

Enantioselective Synthesis of Homo-allylic Alcohols from Chiral Allylic Tin(IV) (+)-Diethyl Tartrate Complexes and Aldehydes

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A quite simple procedure to synthesize optically active secondary homoallylic alcohols from the reaction between aldehydes and allylic tin(IV) complexes containing (+)-diethyl tartrate as chiral auxiliary ligand is reported.

The synthesis of enantiomerically enriched homoallylic alcohols can be performed by condensing η^1 -allylic metal complexes containing optically active auxiliary ligands with prochiral carbonyl compounds. Chiral allylic boranes,¹ boro-

nates,² and more recently stannanes,³ these last containing optically active alkyl substituents on the tin atom, have been used for this purpose.

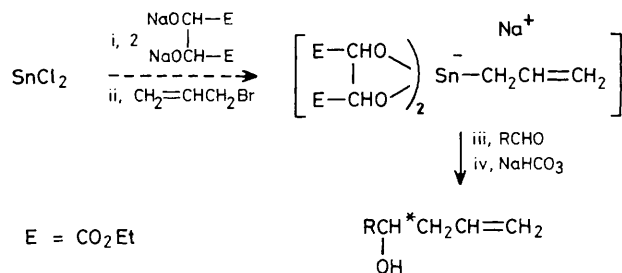
Owing to the possibility of preparing tin(II) alkoxides from

Table 1. Enantioselective syntheses of homoallylic alcohols.^a

Allylic halide	Aldehyde	Reaction time/h	Product (% yield) ^b	$[\alpha]_D^{25}$, deg (c in CCl ₄)	% E.e. (config.)	Ref.
CH ₂ =CHCH ₂ Br	PhCHO	17	PhCH(OH)CH ₂ CH=CH ₂ (82)	-29.0 (7.4) ^c	62(S) ^d	1a
„	Bu ^t CHO	18	Bu ^t CH(OH)CH ₂ CH=CH ₂ (74)	-4.2 (10.9) ^c	36(S)	1a
„	n-C ₈ H ₁₇ CHO	22	n-C ₈ H ₁₇ CH(OH)CH ₂ CH=CH ₂ (78)	+5.8 (2.5)	54(R)	3a
Me ₂ C=CHCH ₂ Br	Me ₂ C=CHCHO	16	Me ₂ C=CHCH(OH)CMe ₂ CH=CH ₂ (72)	+4.4 (0.35)	25(R)	7
CH≡CCH ₂ Br	PhCHO	18	PhCH(OH)CH=C=CH ₂ (58) ^e	+45.6 (1.2)	47(S) ^f	8

^a The reactions were carried out according to the experimental conditions reported in the text. ^b Isolated yields. ^c Benzene as solvent.

^d Carrying out the reaction in 1,2-dimethoxyethane the chemical and optical yield [expressed as % enantiomeric excess (e.e.)] were 71 and 41% respectively. ^e 4-Phenylbut-1-yn-4-ol (8%) is formed as main by-product. ^f 1-Phenylbutan-1-ol obtained from hydrogenation of the dienol (5% Pd on carbon, MeOH, 1 atm H₂) showed $[\alpha]_D^{25} = -19.8$ (c 10, benzene) corresponding to the % e.e. reported.



Scheme 1

SnCl₂⁴ and the ability of tin(II) compounds to oxidatively add to allylic halides,⁵ we have developed a preparation of homoallylic alcohols using optically active allylic tin(IV) complexes containing (+)-diethyl tartrate as chiral auxiliary ligand. Our plan was to prepare allylic tin(IV) tartrate complexes by treating a tin(II) tartrate complex with allylic halides and to examine their reactivity towards aldehydes.

In a series of tests aimed at improving reaction rates and enantioselectivity we found that the best results were obtained when SnCl₂ was allowed to react with two equivalents of (+)-diethyl tartrate disodium salt[†] in tetrahydrofuran (THF),[‡] at -5 °C.§ In a typical experiment (+)-diethyl tartrate (10 mmol) dissolved in THF (10 ml) was added over 10 min to a cold suspension of NaH (20 mmol) in THF (40 ml) with vigorous stirring and under an inert atmosphere. The reaction mixture took on a coagulated consistency. Anhydrous SnCl₂ (5 mmol) was added 10 min after the addition of tartrate, causing a fast fluidization of the reaction mixture. After 30 min the allylic halide (10 mmol) was poured onto the reaction and the reaction mixture further stirred at -5 °C for 5 h to complete the formation of the tin(IV) complex. No direct spectroscopic evidence for the actual tin(IV) complex formed in this process was obtained. Owing to the ability of tin in monoalkylstannanes to expand its valence shell to give penta-, hexa-, and even hepta-co-ordinated species,⁶ we propose that a likely structure is that shown in Scheme 1. Aldehyde (5.5 mmol) was then added and the reaction was followed by capillary gas chromatography (Carbowax 20M); after 15–20 h all the reactions showed 80–85% aldehyde conversion. The reactions took place cleanly, by-products being in general limited to less than 5%. Quenching was carried out by stirring the reaction mixture at -5 °C with 10% aq. NaHCO₃ (10 ml) for 15 min and then at room temperature for 15 min; after filtration, phase separation, and extraction with diethyl ether of the aqueous phase, a series of homoallylic alcohols were

[†] When a 1:1 SnCl₂ (+)-diethyl tartrate disodium salt ratio is used both reaction rates and enantioselectivity are considerably lower.

