COMMUNICATIONS

Improved Synthesis of Long Chain 1-Alkynes and Terminal Alkadiynes

W. Beckmann, G. Doerjer, E. Logemann, C. Merkel, G. Schill, C. Zürcher

Chemisches Laboratorium der Universität, D-78 Freiburg, Albertstr. 21

For the alkylation of acetylene a number of methods are available[1]: sodium acetylenide was reacted with alkylating agents in liquid ammonia at −33° or under pressure at ambient temperature[2] as well as in other solvents such as dimethylformamide[3], xylene[4], dimethylformamide/xylene[5], dimethylformamide/di-*n*-butyl ether[4], dimethylformamide/tetrahydrofuran[5], *N*-methylpyrrolidone[6] or tetrahydrofuran/hexamethylphosphoric triamide[7]. Lithium acetylenide, prepared from acetylene and lithium in benzene/hexamethylphosphoric triamide, was alkylated with 1-bromohexane and 1-octyne was obtained in 14% yield[8]. The lithium acetylenide/ethylenediamine complex was reacted with alkyl halides in dimethyl sulfoxide and 1-alkynes and terminal alkadiynes were obtained in good yields[9]. In most of the hitherto described methods, the yields of alkynes or terminal alkadiynes decreased dramatically with increasing chain length of the alkyl residues.

We have found that long chain 1-alkynes and terminal alkadiynes can be synthesised in good yields by reaction of an excess of lithium acetylenide with alkyl chlorides or bromides in tetrahydrofuran/hexamethylphosphoric triamide at room temperature or below. Lithium acetylenide was prepared at 0° from butyllithium and acetylene in tetrahydrofuran.

$$\mathrm{LiC{\equiv}C{-}H} \quad + \quad \mathrm{R{-}X} \xrightarrow{\text{THF / HMPT}} \mathrm{R{-}C{\equiv}CH}$$

X = Cl, Br

Compared with the hitherto used alkylation methods for metal salts of acetylene with long chain alkyl halides the present method has the advantage of higher yields and shorter reaction time. The results are summarised in the table.

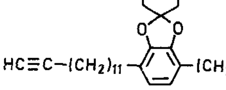
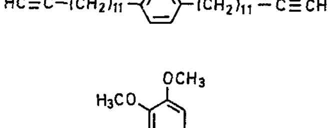
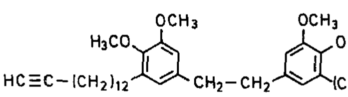
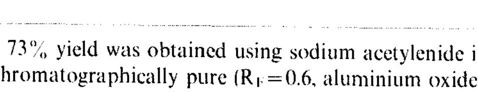
The alkylation of lithium 1-alkynes with alkylating agents in hexamethylphosphoric triamide[10] or tetrahydrofuran/hexamethylphosphoric triamide[11,12] has already been achieved.

In all preparations butyllithium was used as an approximately 2 *N* solution in hexane.

13-(2-Tetrahydropyranyloxy)-tridec-1-yne (1):

Under a nitrogen atmosphere and with stirring, acetylene is introduced into absolute tetrahydrofuran (16 ml) cooled in an ice bath

Table. Preparation of Alkynes and Dialkynes

	Compound	Yield (%)	M.p. or B.p.	Elemental analyses			
1		93	b.p. 115°/0.01 torr	$C_{18}H_{32}O_2$ (280.4)	calc. found	C 77.09 77.04	H 11.50 11.69
2	$HC{\equiv}C{-}(CH_2)_{12}{-}C{\equiv}CH$	87	43 44° (from ethanol) (Ref.[13], m.p. 44 45°)				
3	$HC{\equiv}C{-}(CH_2)_{16}{-}C{\equiv}CH$	90	57.5 58.5° (from ethanol) (Ref.[14], m.p. 58 58.5°)	$C_{20}H_{34}$ (274.5)	calc. found	C 87.51 87.42	H 12.49 12.72
4	$HC{\equiv}C{-}(CH_2)_{20}{-}C{\equiv}CH$	90	69 70° (from ethanol)	$C_{24}H_{42}$ (330.6)	calc. found	C 87.19 87.02	H 12.81 12.72
5		83	colourless oil[b]	$C_{38}H_{58}O_2$ (546.9)	calc. found	C 83.46 83.35	H 10.69 10.72
6		91[a]	colourless oil[c]	$C_{36}H_{58}O_2$ (522.8)	calc. found	C 82.70 82.74	H 11.18 11.37
7		92	54.5–55.5° (from ethanol)	$C_{46}H_{70}O_4$ (687.0)	calc. found	C 80.42 80.27	H 10.27 10.25

[a] A 73% yield was obtained using sodium acetylenide in liquid ammonia/dimethylformamide; see experimentel part.

