

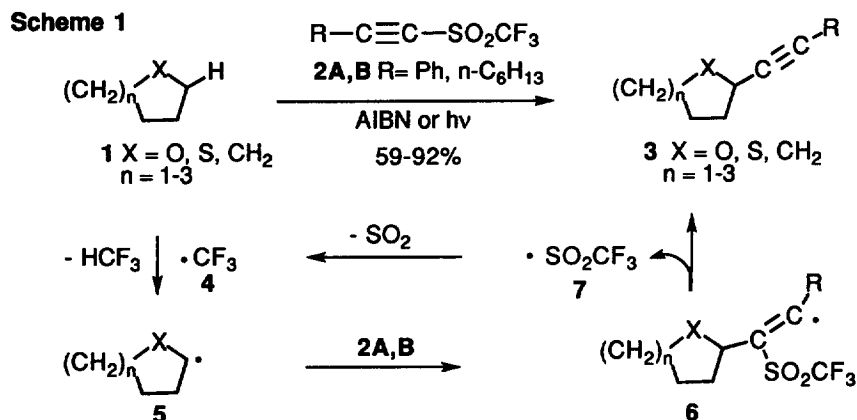
Alkynylation of Aldehydic C-H Bonds via Reaction with Acetylenic Triflones.¹

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Abstract: Reaction of aldehydes with acetylenic triflones affords acetylenic ketones and alkylated acetylenes via the intermediacy of acyl radicals, the product ratio being highly dependent upon aldehyde structure and reaction conditions. © 1997, Elsevier Science Ltd. All rights reserved.

We recently reported that reaction of ethers, sulfides, and hydrocarbons with acetylenic triflones such as **2A,B** provides facile access to substituted alkynes **3** (Scheme 1).² The reaction proceeds via radical C-H abstraction³ by the very electrophilic trifluoromethyl radical **4**,⁵ in a process involving addition of alkyl radical **5** to the α -carbon of the acetylenic triflone **2** followed by efficient conversion of vinyl radical **6** to alkyne **3** and trifluoromethylsulfonyl radical **7** via a unimolecular chain transfer process (UMCT⁶). Entropy-promoted fragmentation⁷ of **7** to sulfur dioxide and the highly reactive trifluoromethyl radical **4** (a second UMCT reaction) efficiently propagates the chain.⁸



Since the success of the above C-H alkynylation reaction is largely determined by the enthalpic differential between the trifluoromethyl radical and the substrate C-H bond energy, we speculated that the 88 Kcal/mole C-H bond of an aldehyde⁴ would be an attractive target for abstraction. While it has long been mechanistically known that aldehydes can serve as direct progenitors of acyl radicals,⁹ most aldehyde-based reactions are inefficient or low-yielding,^{9a} and

the acylselenide moiety has become the *de facto* functional group of choice for generation of acyl radical intermediates.¹⁰ We now report that aldehydes serve as excellent substrates for acetylenic triflones and afford ready access to products formed via the agency of acyl radicals.

Our initial survey involved treatment of phenylacetylenic triflone **2A** and 20 mol% AIBN in hot acetonitrile with a slight excess (1.3-1.5 equiv) of a variety of aldehydes to examine the relative efficiency of trapping the acyl radical versus trapping the radical resulting from decarbonylation (see Scheme 2 and Table 1). As expected, decarbonylation of acyl radical **9a** derived from *n*-butyraldehyde **8a** was slow relative to addition of this intermediate to acetylenic triflone **2A**, and a high yield of acetylenic ketone **11Aa** was obtained (Run A1). Acyl radicals derived from secondary-substituted aldehydes **8b,c** provided a mixture of alkylated and acylated acetylenes **11Ab**, **11Ac** and **12Ab**, **12Ac** respectively, (Runs A2.1-2.8, 3). Aldehyde **8d** generates intermediate **9d** which strongly favors decarbonylation and trapping of the *t*-butyl radical, yielding a 1:11 mixture of acetylenic ketone **11Ad** and alkyl-substituted alkyne **12Ad** under the standard conditions (Run A4). Reactions run under carbon monoxide at high pressure (Runs A5-7) provide substantially improved amounts of acetylenic ketones, presumably by reversing the decarbonylation reaction.^{9b} As can be further seen in Table 1 (Run B3), octynyl triflone **2B** also undergoes this reaction, the lesser reactivity of the aliphatic triflone being responsible for the increased production of decarbonylated product **12Bc**, relative to the analogous reaction of **2A** (run A3). It should be noted that benzaldehyde **8e** is inert to acetylenic triflone **2A** (Run A8).

