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Allylsilanes in Organic Synthesis; Double Asymmetric Induction in the Dihydroxylation of a Chiral Allylsilane.

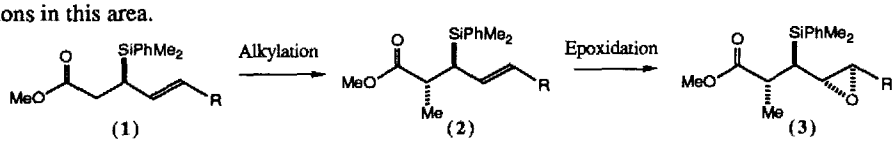
Richard A. Ward and Garry Procter*

Department of Chemistry and Applied Chemistry, University of Salford, Salford, M5 4WT, Great Britain.

Key Words: Allylsilanes; Dihydroxylation; Enantioselective catalysis; Kinetic resolution; Baciphelacin.

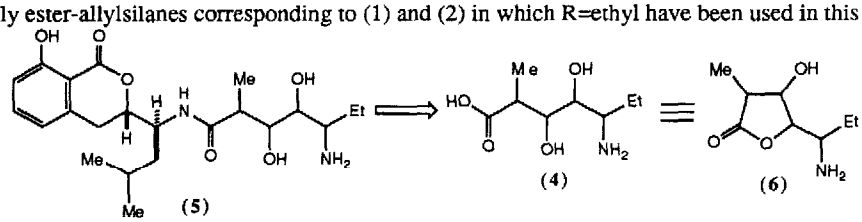
Abstract: *Double asymmetric induction has been used to increase the diastereoselectivity of the dihydroxylation of the allylsilane +(11) using dihydroquinidine p-chlorobenzoate as catalyst.*

Functionalised, chiral allylsilanes have considerable potential as intermediates for stereoselective organic synthesis as the silyl substituent can provide high levels of stereochemical control in the reactions at both 'flanking' prochiral centres, e.g. (1)-(2)-(3).[1] We have been particularly interested in the oxidation of allylsilanes such as (1) and (2) with *meta*-chloroperbenzoic acid (*m*CPBA).[2] A natural extension of these investigations is the dihydroxylation of such allylsilanes using osmium tetroxide. This Letter reports our observations in this area.



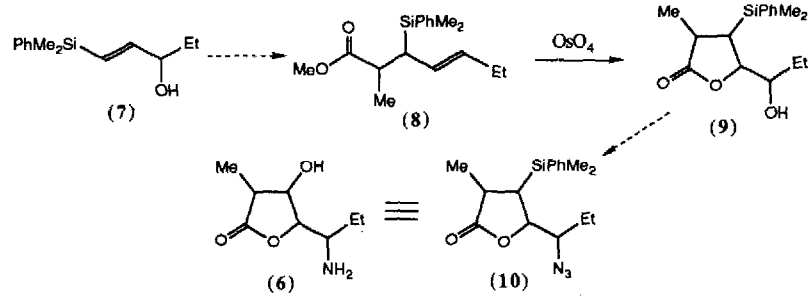
(1) (2) (3)

One of the aims of this work is the development of routes for the construction of the various stereoisomers of the 'amino acid' unit (4) of the antiviral, antileukaemic antibiotic baciphelacin (5).[3] Accordingly ester-allylsilanes corresponding to (1) and (2) in which R=ethyl have been used in this study.



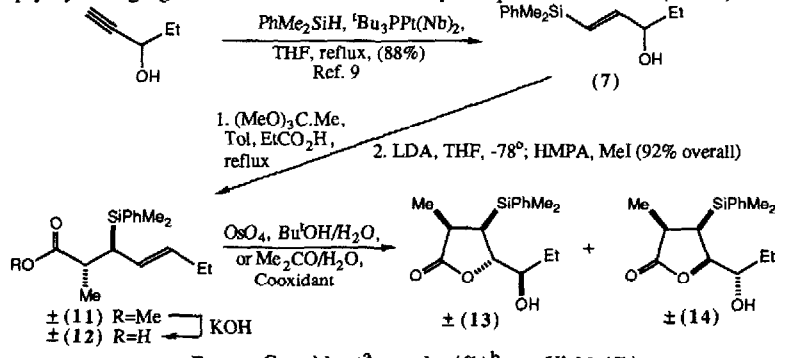
(5) (4) (6)

The general strategy which was adopted for the proposed synthesis of units equivalent to (6) is shown in Scheme 1. The vinylsilane (7), an excellent substrate for Sharpless (epoxidation) kinetic resolution,[4] could be converted into either the *syn*- or *anti*- methylated allylsilane (8) by choice of route[5] and osmium tetroxide mediated dihydroxylation should provide the γ-lactone (9). Conversion of the hydroxyl group into an azide would then produce the desired system (10). The γ-lactone (10) is an attractive synthetic equivalent for (6) since the phenyldimethylsilyl group could be converted into the required hydroxyl group,[6] and the azide should function as a precursor to the amine.