[b] Chromatographically pure (R_F = 0.6, aluminium oxide, petroleum ether/benzene 3 : 1).

[c] Chromatographically pure (R_F = 0.45, aluminium oxide, petroleum ether/benzene 1 : 1; R_F = 0.26, petroleum ether/ether 10 : 1).

while butyllithium (16 ml, 32 mmol) is added dropwise in such a manner that the temperature does not exceed 5°. The mixture is stirred for 1 h between 5 and 10°, and then 11-(2-tetrahydropyranyloxy)-undecyl bromide[15] (10 g, 30 mmol) in absolute hexamethylphosphoric triamide (30 ml) is added dropwise. The temperature should not exceed 15°. The mixture is stirred for 30 min at room temperature, ice/water is added, and the mixture is then extracted with ether. The organic layer is washed with water and dried over potassium carbonate. The solvent is evaporated off, a small amount of powdered sodium hydroxide is added, and the residue is distilled; yield: 7.5 g (93%).

^{1}H-N.M.R. (CS_2): $\delta = 1.1$–1.7 (m, 24H, $>CH_2$), 1.75 (t, 1H, $-C\equiv C-H$, $J = 3$ Hz), 1.9–2.3 (m, 2H, $-C\equiv C-CH_2-$), 3.0–4.0 (m, 4H, $-CH_2-O$), 4.5 ppm (m, 1H, $-O-\underset{|}{CH}-O-$).

Hexadeca-1,15-diyne (2):
Lithium acetylenide is prepared as described above from butyllithium (150 ml, 0.3 mol) and acetylene in tetrahydrofuran (125 ml). A solution of 1,12-dibromododecane (16.4 g, 0.05 mol) in hexamethylphosphoric triamide (100 ml) is added at 0° in about 30 min and stirring is continued for 2 h at room temperature. The mixture is cooled to 0° and methanol is cautiously added followed by ice/water. The mixture is extracted with ether, the ethereal solution is washed with water, dried with sodium sulfate, and evaporated. The residue is eluted with petroleum ether (60–70°) through a short column of aluminium oxide (grade II–III) and recrystallised; yield: 9.5 g (87%).

Eicosa-1,19-diyne (3):
Using the procedure described for **2**, lithium acetylenide prepared from butyllithium (7.5 ml, 15 mmol) and acetylene in tetrahydrofuran (40 ml) is reacted with 1,16-dibromohexadecane (1.92 g, 5 mmol) in hexamethylphosphoric triamide (40 ml); yield: 1.24 g (90%).

Tetracosa-1,23-diyne (4):
Using the procedure described for **2**, lithium acetylenide prepared from butyllithium (37.5 ml, 75 mmol) and acetylene in tetrahydrofuran (33 ml) is reacted with 1,20-dibromoeicosane (5.5 g, 12.5 mmol) in tetrahydrofuran (5 ml). Hexamethylphosphoric triamide (25 ml) is then added and after work-up as described for **2** the residue is eluted through a short column of aluminium oxide with benzene/petroleum ether (1 : 1) and recrystallised; yield: 3.74 g (90%).

4,7-Bis[tridec-12-ynyl]-spiro{1,3-benzodioxole-2,1′-cyclohexane} (5):
As described for **2** above, lithium acetylenide is prepared from butyllithium (90 ml, 180 mmol) and acetylene in tetrahydrofuran (90 ml). To the mixture thus obtained (at 0°) is added dropwise a solution of 4,7-bis[11-chloroundecyl]-spiro[1,3-benzodioxole-2,1′-cyclohexane][16] (11.3 g, 20 mmol) in hexamethylphosphoric triamide (180 ml) at such a rate that the temperature does not exceed 5°. After being stirred for 30 min at room temperature the mixture is worked up as described for **2** and chromatographed on aluminium oxide (grade II–III) with petroleum ether/benzene (3:1); yield: 9.0 g (83%).

