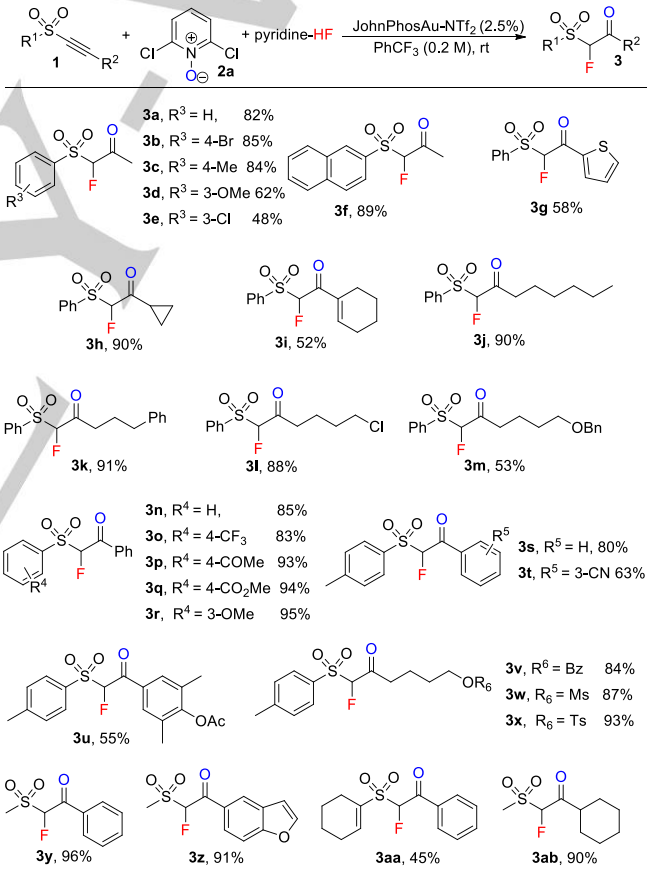


Entry	[Au]+Activator	N-Oxide	Solvent	Product	Yield(%)[b]
1	PPh_3AuCl+$AgOTf$	**2a**	$PhCF_3$	**3a**	58
2	PPh_3AuCl+$AgNTf_2$	**2a**	$PhCF_3$	**3a**	60
3	PPh_3AuCl+$AgSbF_6$	**2a**	$PhCF_3$	**3a**	55
4	$(RO)_3PAuCl$[c]+$AgNTf_2$	**2a**	$PhCF_3$	**3a**	62
5	$Dppf(AuCl)_2$+$AgNTf_2$	**2a**	$PhCF_3$	**3a**	57
6	JohnPhosAuCl+$AgNTf_2$	**2a**	$PhCF_3$	**3a**	85
7	SPhosAuCl+$AgNTf_2$	**2a**	$PhCF_3$	**3a**	50
8	JohnPhosAuNTf_2	**2a**	$PhCF_3$	**3a**	89 (82[d])
9	JohnPhosAuNTf_2	**2b**	$PhCF_3$	**3a**	40
10	JohnPhosAuNTf_2	**2c**	$PhCF_3$	**3a**	NR
11	JohnPhosAuNTf_2	-	$PhCF_3$	**4a**	74 (64[d])
12	JohnPhosAuNTf_2	-	DCM	**4a**	68
13	JohnPhosAuNTf_2	-	Ph-F	**4a**	63
14	-	**2a**	$PhCF_3$	**-**	0

Reaction conditions: **1a** (0.2 mmol), N-Oxide **2** (0.3 mmol), pyridine-HF (1.3 mmol HF, 6.5 equiv), L-AuCl (2.5 mol%), activator (2.5 mol%), solvent (0.4 mL), RT in a sealed polypropylene tube for 8 h. [b] Determined by GC-MS analysis. [c] R = 2,4-di-*t*Bu-C_6H_3-. [d] isolated yield.

