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LETTERS

# Use of Allylic Triflones for Allylation of C-H Bonds[0]

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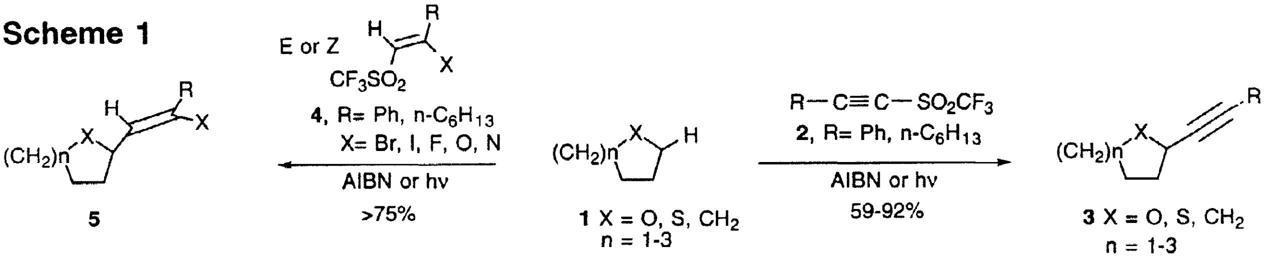
**Abstract:** Allylic triflones react with THF and cyclohexane and related molecules to undergo a trifluoromethyl radical mediated C-H functionalization reaction. Due to polar effects, the reactions benefit from the presence of electron-withdrawing group at the 2-position of the allylic triflones.

Free-radical allylations are powerful tools for the selective formation of carbon-carbon bonds under mild conditions. These transformations have been accomplished by reacting alkyl halides with allyl tin derivatives,[1] allylsilanes,[2] allyl sulfides,[3] allyl sulfones,[4] and other derivatives.[5] Radical allylation is synthetically very useful since the allyl group (which may be substituted in the 2-position) can serve as a precursor to a host of other derivatives. For example, a total synthesis of the natural product (+)-pseudomonic acid C features a stereoselective free-radical allylation.[6] Some allylation processes, however, are not always convenient. For example, when tin hydrides are used, slow addition is necessary in order to avoid simple reduction of halides. The toxicity of organostannanes and difficulty in removing tin residues from the products are drawbacks. Two research groups have reported new carbon-carbon bond forming reactions using electron deficient allylic sulfones which do not involve tin chemistry.[7] All of these processes use traditional radical precursors like halogens.

We recently reported that reaction of ethers, sulfides, and hydrocarbons with acetylenic and β-heteroatom substituted vinyl triflones such as **2** and **4** provides facile access to substituted alkynes **3** and alkenes **5** (Scheme 1).[8] The reaction proceeds via radical C-H abstraction by the highly electrophilic trifluoromethyl radical[9] in a process involving subsequent addition of the substrate radical to the α-carbon of the acetylenic (or vinyl) triflone. Elimination of trifluoromethylsulfonyl radical, followed by fragmentation to sulfur dioxide and trifluoromethyl radical, propagates the chain. The power of this method lies in the fact that the chain transfer reaction (fragmentation) is rapid and unimolecular.[10]

**Scheme 1**



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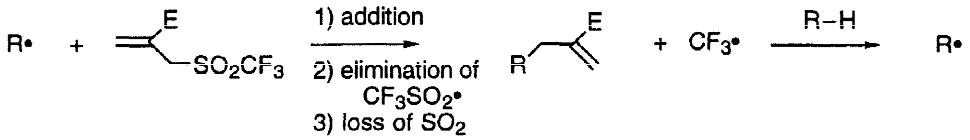
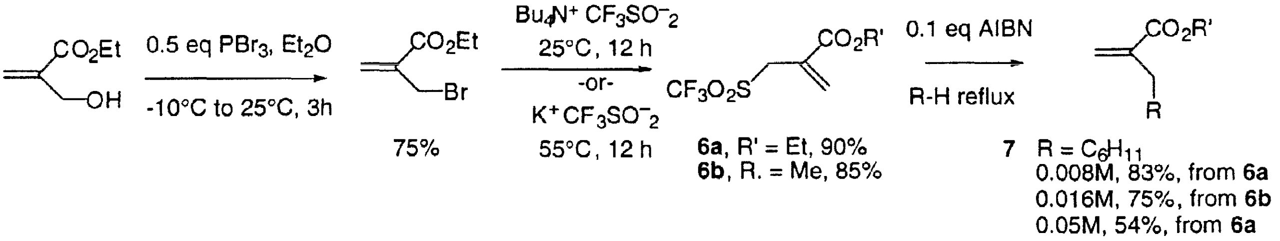
The powerful electron withdrawing ability of the trifluoromethylsulfonyl group suggests that an alkyl radical should add readily to an electron deficient allylic triflone. Elimination of trifluoromethylsulfonyl radical would complete an $S_H2'$ reaction leading to allylation products. Loss of $SO_2$ and hydrogen abstraction by the resulting trifluoromethyl radical builds a viable chain, as suggested in Scheme 2. Due to the electrophilicity of the trifluoromethyl radical, we were confident that hydrogen abstraction from the solvent would be faster than direct addition of $CF_3\bullet$ to the acceptor.[9]

