

STEREOELECTRONICALLY CONTROLLED [2,3]WITTIG REARRANGEMENT OF
ISOPROPYL 2'-HETEROSUBSTITUTED-2'-ALKENYLOXYACETATES

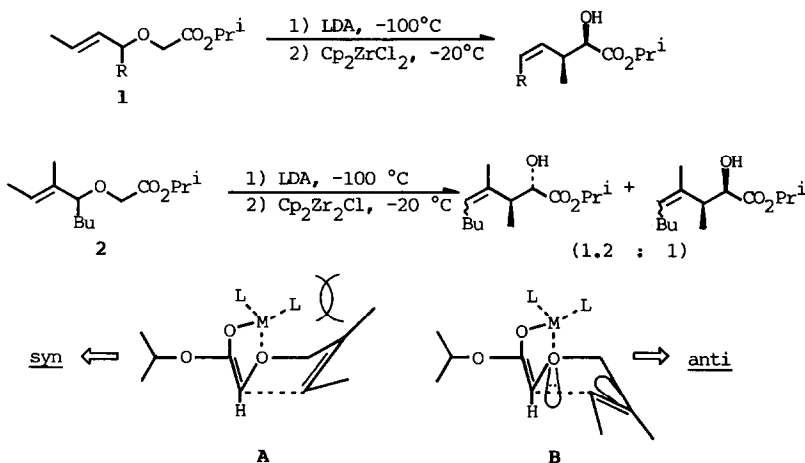
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Summary: [2,3]Wittig rearrangement of 2'-heterosubstituted alkenyloxyacetic acid esters exhibited anti,Z-selectivity, which can be attributed to the interaction between the nonbonding orbital on the ether oxygen atom and the anti-bonding orbital of carbon-heteroatom bond.

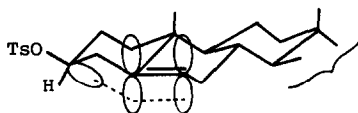
Quite a few stereoselective [2,3]Wittig rearrangement reactions have so far been reported and the stereochemistry of their products has mostly been explained in terms of steric factors.^{1,2)} Here, we wish to describe examples where stereoelectronic effect should also be counted as an important factor in their stereocontrol.

Recently we reported a zirconium-mediated [2,3]Wittig rearrangement of isopropyl (E)-2'-alkenyloxyacetates (1) which proceeded with high syn,Z-selectivity.^{2b)} As an extension of this study, we examined the rearrangement of isopropyl (E)-1'-butyl-2'-methyl-2'-butenyloxyacetate (2) and found that the reaction exhibited opposite anti-selectivity, though of a low level (Scheme 1). This unexpected result may be rationalized by the steric repulsion between the C-2' substituent and a ligand on metal



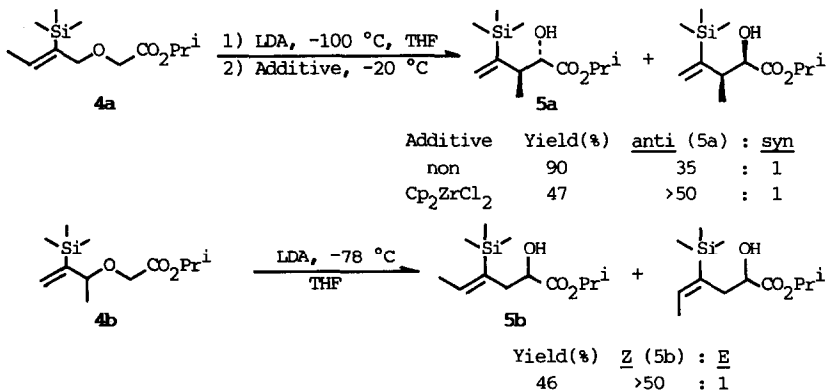
Scheme 1

ion, which makes the conformer (A) leading to the syn-isomer unfavorable. However, it is well known that the solvolysis of cholesteryl tosylate (3) is greatly accelerated by the π - σ^* interaction, as compared with that of 5 α -cholestan-3 β -yl tosylate (Fig. 1).³⁾ Since the spatial arrangement of the n-orbital of the ether oxygen atom and the σ^* -