With optimized conditions in hand, we explored the scope and functional group tolerance of our HF insertion protocol (Table 2). First, we evaluated the effect of R^1 substitution on the alkynylsulfone **1** (Table 2, **3a**-**3f**). The substitution pattern (*meta*, *para*) of R^1 played a small role; good yields were obtained regardless (Table 2, **3a**-**3f**). Then we evaluated the effect of R^2 substitution (Table 2, **3g**-**3m**). The reaction tolerated a wide variety of R^2 substituents: heteroaromatics, such as thiophene (Table 2 , **3g**), small rings, such as cyclopropyl (Table 2 , **3h**), the alkenyl group (Table 2 , **3i**), simple or functionalized alkyl groups (Table 2 , **3j-3m**). We also evaluated more [R^1, R^2] combinations, such as [R^1 = aryl, R^2 = aryl] (Table 2, **3n**-**3u**), [R^1 = aryl, R^2 = alkyl] (Table 2, **3v**-**3x**), [R^1 = alkyl, R^2 = aryl] (Table 2, **3y**), [R^1 = alkyl, R^2 = heteroaromatic] (Table 2, **3z**), [R^1 = alkenyl, R^2 = aryl] (Table 2, **3aa**) and [R^1 = alkyl, R^2 = alkyl] (Table 2, **3ab**). All of these combinations gave good yields of product **3**. Only when R^1 or R^2 were alkenyl groups, the yields were moderate (Table 2, **3i** and **3aa**). This last result could be rationalized by considering the relative instability of the starting material and/or product under the reaction conditions. It should be noted that functional groups as diverse as ketones (Table 2, **3p**), esters (Table 2, **3q**, **3u**, **3v**), ethers (Table 2, **3d**, **3r**), nitriles (Table 2, **3t**), benzylic (Table 2, **3m**), sulfonates (Table 2, **3w**, **3x**), or alkenes (Table 2, **3i**, **3aa**) did not hinder the efficiency of our method.

Table 2. Scope for the synthesis of α-fluoroketone 3.[a]



[a] Reaction conditions: alkyne **1** (0.2 mmol), N-Oxide **2a** (0.28 mmol), pyridine-HF (0.8 mmol HF), JohnPhosAuNTf_2 (2.5 mol %), $PhCF_3$ (0.5 mL), rt. All yields are isolated yields.

The results illustrated in equations 1-3 underscore the importance of the sulfonyl group: **1ad** furnished the diketone product **6a** whereas alkynylketone **1ae** and phosphonyl alkyne **1ag** showed no reactivity under the same reaction conditions. The formation of **6a** was attributed to the fact that the corresponding gold carbene intermediate is electron rich, which makes it easily oxidized by N-oxide.[16h]

The substrate scope of our HF addition protocol is depicted in Table 3. First, we evaluated the effect of R^1 substitution of alkynylsulfone **1** on the reaction (Table 3, **4a**-**4d**): electron rich and electron deficient substituents only had a very small effect on the chemical yields. We then evaluated the effect of R^2 substitution of **1** (Table 3, **4e**-**4i**). Similarly, the effect of both electron rich and electron deficient substituents was minor. We also evaluated other [R^1, R^2] combinations, such as [R^1 = aryl, R^2 = alkyl] (Table 3, **4j**-**4l**, **4n**, **4o**, **4s**, **4t**), [R^1 = alkyl, R^2 = aryl] (Table 3, **4q**, **4r**), [R^1 = aryl, R^2 = alkenyl] (Table 3, **4p**), [R^1 = alkenyl, R^2 = aryl] (Table 3, **4u**). All of these combinations gave good yields of product **4,** demonstrating that the substrate scope was broad. It should be noted that acid sensitive groups such as cyclopropyl and alkenyl were well tolerated (Table 3, **4l**).