Scheme 2



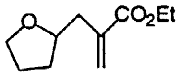
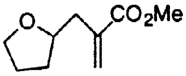
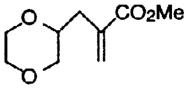
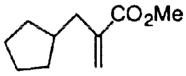
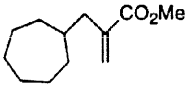
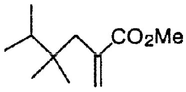
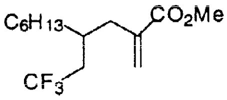
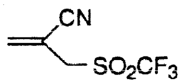
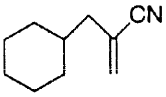
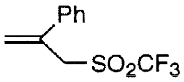
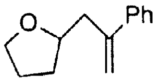
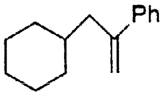
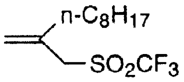
We have undertaken the synthesis of allylic triflones[11] and explored their reactions (Scheme 3), and we describe herein some salient results. Triflone **6a** (ethyl ester) was prepared by substitution of ethyl 2-bromomethylpropenoate with tetrabutylammonium triflinate while the closely related **6b** (methyl ester) was made with potassium triflinate. This use of pure triflone **6b** was crucial for good yields in its subsequent radical allylations.[12] In typical reactions, triflone **6a** or **6b** (1 equiv) was heated at reflux in cyclohexane containing AIBN (10%) for 14 h. Evaporation of the solvent, bulb-to-bulb distillation and/or flash chromatography provide the pure product **7**. The yields of reactions increased with decreasing concentration, possibly due to suppression of polymerization of **6**. In general, yields in the concentration range of 0.008-0.016 M were good, but higher concentrations gave significantly lower yields.

Scheme 3



The scope of this addition reaction is demonstrated by the examples in Table 1. Ethers and hydrocarbons are good substrates in the reaction with **6**, as expected from prior work[8] (entries 1-6). The reaction with 1-octene provides the tandem adduct resulting from addition of the trifluoromethyl radical to 1-octene and subsequent addition to **6** (entry 7). 2-Cyano and 2-phenylallyl triflones are also good acceptors, as shown in entries 8-11. These products furnish the possibility of facile construction of more complex molecules The importance of polar and substituent effects are indicated by the types of allyl trilfones that do not participate in the reaction. An unactivated allyl triflone did not provide any product with cyclohexane (entry 12), nor did other activated but more highly substituted triflones.[13] These results are fully consistent with the proposed $S_H2'$ mechanism.

**Table 1. Allylation of C-H Bonds Using Allylic Triflones[a]**

| Entry | Allylic Triflones | Conc. | Solvent | Product | Time | Yield |
|---|---|---|---|---|---|---|
| 1 | **6a** | 0.008 M | THF |  | 16 h | 90% |
| 2 | **6a** | 0.016 M | THF |  | 14 h | 79% |
| 3 | **6b** | 0.016 M | 1,4-dioxane |  | 14 h | 77% |
| 4[b] | **6b** | 0.016 M | $c$-$C_5H_{10}$ |  | 14 h | 61% |
| 5 | **6b** | 0.016 M | $c$-$C_7H_{14}$ |  | 14 h | 73% |
| 6 | **6b** | 0.016 M | 2,3-dimethyl-butane |  | 14 h | 70% |
| 7 | **6b** | 0.016 M | 1-octene |  | 12 h | 60% |
| 8 |  **8** | 0.01 M | THF |  | 15 h | 91% |
| 9 | **8** | 0.01 M | $c$-$C_6H_{12}$ |  | 15 h | 84% |
| 10 |  **9** | 0.01 M | THF |  | 48 h | 56% with<br>25% SM |
| 11 | **9** | 0.01 M | $c$-$C_6H_{12}$ |  | 48 h | 71% |
| 12 |  | 0.01 M | $c$-$C_6H_{12}$ | NA | 48 h | 0% |

[a] Reactions were generally conducted at reflux with 10% AIBN.

