Tetrahedron Letters, Vol. 34, No. 32, pp. 5067-5070, 1993
Printed in Great Britain

0040-4039/93 $6.00 + .00
Pergamon Press Ltd

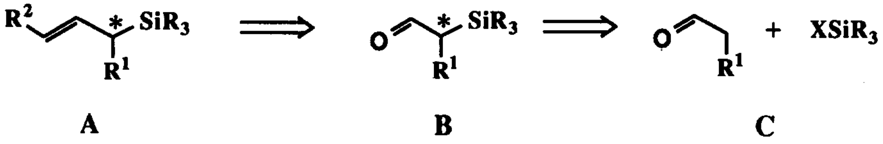
# Efficient Enantioselective Synthesis of Allylsilanes by Wittig Olefination of α-Silylaldehydes

**Vidya Bhushan, Braj B. Lohray and Dieter Enders** *

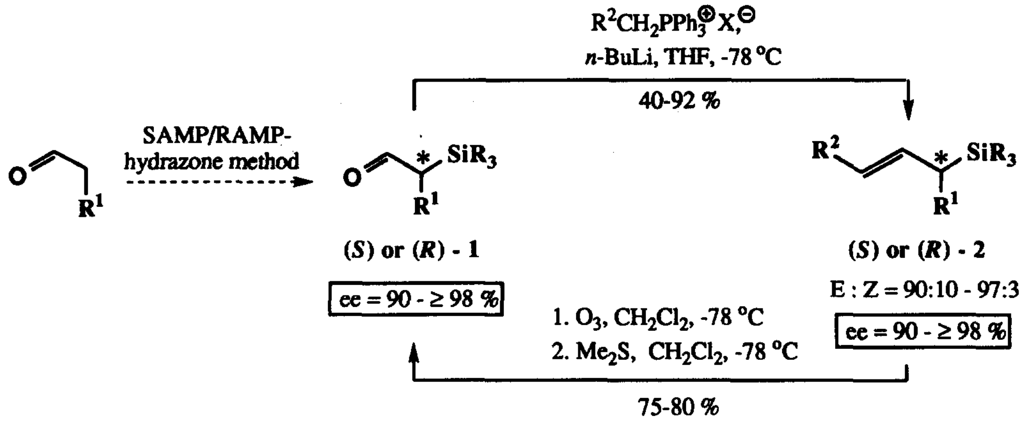
Institut für Organische Chemie, Rheinisch-Westfälische Technische Hochschule,
Professor-Pirlet-Straβe 1, D-52074 Aachen, Germany

**Abstract:** Allylsilanes **2** of high enantiomeric purity (ee = 90 - ≥ 98 %) are prepared in good yields from optically active α–silylaldehydes **1** *via* Wittig olefination with various alkylidene triphenylphosphoranes in high *E:Z* selectivities (90:10 - 97:3) and without racemization of the α-silylaldehydes. The latter are easily obtained from simple aldehydes and silylating agents employing the SAMP/RAMP-hydrazone method.

Allylsilanes are outstandingly useful intermediates in organic synthesis, especially as important carbon nucleophiles reacting with a wide variety of electrophilic reagents in a highly regio- and stereoselective manner [1]. In the last twelve years a large number of methods have been developed for the preparation of allylsilanes [2] and created the basis for the rapid growth of allylsilane chemistry and the numerous synthetic applications of these reagents [1,3]. Recently, the trend has been towards using them in asymmetric synthesis and several general approaches for the synthesis of optically active allylsilanes, such as the Pd-catalyzed asymmetric Grignard cross-coupling reaction [4], the hydrosilylation of olefins [5], and several other techniques [6], have been reported. Chiral allylsilanes of type **A**, bearing the stereogenic center in allylic position α to silicon, may be retrosynthetically traced back to α-silylaldehydes **B** and thus, to simple aldehydes and silylating agents (**C**).