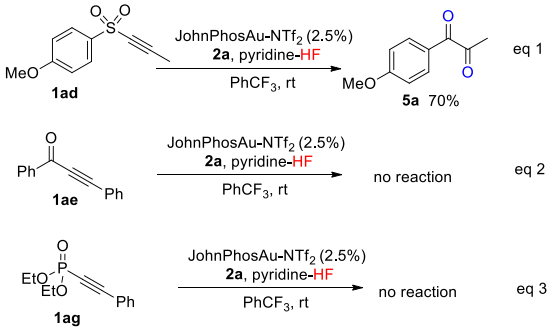
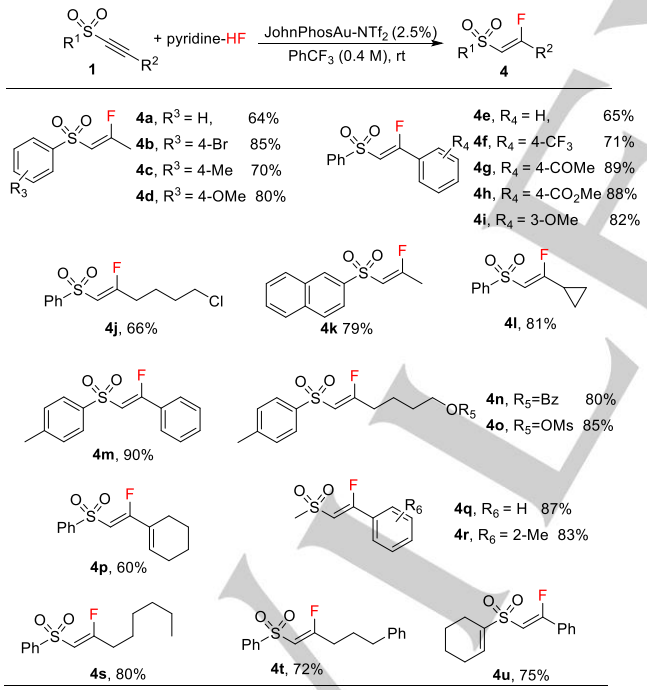
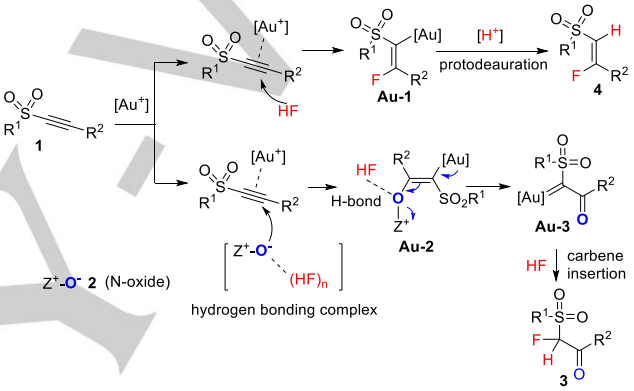


Table 3. Scope for the synthesis of fluoro-vinyl Sulfones **4**.[a]



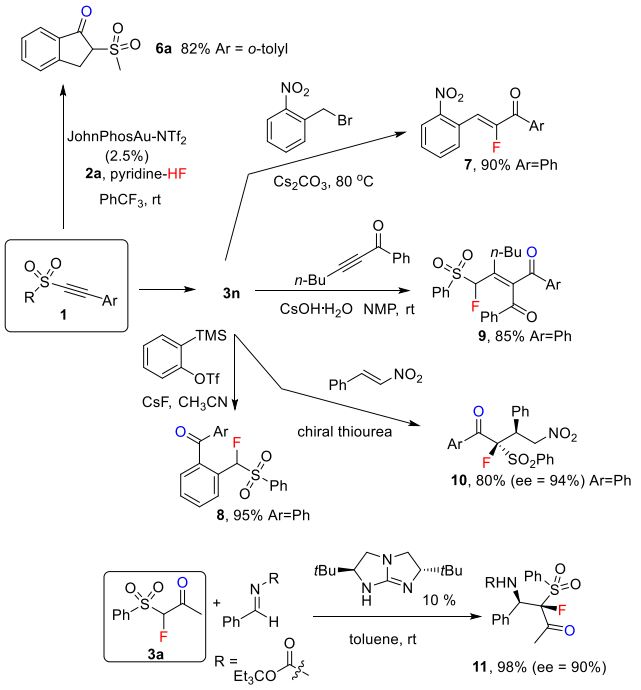
[a] Reaction conditions: alkyne **1** (0.2 mmol), pyridine-HF (HF content 0.8 mmol), JohnPhosAuNTf$_2$ (2.5 mol %), PhCF$_3$ (0.5 mL), RT. All yields are isolated yields.

Scheme 2 illustrates the proposed mechanism. In the absence of N-oxide **2**, the addition of HF to the gold activated alkyne **1** generates a vinyl gold intermediate **Au-1**, its subsequent protodeauration leads to the addition product **4**. In our opinion, the presence of a strongly activating group such as sulfonyl, renders unnecessary a more reactive HF-based reagent such as DMPU-HF.[13e] It is surprising to find that this HF addition pathway is completely inhibited by the addition of N-oxide **2** because only the carbene insertion product **3** was obtained. As both reactions proceeded at room temperature, we proposed that the strong hydrogen bonding interaction between HF and N-oxide **2** precluded the HF addition pathway. Actually, HF is one of the strongest hydrogen bonding donors and N-oxides are among the strongest hydrogen bonding acceptors.[20] Their hydrogen bonding interaction reduces significantly the nucleophilicity of HF, which, in turn, leads to the shutdown of the HF addition pathway (Scheme 2, bottom). Because N-oxide is a much stronger nucleophile, the addition of N-oxide to the alkyne is not inhibited, which leads to the formation of reactive gold carbene intermediate **Au-3**.[21] The hydrogen bonding interaction between HF and **Au-2** may accelerate the formation of gold carbene **Au-3**. This behavior could explain the very mild conditions needed for the formation of **4**.



Scheme 2. Proposed mechanism for the formation of **3** and **4**.

The advantages of the alkynylsulfone starting material and the versatility of fluorosulfone **3** are clearly underscored in Scheme 3.



Scheme 3. Divergent syntheses from alkynylsulfone **1**.

Reaction of alkynylsulfone **1ac** (R = methyl, Ar = *o*-tolyl) gave a very interesting, carbene insertion product **6a** in very good yield. This result can be attributed to the presence of a reactive benzylic C-H in close proximity to the generated gold carbene intermediate.[22],[16i] Nucleophilic fluoromethylation and subsequent sulfone elimination of **3n** gives fluoroalkene **7** in very good yield.[9] **3n** also reacts with an *in situ* generated aryne to furnish **8** in excellent yield.[23] In similar fashion, **3n** reacted with an electron deficient alkyne to give the highly functionalized α-fluorosulfone **9**.[23] We were pleased to observe that **3n** underwent an asymmetric Michael addition to a nitroolefin to yield **10** in high chemical yield and very high ee.[24] Equally noteworthy was the asymmetric Mannich reaction of **3a** to furnish **11** in excellent chemical yield and enantioselectivity.[25]

In summary, we have developed a widely applicable, highly efficient synthesis of α-fluorosulfones and β-fluorovinylsulfones from a common alkynyl sulfone precursor. Our fluorine source is the most economical fluorine source available. The reactions exhibited high functional groups tolerance and needed only ambient atmosphere. Other fluorination systems based on HF/gold system are currently being investigated in our laboratories.

Acknowledgements

We are grateful to the National Science Foundation of China (NSFC-21472018) and China Recruitment Program of Global Experts for financial support. G.B.H. is grateful to the National Science Foundation (CHE-1401700). XZ is grateful to China Scholarship Council for financial support.

