

## Regio- and Stereo-specific Allylation of Grignard Reagents using Allylic Phosphates

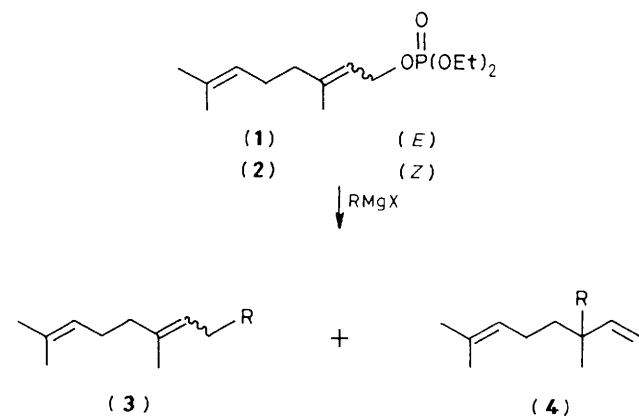
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Geranyl and neryl diethyl phosphates are found to react regio- and stereo-specifically with a variety of Grignard reagents giving high yields of coupling products.

Although the reactions of trialkyl and triaryl phosphates with Grignard reagents have been investigated in detail,<sup>1</sup> few examples of the Grignard reaction of allylic phosphates have been reported so far. In 1969, Wood and his co-workers described<sup>2</sup> the reaction of geranyl diphenyl phosphate with phenylmagnesium bromide in refluxing diethyl ether to give a coupling product, 3,7-dimethyl-1-phenylocta-2,6-diene, in 69% yield. However, the resulting diene was a mixture of (*E*)- and (*Z*)-stereoisomers in the ratio of 75:25. The similar Grignard coupling with neryl diphenyl phosphate has also been reported to be non-stereospecific.

We report the regio- and stereo-specific coupling of geranyl (1) and neryl (2) diethyl phosphates with Grignard reagents (Scheme 1). The reactions were conducted in tetrahydrofuran (THF) at room temperature,<sup>†</sup> and the products,



Scheme 1

<sup>†</sup> The following procedure is representative. To a solution of phenylmagnesium bromide, prepared from magnesium (5 mmol) and phenyl bromide (5 mmol) in THF (5 ml), was added (1) (2.8 mmol) in THF (5 ml) at room temperature. The mixture was left overnight, and then quenched with saturated aqueous ammonium chloride. The usual work-up and column chromatography on silica gel gave the products (97%) which were analysed by g.l.c.

after hydrolysis, were purified by distillation or column chromatography before characterization.<sup>‡</sup> As shown in Table 1, the reaction of the allylic phosphates (1) and (2) with a variety (alkyl, aryl, allyl, benzyl, and ethynyl) of Grignard reagents proceeded smoothly to afford high yields of coupling products. Gas chromatographic analyses of the products revealed that all the reactions were regio- and stereo-specific to yield the corresponding (*E*)- and (*Z*)-olefins when starting with the geranyl (1) and neryl (2) phosphates, respectively, though with *n*-hexylmagnesium bromide the regioselectivity was lower. These results contrast sharply with the report of Wood *et al.*,<sup>2</sup> probably owing to differences in the reaction conditions and the phosphates used. The alkylative cyclization of the neryl phosphate (2) with trialkylaluminum has been reported,<sup>3</sup> but in the present Grignard reaction no trace of cyclized products could be found.

Although examined only with primary allylic phosphates, the good yields, mild experimental conditions, and high regio- and stereo-specificity of these reactions promise to provide a synthetically useful method leading to carbon-carbon bond

Table 1. Results of the Grignard reactions of geranyl (1) and neryl (2) diethyl phosphates.

Diethyl phosphate	RMgX	Yield/%	Product ratio <sup>a</sup> (3) ( <i>E</i> / <i>Z</i> ):(4)
Geranyl (1)	<i>n</i> -C <sub>6</sub> H <sub>13</sub> MgBr	89	92 (100/0):8
"	PhMgBr	97	99 (99/1):1
"	CH <sub>2</sub> =CHCH <sub>2</sub> MgCl	80	100 (100/0):0
"	PhCH <sub>2</sub> MgCl	79	99 (99/1):1
"	PhC≡CMgBr	72	100 (99/1):0
Neryl (2)	<i>n</i> -C <sub>6</sub> H <sub>13</sub> MgBr	87	89 (0/100):11
"	PhMgBr	92	59 (4/96):1
"	CH <sub>2</sub> =CHCH <sub>2</sub> MgCl	77	100 (0/100):0
"	PhCH <sub>2</sub> MgBr	72	98 (1/99):2
"	PhC≡CMgBr	66	100 (4/96):0

<sup>a</sup> Determined by g.l.c. using an Apiezone Grease L column (2 m).

<sup>‡</sup> All new compounds gave satisfactory elemental analyses and spectroscopic data.

formation at the  $\alpha$ -position of an allylic system without loss of stereochemistry.<sup>4</sup>

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  - 4 For a recent review, see R. M. Magid, *Tetrahedron*, 1980, **36**, 1901.
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