^{1}H-N.M.R. (CS_2): $\delta = 1.1$–2.0 (m, 46H, $>CH_2$), 1.8 (t, 2H, $-C\equiv C-H$, $J = 3$ Hz), 2.1 (m, 4H, $-C\equiv C-CH_2-$), 2.49 (t, 4H, $Ar-CH_2-$, $J = 7$ Hz), 4.4 ppm (s, 2H, $Ar-H$).

3,5-Bis[tetradec-13-ynyl]-1,2-dimethoxybenzene (6):
Method A: As described for **2**, lithium acetylenide prepared from butyllithium (60 ml, 120 mmol) and acetylene in tetrahydrofuran (40 ml) is reacted with 3,5-bis[12-bromododecyl]-1,2-dimethoxybenzene[17] (11.0 g, 17.4 mmol) in hexamethylphosphoric triamide (120 ml). The mixture is stirred for 90 min at room temperature then methanol (50 ml) and water (900 ml) are added. The mixture is extracted with ether, the ethereal solution is washed with water, dried with sodium sulfate, and evaporated. After several chromatographic separations by column chromatography with petroleum ether/ether (10:1) on aluminium oxide (grade II–III), a colourless oil is obtained; yield: 8.35 g, (91%).

Method B: *Under a nitrogen* atmosphere, acetylene is introduced into liquid ammonia (150 ml) while small pieces of sodium (2.76 g, 120 mmol) are added. Absolute dimethylformamide (100 ml) is added and the ammonia evaporated. 3,5-Bis[12-bromododecyl]-1,2-dimethoxybenzene[17] (9.49 g, 15 mmol) in dimethylformamide (80 ml) is added dropwise at room temperature. After being heated at 70° for 3 h, the reaction mixture is cooled and poured into a mixture of ice and water. The mixture is extracted with ether, the organic layer is washed with water, dried with sodium sulfate, and evaporated. The residue is purified as described in Method A; yield 5.75 g (73%).

^{1}H-N.M.R. (CCl_4): $\delta = 1.05$–1.69 (m, 40H, CH_2), 1.75 (t, 2H, $-C\equiv CH$, $J = 2$–3 Hz), 1.90–2.29 (m, 4H, $-C\equiv C-CH_2-$), 2.29–2.70 (m, 4H, $Ar-CH_2$), 3.72, 3.80 (2s, 2 × 3H, $Ar-OCH_3$), 6.46 ppm (s, 2H, $Ar-H$).

In the first fractions of the chromatographic separations a chromatographically not separated mixture (200 mg, 2.5%) of 3-(tetradec-13-ynyl)-5-(tetradeca-12,13-dienyl)-1,2-dimethoxybenzene and 5-(tetradec-13-ynyl)-3-(tetradeca-12,13-dienyl)-1,2-dimethoxybenzene could be isolated as a colourless oil; $R_F = 0.29$ (aluminium oxide, petroleum ether/ether 10 : 1).

^{1}H-N.M.R. (CCl_4): $\delta = 1.05$–1.70 (m, 38H, CH_2), 1.77 (t, 2H, $-C\equiv C-H$, $J = 2.5$ Hz), 1.85–2.30 (m, 4H, $-C\equiv C-CH_2-$, $-C\underline{H}_2-CH=C=C<$), 2.30–2.75 (m, 4H, $Ar-CH_2-$), 3.72, 3.80 (2s, 2 × 3H, $-OCH_3$), 4.38–4.77 (m, 2H, $>C=C=CH_2$), 4.77–5.20 (m, 1H, $-C\underline{H}=C=CH_2$), 6.35 ppm (s, 2H, $Ar-H$).