Keywords: α-fluorosulfone, gold carbene, fluorination, hydrogen fluoride, N-oxide

[1] a) M. M. Kandeel, *J. Chin. Chem. Soc.* **2001**, *48*, 37-43; b) M. M. Kandeel, *Bull. Pol. Acad. Sci., Chem.* **2002**, *50*, 309-322; c) I. P. Nnane, L. A. Damani, *Biomed. Chromatogr.* **2005**, *19*, 87-98; d) G. De Martino, G. La Regina, R. Ragno, A. Coluccia, A. Bergamini, C. Ciaprini, A. Sinistro, G. Maga, E. Crespan, M. Artico, R. Silvestri, *Antiviral Chem. Chemother.* **2006**, *17*, 59-77; e) M. Tiwari, D. Kishore, *Int. J. Chem. Sci.* **2007**, *5*, 2454-2462; f) P. Sah, N. Kumari, *J. Pure Appl. Microbiol.* **2010**, *4*, 637-646; g) S. Soni, M. Seth, P. Sah, *Res. J. Pharm., Biol. Chem. Sci.* **2012**, *3*, 898-907; h) S. Doswald, H. Estermann, E. Kupfer, H. Stadler, W. Walther, T. Weisbrod, B. Wirz, W. Wostl, *Biorg. Med. Chem.* **1994**, *2*, 403-410.
[2] a) N. S. Simpkins, *Sulphones in organic synthesis*, 1st ed., Pergamon, Oxford England ; New York, **1993**; b) B. K. Peters, T. Zhou, J. Rujirawanich, A. Cadu, T. Singh, W. Rabten, S. Kerdphon, P. G. Andersson, *J. Am. Chem. Soc.* **2014**, *136*, 16557-16562.
[3] P. R. Blakemore, *J. Chem. Soc., Perkin Trans. 1* **2002**, 2563-2585.
[4] R. J. K. Taylor, G. Casy, in *Organic Reactions*, John Wiley & Sons, Inc., **2004**.
[5] a) Y. Fang, Z. Luo, X. Xu, *RSC Adv.* **2016**, *6*, 59661-59676; b) N. S. Simpkins, *Tetrahedron* **1990**, *46*, 6951-6984; c) I. Forristal, *Journal of Sulfur Chemistry* **2005**, *26*, 163-185; d) L. Zong, S. Du, K. F. Chin, C. Wang, C.-H. Tan, *Angew. Chem. Int. Ed.* **2015**, *54*, 9390-9393; e) C. Le Guen, M.-L. Tran Do, A. Chardon, C. Lebargy, J.-F. Lohier, E. Pfund, T. Lequeux, *J. Org. Chem.* **2016**, *81*, 6714-6720.
[6] a) D. J. Wardrop, J. Fritz, *Org. Lett.* **2006**, *8*, 3659-3662; b) J. E. Toth, P. R. Hamann, P. L. Fuchs, *J. Org. Chem.* **1988**, *53*, 4694-4708.
[7] a) R. D. Chambers, *Fluorine in organic chemistry*, Blackwell Publishing Ltd./CRC Press, Boca Raton, Fl, **2004**; b) P. Kirsch, *Modern fluoroorganic chemistry*, Wiley-VCH, Weinheim, **2004**; c) K. Muller, C. Faeh, F. Diederich, *Science* **2007**, *317*, 1881-1886; d) V. A. Soloshonok, *Fluorine-containing synthons, ACS symposium series 911*, Oxford University Press,Washington, D.C, **2005**; e) K. Uneyama, *Organofluorine Chemistry*, Blackwell publishing, Oxford, **2006**; f) G. Gerebtzoff, X. Li-Blatter, H. Fischer, A. Frentzel, A. Seelig, *ChemBioChem* **2004**, *5*, 676-684; g) K. Mueller, C. Faeh, F. Diederich, *Science* **2007**, *317*, 1881-1886; h) P. A. Champagne, J. Desroches, J.-D. Hamel, M. Vandamme, J.-F. Paquin, *Chem. Rev.* **2015**, *115*, 9073-9174.
[8] C. Ni, L. Zhang, J. Hu, *J. Org. Chem.* **2009**, *74*, 3767-3771.
[9] G. K. S. Prakash, S. Chacko, H. Vaghoo, N. Shao, L. Gurung, T. Mathew, G. A. Olah, *Org. Lett.* **2009**, *11*, 1127-1130.
[10] a) H. Loghmani-Khouzani, M. R. Poorheravi, M. M. M. Sadeghi, L. Caggiano, R. F. W. Jackson, *Tetrahedron* **2008**, *64*, 7419-7425; b) F. Jiang, Y. Zhao, J. Hu, *Organic Chemistry Frontiers* **2014**, *1*, 625-629.
[11] a) F. C. Pigge, in *Encyclopedia of Reagents for Organic Synthesis*, John Wiley & Sons, Ltd, **2001**; b) S. Yamada, K. Shimoji, T. Takahashi, T. Konno, T. Ishihara, *Chem. Asian J.* **2010**, *5*, 1846-1853.
[12] X. Zeng, S. Liu, Z. Shi, G. Liu, B. Xu, *Angew. Chem. Int. Ed.* **2016**, *55*, 10032-10036.
[13] a) J. A. Akana, K. X. Bhattacharyya, P. Mueller, J. P. Sadighi, *J. Am. Chem. Soc.* **2007**, *129*, 7736-7737; b) B. C. Gorske, C. T. Mbofana, S. J. Miller, *Org. Lett.* **2009**, *11*, 4318-4321; c) G. He, S. Qiu, H. Huang, G. Zhu, D. Zhang, R. Zhang, H. Zhu, *Org. Lett.* **2016**, *18*, 1856-1859; d) F. Nahra, S. R. Patrick, D. Bello, M. Brill, A. Obled, D. B. Cordes, A. M. Z. Slawin, D. O'Hagan, S. P. Nolan, *ChemCatChem* **2015**, *7*, 240-244; e) O. E. Okoromoba, J. Han, G. B. Hammond, B. Xu, *J. Am. Chem. Soc.* **2014**, *136*, 14381-14384.
[14] a) M. N. Hopkinson, A. D. Gee, V. Gouverneur, *Isr. J. Chem.* **2010**, *50*, 675-690; b) T. de Haro, C. Nevado, *Adv. Synth. Catal.* **2010**, *352*, 2767-2772; c) Z. Jin, G. B. Hammond, B. Xu, *Aldrichimica Acta* **2012**, *45*, 67-83.
[15] a) Y. Wang, M. E. Muratore, A. M. Echavarren, *Chem. Eur. J.* **2015**, *21*, 7332-7339; b) Y. Xi, Y. Su, Z. Yu, B. Dong, E. J. McClain, Y. Lan, X. Shi, *Angew. Chem. Int. Ed.* **2014**, *53*, 9817-9821; c) Y. Liu, Z. Yu, J. Z. Zhang, L. Liu, F. Xia, J. Zhang, *Chem. Sci.* **2016**, *7*, 1988-1995; d) L. Liu, J. Zhang, *Chem. Soc. Rev.* **2016**, *45*, 506-516; e) L. Nunes dos Santos Comprido, J. E. M. N. Klein, G. Knizia, J. Kästner, A. S. K. Hashmi, *Angew. Chem. Int. Ed.* **2015**, *54*, 10336-10340; f) A. S. Hashmi, F. D. Toste, *Modern gold catalyzed synthesis*, Wiley-VCH, Weinheim, Germany, **2012**; g) F. D. Toste, V. Michelet, *Gold catalysis : an homogeneous approach*, Imperial College Press, London, **2014**.

[16] a) Y. Luo, K. Ji, Y. Li, L. Zhang, *J. Am. Chem. Soc.* **2012**, *134*, 17412-17415; b) W. He, C. Li, L. Zhang, *J. Am. Chem. Soc.* **2011**, *133*, 8482-8485; c) L. Ye, W. He, L. Zhang, *J. Am. Chem. Soc.* **2010**, *132*, 8550-8551; d) L. Ye, L. Cui, G. Zhang, L. Zhang, *J. Am. Chem. Soc.* **2010**, *132*, 3258-3259; e) B. Lu, C. Li, L. Zhang, *J. Am. Chem. Soc.* **2010**, *132*, 14070-14072; f) W. He, L. Xie, Y. Xu, J. Xiang, L. Zhang, *Org. Biomol. Chem.* **2012**, *10*, 3168-3171; g) Y. Wang, K. Ji, S. Lan, L. Zhang, *Angew. Chem. Int. Ed.* **2012**, *51*, 1915-1918; h) H. Chen, L. Zhang, *Angew. Chem. Int. Ed.* **2015**, *54*, 11775-11779; i) Y. Wang, Z. Zheng, L. Zhang, *J. Am. Chem. Soc.* **2015**, *137*, 5316-5319; j) R. K. Kawade, R.-S. Liu, *Org. Lett.* **2013**, *15*, 4094-4097; k) H.-H. Hung, Y.-C. Liao, R.-S. Liu, *J. Org. Chem.* **2013**, *78*, 7970-7976; l) S. Ghorpade, M.-D. Su, R.-S. Liu, *Angew. Chem., Int. Ed.* **2013**, *52*, 4229-4234; m) E. P. A. Talbot, M. Richardson, J. M. McKenna, F. D. Toste, *Adv. Synth. Catal.* **2014**, *356*, 687-691; n) L. Wang, X. Xie, Y. Liu, *Angew. Chem. Int. Ed.* **2013**, *52*, 13302-13306; o) D. Qian, H. Hu, F. Liu, B. Tang, W. Ye, Y. Wang, J. Zhang, *Angew. Chem. Int. Ed.* **2014**, *53*, 13751-13755; p) J. Zhao, J. Liu, X. Xie, S. Li, Y. Liu, *Org. Lett.* **2015**, *17*, 5926-5929; q) M. Xu, T.-T. Ren, C.-Y. Li, *Org. Lett.* **2012**, *14*, 4902-4905; r) L. Xie, Z. Liang, D. Yan, W. He, J. Xiang, *Synlett* **2013**, *24*, 1809-1812.

