A Reaction of γ-Chalcogen-substituted Prop-2-ynyl Cations with Mild Nucleophiles

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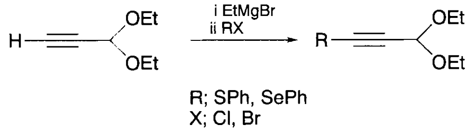
γ-Chalcogen-substituted prop-2-ynyl cations are generated by the reactions of diethyl acetals **1** and **2** with BF_3–Et_2O and react with various mild nucleophiles without isomerisation to allenyl cations to afford the prop-2-ynylated products **3a–e** and **5a–c** in good yields.

Isomerisation of the prop-2-ynyl group to allenyl group is well recognised and widely employed in the synthesis of allenic compounds.[1] Therefore, prop-2-ynylation is an important functionalisation to be solved. α-Prop-2-ynyl ketones are versatile intermediates and are converted into chromanols,[2] other heterocycles,[3] cyclohexenones,[4] and 1,4-diketones.[5] Direct coupling of ketone enolate with prop-2-ynyl halides or tosylates has rarely been reported because of the isomerisation to allenes. Nicholas *et al.* explored an elegant method using (prop-2-ynyl)$Co_2(CO)_6^+$ complexes[6] which react not only with trimethylsilyl enol ethers,[7] but also with allylsilanes,[8] and alkyl- and alkynyl-aluminium reagents.[9] Dicobalt octacarbonyl is highly toxic and air sensitive, and all operations with this reagent should be carried out in an inert atmosphere. If prop-2-ynyl cations can be generated by a method without dicobalt octacarbonyl, this novel method will be useful and convenient for prop-2-ynylation. Since the Lewis acid mediated reaction of prop-2-ynyl aldehyde acetals with nucleophiles has not been reported, we examined reactions of prop-2-ynyl cations generated from γ-chalcogen-substituted propynal diethyl acetals and report here the reactions of prop-2-ynyl cations with the mild nucleophiles. γ-Chalcogen-substituted propynal diethyl acetals **1** and **2** were prepared by the reaction of propynal diethyl acetal with ethylmagnesium bromide followed by treatment with benzenesulfenyl or benzeneselenenyl chloride (Scheme 1).



Scheme 1

γ-Selenopropynal diethyl acetal **1** reacted with trimethylsilyl enol ethers in the presence of BF_3–Et_2O to give α-alkoxyprop-2-ynyl ketones **3a** and **3b** accompanied by the alkynyl ether **4a**, which would be formed by the hydride abstraction (entry 1). The addition reactions of **1** with various nucleophiles were performed and their results are shown in Table 1. The reaction of **1** with allyltrimethylsilane afforded the allylated selenoalkyne **3d** in good yield, while the reaction of **1** with trimethylsilylnitrile gave a complex mixture. Although the (prop-2-ynyl)-$Co_2(CO)_6^+$ complex reacted with trialkylaluminium reagents, the yields of the alkylated products were low.[9] The chalcogen-substituted propynal diethyl acetal **1** reacted with triethylaluminium or diethylzinc to give the ethylated product **3d** in high yield (entries 4 and 5). Alkynylation using diethyl octynyl aluminium provided the octynylated product **3e** (20%) and the ethylated product **3d** (25%) (entry 6), and reaction with trioctynylaluminium produced the product **3e** in low yield.

γ-Phenylthiopropynal diethyl acetal **2** reacted similarly with the soft nucleophiles in the presence of BF_3–Et_2O (entries 8–10). The prop-2-ynylated products **5a**, **5b** and **5c** were obtained in good yields. Reactions of other prop-2-ynyl aldehyde diethyl acetals bearing an alkyl, a phenyl, a silyl and a stannyl groups at the terminal acetylenic carbon were fruitless and gave the complex mixtures. This indicates that γ-substituted chalcogen atoms stabilised the prop-2-ynyl cations and have an effect on the α-selective prop-2-ynylations.

Table 1 Reactions of γ-chalcogen-substituted prop-2-ynyl cations with nucleophiles

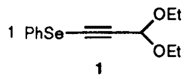
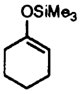
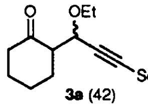
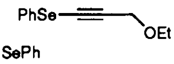
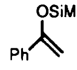
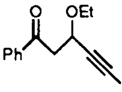
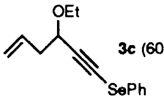
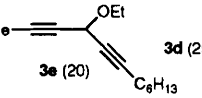
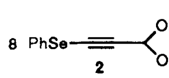
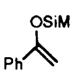
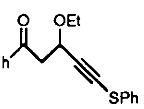
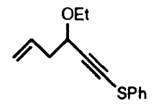
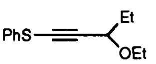
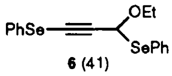
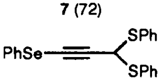
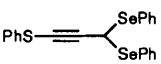
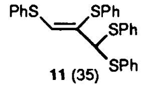
Entry	Acetal	Nucleophile	Products (% yields)
1	 **1**		 **3a** (42)  **4a** (17)
2	**1**		 **3b** (61)
3	**1**		 **3c** (60)
4	**1**	Et_3Al	 **3d** (81)
5	**1**	Et_2Zn	**3d** (76)
6	**1**	$C_6H_{13}{-}{\equiv}{-}AlEt_2$	 **3e** (20) **3d** (25)
7	**1**	$(C_6H_{13}{-}{\equiv})_3Al$	**3e** (13)
8	 **2**		 **5a** (75)
9	**2**		 **5b** (44)
10	**2**	Et_3Al	 **5c** (70)

Table 2 Synthesis of γ-chalcogen-substituted propynal mono- and diheteroacetals at room temp.

