

[1,3]-SIGMATROPIC SHIFTS OF ALKOXIDES

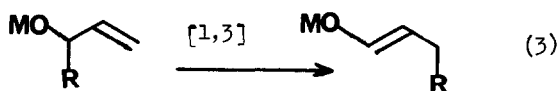
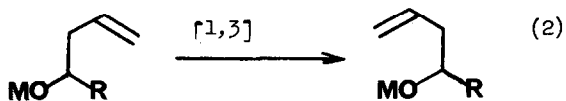
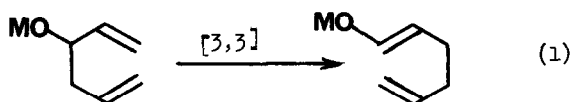
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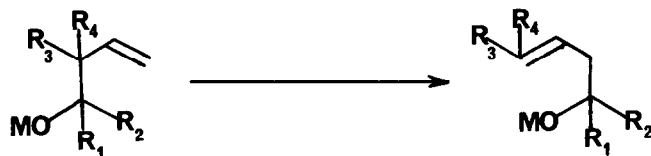
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The report by Evans¹ that [3,3]-sigmatropic rearrangements (eq 1) are strongly accelerated



when $M = K$ has led us to investigate the effect of the potassium alkoxide substituent on [1,3]-sigmatropic rearrangements (eq. 2 and 3).

Apparent [1,3]-shifts of alkoxides have been reported as early as 1966⁵ and certain anomolous Grignard reactions have been known for a very long time.⁶ Benkeser⁷ reported "the first documented case of a reversible Grignard reaction" in 1969. He showed that the initial adduct of crotyl magnesium bromide and di-tert-butyl ketone was the more hindered alkoxide 1a which slowly rearranged to 2a.⁸



- | | | | |
|-----|---|-----|---|
| 1a. | $R_1=R_2=\text{tert-butyl}$
$R_3=\text{H}, R_4=\text{CH}_3$
$M=\text{MgX}$ | 2a. | $R_1=R_2=\text{tert-butyl}$
$R_3=\text{H}, R_4=\text{CH}_3$
$M=\text{MgX}$ |
| b. | $R_1=\text{H}, R_2=n\text{-C}_6\text{H}_{13}$
$R_3=\text{H}, R_4=\text{CH}=\text{CH}_2$
$M=\text{ZnBr}$ | b. | $R_1=\text{H}, R_2=n\text{-C}_6\text{H}_{13}$
$R_3=\text{H}, R_4=\text{CH}=\text{CH}_2$
$M=\text{ZnBr}$ |
| c. | $R_1=\text{H}, R_2=\text{C}_6\text{H}_5$
$R_3=\text{CH}_3, R_4=\text{CH}=\text{CH}_2$
$M=\text{K}$ | c. | $R_1=\text{H}, R_2=\text{C}_6\text{H}_5$
$R_3=\text{CH}_3, R_4=\text{CH}=\text{CH}_2$
$M=\text{K}$ |
| d. | $R_1=\text{OLi}, R_2=\text{CH}_3$
$R_3=R_4=\text{CH}_3$
$M=\text{Li}$ | d. | $R_1=\text{OLi}, R_2=\text{CH}_3$
$R_3=R_4=\text{CH}_3$
$M=\text{Li}$ |

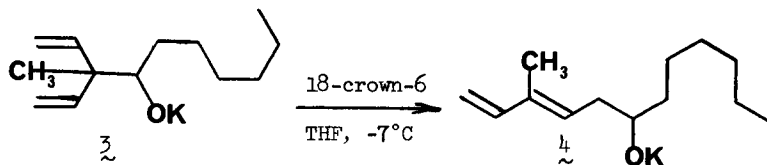
This reaction has been pursued in a number of elegant papers by Miginiac,¹⁰ who investigated MgBr and ZnBr salts in a wide variety of solvent systems. For example, the rearrangement 1b → 2b requires > 100 hours in refluxing THF. The bis-alkoxide rearrangement 1d → 2d has also been reported.¹¹

We have determined that the so-called "reversible Grignard reaction" is strongly cation dependent and, as a [1,3]-sigmatropic shift, is subject to the same sorts of solvent effects as the [3,3]-shifts reported by Evans.¹ Whereas the magnesium or zinc salts^{7,9,10} usually require several days at 65° or above, the potassium salt 1c rearranges rapidly to 2c below room temperature.¹² A summary of a number of [1,3]-sigmatropic shifts in this series is outlined in Table 1.