[17] W. Wang, G. B. Hammond, B. Xu, *J. Am. Chem. Soc.* **2012**, *134*, 5697-5705.

[18] Z. Lu, J. Han, G. B. Hammond, B. Xu, *Org. Lett.* **2015**, *17*, 4534-4537.

[19] N. Mézailles, L. Ricard, F. Gagosz, *Org. Lett.* **2005**, *7*, 4133-4136.

[20] C. Laurence, K. A. Brameld, J. r. m. Graton, J.-Y. Le Questel, E. Renault, *J. Med. Chem.* **2009**, *52*, 4073-4086.

[21] Z. Xu, H. Chen, Z. Wang, A. Ying, L. Zhang, *J. Am. Chem. Soc.* **2016**, *138*, 5515-5518.

[22] S. Bhunia, S. Ghorpade, D. B. Huple, R.-S. Liu, *Angew. Chem. Int. Ed.* **2012**, *51*, 2939-2942.

[23] C. Ni, L. Zhang, J. Hu, *J. Org. Chem.* **2008**, *73*, 5699-5713.

[24] H.-F. Cui, P. Li, X.-W. Wang, S.-Z. Zhu, G. Zhao, *J. Fluorine Chem.* **2012**, *133*, 120-126.

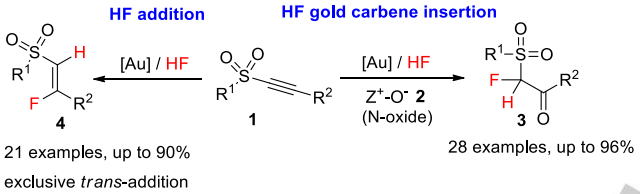
[25] Y. Pan, Y. Zhao, T. Ma, Y. Yang, H. Liu, Z. Jiang, C.-H. Tan, *Chem. Eur. J.* **2010**, *16*, 779-782.

10.1002/chem.201703179

WILEY-VCH

COMMUNICATION

We developed a widely applicable, highly efficient synthesis of α-fluorosulfones and β-fluorovinylsulfones from a common alkynyl sulfone precursor. The reactions exhibited high functional groups tolerance and needed only ambient atmosphere..



Xiaojun Zeng, Shiwen Liu, Gerald B. Hammond and Bo Xu**

Page No. – Page No.

Title