Entry	Acetal	Conditions	Products (% yields)
1	**1**	2 equiv. $Bu^i{}_2AlSePh$	 **6** (41)
2	**1**	4 equiv. $Bu^i{}_2AlSePh$	Complex mixture
3	**1**	2 equiv $Bu^i{}_2AlSPh$	 **7** (72)
4	**1**	4 equiv. $Bu^i{}_2AlSPh$	 **8** (48)
5	**1**	4 equiv. $Bu^i{}_2AlSPh$/ CF_3CO_2H	**8** (56) **7** (39)
6	**2**	4 equiv. $Bu^i{}_2AlSePh$	 **9** (46)
7	**2**	4 equiv. $Bu^i{}_2AlSPh$	 **10** (16)  **11** (35)

We also examined the nucleophilic addition reactions with other soft nucleophiles such as $B(SePh)_3$,[10] TMSSePh,[11] and $Bu^i_2AlSePh$.[12] Reaction of acetal **1** with 2 equiv. of $Bu^i_2AlSePh$ gave *O,Se*-heteroacetal **6** (Table 2, entry 1) and reaction with Bu^i_2AlSPh afforded *O,S*-heteroacetal **7** in good yield (entry 3). The structures of these compounds could be satisfied by the analytical and spectral data. When 4 equiv. of Bu^i_2AlSPh was used, no *O,S*-heteroacetal but dithioacetals **8** and **10** were obtained from γ-phenylseleno- **1** and γ-phenylthiopropynal **2**, respectively. The diselenoacetal **9** was similarly obtained from **2** and 4 equiv. of $Bu^i_2AlSePh$ in 46% yield. We made attempts to prepare γ-phenylselenopropynal diselenoacetal, but could not obtain it in a pure form. These heteroacetals would be utilised as a source of prop-2-ynyl cations stabilized by a chalcogen atom.[13] Since the alkynyl chalcogenmoieties can be easily transformed to other functional groups,[14] γ-chalcogen-substituted prop-2-ynyl compounds will become useful intermediates for organic synthesis.

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References

1 F. Theron, M. Verry and R. Vessiere, in *The Chemistry of the Carbon–Carbon Triple Bond*, ed. S. Patai, Wiley, Chichester, 1978, pt. 2, ch. 10.
2 P. Dufey, *Bull. Soc. Chim. Fr.*, 1968, 4653.
3 K. E. Schulte, J. Reisch and D. Bergenthal, *Chem. Ber.*, 1968, **101**, 1540.
4 D. Caine and F. N. Tuller, *J. Org. Chem.*, 1969, **34**, 222.
5 G. Stork and R. Borch, *J. Am. Chem. Soc.*, 1964, **86**, 935; S. Padmanabhan and K. M. Nicholas, *Synth. Commun.*, 1980, **10**, 503; M. Saha and K. M. Nicholas, *Isr. J. Chem.*, 1984, **24**, 105.
6 K. M. Nicholas, *Acc. Chem. Res.*, 1987, **20**, 207.
7 V. Valsama, M. Saha and K. M. Nicholas, *Org. Synth.*, Coll. Vol. VIII, 1993, 460.
8 J. E. O'Boyle and K. M. Nicholas, *Tetrahedron Lett.*, 1980, **21**, 1595.
9 S. Padmanabham and K. M. Nicholas, *J. Organomet. Chem.*, 1981, **212**, 115; *Tetrahedron Lett.*, 1983, **24**, 2239.
10 D. L. J. Clive and S. M. Menchen, *J. Org. Chem.*, 1979, **44**, 4279. T. Kataoka, M. Yoshimatsu, Y. Noda, T. Sato, H. Shimizu and M. Hori, *J. Chem. Soc., Perkin Trans 1*, 1993, 121.
11 N. Miyoshi, Y. Hatayama, I. Ryu, N. Kambe, T. Murai, S. Murai and N. Sonoda, *Synthesis*, 1988, 175.
12 K. Maruoka, T. Miyazaki, M. Ando, Y. Matsumura, S. Sakane, K. Hattori and H. Yamamoto, *J. Am. Chem. Soc.*, 1983, **105**, 2831. Y. Nishiyama, S. Nakata and S. Hamanaka, *Chem. Lett.*, 1991, 1775.
13 K. Nsunda and L. Hevesi, *Tetrahedron Lett.*, 1984, **25**, 4441; M. Yoshimatsu, T. Sato, H. Shimizu, M. Hori and T. Kataoka, *J. Org. Chem.*, 1994, **59**, 1011.
14 A. L. Braga, J. V. Comasseto and N. Petragnani, *Synthesis*, 1984, 240; J. V. Comasseto, V. Catani, J. T. B. Ferreira and A. L. Braga, *J. Chem. Soc., Chem. Commun.*, 1986, 1067.