A few years ago we described a general and efficient asymmetric synthesis of α-silylated aldehydes and ketones via SAMP-/RAMP-hydrazones [7] and a number of applications of α-silylated ketones. [8] We now wish to report that α-silylaldehydes **1** can be converted into optically active allylsilanes **2** by a racemization free Wittig reaction with a number of phosphonium ylides in good to excellent yields and high ee-values and E/ Z - ratios (Scheme 1).



Scheme 1

The results are summarized in Table 1. Use of $NaNH_2$ or KDA as a base to generate the alkylidene triphenylphosphoranes lead to substantial racemization of the chiral α-silylaldehydes and therefore, resulted in allylsilanes of lower enantiomeric purity (Table 1, footnote d). On the other hand, use of *n*-BuLi (0.9 equiv.) as the base to generate the ylides at -78 °C from the alkyltriphenylphosphonium salts (1.0 equiv.), followed by slow addition of the ylide to a precooled solution (-78 °C) of α-silylaldehydes (0.5 M in THF) lead to high yields (up to 92 %) of the allylsilanes of high enantiomeric purity (ee = 90 - ≥ 98%) . The enantiomeric excesses of the allylsilanes **2** were determined by polarimetry and chemical correlation. Alternatively, in a few cases the allylsilanes were subjected to ozonolysis followed by reductive work-up with dimethyl sulfide at -78 °C to furnish the parent α-silylaldehydes **1** free of racemization. The stereochemistry of the CC double bond was assigned either by $^{13}C$ NMR spectroscopy or by gas chromatography. As indicated in Table 1, both enantiomers of chiral allylsilanes **2** are available based on the flexibility of the SAMP-/ RAMP-hydrazone method (auxiliary and synthon control)[7,8].

*General procedure for the synthesis of highly enantioenriched allylsilanes:*

To a well stirred suspension of alkyltriphenylphosphonium halide (16 mmol) in dry THF (50 mL) cooled to -78 °C is added *n*-BuLi (10 mmol, 1.6 M in hexane) in *ca.* 20 min under argon atmosphere and the reaction mixture is allowed to warm up to room temperature (*ca.* 20 °C) in 2 h. In a separate flask, the chiral α-silylaldehyde **1** (10 mmol) is dissolved in dry THF (20 mL) with stirring and cooled to -78 °C. The pregenerated ylide is then added slowly to the aldehyde *via* a double ended needle. The color of the ylide disappears instantaneously. The reaction mixture is stirred for additional 1-1.5 h and then poured on crushed ice. The reaction mixture is extraced with pentane (4 x 25 mL) and the organic phase is washed with water (25 mL), brine (25 mL), dried ($MgSO_4$), filtered and evaporated under reduced pressure (*ca.* 20 °C, 15 Torr). The residue is purified by flash chromatography over silica gel (ether:pentane, 1:49, $R_f$ 0.8) to furnish 40-92 % yield of pure allylsilanes. In the case of relatively unstable and highly volatile α-silylaldehydes, the corresponding α-silyl-SAMP-hydrazone is cleaved by ozonolysis in dry pentane at -78 °C and the reaction mixture is used directly for the Wittig olefination after evaporation of the solvent at *ca.* 0 °C under reduced pressure (15 Torr).

Table 1. Synthesis of Optically Active Allylsilanes from α-Silylaldehydes by Wittig Reaction