[b] Conducted 60°C with UV irradiation.

**In conclusion, we have developed a method for the allylation of C-H bonds based on allylic triflones. The reaction is believed to proceed via an $S_H2'$ mechanism.**

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## References and Notes

0 . Synthesis via vinyl sulfones 76. Triflone Chemistry 11.

1 . (a) Curran, D. P.; Porter, N. A.; Giese, B. *Stereochemitry of Radical Reactions*; VCH: Weinheim, 1995. (b) Keck, G. E.; Enholm, E. J.; Yates, J. B.; Wiley, M. R. *Tetrahedron* **1985**, 41, 4079-4094.

2 . (a) Kosugi, M.; Kurata, H.; Kawata, K.; Migita, T. *Chemistry Lett.* **1991**, 1327-1328. (b) Curran, D. P.; Yoo, B. W. *Tetrahedron Lett.* **1992**, *33*, 6931. (c) Chatgilialoglu, C.; Ferreri, C.; Ballestri, M.; Curran, D. P. *Tetrahedron Lett.* **1996**, *37*, 6387.

3 . Keck, G. E.; Byers, J. H. *J. Org. Chem.* **1985**, 50, 5442-5444.

4 . Giese, B.; Erdmann, P.; Gobel, T.; Springer, R. *Tetrahedron Lett.* **1992**, 33, 4545-4548.

5 . (a) Russell, G. A. *Acc. Chem. Res.* **1989**, 22, 1-8. (b) Russell, G. A.; Ngoviwatchai, P.; Wu, Y. W. *J. Am. Chem. Soc.* **1989**, 111, 4921-4927. (c) Huval, C. C.; Singleton, D. A. *Tetrahedron Lett.* **1993**, *34*, 3041.

6 . Keck, G. E.; Tafesh, A. M. *J. Org. Chem.* **1989**, 54, 5845-5846.

7 . (a) Guyader, F. L.; Quiclet-Sire, B.; Seguin, S.; Zard, S, Z, *J. Am. Chem. Soc.* **1997**, 119,7410-7411. (b) Quiclet-Sire, B.; Zard, S. Z. *J. Am. Chem. Soc.* **1996**, 118, 1209-1210. (c)Phillips, E. D.; Whitham, G. H. *Tetrahedron Lett.* **1993**, 34, 2537-2540. (d) Chatgilialoglu, C.; Alberti, A.; Ballestri, M.; Macciantelli, D.; Curran, D. P. *Tetrahedron Lett.* **1996**, *37*, 6391.

8 . (a) Gong, J.; Fuchs, P. L. *J. Am. Chem. Soc.* **1996**, 118, 4486-4487; (b) Xiang, J.; Fuchs, P. L. *J. Am. Chem. Soc.* **1996**, 118, 11986-11987; (c) Xiang, J.; Jiang, W.; Gong, J.; Fuchs, P. L. *J. Am. Chem. Soc.* **1997**, 119, 4123-4129; (d) Xiang, J.; Jiang, W.; Fuchs, P. L. *Tetrahedron Lett.*, **1997**, 6635-6638.

9. Dolbier, W. R. *Chem. Rev.* **1996**, *96*, 1557.

10 . Curran, D. P.; Xu, J. Y.; Lazzarini, E. *J. Chem. Soc., Perkin Trans. 1* **1995**, 3049.

11 . (a) Hendrickon, J. B.; Judelon, D. A.; Chancellor, T. *Synthesis*, **1984**, 320-322; (b) Baldwin, J. E.; Adlington, R. M.; Lowe, C.; O'Neil, I. A.; Sanders, G. L.; Schofield, C. C.; Sweeney, J. B. *J. Chem. Soc., Chem. Commun.*, **1988**, 1030-1031.

12. The impure triflone from the reaction with the potassium salt seems to contain an inhibitor. Its reactions are very slow and provide large amounts of the non-chain adduct derived from addition of isobutyronitrile radical (from the AIBN). Distillation followed by flash chromatography gives pure **6**, which is well behaved in the additions.

13 . The following alkenes provided no adducts in reactions with cyclohexane: