ELSEVIER

Journal of Organometallic Chemistry 643–644 (2002) 501–503

Journal of Organometallic Chemistry

www.elsevier.com/locate/jorganchem

Note

A general convenient synthesis of conjugated dieneynes

Iwona Maciągiewicz, Piotr Dybowski, Aleksandra Skowrońska *

Centre of Molecular and Macromolecular Studies, Polish Academy of Sciences, Sienkiewicza 112, 90-363 Lodz, Poland

Received 28 June 2001; accepted 18 September 2001

Abstract

A convenient synthesis of dieneynes **1** is described. Our strategy involves reaction of readily available thiophosphates with sodium acetylides, in which new single and double carbon–carbon bonds are formed. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Conjugated dieneynes; Thiophosphates; Sodium acetylides

As part of our studies on the development of a novel approach to unsaturated systems [1] based on thiophosphates, we report on the preparation of non-linear dieneynes **1**.

Previously, using this methodology, we elaborated the synthesis of a number of versatile and synthetically valuable unsaturated compounds [2,3] including eneynes [4]. It was envisaged that this synthetic concept might also be applicable to the preparation of conjugated dieneynes **1**. Such highly unsaturated compounds are useful intermediates in organic synthesis [5,6], in particular as attractive precursors of conjugated trienes [7]. Synthesis of only a few simple examples of dieneynes **1**, have been published so far [8–10], generally with low yield. A general method for the synthesis of **1** is needed.

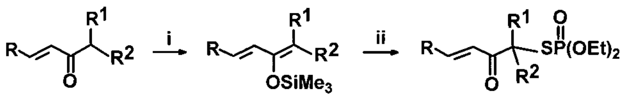
As shown in Scheme 1 a wide range of new thiophosphates **2** containing an α,β-unsaturated carbonyl moiety is readily made from the corresponding carbonyl compounds **3** in high yield [11]. Formation of **2** proceeds via initial conversion of **3** into *O*-silylated dienolates **4** [12], followed by the addition of readily available $(EtO)_2P(O)SCl$ (**5**) [13].

We have found that thiophosphates **2** are good candidates to be precursors of dieneynes **1**. Reactions of **2** with sodium acetylides (generated from acetylenic derivatives with $NaNH_2$ in THF at room temperature) provide, in one operation via single and double carbon–carbon bond formation, highly substituted conjugated dieneynes **1**. 'One-pot' transformation of **2** into **1** is illustrated in Scheme 2.

Addition of sodium acetylides to thiophosphates **2** affords two diastereoisomeric anions **6**. The intermediate anions rearrange with the migration of a phosphoryl group from sulphur to oxygen affording thiolate anions **7**. Subsequent cyclization via nucleophilic attack with the elimination of phosphate anion gives episulphides **8**, which lose sulphur spontaneously to provide conjugated dieneynes **1**. The reaction described generally proceeds in good yield, except in the few cases indicated in Table 1 (entries 7–10).

The structure of all compounds described in Table 1 was confirmed by ^{1}H-, ^{13}C-NMR, IR and CI-MS spectroscopy.

The reaction of **2** to form **1** is of low stereoselectivity except when the R^1 substituent is quite large (i-C_3H_7) (see Table 1, entry 7, $R^1 = i$-C_3H_7). In this case the



3 4 2

i, Me_3SiCl, NaI, Et_3N, CH_3CN; r.t. to 70 °C ii, $(EtO)_2P(O)SCl$ 5, CH_2Cl_2; -78 °C

2a: R=Ph, R^1=R^2=Me (92%)
2b: R=p-Cl-C_6H_4, R^1=R^2=Me (74%)
2c: R=Ph, R^1=n-Hex, R^2=Me (88%)
2d: R=Ph, R^1=n-Pr, R^2=Me (96%)
2e: R=Ph, R^1=i-Pr, R^2=Me (86%)
2f: R=2-furyl, R^1=R^2=Me (22%)

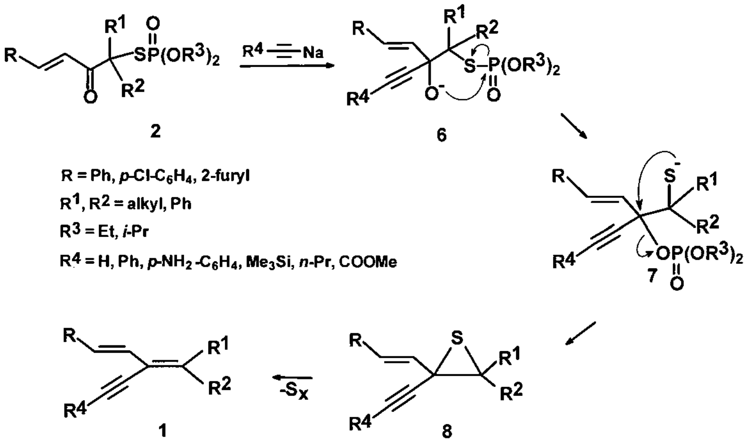
Scheme 1.