Scheme 1

The dihydroxylation of chiral allylsilanes is known to be less selective than epoxidation (and other related reactions)[7] and the immediate aim of this work was to investigate possible methods for increasing the diastereoselectivity of this step. The racemic *anti*- allylsilanes (11) and (12), prepared as shown in Scheme 2, were studied initially and it was found that the diastereoselectivity of the dihydroxylation could be increased significantly simply by changing the cooxidant from N-methylmorpholine N-oxide (NMO) to ferricyanide.[8]

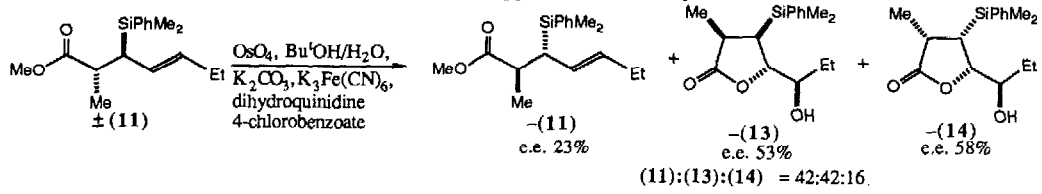


R	Cooxidant[a]	d.e.(%)[b]	Yield (%)
Me	NMO[c]	50	90
Me	$K_3Fe(CN)_6$[d]	70	93
OH	NMO	46	95
OH	$K_3Fe(CN)_6$	66	~80[e]

[a]NMO=N-Methylmorpholine N-oxide; [b]Combined yield of separated (13)+(14); [c]NMO reactions used Me_2CO/H_2O as solvent; [d] $K_3Fe(CN)_6$ reactions used Bu^tOH/H_2O as solvent, and were run in the presence of 3 equivalents of K_2CO_3; [e]Estimated from 1H.nmr spectrum of the crude product.

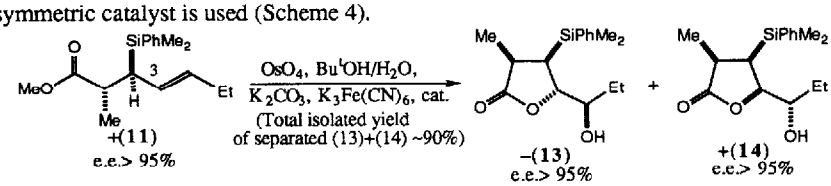
Scheme 2

To investigate the possibility of kinetic resolution of allylsilane (11), dihydroxylation of (11) was carried out using the Sharpless asymmetric catalysts dihydroquinidine and dihydroquinine 4-chlorobenzoates.[10] The results of the reaction using the dihydroquinidine catalyst are shown in Scheme 3. The results with the dihydroquinine catalyst were similar except that the opposite sense of asymmetric induction was observed.

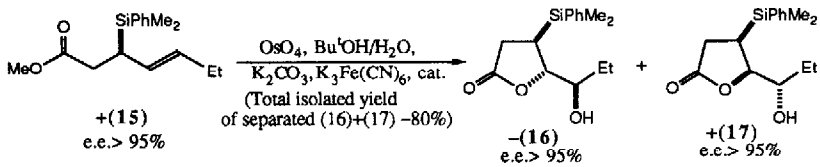


Scheme 3

These results suggested that a moderate amount of 'double asymmetric induction'[11] was occurring in these reactions, and it follows that a 'matched pair' of substrate and catalyst should produce somewhat higher levels of diastereoselectivity in the dihydroxylation of (11). This was shown to be the case by the catalysed reactions of +(11) (>95%e.e.)[12] with the absolute configuration shown in Scheme 4. An interesting result was obtained with +(15) (e.e.>95%). In this case essentially no diastereoselectivity is observed in dihydroxylation without the asymmetric catalysts, and the facial selectivity of the dihydroxylation depends only on which asymmetric catalyst is used (Scheme 4).



cat. = Dihydroquinidine 4-chlorobenzoate, **(13):(14)** = 91:9
cat. = Dihydroquinine 4-chlorobenzoate, **(13):(14)** =43:57

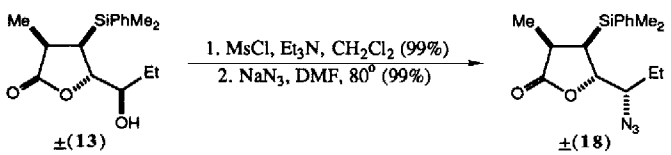


No catalyst, **(16):(17)** = 57:43
cat. = Dihydroquinidine 4-chlorobenzoate, **(16):(17)** = 87:13
cat. = Dihydroquinine 4-chlorobenzoate, **(16):(17)** = 13:87

Scheme 4

The matched pair of +(11) and the dihydroquinidine catalyst is that expected from the known facial selectivity of the reactions of these systems. In this case the catalyst favours attack on the face of the double bond *anti*-to the silicon (assuming that reaction occurs in a conformation with H-3 *syn*-planar with the double bond),[1] which corresponds to the intrinsic selectivity of (11).