1,2-Bis[3,4-dimethoxy-5-(tetradec-13-ynyl)-phenyl]ethane (7):
As described for **2**, lithium acetylenide, prepared from butyllithium (24 ml, 48 mmol) and acetylene in tetrahydrofuran (24 ml), is reacted with 1,2-bis[12-chlorododecyl-3,4-dimethoxyphenyl]ethane[16] (5.64 g, 8 mmol) in hexamethylphosphoric triamide (32 ml). The crude reaction mixture obtained after hydrolysis was filtered with benzene over aluminium oxide and then recrystallised; yield: 5.1 g (92%).

^{1}H-N.M.R. (CCl_4): $\delta = 1.10$–1.70 (m, 40H, $>CH_2$), 1.78 (t, 2H, $-C\equiv CH$, $J = 2$–3 Hz), 1.95–2.35 (m, 4H, $-C\equiv C-CH_2-$), 2.35–2.70 (m, 4H, $Ar-C\underline{H}_2-CH_2-CH_2-$), 2.76 (m, 4H, $Ar-CH_2-CH_2-Ar$), 3.72, 3.75 (2s, 2 × 6H, $Ar-OCH_3$), 6.37 to 6.58 ppm (m, 4H, $Ar-H$).

This work is dedicated to Professor Eugen Müller on the occasion of his 70th birthday.

We thank the Deutsche Forschungsgemeinschaft and the Fonds der Chemischen Industrie for support of this work.

Received: April 17, 1975

---

[1] W. Ziegenbein in *Chemistry of Acetylenes*, H. G. Viehe, Ed., Marcel Dekker, New York, 1969, p. 169ff.
W. Ziegenbein, *Einführung der Äthinyl- und Alkinyl-Gruppe in organische Verbindungen*, Verlag Chemie, Weinheim, 1963, p. 5ff.
T. L. Jacobs in *Organic Reactions*, Vol. V, R. Adams, Ed., J. Wiley, New York, 1949, p. 1ff.

[2] G. Eglinton, A. R. Galbraith, *J. Chem. Soc.* **1959,** 889.

[3] E. F. Jenny, K. D. Meier, *Angew. Chem.* **71,** 245 (1959).

[4] T. F. Rutledge, *J. Org. Chem.* **24,** 840 (1959).

[5] M. Kracht, H. Pasedach, *German Patent* 944311, June 14, 1956, Badische Anilin & Soda Fabrik; *C. A.* **52,** 16194 (1958).

[6] T. Matsuoka, et al., *Bull. Chem. Soc. Japan* **45,** 1825 (1972).

[7] J. F. Normant, *Bull. Soc. Chim. France* **1965,** 859.

[8] H. Normant, T. Cuvigny, J. Normant, B. Angelo, *Bull. Soc. Chim. France* **1965,** 3446.

[9] W. N. Smith, O. F. Beumel, Jr., *Synthesis* **1974,** 441.
R. Sood, M. Nagasawa, C. J. Sih, *Tetrahedron Lett.* **1974,** 423.

[10] D. N. Brattesani, C. H. Heathcock, *Synth. Commun.* **3**, 245 (1973).
N. Gilman, B. Holland, *Synth. Commun.* **4**, 199 (1974).
[11] M. Schwarz, R. M. Waters, *Synthesis* **1972**, 567.
J. H. P. Tyman, J. Caplin, *Chem. Ind. (London)* **1973**, 40.
[12] G. Schill, U. Keller, *Synthesis* **1972**, 621.
[13] M. Lespieau, *C. R. Acad. Sci. Paris* **178**, 1565 (1924).
R. Lespieau, *Bull. Soc. Chim. France* [4] **37**, 421 (1925).
[14] M. Lespieau, *C. R. Acad. Sci. Paris* **184**, 460 (1927).
R. Lespieau, *Bull. Soc. Chim. France* [4] **43**, 1189 (1928).
L. Canonica, M. Martinolli, T. Bacchetti, *Atti Accad. Nazl. Lincei, Cl. Sci. Fis. Mat. Nat., Rend.* **13**, 61 (1952); *C. A.* **47**, 11131 (1953).
[15] G. Schill, K. Murjahn, *Chem. Ber.* **104**, 3587 (1971).
[16] To be published.
[17] G. Schill, *Chem. Ber.* **99**, 2689 (1966).