Carbometalation of Vinyllithiums by Zincated Allyltrimethylsilane

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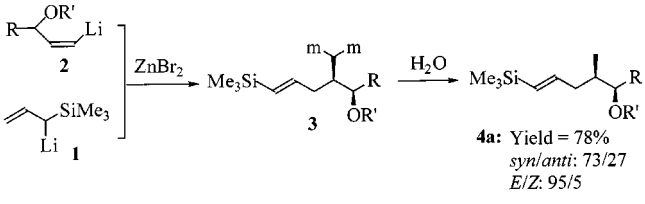
The addition of zincated allytrimethylsilane to γ-alkoxyvinyllithiums in the presence of an excess of $ZnBr_2$ (and $MgBr_2$) is highly diastereoselective when performed under precise temperature conditions. A formal synthesis of serricornin is proposed.

Introduction

In a previous paper,[1] we have shown that the allylzinc reagent derived from lithiated allyltrimethylsilane **(1)**[2] carbometalates vinyllithium **(2a)** in good yield (Scheme 1).



2a: R = *n*Pr, R' = *t*Bu **2b:** R = Et, R' = *t*Bu **2c:** R = Me, R' = *t*Bu
2d: R = *n*Pr, R' = MOM **2e:** R = Et, R' = MOM **2f:** R = Me, R' = MOM

Scheme 1. Carbometalation of vinyllithium compounds by zincated allyltrimethylsilane

The fair selectivity (73:27) of this reaction was attributed to the presence of TMEDA, which is necessary for the lithiation of the allylsilane, but precludes a synthetic use of the interesting bismetallic synthon **3**. We have now found a way to obtain **3** in high purity. Here, we report on the influence of various amounts of zinc- and magnesium salts on this reaction. Magnesium bromide has previously been shown to play an important role in the corresponding reaction performed with allylic zinc reagents derived from alkylallyl ethers.[3]

Results and Discussion

Study of the Carbometalation

With the protecting group *tert*-butyl, if the reaction is run at 20 °C in the presence of three equivalents of $ZnBr_2$ instead of two (compare entries 1 and 2 of Table 1), a similar yield is attained within 48 h, instead of 92 h, with a *dr* of 83:17 and an *E*/*Z* ratio of 95:5. If the mixture is quenched after 24 h, the *dr* is the same, but the *E*/*Z* ratio is only 85:15 (entry 3). However, the presence of $MgBr_2$ speeds up the reaction more than $ZnBr_2$ does. This acceleration now allows us to perform the reaction at 0 °C, within 24 h (entry 4), and the *dr* jumps to 95:5, albeit at the expense of a diminished *E*/*Z* ratio of 87:13. Curiously enough, if the mixture is subsequently warmed to room temperature prior to hydrolysis, this latter ratio raises to 95:5 (entry 5). Thus, although *Z* and *E* vinylsilanes are considered to be configurationally stable in a variety of conditions,[4] it turns out that in this reaction, some kinetically formed *Z* form isomerizes readily at room temperature to the *E* form. One interpretation for this might be an intramolecular ring closure−ring opening of the *gem*-bismetallic **3** onto the C=C double bond, although we could not find any product of the cyclobutane type. These types of carbometalations are known to be reversible processes[5] and we considered also that this isomerization could be related to such a process. However, since the diastereoselection (between the two sp^3 carbons) is lower at 20 °C (83:17) than at 0 °C (95:5), if the reversibility were responsible for this isomerization, the good *E*/*Z* ratio obtained at higher temperature should be

Table 1. Carbometalation of **2** by **1** in the presence of 3 equiv. of $ZnBr_2$

Entry	**2**	*T* (°C)	Time (h)	Yield (%)[a]	*E*/*Z*[b]	*syn*/*anti*[b]
1	**2a**	20	92[c]	78	95:5	73:27
2	**2a**	20	48	67	95:5	83:17
3	**2a**	20	24	(73)	85:15	83:17
4	**2a**	0[d]	24	72	87:13	95:5
5	**2a**	0[d] then 20	48[e]	64	95:5	95:5
6	**2b**	0[d] then 20	48[e]	63	95:5	95:5
7	**2c**	0[d] then 20	48[e]	60	90:10	95:5
8	**2d**	0	24	(65)	70:30	95:5
9	**2d**	0 then 20	48[e]	61	95:5	95:5
10	**2e**	0	24	(69)	67:33	95:5
11	**2e**	0 then 20	48[e]	60	95:5	95:5
12	**2f**	0	24	(70)	66:34	95:5
13	**2f**	0 then 20	48[e]	51	73:27	95:5

[a] Yields after chromatography; in parenthesis the yields by GC. − [b] Determined by ^1H NMR 400 MHz. − [c] In the presence of only 2 equiv. of $ZnBr_2$. − [d] In the presence of 3 equiv. of $MgBr_2$. − [e] 24 h at 0 °C and then 24 h at 20 °C.

