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ALLENES AND ACETYLENES XXVI. ORGANOCUPRATE REACTIONS OF 1,3-ALKADIEN-2-YL PHOSPHATES. A NEW APPROACH TO THE SYNTHESIS OF ALLENES

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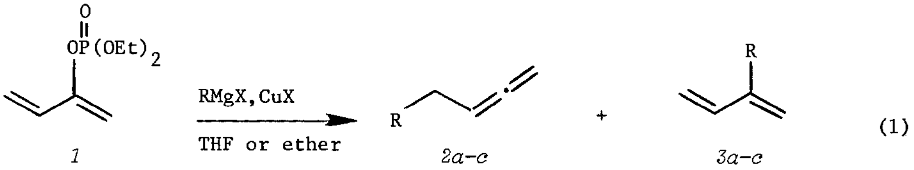
Abstract. Allenic hydrocarbons and one γ-allenic ketone were prepared in poor to good yields by the reactions of diethyl 1-methylene-2-propenyl phosphate and diethyl 1-(1-cyclohexenyl)vinyl phosphate with various organocuprates.

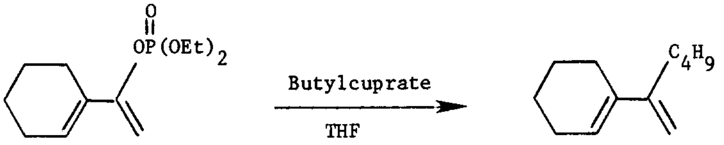
The interest in practical aspects of allenes such as their use as intermediates in organic synthesis[1a] and as biologically active compounds[1b] has increased during recent years. The most important synthetic route to the 1,2-alkadiene system consists of various 1,3-substitution (S_N2') reactions of propargylic derivatives.[1c,2] Other modes of formation like the ring opening of cyclopropyl carbenes, sigmatropic rearrangements and various elimination reactions have considerably less general applicability.[1c,3] We report here a new approach to the formation of the allene system. Although the scope of this new reaction is uncertain we believe that it can be developed into a useful synthetic method for quite a number of allenes. In short it consists of a 1,3-substitution reaction of a 1,3-alkadien-2-ol phosphate with an organocuprate reagent formed from a Grignard reagent and a copper(I) salt (Eq. 1). In most reactions we have used diethyl 1-methylene-2-propenyl phosphate[4] (*1*). The results of these reactions are summarized in the Table.[5]



a, R = benzyl *b*, R = octyl
c, R = cyclohexyl

Compound *1* belongs to a class of unsaturated phosphates which is virtually unknown in the literature.[4] We have found that such compounds are readily available by the addition of a THF solution of a lithium 1,3-dien-2-olate to a slight excess of diethyl chlorophosphate at -70 °C. Inverse addition is essential. Phosphates *1* and *4* were purified by silica gel column chromatography (light petroleum-ether). Typical yields of phosphate *1* on a 50 mmol scale were in the range of 60-70 % while compound *4*, in a single experiment, was obtained in 45 % yield from 1-cyclohexenyl-1-ethanone. Compound *1* is stable for at least one month in the freezer whereas the more substituted phosphate *4* appears to be more unstable.

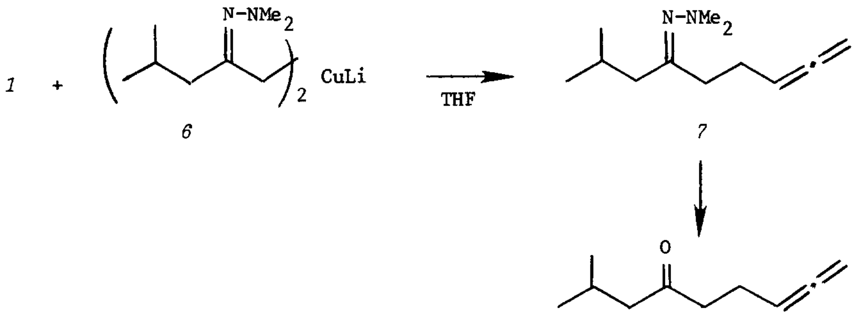
Inspection of the Table reveals that when benzylmagnesium chloride was used in the reaction with *1* the best yield of allenes was obtained by using CuI in not too large relative amount. It was not possible to completely suppress the concurrent formation of a conjugated diene (*3a-c*) resulting from direct substitution of the phosphate group. On the contrary it was possible to form the diene *3a* to the exclusion of the allene product *2a* by using 20 % of the complex $Me_2S \cdot CuBr$ (run 4). In fact, when we applied the above type of reaction to the phosphate *4* (Eq. 2) we could detect only the conjugated diene *5*. Lithium dibutylcuprate and BuMgBr plus a copper(I) salt both gave this result. GLC yields were in the range of 20-40 %. Furthermore, by using a nickel(II) catalyst in the reactions of phosphate *1* with Grignard reagents it was possible to obtain the conjugated diene as the sole product and in good yield.[6,7]