In order to achieve the synthesis of one diastereoisomer of the desired unit for the baciphelacin amino acid (*inter alia*), replacement of the hydroxyl group of ±(13) with azide was investigated. After mesylation the displacement with sodium azide was found to be clean and high yielding, thereby providing (18) as a single diastereoisomer.



In conclusion we have demonstrated that it is possible to achieve relatively high diastereoselectivity in the dihydroxylation of a functionalised, chiral allylsilane, and that the lactone (13) can provide a synthetic equivalent for the amino acid portion of the antiviral antibiotic baciphelacin.

Acknowledgement: We thank Wellcome and the SERC for a CASE studentship (to R.A.W.).

References

1. For an excellent review of this topic see I. Fleming, J. Dunoguès, and R. Smithers: The Electrophilic Substitution of Allylsilanes and Vinylsilanes. In *Organic Reactions*; R. Bittman, E. Ciganek, H.W.

Gschwend, S. Hanessian, R.M. Joyce, A.S. Kende, S.V. Ley, L.E. Overman, L.A. Paquette, G.H. Posner, J.B. Press, H.J. Reich, and M. Semmelhack Eds.; John Wiley and Sons, Inc.: New York, **1989** *37*, pp. 57-575.

2. G. Procter, A.T. Russell, P.J. Murphy, T.S. Tan, and A.N. Mather, *Tetrahedron*, **1988**, *44*, 3953-3973, and references therein; P.J. Murphy, A.T. Russell, and G. Procter, *Tetrahedron Lett.*, **1990**, *31*, 1055-1058; P.J. Murphy, and G. Procter, *Tetrahedron Lett.*, **1990**, *31*, 1059-1062.
3. H. Okazaki, T. Kishi, T. Beppu, and K. Arima, *J. Antibiotics*, **1975**, *28*, 717-719.
4. V.S. Martin, S.S. Woodward, T. Katsuki, Y. Yamada, M. Ikeda, and K.B. Sharpless, *J. Amer. Chem. Soc.*, **1981**, *103*, 6237-6240; Y. Gao, R.M. Hanson, J.M. Klunder, S.Y. Ko, H. Masamune, and K.B. Sharpless, *J. Amer. Chem. Soc.*, **1987**, *109*, 5765-5780; Y. Kitano, T. Matsumato, and F. Sato, *J. Chem. Soc., Chem. Commun.*, **1986**, 1323-1324.
5. The *anti*-alkylated allylsilanes can be obtained by our previous route (ref. 2), and both the *anti*- and *syn*-isomers *via* Claisen rearrangement of the appropriate C3-acyloxy-*E*-vinylsilane, M.A. Sparks and J. Panek, *J. Org. Chem*, **1991**, *56*, 3431-3438.
6. I. Fleming and P.E.J. Sanderson, *Tetrahedron Lett.*, **1987**, *28*, 4229-4232.
7. Reference 1, pp. 159-161 and references therein.
8. H.-L. Kwong, C. Sorato, Y. Ogino, H. Chen, and K.B. Sharpless, *Tetrahedron Lett.*, **1990**, *31*, 2999-3002.
9. The catalyst used in this work was $Bu^t_3PPt(Nb)_2$ (Nb=norbornene); P.J. Murphy, J.L. Spencer, and G. Procter, *Tetrahedron Lett.*, **1990**, *31*, 1051-1054.
10. Y. Ogino, H. Chen, E. Manoury, T. Shibata, M. Beller, D. Lübben, and K.B. Sharpless, *Tetrahedron Lett.*, **1991**, *32*, 5761-5764, and references therein. In our experiments on the kinetic resolution of (11) a limiting amount of cooxidant was used [1.1 equiv. $K_3Fe(CN)_6$].
11. Double asymmetric induction has been observed previously in the dihydroxylation of γ-alkoxy-α,β-unsaturated esters with OsO_4/dihydroquinine(or dihydroquinidine) catalysts, R. Annunziata, M. Cinquini, F. Cozzi, and L. Raimondi, *Tetrahedron*, **1988**, *44*, 6897-6902.
12. +(11) Prepared as shown in Scheme 2, using R-(7) [from Sharpless (epoxidation) kinetic resolution, e.e. >95% by analysis of O-acetylmandelate and Mosher's ester] exhibited $[\alpha]_D$ = +19.3° (c=3.62, $CHCl_3$), and was presumed to be of equal enantiomeric purity to (7), since the chirality transfer in this type of rearrangement is known to be very high V.G. Matassa, P.R. Jenkins, A. Kümin, L. Damm, J. Schreiber, D. Felix, E. Zass, and A. Eschenmoser, *Israel J. Chem.*, **1989**, *29*, 321-343. The e.e's reported in this Letter for the allylsilanes and γ-lactones were estimated from the following optical rotations: (15), +6.9° (c=2.17, $CHCl_3$); (13), -22.4° (c=2.32, $CHCl_3$); (14), +20.6° (c=2.52, $CHCl_3$); (16), -27.1° (c=2.14, $CHCl_3$); (17), +27.0° (c=2.08, $CHCl_3$).

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