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PROPARGYLOXY KETONE ENOL ETHER-CLAISEN REARRANGEMENT. SYNTHESIS OF ALLENYL KETONES FROM PROPARGYL ALCOHOLS

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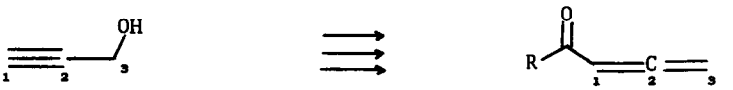
The Claisen rearrangement is effective for 1,3-transposition of oxygen and carbon functions, and continues to play an increasingly important role in synthetic methodology.[1] We recently demonstrated a method for conversion of allyl alcohols into 1,3-transposed allyl ketones involving Claisen rearrangement of allyloxy ketone enol silyl ethers.[2] We now report an analogous new approach to the synthesis of allenyl ketones 2 from propargyl alcohols 1 via Claisen rearrangement of propargyloxy ketone enol silyl ethers.



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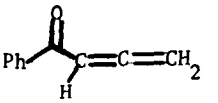
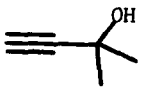
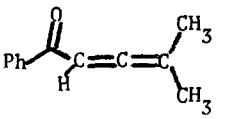
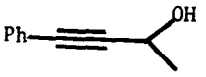
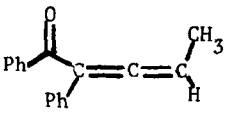
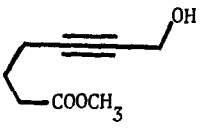
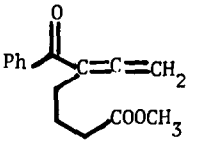
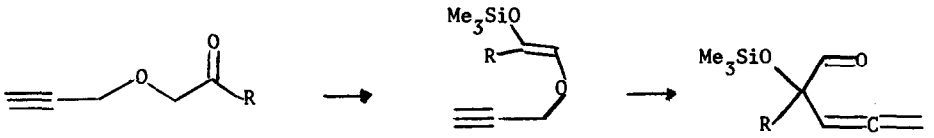
Two methods were examined for the conversion of propargyl alcohols 1 into α-propargyloxy ketones 3 (see table): conversion of 1 into the corresponding tri-n-butyltin propargyloxide[3] and treatment of the latter with an α-bromoketone[4] (method A); treatment of 1 with a diazoketone and rhodium acetate catalyst[5] (method B). We found that α-propargyloxy ketones 3 afford α-allenyl-α-trimethylsiloxy aldehydes 5 upon treatment with chlorotrimethyl silane and triethyl amine in dimethyl formamide. This conversion presumably involves Claisen rearrangement *in situ* of intermediate enol silyl ethers 4.[6] In a one-pot procedure, the α-siloxy aldehydes 5 were

Table. Preparation of Allenyl Ketones from Propargyl Alcohols

ENTRY	PROPARGYL ALCOHOL 1	PROPARGYLOXY KETONE 3 (% yield)	α-SILOXY ALDEHYDE 5 (% yield)	ALLENYL KETONE 2	% YIELD
a		61-64[a,b]	83		88
b		64[a,b]	79		72
c		63[b]	92		81
d		73[b]	88		90

(a) Tin propargyloxide method: (b) Diazoketone method
Physical data:
3-Phenacyloxyprop-1-yne (3a): PMR (CCl_4) δ2.40(1H,t,J=3Hz), 4.28(2H,d,J=3Hz), 4.69(2H,s), 7.2-8.0 (5H); bp 105°/1.0mm. 3-Methyl-3-phenacyloxybut-1-yne (3b): PMR (CCl_4) δ 1.52(6H,s), 2.55(1H,s), 4.86(2H,s), 7.2-7.7(3H,m), 7.8-8.1(2H,m); bp 90°/1.0mm. 3-Phenacyloxy-1-phenylbut-1-yne (3c):PMR (CCl_4) δ 1.55(3H,d,J=6Hz), 4.59(1H,q,J=6Hz), 4.78(2H,s), 7.1-7.7(8H,m), 7.8-8.1(2H,m). Methyl 7-phenacyloxyhept-5-ynoate (3d): PMR ($CDCl_3$) δ 1.5-2.6(6H), 3.62(3H,s), 4.31(2H,t,J=2Hz), 4.78(2H, s), 7.1-7.6(3H,m), 7.8-8.1(2H,m). (4a): PMR ($CDCl_3$) δ 0.0(9H,s),4.77(2H,d,J=7Hz), 5.44(1H,dd, J=6, 7Hz), 7.0-7.5(5H,m), 9.48(1H,s). (4b): PMR ($CDCl_3$) δ 0.0(9H,s), 1.53(6H), 5.18(1H,m), 7.0-7.5(5H,m), 9.48(1H,s). (4c): PMR (CCl_4) δ 0.0(9H,s), 1.87(3H,d,J=7Hz), 5.53(1H,q,J=7Hz), 6.9-7.6 (10H), 9.37(1Hs). (4d): PMR ($CDCl_3$) δ 0.0(9H,s), 1.3-2.3(6H), 3.33(3H,s), 4.7-4.9(2H,m), 6.9-7.4 (5H,m), 9.36(1H,s). 1-Phenyl-2,3-butadien-1-one (2a): PMR (CCl_4) δ 5.16(2H,d,J=6Hz), 6.29(1H,t, J=6Hz), 7.1-7.6(3H), 7.7-8.0(2H); IR (neat) 1630, 1750, 1920, 1950 cm^{-1}; mass spectrum (70eV)m/e (rel intensity) 51(32), 77(53), 105(100), 144(21). 4-Methyl-1-phenyl-2,3-pentadien-1-one (2b): PMR (CCl_4) δ 1.80(6H,d,J=3Hz), 5.9-6.2(1H,m), 7.2-7.5(3H), 7.6-7.9(2H); mass spectrum (70eV)m/e (rel intensity) 51(28), 77(60), 105(100), 172(50). 1,2-Diphenyl-2,3-pentadien-1-one (2c): PMR ($CDCl_3$) δ 1.73(3H,d,J=7Hz), 5.61(1H,q,J=7Hz), 7.0-7.6(8H), 7.7-8.0(2H); IR (neat) 1600, 1630-1770, 1950 cm^{-1}; mass spectrum (70eV)m/e (rel intensity) 51(24), 77(57), 82(32), 84(31), 105(100), 117 (98), 145(13), 234(11). Methyl 5-benzoyl-5,6-heptadienoate (2d): PMR ($CDCl_3$) δ 1.67-2.7(6H), 3.65 (3H,s), 5.0-5.2(2H,m), 7.2-7.6(3H), 7.6-7.9(2H); IR (neat)1630, 1720, 1920 cm^{-1}; mass spectrum (70eV)m/e(rel intensity) 77(25), 105(48), 117(51), 119(46), 128(15), 157(23), 170(24), 244(27).