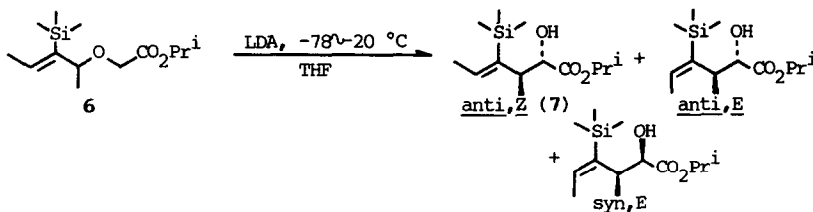
3
Fig. 1

orbital of the bond of C-2' carbon and C-2' substituent in the conformer (B) is very similar to that of π - and σ^* -orbitals of 3, we thought that the n- σ^* interaction also contributed to the stabilization of B and that high anti-selectivity would be realized if an appropriate σ^* -orbital of a low energy level existed. It is obvious that the conformer (A) has the unsuitable orbital arrangement for the n- σ^* interaction. The σ^* -orbital of C-Si bond is known to partly contribute to the stabilization of its α -carbanion through the interaction of both orbitals.⁴⁾ Thus we examined the rearrangement of isopropyl 2'-trimethylsilyl-2'-alkenyloxyacetate (4),⁵⁾ where both stereoelectronic and steric effects by trimethylsilyl group were expected to cooperate in favor of anti,Z-selection.⁶⁾ Actually the rearrangement of compounds (4a and 4b) provided anti- (5a)⁷⁾ and Z-isomers (5b), respectively, with high stereoselectivity, as shown in Scheme 2.

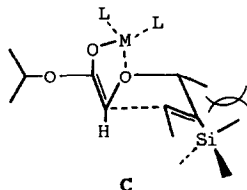


Scheme 2

The above effect seems to hold to a considerable extent even in a very crowded substrate such as 6. It gave anti,Z-isomer (7) still as a major product (Scheme 3), though the yield was poor. In this case, a bulky trimethylsilyl group is situated inbetween a vinylic cis-methyl and C-1' syn-methyl group, the steric repulsion between them being considered to destabilize the conformer (C) to a large extent.

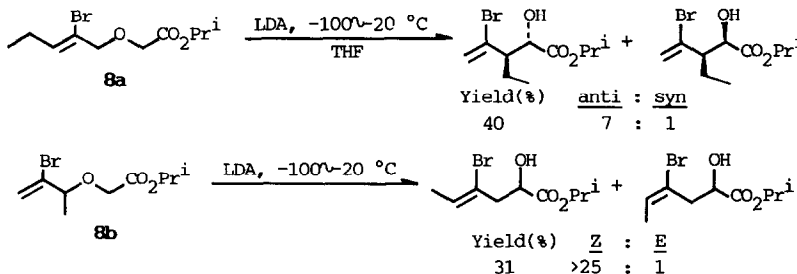


Yield(%) anti,Z : anti,E : syn,E
 10 3.6 : 1.0 : 1.6



Scheme 3

Next, we examined the rearrangement of isopropyl (Z)-2'-bromo-2'-alkenyloxyacetates (**8a** and **8b**).⁵⁾ In these substrates, it is considered that the stereoelectronic effect also acts in favor of anti- or Z-isomer formation but that the steric effect is smaller than that in **2**. In accord with this discussion, the rearrangement of **8a** showed a level of anti-selectivity between **4a** and **2** (Scheme 4).



Scheme 4

This type of $n-\sigma^*$ interaction may explain some unusual phenomena which often appear in reactions of compounds having heteroatom(s). For example, extremely effective kinetic resolution of dl-heterosubstituted allylic alcohols⁸⁾ may be partly rationalized by this interaction,⁹⁾ which contributes the stabilization of the conformation of allylic alcohols required for the epoxidation.¹⁰⁾

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References and Notes

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- 3) D. N. Kirk and M. P. Hartshorn, "Steroid Reaction Mechanism," Elsevier Publishing Company, New York (1968).
- 4) The stabilization of the carbanion alpha to silicon has also been attributed to the interaction of 2p-orbital and the empty 3d orbital on silicon.
- 5) Starting materials (**4**, **6**, and **8**) were prepared as follows: **4a**; (*Z*)-1-trimethylsilyl-1-propenylmagnesium bromide (**i**) prepared according to Sato's procedure (ref. 11), was treated with 1,3-dioxolane in the presence of trimethylsilyl iodide (ref. 12) and the resulting 2-(2-trimethylsilyl-2-butenyloxy)ethanol was submitted to oxidation followed by esterification, giving **4a**. **4b**; it was prepared from 1-trimethylsilylvinylmagnesium bromide in the same manner as described for **4a**, except that 2-methyl-1,3-dioxolane was used instead of 1,3-dioxolane. **6**; it was also prepared from **i** in the same manner as described for **4a**, except that 2-methyl-1,3-dioxolane was used instead of 1,3-dioxolane. **8a**; 2-[(*E*)-2-trimethylsilyl-2-pentenyl]oxyethanol prepared in a similar manner to that described for **4a**, was treated with bromine (ref. 13) and the resulting (*Z*)-bromo alcohol was converted to **8a**. **8b**; the treatment of **4b** with bromine gave **8b**.
- 6) Note that, although the double bond of the rearrangement product of **1** and that of **4b**, **6**, or **8b** have the same *Z*-configuration on the basis of *E,Z*-nomenclature, they have opposite geometry to each other.
- 7) All the products gave satisfactory spectroscopic analyses and their stereochemistry was established by appropriate chemical correlations.
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