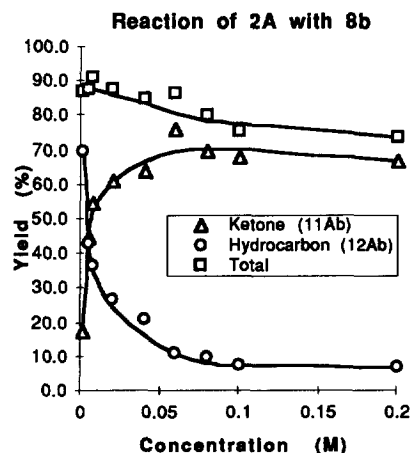
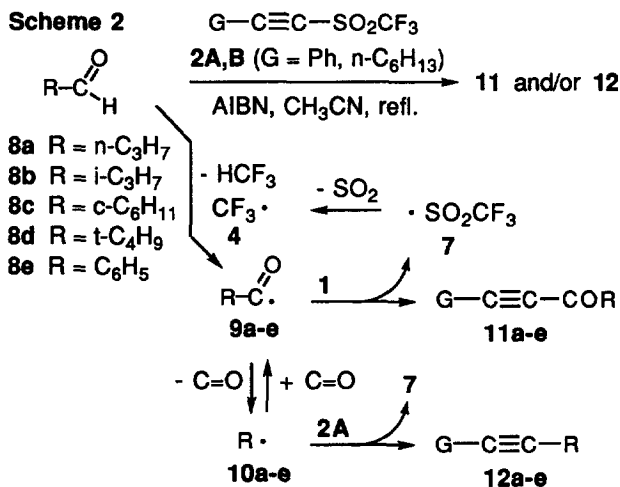
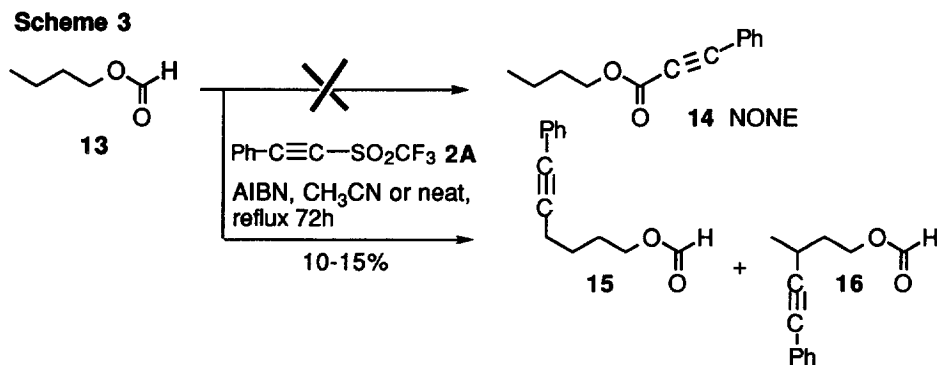


Table 1. Reactions of Aldehydes with Acetylenic Triflones **2A** and **2B**.

Run	RCHO	Conditions [#]	Products	Yield	11:12
A1	8a	1.5h, 0.02M	11Aa + 12Aa	84%	47:1
A2.1	8b	30h, 0.001M	11Ab + 12Ab	87%	0.5:1
A2.2	8b	20h, 0.005M	11Ab + 12Ab	88%	1:1
A2.3	8b	3h, 0.01M	11Ab + 12Ab	91%	1.5:1
A2.4	8b	1.5h, 0.02M	11Ab + 12Ab	88%	2.3:1
A2.5	8b	1h, 0.04M	11Ab + 12Ab	85%	3:1
A2.6	8b	1h, 0.06M	11Ab + 12Ab	87%	6.5:1
A2.7	8b	0.7h, 0.08M	11Ab + 12Ab	80%	7:1
A2.8	8b	0.7h, 0.10M	11Ab + 12Ab	76%	9:1
A3	8c	0.7h, 0.02M	11Ac + 12Ac	90%	20:1
B3	8c	6.0h, 0.03M	11Bc + 12Bc	71%	1.7:1
A4	8d	0.7h, 0.02M	11Ad + 12Ad	81%	1:11
A5	8d	7.0h, 0.02M, 60atm CO, O ₂ free	11Ad + 12Ad	20%	1.5:1
A6	8d	7.0h, 0.02M, 60atm CO, Tr. O ₂	11Ad + 12Ad	89%	1:1.5
A7	8d	7.0h, 0.06M, 60atm CO, Tr. O ₂	11Ad + 12Ad	85%	1.8:1
A8	8e	72h, 0.02M	11Ae + 12Ae	0%	NR

[#]Aldehyde (1.3-1.5 equiv.), AIBN (20 mol%), acetonitrile at reflux.

In an effort to extend the method to alkoxy carbonyl radicals¹¹ via direct reaction of acetylenic triflones with formates (C-H bond dissociation energy = 94 Kcal/mol⁴), we examined the reaction of n-butyl formate with acetylenic triflone **2A**. As might be expected, the reaction was extremely slow, returning mostly unreacted acetylenic triflone **2A** after three days, and only provided a low yield of a ~1:1 mixture of butyl-functionalized formates **15** and **16** to the total exclusion of acetylenic ester **14** (Scheme 3).



Acknowledgment. We thank the National Institutes of Health (GM 32693) and the NSF (CHE 9626837) for support of this work. Special thanks are due to Dr. Doug Lantrip for assistance with reverse phase HPLC analysis. A referee is thanked for providing references 5,6 in addition to valuable comments.

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(Received in USA 22 October 1996; revised 2 December 1996; accepted 5 December 1996)