Table 1: Solvent and Cation Effects on the Rearrangement 1 → 2

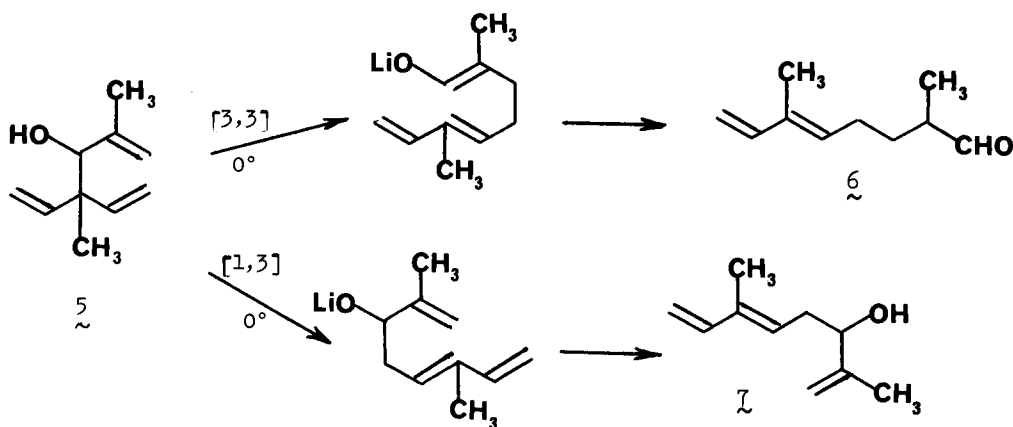
Entry	R ₁	R ₂	R ₃	R ₄	M	Solvent	Temp.	Half-Life
1.	n-C ₆ H ₁₃	H	CH=CH ₂	CH ₃	Li	THF	65°	4 hours
2.	n-C ₆ H ₁₃	H	CH=CH ₂	CH ₃	Na	THF	65°	2 hours
3.	n-C ₆ H ₁₃	H	CH=CH ₂	CH ₃	Na	THF/Crown	0°	30 min
4.	n-C ₆ H ₁₃	H	CH=CH ₂	CH ₃	Na	HMPA	0°	30 min
5.	n-C ₆ H ₁₃	H	CH=CH ₂	CH ₃	K	THF	0°	10 min
6.	n-C ₆ H ₁₃	H	CH=CH ₂	CH ₃	K	Et ₂ O	0°	40 min

A clear trend is seen in going from covalent to more highly ionized salts: $K > Na > Li$. The reaction is also accelerated by highly ionizing solvents $HMPA > THF > Ether$ and by complexing agents 18-crown-6 or 15-crown-5. For example, the rearrangement $\underline{3} \rightarrow \underline{4}$ has a half-life at $-7^\circ C$ of 40 minutes, but in the presence of one equivalent of 18-crown-6, the reaction is complete in

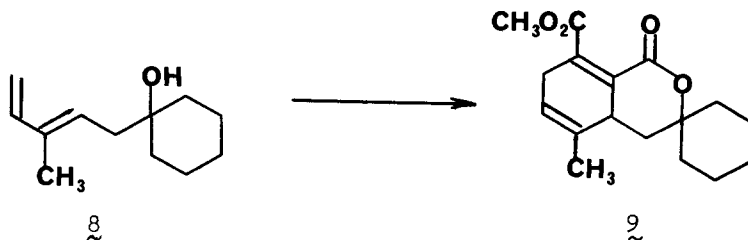


5 minutes!

Our initial interest in diene rearrangements of this type derived from investigations of new methods for terpene synthesis.¹³ The lithium salt of $\underline{5}$ ¹³ has available both [3,3] and [1,3]-sigmatropic rearrangement pathways. The Cope rearrangement is virtually the exclusive reaction.¹⁴



An important feature of the [1,3] shifts described in this work is that the geometry of the trisubstituted double bond in the product is exclusively E. Thus, the reaction constitutes a new trisubstituted olefin synthesis and yields 1,3-dienes suitable for Diels-Alder reactions. For example, compound $\underline{8}$ yields Diels-Alder adduct $\underline{9}$ when heated with dimethylacetylene dicarboxylate



at 45° overnight. Synthetic and mechanistic studies are currently being pursued and will form the basis of subsequent reports.

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REFERENCES AND NOTES

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12. Yields for reactions reported here are in the 60-80% range. All new compounds possess spectral and analytic data consistent with the assigned structures.
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14. This contrasts with the rearrangements reported by Thies⁴ in which the [1,3] shift predominates.