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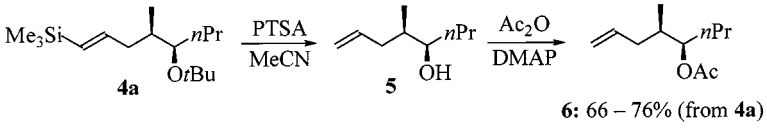
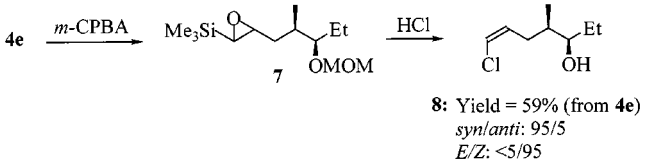


Scheme 2. Determination of the stereochemistry of the vinylsilane **4a**

accompanied by a lower *syn*/*anti* ratio. In summary, with both an excess of zinc- and magnesium bromide, a good diastereoselection is secured at 0 °C, but the mixture has to be warmed up to epimerize the C=C bond to the thermodynamic *E* isomer. Smaller alkyl groups on **2** (as in **2b** and **2c**) give analogous results (entries 6 and 7).

When the alcohol is protected as a MOM ether, the presence of three equivalents of $ZnBr_2$ is also beneficial, but in this case, the addition of $MgBr_2$ was precluded, since it would promote a γ-elimination of the OMOM group.[3,6] However, with this protection, the reaction is faster and takes place within 24 h at 0 °C and, except for reagent **2f**, a unique diastereomer is obtained after the initial mixture of *E* and *Z* isomers has been warmed up to room temperature (entries 8−11). In the case of **2f** (entries 12−13), epimerization of the C=C bond to the thermodynamic *E* isomer is much slower and only an *E*/*Z* ratio of 73:27 is attained within 24 h at room temperature (entry 13). Unfortunately, longer reaction times give mainly by-products.



Scheme 3. Synthesis of the *Z*-vinyl chloride **8** from the *E*-vinylsilane **4e**

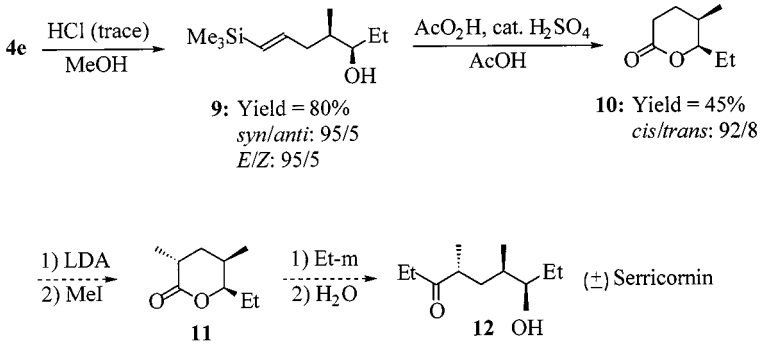
This approach now represents a simple and straightforward way to *syn* α-methyl-γ-ethylenic alcohols. This *syn* stereochemistry had been suggested[1] by analogy with other cases. It has now been proved, starting with 83:17 and 95:5 mixtures of isomers of **4a** which have been converted into **5** with *dr*'s of 83:17 and 95:5, respectively (Scheme 2). As seen from the NMR spectra of acetate **6,** the major diastereomer is the same as in the carbometalation of **2a** by allyzinc bromide.[7] In this latter reaction, the *syn* stereochemistry of **5** has been already proved by nOe spectroscopy on the substituted tetrahydrofuran derived from **5** by intramolecular iodoetherification.[8]

Vinylsilanes are well-known to be easily oxidized into α,β-epoxysilanes, which are useful intermediates for the preparation of carbonyl compounds.[9] It has also been shown that pure *cis* or *trans* α,β-epoxysilanes can be readily converted into heterosubstituted alkenes, such as vinyl halides, in high stereochemical purity.[10] Thus, the *Z* vinyl chloride **8** can be prepared in a simple way from vinylsilane **4e** (*E*/*Z*: 95:5) by oxidation, followed by treatment with HCl, in 59% overall yield (Scheme 3).

Formal Synthesis of Serricornin

The *syn* relationship between the methyl- and hydroxy groups is present in numerous natural products and can be set up in a straightforward manner, the vinylsilane being used for further functionalization of the chain. For example, lactone **10** is easily prepared from **4e**, in 36% overall yield, by hydrolysis to the alcohol followed by oxidation according to Magnus[11] (Scheme 4).

