COMMUNICATION

A novel utilization of trifluoromethanide as a base: a convenient synthesis of trimethylsilylacetylene

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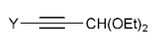
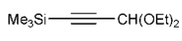
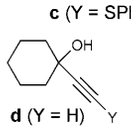
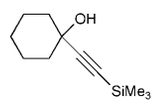
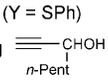
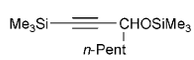
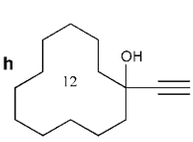
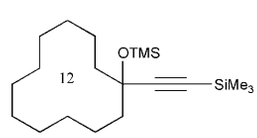
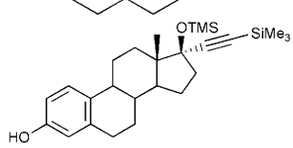
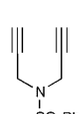
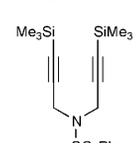
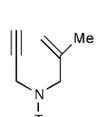
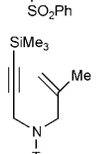
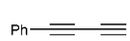
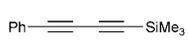
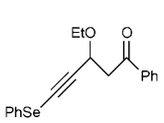
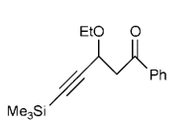
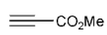
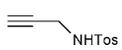
Trifluoromethanide generated from CF_3SiMe_3–Bu_4NF reacted with terminal acetylenes and acetylenic selenides as a base or a nucleophile to give trimethylsilylacetylenes in high yields.

Trifluoromethyltrimethylsilane (Ruppert's reagent, CF_3SiMe_3) has recently attracted attention as a source of the trifluoromethyl functional group, and has been widely used for the conversions of aldehydes and ketones to trifluoromethyl alcohols,[1] of esters to trifluoromethyl ketones[2] and of azirines to trifluoromethylaziridines.[3] In particular, the reactions of acylsilanes with CF_3SiMe_3 have produced the versatile intermediate, difluoroenoxysilane, which is readily converted to difluoromethyl ketones, alcohols and their derivatives.[4] These effective trifluoromethylations are considered to be due to the strong nucleophilicity of the trifluoromethanide (CF_3^-) analog formed upon initiation by the fluoride ion. However, the trifluoromethanide liberated in these reaction systems is also a strong base (pK_a of HCF_3 = 31) and this usually makes it difficult to control these reactions, which give low yields of the products.[5] We have fortunately found that the reactions of acetylene with CF_3SiMe_3–Bu_4NF effectively produce trimethylsilylacetylenes *via* the corresponding acetylides. The trimethylsilyl group can be conveniently used as a good protecting group of terminal acetylenes.[6] Furthermore, they can then be converted to other useful compounds such as the trimethylsilylethynyl ketones,[7] ethynyl sulfones,[8] vinyl silanes,[9] and allenyl silanes.[10] However, the carbon–silyl bonds are easily cleaved upon usual work-up or purification of the products. If convenient methods for the trimethylsilylation of the various types of terminal acetylenes could be found, they would be useful as a good protection procedure in the syntheses of various complex targets. We now report the novel trimethylsilylation of acetylenes using CF_3SiMe_3–Bu_4NF.

Results and discussion

First, we examined the reaction of propynal diethyl acetal and CF_3SiMe_3. To a reaction mixture of CF_3SiMe_3 (3.00 mmol) and the propynal acetal (1.00 mmol) was added a drop of Bu_4NF (1 M THF solution) at 0 °C. The vigorous formation of gases quickly ceased and the reaction was complete in less than 1 min. Trimethylsilylpropynal diethyl acetal **2a** was obtained in 60% yield. The reactions of various acetylenes were examined and these results are shown in Table 1. Interestingly, acetylenic selenide **1b** also afforded the product in high yield; however, the corresponding sulfur analog did not give the silylated acetylene **2a**. The 1-ethynylcyclohexanols **1d**–**f** provided almost the same results as those of the propynal acetals. The hydroxy group of alcohols **1g**–**i** underwent trimethylsilylation to give **2g**–**i** in high yields. A large number of silylating agents are available for the introduction of the trimethylsilyl group into various alcohols. However, in general, it is difficult to incorporate the bulky trimethylsilyl group in sterically hindered alcohols. Therefore, this method would also be convenient for the easy silylation of bulky tertiary alcohols. The 1,6-diyne **1j**, -enyne **1k** and 1,3-diyne **1l** also gave the silylated products **2j**–**l**. The reactions of the acetylenic ketone **1m**, ester **1n** and amide **1o** resulted in low yields or the formation of a complex mixture.

Table 1 Trimethylsilylation of acetylenes with trifluoromethyltrimethylsilane–Bu_4NF

Acetylene **1**	Product **2**	Yield (%)
		
a (H)		60
b (Y = SePh)		88
c (Y = SPh)		Recovery
		
d (Y = H)		77
e (Y = SePh)		53
f (Y = SPh)		Recovery
g 		85
h 		96
i Ethynylestradiol		Quant.
j 		Quant.
k 		97
l 		69
m 		18
n 		Complex mixture
o 		Recovery

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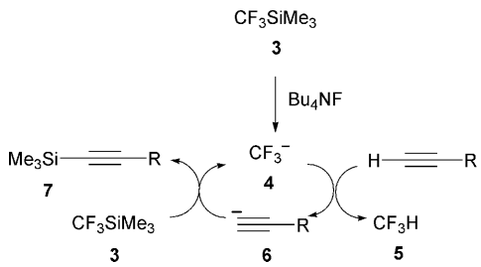
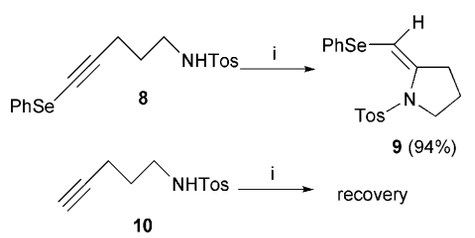
A plausible mechanism for the fluoride-catalyzed trimethylsilylation of acetylenes is given in Scheme 1. Trifluoromethanide



Scheme 1

4, initially formed from the reaction of CF_3SiMe_3 **3** with Bu_4NF, abstracts the proton of the terminal acetylene to give trifluoromethane **5** and an acetylide **6**. The reaction of the acetylide **6** with CF_3SiMe_3 **3** gives the trimethylsilylacetylene **7** and trifluoromethanide **4**. The trifluoromethanide ion is then involved in the trimethylsilylation catalytic cycle of the acetylenes using CF_3SiMe_3. Treatment of the acetylenic selenides with a strong base is well known to give the corresponding acetylides, which were trapped with a variety of electrophiles to afford the acetylenes.

The acetylenic selenides are easily converted to the trimethylsilylacetylenes under the given conditions, CF_3SiMe_3–Bu_4NF, and, therefore, we next examined the reactions of other selenides and found that the reaction of the sulfonamide **8** with CF_3SiMe_3 involves cyclization to give the 2-(phenylselenomethylene)pyrrolidine **9** in 94% yield (Scheme 2).[11] We also



Scheme 2 *Reagent*: CF_3SiMe_3–Bu_4NF–THF.

performed the reaction of **8** with Bu_4NF in THF, but only the acetylene **8** was recovered. In order to ascertain the generality of this cyclization, we performed the reaction with the non-seleno-substituted *N*-pent-4-ynylsulfonamide **10**. However, this reaction did not proceed and gave only the starting amide.[12] These results show that the phenylseleno group effectively stabilizes the intermediate vinyl anion that undergoes the cyclization reaction.

Acknowledgements

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Notes and references

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11 Compound **9**: colorless prisms; mp 136–140 °C; IR ν(KBr)/cm^{-1} 1340, 1160 (SO_2); δ_H (400 MHz; $CDCl_3$) 1.57–1.66 (2H, m, CH_2), 2 08 (2H, t, J = 7 Hz, CH_2), 2.43 (3H, s, Me), 3.58 (2H, t, J = 7 Hz, CH_2), 6.12 (1H, d, J = 1 Hz, olefinic H), 7.23–7.32 (5H, m, ArH), 7.51–7.57 (2H, m, ArH), 7.75 (2H, d, J = 8 Hz, ArH); δ_C (100 MHz; $CDCl_3$) 21.78 (q), 22.03 (t), 33.46 (t), 51.44 (t), 108.56 (d), 127.19 (d), 128.03 (d × 2), 129.17 (d × 2), 129.82 (d × 2), 132.36 (d × 2), 133.58 (s), 134.55 (s), 140.56 (s), 144.30 (s); MS *m*/*z* 393 (M^+), 238 ($M^+ - SO_2Tol$). Anal. calcd for $C_{18}H_{19}NO_2SSe$: C, 55.10; H, 4.88; N, 3.57, found: C, 54.63; H, 4.80; N, 3.54%.
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