4 *5* (2)

The copper-catalyzed formation of the allenes *2b* and *2c* proceeded in even lower yields and less selectivily than that of *2a* (Table).

We also tried the reaction of phosphate *1* with an organocuprate (*6*) derived from a heteroatom-stabilized anion (Eq. 3). This reaction surprisingly afforded only the allenic

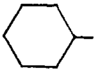


6 *7* (3)

8 (45 %)

hydrazone *7*. The crude product was not purified but was hydrolyzed by leaving it on a silica gel column for a couple of hours and then eluting with pentane. In this way the pure ketone *8* could be isolated in a yield of 45 %. The Cu^{2+}-catalyzed procedures for hydrazone hydrolysis, which were developed by Corey and Knapp,[8] met with considerably less success.

Table. Copper(I)-catalyzed reactions of phosphate *1* with Grignard reagents in THF.

Run	RMgX(equiv.)[a]	CuX (%)[b]	Allene (% yield)[c]	Diene (% yield)[c]
1	PhCH$_2$MgCl(3)	CuI(10)	*2a*(41)[d]	*3a*(6)[d]
2	PhCH$_2$MgCl(5)	CuI(10)	*2a*(72)	*3a*(12)
3[e]	PhCH$_2$MgCl(5)	CuI(20)	*2a*(54)	*3a*(7)
4	PhCH$_2$MgCl(5)	CuBr·Me$_2$S(20)	*2a*(<3)	*3a*(50)
5	OctylMgBr(5)	CuBr·Me$_2$S(50)	*2b*(21)	*3b*(6)
6	 MgBr(4)	CuI(20)	*2c*(23)	*3c*(7)

[a] Number of equivalents of halide used in the preparation of Grignard reagent.

[b] Counted on the halide used in the preparation of the Grignard reagent.

[c] GLC yield using internal standard (mesitylene or isopropylbenzene) if not otherwise stated.

[d] Yield of product in a distilled mixture of diene and allene.

[e] Solvent diethyl ether.

Although the present reactions have not been optimized, useful yields of allenes can still be isolated as shown for the hydrocarbon *2a* and the ketone *8*. Further studies are needed to elucidate the full potential of this type of reaction.[9]

REFERENCES AND NOTES

1. *The Chemistry of the Allenes*, S.R. Landor (ed.), Academic Press, London 1982. (a) A. Claesson and L.I. Olsson, Vol. 3, 735, (b) A. Claesson, Vol. 3, 709, (c) P.D. Landor in Vol. 1.
2. L.I. Olsson and A. Claesson, *Acta Chem. Scand.* 1979, *B33*, 679; T. Sato, M. Kawashima and T. Fujisawa. *Tetrahedron Lett.* 1981, 2375 and references cited in these papers.
3. L. Brandsma and H.D. Verkruijsse. *Synthesis of Acetylenes, Allenes and Cumulenes*, Elsevier, Amsterdam 1981; M. Murray, in Houben-Weyl, *Methoden der Organischen Chemie*, Thieme Verlag 1977, *Band 5/2a*, 963.

4. F. Kienzle and P. Rosen. *Helv. Chim. Acta,* 1979, *62*, 442. These authors prepared compound *1* in a low yield by the Perkow reaction of 3,4-dichloro-2-butanone and subsequent elimination of HCl.

5. Pure products were isolated by preparative GLC (Carbowax 20M or OV-25).

6. A. Quader, C. Sahlberg and A. Claesson, unpublished results.

7. Other authors have reported that the nickel-catalyzed reactions of 2-chloro-1,3-butadiene with Grignard reagents also give rise to conjugated dienes, see A. Hosomi, M. Saito and H. Sakurai, *Tetrahedron Lett.* 1979, 429.

8. E.J. Corey and S. Knapp, *Tetrahedron Lett.* 1976, 3667.

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