| Entry | Allylsilanes 2 | | | *E*:*Z* [a] | Yield | $[\alpha]_D^{22}$ | ee [b] | Config. [c] |
|---|---|---|---|---|---|---|---|---|
| | $R^1$ | $R^2$ | $SiR_3$ | | ( % ) | (c in $C_6H_6$) | (%) | |
| 1 | $PhCH_2$ | H | *t*-$BuMe_2Si$ | _ | 92 | +12.2 (1.18) | ≥98 [d] | *R* |
| 2 | $PhCH_2$ | H | $PhMe_2Si$ | _ | 51 [e] | -26.7 (1.06) | [f] | *S* |
| 3 | $PhCH_2$ | H | $Et_3Si$ | _ | 49 [e] | -12.98 (1.15) | f | *S* |
| 4 | $PhCH_2$ | Me | *t*-$BuMe_2Si$ | 94:6 | 92 | +10.93 (1.18) | ≥ 98 [d] | *R* |
| 5 | $PhCH_2$ | Me | $PhMe_2Si$ | 97:3 | 50 [e] | -7.56 (1.14) | 95 [g] | *S* |
| 6 | *n*-$C_6H_{13}$ | H | *t*-$BuMe_2Si$ | _ | 80 | +5.67 (1.02) | ≥ 98 | *S* |
| 7 | *n*-$C_6H_{13}$ | Me | *t*-$BuMe_2Si$ | 97:3 | 81 | -29.8 (1.0) | ≥ 98 | *R* |
| 8 | *n*-$C_6H_{13}$ | Me | *t*-$BuMe_2Si$ | 97:3 | 80 | +30.0 (0.56) | ≥ 98 | *S* |
| 9 | Me | Ph | $Ph_3Si$ | 90:10 | 40 | +18.94 (0.47) | 90 [d,h] | *S* |
| 10 | Me | H | $Ph_3Si$ | _ | 40 | -27.12 (0.95) | [f] | *S* |
| 11 | Me | Me | $Et_3Si$ | 7:93 | 55 [e] | +28.5 (1.03) | 93 [g,h] | *S* |
| 12 | Me | H | *t*-$BuMe_2Si$ | _ | 87 | -25.83 (1.18) | ≥ 98 | *S* |

a) The *E*:*Z* ratio of the allylsilanes was determined by capillary GC and $^{13}C$ NMR spectroscopy. b) Determined by ozonolysis in $CH_2Cl_2$ at -78 °C followed by reductive work up to furnish the starting α-silylaldehydes, which showed no change in optical rotation (Scheme 1). c) Based on the configuration of α–silylaldehyde used. d) Use of $NaNH_2$ or KDA lead to partial racemization (e.g. entry 1, 95 % ee; entry 4, 85 % ee and entry 9, 60 % ee). e) Combined yield of ozonolysis of α-silylaldehyde hydrazones and subsequent Wittig reaction. f) The % ee of these allylsilanes could not be determined accurately. g) Based on the result of an electrophilic reaction of the allylsilane with aldehydes catalyzed by $TiCl_4$.[1a] h) Based on optical rotations in comparison with those reported for the corresponding *E*-allylsilanes.[4c]

In summary, we can offer a simple and efficient method for the synthesis of allylsilanes of high enantiomeric purity in a single step procedure starting from readily available α-silylaldehydes or in four steps from the corresponding aldehydes and silylating agents *via* the SAMP/RAMP-hydrazone method.[9]

**Acknowledgement**: This work was supported by the Fonds der Chemischen Industrie. Generous supply of chemicals from BASF AG and Degussa AG is gratefully acknowledged. V.B. and B.B.L. thank the Alexander von Humboldt Foundation for fellowships.