---

* Corresponding author. Tel.: +48-42-6843120; fax: +48-42-6847126.

E-mail address: askow@bilbo.cbmm.lodz.pl (A. Skowrońska).

PII: S0022-328X(01)01275-X



Scheme 2.

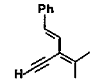
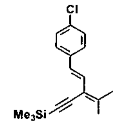
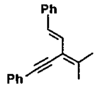
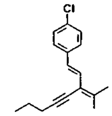
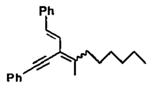
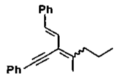
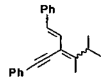
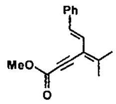
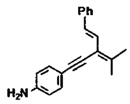
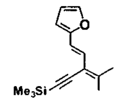
ratio of isomers is 75:25. The observed stereochemistry can be explained by kinetically controlled addition of an acetylenic anion to the carbonyl function in **2**. It obeys the simple Cram asymmetric induction model with the assumption that the $(EtO)_2P(O)S$ group is the largest one.

In summary, application of methodology based on intermediate thiophosphates provides a general and convenient route to a wide range of conjugated dieneynes, via a reaction in which single and double carbon–carbon bonds are formed. Application of these compounds to the synthesis of cyclic systems is currently under investigation in our laboratory.

1. Experimental

A solution of SO_2Cl_2 (2.70 g, 0.02 mol) in CH_2Cl_2 (10 ml) was added dropwise to *O*,*O*,*O*-triethyl phosphorothioate (3.96 g, 0.02 mol) in CH_2Cl_2 (5 ml) at −5 °C. Stirring was continued for 20 min at room temperature (r.t.). After removal in vacuo of about 80% of solvent, crude $(EtO)_2P(O)SCl$ was added dropwise to a stirred solution of freshly prepared *O*-silylated dienolate (0.021 mol) in CH_2Cl_2 (10 ml) at −78 °C. Stirring was continued at r.t. for an additional 1–2 h. The solvent and trimethylsilyl chloride were removed under reduced pressure to give thiophosphate **2**, which was purified by column chromatography on silica gel, using benzene and then benzene–EtOAc 2:1 as eluent. Then pure **2** (0.018 mol) in THF (10 ml) was added dropwise to a stirred solution of sodium acetylide (commercial from Fluka) (0.02 mol) or acetylide derivative generated from appropriate acetylene compound in THF (15 ml) with $NaNH_2$ at r.t. (anion is obtained quantitatively after stirring for 1–3 h). Stirring was continued for 10 min. Then a saturated solution of NH_4Cl (15 ml) was added and the reaction mixture extracted with 3 × 30 ml of Et_2O. The organic layer was washed with

Table 1
Dieneynes **1** from **2** and various sodium acetylides

Entry	Thiophosphates **2**	Products **1**		Yield[a], % (isomers)
1	**2a**		**1a**	75
2	**2b**		**1b**	56
3	**2a**		**1c**	77
4	**2b**		**1d**	53
5	**2c**		**1e**	74 (56:44)
6	**2d**		**1f**	70 (54:46)
7	**2e**		**1g**	21 (75:25)
8	**2a**		**1h**	39
9	**2a**		**1i**	28
10	**2f**		**1j**	34

[a] No attempts were made to optimize the yields. Yields refer to analytically pure compounds.

water, dried over $\mathrm{MgSO_4}$ and dieneynes **1** were purified by flash chromatography on silica gel using benzene as eluent.

1.1. Selected data for compound **1a**

Yield 75%, yellowish oil; ^{1}H-NMR ($\mathrm{CDCl_3}$, 200 MHz): δ 2.05, 2.19 [2s, 6H, $=\mathrm{C(C}H_3)_2$]; 3.34 (br s, 1H, $\equiv$H); 7.03, 7.11 (2d, 2H, $J_{trans}=15.7$ Hz, $\mathrm{PhC}H{=}\mathrm{C}H$); 7.22–7.51 (m, $5\mathrm{H_{arom}}$). ^{13}C-NMR ($\mathrm{CDCl_3}$, AC-200): δ 19.9, 24.5 [$=\mathrm{C(}C\mathrm{H_3)_2}$]; 80.6 ($C{\equiv}\mathrm{CH}$); 82.0 ($\mathrm{C}{\equiv}C\mathrm{H}$); 116.7 ($=C{-}\mathrm{C}{\equiv}$); 123.9, 130.3 ($C\mathrm{H}{=}C\mathrm{H}$); [126.4, 127.2, 128.4, 144.9 (C-4°)–$\mathrm{C_{arom}}$]; 137.5 [$=C\mathrm{(CH_3)_2}$]. IR (neat, $\mathrm{cm^{-1}}$): 3268.4, 2962.3, 2918.3, 2849.6, 2094.7 (C=C), 1618.0 (PhC=C), 1589.8 (C=C), 1568.9 (Ph), 1447.3, 959.6, 797.6. CI-MS (isobutane): 183.2 [M + 1].

