ACYCLIC STEREOSELECTION IN THE REACTION OF CHIRAL ALLYLSILANES WITH ELECTROPHILES

Cristina Nativi^b, Giovanni Palio^a and Maurizio Taddei^{a*}

^aDipartimento di Chimica Organica "U.Schiff", Università di Firenze, Via G.Capponi 9, 50121 Firenze Italy and ^bCentro CNR Composti Eterociclici, Via G.Capponi 9 50121 Firenze, Italy.

Summary. The presence of a stereocenter close to the double bond of an allylsilane has an influence on the stereochemistry of the reaction with electrophiles. The stereoselectivity follows the rule of electrophilic attack on a trigonal carbon adjacent to a stereogenic center proposed by Houk. From chiral allylsilanes and achiral aldehydes it is possible to prepare homo allyl alcohols with three stereocenters with a good stereoselectivity.

The stereochemistry of the reaction of substituted allylsilanes with electrophiles is affected by the nature of the substituents. The influence of a stereocenter on the α carbon of the allylic fragment (allylsilane of type I in Scheme 1) has been widely investigated.¹ The effect of a stereocenter present on one ligand of the silicon atom (allylsilane of type II in Scheme 1) has also been studied.² Only a brief examination of the situation we represented as III in Scheme 1 has been previously reported relatively to epoxidation, deuterodesilylation and reaction with chlorosulfonyl isocyanate.³



We report here the results of the reaction of allylsilanes, containing a stereogenic center in position 4 with respect to the SiR₃ group (type III in Scheme 1), with several electrophiles, showing that the influence of this stereocenter on the stereoselectivity of the reaction can be rationalized using the model of approach of nucleophiles to double bonds (Houk model)⁴ so that this type of allylsilane can be successfully employed in the synthesis of chiral molecules.

We used *E* allylsilanes as starting materials.⁵ 1-(Trimethylsilyl)-3-phenyl-2-pentene (1) was prepared in a 9:1 *E/Z* ratio using the Seyferth-Fleming-Paterson allylsilane synthesis starting from 2phenylpropanal.⁶ Allylsilanes 2 and 3 were prepared starting from the corresponding alkenes 4 and 5 by metallation with butyllithium and potassium *tert*-butoxide in THF at -78°C and, after 2 h at this temperature, reaction of the allyl potassium derivatives with trimethylchlorosilane.⁷ (Scheme 2)



The π system of allylsilanes 1-3 has two diastereotopic faces and the level of the stereocontrol in the reaction with electrophiles could be related to the nature of the substituents on the allylsilane stereocenter.

We performed the reactions of 1-3 with electrophiles which do not need the presence of a Lewis acid, such as *m*-chloroperoxybenzoic acid (MCPBA), phenylsulfenyl chloride (PhSCI) and chlorosulfonyl isocyanate (CSI), or with aldehydes activated by TiCl4.

The stereoselectivity of the reaction with small electrophiles, such as MCPBA,⁸ was quite poor³ as reported in Table 1. Better results in terms of selectivity were obtained using PhSCl⁹ and CSl¹⁰, as reported in Table 2.







The stereochemistry of the major products was found to be 2RS(2S^{*}, 3S^{*}) and was proved, for compounds **9** and **12**, by separation of the major isomer by column chromatography on silica gel and the chemical correlations¹¹ reported in Scheme 3.



The results of the condensation of allylsilanes 1-3 with acetaldehyde or 2-methylpropanal in the presence of TiCl₄ are reported in Table 3.¹² The stereochemistry of the major products was proven in the case of compounds 19 and 22 by the chemical correlations¹³ described in Scheme 4 and was found to be 2RS(2S*, 3S*, 4R*).





a)Gic yields refert to 1-octanol employed as internal standard, without the correction due to the calibration factors. b)Determined by glc analysis of the crude reaction mixture The above results were interpreted on the basis of the following considerations: a) in the reactions with electrophiles which do not have prostereogenic faces, increments in the hindrance of R improve the stereoselectivity, and also the size of the electrophile has a relevant effect; b) in the reactions with electrophiles having prostereogenic faces we observed a correlation between the increase in steric hindrance of the R and R' groups and the increase in stereoselectivity.

