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Regioselective synthesis of functionalized homophthalates by cyclizations of 1,3-bis-(trimethylsiloxy)-1,3-butadienes with α -allenylesters

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Abstract

Reaction of 1,3-bis-(trimethylsiloxy)-1,3-butadienes with α -allenylesters resulted in regioselective formation of functionalized homophthalates which represent useful building blocks for natural product syntheses. © 2000 Elsevier Science Ltd. All rights reserved.

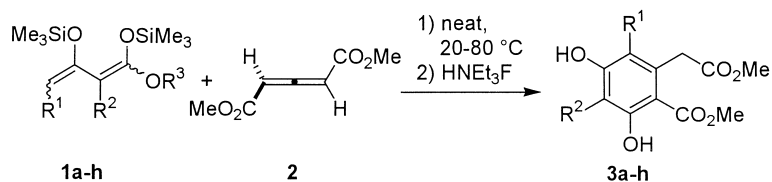
Despite numerous reports of cycloaddition reactions of alkynes there is a relative paucity of work on the use of allenes as dienophiles in Diels–Alder reactions.¹ This is presumably due to the instability of many allenes under the increased temperatures required for cycloaddition reactions. In the course of our interest in cyclization reactions of dianion synthons we have recently reported² cyclizations of 1,3-bis-(trimethylsiloxy)-1,3-butadienes, synthons of 1,3-dicarbonyl dianions,³ with oxalic acid dielectrophiles to give γ -alkylidenebutenolides. Herein, we wish to report, to the best of our knowledge, the first cycloaddition reactions of allenes with 1,3-bis-(trimethylsiloxy)-1,3-butadienes.⁴ These reactions provide a convenient and regioselective access to a variety of functionalized homophthalates which are of interest as building blocks in the synthesis of natural products.⁴

Our first attempts to induce a cyclization reaction of dimethyl allenedicarboxylate **2**⁵ with 1,3-bis-(trimethylsiloxy)-1,3-diene **1a** were unsuccessful: when the reaction was carried out in toluene, no conversion was observed at 20°C. In contrast, at elevated temperatures, decomposition was observed. Equally disappointing results were observed, when the reaction was carried out in CH₂Cl₂ in the presence of Lewis acids. In contrast, a clean cyclization could be induced when the neat starting materials were stirred at 20°C for 1 h to give homophthalate **3a**.^{4,6} Optimal yields (up to 75%) were obtained for **3a** when the reaction mixture was worked up using triethyl ammonium fluoride⁷ in 95% ethanol. Formation of **3a** can be explained by regioselective cyclization

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and subsequent aromatization by fluoride-induced cleavage of the trimethylsilyl groups and elimination of ethanol (Table 1).

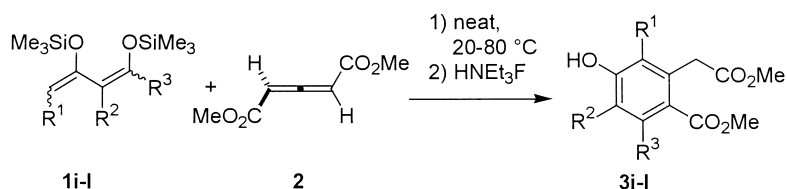
Table 1



3	R ¹	R ²	R ³	T [°C], (t [h])	%	3	R ¹	R ²	R ³	T [°C], (t [h])	%
a	H	H	OEt	20 (1)	75	e	Bn	H	OEt	70 (10)	42
b	Me	H	OMe	20 (5)	55	f	Allyl	H	OEt	20 (14)	60
c	Et	H	OEt	20 (14)	43	g	OMe	H	OMe	20 (18)	40
d	Bu	H	OEt	20 (14)	38	h	H	Me	OEt	20 (14)	32

In order to study the preparative scope of the cyclization reaction the substituents of the 1,3-bis-(trimethylsilyloxy)-1,3-butadienes were systematically varied. Reaction of allene **2** with 1,3-bis-(trimethylsilyloxy)-1,3-dienes **1b-f**, containing a methyl-, ethyl-, butyl-, benzyl-, and allyl group at the terminal carbon atom, afforded the homophthalates **3b-f** in good yields and with very good regioselectivities. Reaction of **2** with 4-methoxy-1,3-bis-(trimethylsilyloxy)-1,3-diene **1g** afforded the highly functionalized homophthalate **3g**. Starting with the 1,3-bis-(trimethylsilyloxy)-1,3-diene **1h**, containing a methyl group at the central carbon atom, the homophthalate **3h** was isolated (Table 2).