[‡] Somewhat inferior results are achieved in 1,2-dimethoxyethane (see footnote d in Table 1), while in *N,N*-dimethylformamide enantioselectivity drops to very poor levels. Owing to the insolubility of the reagents involved, this procedure cannot be carried out in diethyl ether.

[§] A good compromise is reached at this temperature between reaction rate and enantioselectivity.

isolated by flash chromatography. Selected results are given in Table 1.

The involvement of all the alkoxide groups of tartrate in bonds to tin was suggested by the absence of self-condensation products when nonanal was used (a small amount of self-condensed products was formed during the reaction quenching with NaHCO₃). The reaction took place with allylic rearrangement and this allowed the synthesis of (+)-Artemisia alcohol starting from 3-methylbut-2-enyl bromide.

Using a similar type of allylic inversion optically active 1,2-dien-4-ols can be prepared *via* an analogous process with prop-2-ynyl bromide. Temperature control is important in this case to minimize the amount of alk-1-yn-4-ols formed (in fact carrying out the reaction reported in Table 1 at 20 °C the 1,2-dien-4-ol:alk-1-yn-4-ol ratio is 2:1).

Finally we report a preliminary result obtained with but-2-enyl bromide (*E*:*Z* = 8:2) and benzaldehyde. 1-Phenyl-2-methylbut-3-en-1-ol produced (77%) was a 2:1 mixture of *threo* and *erythro* isomers exhibiting optical activity [$[\alpha]_D^{23} = -29.0$ (*c* 1.00, benzene)].

Among other applications of this simple procedure which involves common and cheap chemicals, we are now studying the possibility of combining diastereo- and enantio-selectivity in order to build up two chiral centres with defined absolute stereochemistry starting from configurationally pure *E* and *Z* but-2-enyl-type halides.

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References

- (a) H. C. Brown and P. K. Jadhav, *J. Am. Chem. Soc.*, 1983, **105**, 2092; (b) *J. Org. Chem.*, 1984, **49**, 4091; (c) *Tetrahedron Lett.*, 1984, **25**, 1215; (d) H. C. Brown, P. K. Jadhav, and P. T. Perumal, *ibid.*, 1984, **25**, 5111.
- T. Herold and R. W. Hoffmann, *Angew. Chem., Int. Ed. Engl.*, 1978, **17**, 768; R. W. Hoffmann and T. Herold, *Chem. Ber.*, 1981, **114**, 375; T. Herold, U. Schrott, and R. W. Hoffmann, *ibid.*, 1981, **114**, 359; R. W. Hoffmann, A. Endesfelder, and H.-J. Zeiss, *ibid.*, 1982, **115**, 2357; W. R. Roush and R. L. Halterman, *J. Am. Chem. Soc.*, 1986, **108**, 294.
- J. Otera, Y. Kawasaki, H. Mizuno, and Y. Shimizu, *Chem. Lett.*, 1983, 1529; (b) J. Otera, Y. Yoshinaga, T. Yamaji, T. Yoshioka, and Y. Kawasaki, *Organometallics*, 1985, **4**, 1213; (c) a series of patents from Osaka Soda Co., Ltd., recently appeared describing analogous approaches to optically active allylic stannanes: Jpn. Kokai Tokkyo Koho JP 60 67,488 (*Chem. Abstr.*, 1985, **103**, 123711k); 60 67,487 (*ibid.*, 1985, **103**, 123712m); 60 67,486 (*ibid.*, 1985, **103**, 123713n); 70 72,838 (*ibid.*, 1985, **103**, 177960j).
- W. D. Honnick and J. J. Zuckerman, *Inorg. Chem.*, 1978, **17**, 501.
- J. W. Connolly and C. Hoff, *Adv. Organomet. Chem.*, 1981, **19**, 123; E. J. Bulten, *J. Organomet. Chem.*, 1975, **97**, 167; E. J. Bulten, H. F. M. Gruter, and H. F. Martens, *ibid.*, 1976, **117**, 329; T. Mukaiyama, T. Harada, and S. Shoda, *Chem. Lett.*, 1980, 1507; T. Mukaiyama and T. Harada, *ibid.*, 1981, 621.
- A. Tzschach and K. Jurkschat, *Comments Inorg. Chem.*, 1983, **3**, 35.
- C. D. Poulter, L. L. Marsh, J. M. Hughes, J. C. Argyle, D. M. Satterwhite, R. J. Goodfellow, and S. G. Moesinger, *J. Am. Chem. Soc.*, 1977, **99**, 3816.
- Y. Yamamoto, J. Oda, and Y. Inouye, *J. Org. Chem.*, 1976, **41**, 303.