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SYNTHESIS OF CONJUGATED DIENES BY NICKEL-CATALYZED REACTIONS OF 1,3-ALKADIEN-2-YL PHOSPHATES WITH GRIGNARD REAGENTS

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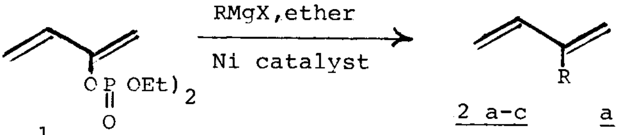
Abstract. 2-Substituted 1,3-alkadienes were prepared in good yields by reactions of diethyl 1-methylene-2-propenyl phosphate and diethyl 1-methylene-3-phenyl-2-propenyl phosphate with various Grignard reagents in the presence of nickel(II) catalysts.

In a recent communication we described some reactions of diethyl 1,3-alkadien-2-yl phosphates with organocuprates.[1] Since the reactions in most cases proceed via 1,3-substitution (S_N2' reaction) they represent a novel approach to the synthesis of allenes. We did, however, notice the concurrent formation of conjugated diene products resulting from direct substitution of the diethyl phosphate group (*cf.* Eq. 1). Such 2-substituted dienes are valuable intermediates in many syntheses,[2] especially of natural products, and we therefore tried to optimize their formation. In this connection, it turned out that certain nickel salts are suitable catalysts. Many 2-substituted 1,3-alkadienes can thus be obtained from readily available[1] diethyl 1-methylen-2-propenyl phosphates.[3]



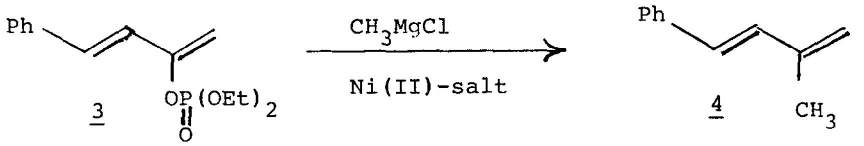
(1)

1

2 a-c a, R=phenyl
b, R=benzyl c, R=octyl

The reaction conditions comprise the following steps: (i) addition of the Ni(II)-catalyst (2.5 mole %) to a Grignard reagent (2.7 equiv.) in ether under nitrogen at room temperature, (ii) after 15 min, addition of the phosphate (1 equiv.), (iii) the reaction was stirred until no starting material was left and (iv) hydrolysis with 0.1 M HCl and ether extraction followed by standard work-up procedures afforded the dienes.[4] The results of these Ni-catalyzed reactions of the phosphate 1[1] with different Grignard reagents (Eq. 1) and the phosphate 3[5] with methylmagnesium chloride (Eq. 2), are summarized in the Table.

Three different Ni(II) phosphine complexes were tested and as can be seen in the Table, the bridged catalysts, $NiCl_2(Ph_2PCH_2CH_2PPh_2)$ = $[NiCl_2(dppe)]$ and



(2)

$NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$ = [$NiCl_2$(dppp)], are superior to $NiCl_2(PPh_3)_2$ (*cf.* entries 1,2 and 3 in the Table). In the reactions of phosphate 3 with MeMgCl, $NiCl_2$(dppe) was somewhat better than $NiCl_2$(dppp). The method is applicable to Grignard reagents derived from phenyl-, benzyl-, and primary alkyl halides. The method does not, however, seem to be applicable to secondary Grignard reagents, since preliminary studies (not shown in the Table) with cyclohexylmagnesium bromide and 1-methylbutylmagnesium bromide indicated only minor amounts (< 5%) of dienes. Further inspection of the Table (entry 7) shows that THF also can be used as the solvent in this reaction.

Entry[a]	Phosphate	RMgX	Catalyst	Diene	Yield (%)[b]
1	1	PhMgBr	$NiCl_2(PPh_3)_2$	2a	24
2	1	PhMgBr	$NiCl_2$(dppe)	2a	64
3	1	PhMgBr	$NiCl_2$(dppp)	2a	67
4	1	$PhCH_2MgCl$	$NiCl_2$(dppp)	2b	55
5	1	$C_8H_{17}MgBr$	$NiCl_2$(dppp)	2c	78
6	3	CH_3MgCl	$NiCl_2$(dppp)	4	57
7[c]	3	CH_3MgCl	$NiCl_2$(dppp)	4	54
8	3	CH_3MgCl	$NiCl_2$(dppe)	4	69

[a] Molar ratio of phosphate:Grignard reagent:catalyst is 1.5:4:0.1
[b] GC yield using ethylbenzene as internal standard [c] Solvent THF

REFERENCES AND NOTES

1. A. Claesson, A. Quader and C. Sahlberg, *Tetrahedron Lett.* 1983, 1297.
2. K.J. Shea and P.Q. Pham, *Tetrahedron Lett.* 1983, 1003 and references cited.
3. Other authors have reported the analogous nickel-catalyzed reaction of 2-chloro-1,3-butadiene with Grignard reagents, see A. Hosomi, M. Saito and H. Sakurai, *Tetrahedron Lett.* 1979, 429.
4. The reactions were monitored by GC, using a 2.7 m 5% OV-25 column. The compounds were isolated by preparative GC on a 2.7 m 20% OV-25 column and characterized by NMR and IR spectroscopy.
5. After purification on neutral aluminia, this compound was obtained in a yield of 59% following the general procedure described in ref. 1.

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