Table 2



3	R ¹	R ²	R ³	T [°C], (t [h])	%	3	R ¹	R ²	R ³	T [°C], (t [h])	%
i	H	H	Me	20 (1)	55	k	H	CO ₂ Me	Me	70 (10)	20
j	H	Me	Me	20 (14)	44	l	H	H	Ph	70 (10)	40

Reaction of allene **2** with the diketone derived 1,3-bis-(trimethylsilyloxy)-1,3-dienes **1i-l** resulted in regioselective cyclization and elimination of water upon treatment with HNEt₃F to give the homophthalates **3i-l**. These products contain an alkyl or an aryl group (R³) rather than a hydroxy group at carbon C-5. Starting with the dienes derived from acetylacetone, 2-methyl-acetylacetone, methyl 2-acetyl-acetoacetate and benzoylacetone, the homophthalates **3i-l** were prepared in good yields.

Acknowledgements

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References

- (a) De Schrijver, J.; De Clerq, P. J. *Tetrahedron Lett.* **1993**, *34*, 4369; (b) Spitzner, D.; Klein, I. *Liebigs Ann. Chem.* **1990**, 63; (c) Gibbs, R. A.; Bartels, K.; Lee, R. W. K.; Okamura, W. H. *J. Am. Chem. Soc.* **1989**, *111*, 3717; (d) Reich, H. J.; Eisenhart, E. K.; Olson, R. E.; Kelly, M. J. *J. Am. Chem. Soc.* **1986**, *108*, 7791; (e) Hayakawa, K.; Nishiyama, H.; Kanematsu, K. *J. Org. Chem.* **1985**, *50*, 512; (f) Fink, M.; Gaier, H.; Gerlach, H. *Helv. Chim. Acta* **1982**, *65*, 2563; (g) Danishefsky, S.; Singh, R. K.; Gammill, R. B. *J. Org. Chem.* **1978**, *43*, 379; (h) Kozikowski, A. P.; Floyd, W. C.; Kuniak, M. P. *J. Chem. Soc., Chem. Commun.* **1977**, 582; (i) Banville, J.; Brassard, P. *J. Chem. Soc., Perkin Trans. 1* **1976**, 1852.
- (a) Langer, P.; Stoll, M. *Angew. Chem.* **1999**, *111*, 1919; *Angew. Chem., Int. Ed.* **1999**, *38*, 1803; (b) Langer, P.; Schneider, T.; Stoll, M. *Chem. Eur. J.* **2000**, in press; (c) Langer, P.; Holtz, E. *Angew. Chem.* **2000**, accepted for publication.
- (a) Chan, T.-H.; Brownbridge, P. *J. Am. Chem. Soc.* **1980**, *102*, 3534; (b) Molander, G. A.; Cameron, K. O. *J. Am. Chem. Soc.* **1993**, *115*, 830.
- Homophthalate **3a** has been previously prepared and used for the synthesis of a naphthoate precursor to olivin, see: Roush, W. R.; Murphy, M. *J. Org. Chem.* **1992**, *57*, 6622.
- Bryson, T. A.; Dolak, T. M. *Org. Synth.* **1977**, *57*, 62.
- Procedure for the preparation of homophthalate **3a**: To neat allene **2** (0.315 ml, 1.2 mmol) was added neat diene **1a** (410 mg, 1.5 mmol) at 0°C under nitrogen. The reaction mixture was stirred at 20°C for 1 h. The solution was then treated with a solution of triethylammonium fluoride (230 mg, 1.8 mmol) in 96% ethanol (2 ml). The solution was diluted with water and repeatedly extracted with ether. The combined organic extracts were dried (MgSO₄), filtered and the solvent of the filtrate was removed in vacuo. The residue was purified by column chromatography (silica gel, ether/petrol ether = 1:1) to give **3a** as a colorless solid (215 mg, 75%): ¹H NMR (MeOH-*d*₄, 200 MHz): 3.70, 3.81 (s, 2×3H, CH₃), 3.82 (s, 2H, CH₂), 6.23, 6.25 (2×d, 3 Hz, 2×1H, CH). ¹³C NMR (MeOH-*d*₄, 50 MHz): 43.26, 52.10, 52.38, 103.07, 105.05, 114.19, 140.01, 164.24, 166.43, 172.36, 174.19. MS (70 eV, *m/z*): 240 (M⁺, 20). Anal. calcd for C₁₁H₁₂O₆: C, 55.00; H, 5.04. Found: C, 55.25; H, 4.92. All new compounds gave satisfactory spectroscopic and analytical and/or high resolution mass data.
- Hung, S.; Wehner, G. *Synthesis* **1975**, 180.