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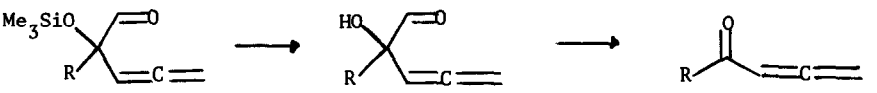
hydrolyzed to α-hydroxy aldehydes with a water-methanol solution and a trace of p-toluenesulfonic acid, and then oxidatively cleaved with periodate to give allenyl ketones 2.[7]



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The examples presented in the table show the versatility of this new synthetic method. It can accommodate terminal (entries a and b) or internal (entries c and d) alkynes, as well as primary (entries a and d), secondary (entry c), or tertiary (entry b) propargyl alcohols. Furthermore, it can tolerate reactive functionality such as carbomethoxyl group (entry d). Previous methods for conversion of propargyl alcohols or halides into allenyl ketones are not as generally applicable.[8,9] The present method complements syntheses of allenyl ketones by the reaction of allenyl Grignard reagents[10] with esters and amides.[11]

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References and Notes

1. Reviews: (a) A. Jefferson and F. Scheinmann, Quart. Rev. (London), 22, 391 (1968); (b) D.J. Faulkner, Synthesis, 175 (1971); (c) S.J. Rhoads and N.R. Rawlins, Org. React., 22, 1 (1975); (d) G.B. Bennett, Synthesis, 589 (1977).

2. J.L.C. Kachinski and R.G. Salomon, Tetrahedron Lett., 3235 (1977).

3. A. Davies, D. Kleinschmidt, P. Palan, and S. Vasistha, J. Chem. Soc., (C), 3972 (1971): Tri-n-butyltin propargyloxide; A solution of propargyl alcohol (5.8 mL) and bis-(tri-n-butyltin)oxide (15.3 mL) in benzene (40 mL) is boiled under reflux with azeotropic removal of water (Dean-Stark trap) until water separation ceases. After removal of solvent and excess alcohol, the residual oil is distilled under reduced pressure to give 19.4g (94%), bp 115°/0.4mm; PMR (CCl_4) δ 0.7-1.8(27H), 2.29(1H,t,J=2Hz), 4.28(2H,d,J=2Hz). Tri-n-butyltin α,α-dimethylpropargyloxide is prepared analogously, bp 105°/0.2mm; PMR (CCl_4) δ 0.7-1.8(33H), 2.26(1H,s).

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5. R. Paulissen, H. Reimlinger, E. Hayez, A. Hubert, and P. Teyssie, Tetrahedron Lett., 2233 (1973); also see N. Petinoit, A.J. Anciaux, A.F. Noels, A.J. Hubert and P. Theysie, ibid., 1239 (1978).

6. The silylation was performed exactly as described for the preparation of enol silyl ethers: H.O. House, L.J. Czuba, M. Gall, and H.D. Olmstead, J. Org. Chem., 34, 2324 (1969).

7. The siloxy aldehyde 5 (1 mmol) is combined with methanol (5 mL), water (1 mL), and a catalytic amount of p-toluenesulfonic acid (1 to 3 mg). Two phases are present initially, but after boiling under reflux with magnetic stirring for a few minutes, a homogeneous solution is obtained. The hydrolyzed product is then oxidized *in situ* by addition of aqueous periodic acid (1.3 mL of a 1.0M solution). Reaction progress for both the hydrolysis and oxidation, which generally require about 15 min for each reaction, must be monitored by thin layer chromatography on silica gel (chloroform as developing solvent) since excessively long reaction times cause reduced yields. The α-siloxy aldehyde 5b requires longer hydrolysis (1 hr) and oxidation (1 hr). The oxidation is quenched by addition of ethylene glycol (50 μL). The mixture is diluted with water and the product extracted into pentane (3 x 20 mL). The crude allenyl ketones are generally better than 80% pure by pmr. Pure samples for analysis are obtained by preparative vapor-liquid phase chromatography or by preparative thin layer chromatography on silica gel.

8. For substitution with 1,3-transposition of an acyl group for a propargyl alcohol, applicable only to terminal alkynes and requiring a harsh reduction step with lithium aluminum hydride, see: J.S. Cowie, P.D. Landor and S.R. Landor, J. Chem. Soc., Chem. Commun., 541 (1969).

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