## References

1. a) Fleming, I.; Dunogues, J.; Smithers, R. *Org. React.* **1989**, *37*, 57. b) Colvin, E. W. *Silicon in Organic Synthesis*; Butterworths, London, 1981. c) Weber, W. P. *Silicon Reagents for Organic Synthesis*; Springer Verlag, Berlin, 1983. d) Colvin, E. W. *Silicon Reagents in Organic Synthesis;* Academic Press, 1988. e) Bassindale, A. R.; Gasper, P. P. Eds. *Frontiers of Organosilicon Chemistry,* The Royal Society of Chemistry, Cambridge, 1991.
2. Sarkar, T. K. *Synthesis* **1990**, 969 and 1101.
3. For some recent applications of allylsilanes see: a) Hosomi, A. *Acc. Chem. Res.* **1988**, *21*, 200. b) Tokoroyama, T.; Pan L.-R. *Tetrahedron Lett.* **1989**, *30*, 197. c) Pernez, S.; Hamelin, J. *Tetrahedron Lett.* **1989**, *30*, 3419. d) Kira, M.; Sato, K.; Sakurai, H. *J. Am. Chem. Soc.* **1990**, *112*, 257. e) Imai, T.; Nishida, S. *J. Org. Chem.* **1990**, *55*, 4849. f) Davis, A. P.; Jaspars, M. *J. Chem. Soc. Chem. Commun.* **1990**, 1176. g) Simpkins, N. S. *Tetrahedron* **1991**, *47*, 323. h) Nishigaichi, Y.; Takuwa, A.; Jodai, A. *Tetrahedron Lett.* **1991**, *32*, 2383. i) Nishitani, K.; Yamakawa, K. *Tetrahedron Lett.* **1991**, *32*, 387. j) Nativi, C.; Palio, G.; Taddei, M. *Tetrahedron Lett.* **1991**, *32*, 1583. k) Funita, K.; Mouri, M.; Yamamoto, H. *Synlett* **1991**, 561. l) Panek, J. S.; Yang, M. *J. Am. Chem. Soc.* **1991**, *113*, 6594. m) Panek, J. S.; Yang, M. *J. Am. Chem. Soc.* **1991**, *113*, 9868.
4. a) Hayashi, T.; Konishi, M.; Ito, H.; Kumada, M. *J. Am. Chem. Soc.* **1982**, *104*, 4962. b) Hayashi, T. *Chem. Scripta* **1985**, *25*, 61. c) Hayashi, T.; Konishi, M.; Okamoto, Y.; Kabeta, K.; Kumada, M. *J. Org. Chem.* **1986**, *51*, 3772.
5. a) Kiso, Y.; Yamamoto, K.; Tamao, Y.; Kumada, M. *J. Am. Chem. Soc.* **1972**, *94*, 4373. b) Yamamoto, K.; Kiso, Y.; Ito, R.; Tamao, K.; Kumada, M. *J. Organometal. Chem.* **1981**, *210*, 9. c) Hayashi, T.; Kabeta, K.; Yamamoto, T.; Tamao, K.; Kumada, M. *Tetrahedron Lett.* **1983**, *24*, 5661. d) Hayashi, T.; Kabeta, K. *Tetrahedron Lett.* **1985**, *26*, 3023.
6. a) Franciotti, M.; Mordini, A.; Taddei, M. *Synlett* **1992**, 137. b) Gais, H.-J.; Bülow, G. *Tetrahedron Lett.* **1992**, *33*, 461. c) Gais, H.-J.; Bülow, G. *Tetrahedron Lett.* **1992**, *33*, 465. d) Fleming, I.; Thomas, A. P. *J. Chem. Soc. Chem. Commun.* **1986**, 1456. e) Mikami, K.; Maeda, T.; Kishi, N.; Nakai, T. *Tetrahedron Lett.* **1984**, *25*, 5151.
7. a) Enders, D.; Lohray, B. B. *Angew. Chem.* **1987**, *99*, 359.; *Angew. Chem. Int. Ed. Engl.* **1987**, *26*, 351. b) Enders, D.; Lohray, B. B.; Bhushan, V. *Chem. Ber.*, submitted.
8. a) Enders, D.; Lohray, B. B. *Angew. Chem.* **1988**, *100*, 594; *Angew. Chem. Int. Ed. Engl.* **1988**, *27*, 581. b) Lohray, B. B. ; Enders, D. *Helv. Chim. Acta.* **1989**, *72*, 980. c) Enders, D.; Nakai, S. *Helv. Chim. Acta.* **1990**, *73*, 1833. d) Enders, D.; Nakai, S. *Chem. Ber.* **1991**, *124*, 219.
9. a) Enders, D.; Eichenauer, H. *Chem. Ber.* **1979**, *112*, 2933. b) Enders D. in *Asymmetric Synthesis;* Morrison, J. D. Ed.; Academic Press: Orlando, 1984; vol. 3, p. 275. c) Enders, D.; Fey, P.; Kipphardt, H. *Org. Synth.* **1987**, *65*, 173, 183.

(Received in Germany 25 May 1993)