Two models can then be invoked to describe the mode of approach of the two π systems. The diastereoselection between the π faces of the allylsilanes arises from the transition state A in Scheme 5, which resembles one of those suggested by Houk,⁴ whereas the antiperiplanar transition state⁵ (Model B in Scheme 5) dictates the stereochemistry of the two new stereogenic centers of the products.



We have demonstrated that chiral allylsilanes can be used to prepare molecules with two new stereocenters controlled by the chirality resident in the reagent (it is a case of efficient reagent control)¹⁴. Applications of chiral (and homochiral)¹⁴ allylsilanes in the stereocontrolled synthesis of enantiomerically pure compounds will be the subject of a following report.

References and notes.

1) Fleming, I.; Dunogues, J.; Smithers, R. Org.React. 1989, 37, pag. 66-72. 2) Coppi, L.; Mordini, A.; Taddei, M. Tetrahedron Lett. 1987, 28, 969. Jung, M.E.; Hogan, K.T. Tetrahedron Lett. 1988, 29, 6199. Chan, T.H.; Pellon, P. J.Am.Chem.Soc. 1989, 111, 8737. Nativi, C.; Ravidà, N.; Seconi, G.; Ricci, A.; Taddei, M. J. Org. Chem. 1990, in press. 3) Lewis J.J. Ph.D Thesis, Cambridge University 1986 and Ref. 1. pp 212, 213, 248, 249, 492 and 493. 4) Padden-Row, M.N.; Rondan, N.G.; Houk, K.N. J.Am.Chem.Soc. 1982, 104, 7162. For recent applications see: Fleming, I.; Lewis, J.J. J.Chem.Soc.Chem.Commun. 1985, 149. Fleming, I.; Lawrence, N.J. Tetrahedron Lett. 1990, 31, 3645. 5) It is known that E allylsilanes react with aldehydes in the presence of a Lewis acid with better selectivity than the corresponding Z isomers. Hayashi, T.; Kabeta, K.; Hamachi, I.; Kumada, K. Tetrahedron Lett. 1983, 24, 2865. 6) Sevferth. D.; Wursthorn, K.R.; Mammarella, R.E. J.Org.Chem. 1977, 42, 3104. Fleming, I.; Paterson, I. Synthesis, 1979, 446. 7) Mordini, A.; Palio, G.; Ricci, A.; Taddei, M. Tetrahedron Lett. 1988, 29, 4991 and references therein. 8) The reaction was performed as described in ref. 1 pag. 189. 9) The reaction was performed as described in: Nishiyama, H.; Narimatsu, S.; Itoh, K.; Tetrahedron Lett. 1981, 22, 5285. 10) The reaction was performed as described in: Deleris, G.; Pillot, J.-P.; Rayer, J.-C. Tetrahedron 1980, 36, 2215. 11) ¹H and ¹³C NMR and ir spectra of 11 and 18 were consistent with the hypotesized structures.Mitsudo, T.; Kadokura, M.; Watanabe, Y. J.Org.Chem. 1987, 52, 1695. Vaultier, M.; Truchet, F.; Carboni, B.; Hoffmann, R.W.; Denne, I. Tetrahedron Lett. 1987, 28, 4169. 12) The reaction was performed as described in ref. 1 pag. 185. 13) ¹H NMR spectra were consistent with the hypotesized structures. Hoffmann, R.W.; Herold, T. Chem.Ber. 1981, 114, 375. Mulzer, J.; Zippel, M.; Bruntrup, G.; Segner, J.; Finke, J. Liebigs Ann. Chem. 1980, 1108. 14) Masamune, S.; Choy, W.; Petersen, J.S.; Sita, L.R. Angew.Chem.Int.Ed.Engl. 1985, 24, 1.