1.2. Selected data for compound **1d**

Yield 53%, brownish oil; ^{1}H-NMR ($\mathrm{CDCl_3}$, 200 MHz): δ 1.09 (t, 3H, $J=7.3$ Hz, $\equiv\mathrm{CCH_2CH_2C}H_3$); 1.67 (sext, 2H, $J=7.2$ Hz, $\equiv\mathrm{CCH_2}C\mathrm{H_2CH_3}$); 1.99, 2.11 [2s, 6H, $=\mathrm{C(C}H_3)_2$]; 2.46 (t, 2H, $J=7.0$ Hz, $\equiv\mathrm{CC}H_2\mathrm{CH_2CH_3}$); 6.90 (d, 1H, $J_{trans}=15.6$ Hz, $\mathrm{ArCH}=\mathrm{C}H$); 7.05 (d, 1H, $J_{trans}=15.6$ Hz, $\mathrm{ArC}H{=}\mathrm{CH}$); 7.28 (d, 2H, $J=8.7$ Hz, $\mathrm{H_{arom}}$: $=\mathrm{CHC{=}C}H$); 7.36 (d, 2H, $J=8.6$ Hz, $\mathrm{H_{arom}}$: $\mathrm{ClC{=}C}H$). ^{13}C-NMR ($\mathrm{CDCl_3}$, 50.32 MHz): δ 13.6 ($\equiv\mathrm{CCH_2CH_2}C\mathrm{H_3}$); 19.9, 24.6 [$=\mathrm{C(}C\mathrm{H_3)_2}$]; 21.5 ($\equiv\mathrm{CCH_2}C\mathrm{H_2CH_3}$); 22.5 ($\equiv\mathrm{C}C\mathrm{H_2CH_2CH_3}$); 77.3 ($\equiv C\mathrm{CH_2CH_2CH_3}$); 95.1 ($=\mathrm{C}{-}C{\equiv}$); 117.8 ($=C{-}\mathrm{C}{\equiv}$); 125.4, 128.6 ($C\mathrm{H}{=}C\mathrm{H}$); [127.6 ($=\mathrm{CHC}C\mathrm{H}$), 128.6 ($\mathrm{ClC}C\mathrm{H}$), 136.4 (C-4°: $\mathrm{Cl}C\mathrm{CH}$), 142.7 (C-4°: $=\mathrm{CH}C\mathrm{CH}$)–$\mathrm{C_{arom}}$]; 132.5 [$=C\mathrm{(CH_3)_2}$]. IR (neat, $\mathrm{cm^{-1}}$): 2961.3, 2930.6, 2905.4, 2870.7, 2226.2 (C≡C), 1620.8, 1595.1 (C=C), 1489.4, 956.3, 810.6.

Acknowledgements

We gratefully acknowledge financial support from the Polish State Committee for Scientific Research (KBN) grant no 3 T09A 029 15.

References

[1] P. Dybowski, A. Skowrońska, Tetrahedron Lett. 32 (1991) 4380.
[2] I. Maciągiewicz, P. Dybowski, A. Skowrońska, Tetrahedron Lett. 40 (1999) 3791 (and references therein).
[3] E. Krawczyk, A. Skowrońska, Heteroat. Chem. 11 (2000) 353 (and references therein).
[4] I. Maciągiewicz, A. Skowrońska, Synlett (2000) 1781.
[5] J. ApSimon (Ed.), The Total Synthesis of Natural Products, Wiley, New York, 1981.
[6] F. Bolman, T. Burkhardt, C. Zolero, Naturally Occuring Acetylenes, Academic Press, New York, 1973.
[7] R.F. Heck, Palladium Reagents in Organic Synthesis, Academic Press, New York, 1985.
[8] M. Hoshi, A. Arase, J. Chem. Soc. Perkin Trans. 1 (1993) 2693.
[9] K. Karabelas, A. Halberg, J. Org. Chem. 53 (1988) 4409.
[10] M. Bujard, F. Ferri, M. Alami, Tetrahedron Lett. 38 (1998) 4243.
[11] P. Dybowski, M. Koprowski, I. Maciągiewicz, A. Skowrońska, Synthesis (1999) 844.
[12] P. Cazeau, F. Duboudin, F. Moulines, O. Babot, T. Dunogues, Tetrahedron 43 (1987) 2089.
[13] A. Skowrońska, R. Dembiński, J. Gwara, J. Michalski, Phosphorus, Sulfur, Silicon (1988) 119 (and references therein).