The difficulty of accessing a pure isomer of this lactone, without separations, has been illustrated several times.[12] Since it can be stereoselectively methylated to **11** according to Pilli,[12f] followed by a ring opening, by EtLi[12g] or EtMgBr,[12f] leading to serricornin **12**, our strategy corresponds to a formal, simple way to this ketone (Scheme 4) which elicits pheromone activity in cigarette bark beetles in the racemic form.[12f] This excellent diastereoselection is, however, limited to the elaboration of *syn* derivatives. Indeed, contrary to crotylzinc bromide, reagent **1** reacts at the least-substituted allylic terminus, and its addition to compounds of type **2** *E,* delivers the same *syn* diastereomer **4**, with a low diastereoselection, whereas with crotylzinc



Scheme 4. Formal synthesis of serricornin

bromide, *E* or *Z* vinyl metals deliver opposite diastereomers.[13]

Conclusion

The trimethylsilyl allyl zinc reagent **1** carbometalates vinyllithiums **2** diastereoselectively if the reaction is performed at 0 °C in the presence of an excess of $ZnBr_2$. If **2** is blocked as a *tert*-butyl ether, the presence of $MgBr_2$ is necessary to speed up the reaction at this temperature. If **2** is blocked as a MOM ether, use of this latter salt can be avoided. In both cases, the *gem*-bismetallic **3** was obtained as a mixture of *E* and *Z* isomers with a *dr* of 95:5. However, except for **2f**, raising the temperature to 20 °C promotes an isomerization of this mixture to a unique *E* isomer. The presence of a vinylsilane moiety in the hydrolysed product **4**, and the easy deprotection of the MOM group, allows a straightforward access to *cis*-1-alkyl-2-methyl valerolactones, such as **10** which has already led to serricornin.

Experimental Section

General Remarks: Experiments involving organometallic compounds were carried out in dried glassware under a positive pressure of dry N_2. Liquid nitrogen was used as a cryoscopic fluid. A four necked round bottom flask equipped with an internal thermometer, a septum cap, a nitrogen inlet and a mechanic stirring was used. − Et_2O was freshly distilled from sodium−benzophenone ketyl prior to use. − Zinc bromide (98%) was purchased from Aldrich. It was melted under dry N_2 and, immediately after cooling down at room temperature, was dissolved in anhydrous Et_2O. − TMEDA (99.5+%, redistilled) and all other reagents and solvents were of commercial quality and were used without purification. − Flash column chromatographic separations were carried out over Merck silica gel 60 (0.015×0.040 mm). − ^1H NMR and ^{13}C NMR spectra were recorded on a Bruker ARX 400 spectrometer (400 and 100.6 MHz, respectively). Chemical shifts are reported in δ relative to an internal standard of residual chloroform (δ = 7.27 for ^1H NMR and δ = 77.1 for ^{13}C NMR). The NMR shifts corresponding to the minor isomer are indicated with an asterisk (*) − IR spectra were recorded with a Perkin−Elmer 1420 spectrophotometer. − Mass spectra were performed by the Service de Spectrométrie de Masse de l'Université Pierre et Marie Curie. − Elemental analyses were performed by the Service de Microanalyses de l'Université Pierre et Marie Curie.

Typical Procedure for the Preparation of Lithiated Allyltrimethylsilane (1): To a 0.5 M solution of TMEDA (1.4 equiv.) in anhydrous Et_2O was added *sec*-butyllithium (1.3 M in cyclohexane/hexane, 1.4 equiv.) at −20 °C. After cooling to −80 °C, allyltrimethylsilane (1.4 equiv.) was added and the resulting mixture was slowly warmed up to −40 °C, stirred for 1 h at this temperature and used immediately in the carbometalation reaction.

Typical Procedure for the Preparation of Vinyllithiums (2a−f): To a 1 M solution of the corresponding vinyl iodides (prepared according to the literature procedure[14]) in dry Et_2O was slowly added *tert*-butyllithium (1.7 M in pentane, 2.1 equiv.) at −80 °C. After warming to −50 °C, the mixture was stirred until no starting material was detectable by GC (20−30 min) and was then cooled to −80 °C and used immediately in the carbometalation reaction.

Typical Procedure for the Preparation of Vinylsilanes (4a−c): A cooled (−40 °C) solution of lithiated allyltrimethylsilane **1** was added dropwise to a cooled (−80 °C) solution of vinyllithiums **2a−c**. A 1 M solution of $ZnBr_2$ (3.0 equiv.) in Et_2O and $MgBr_2{\cdot}Et_2O$ (3.0 equiv.) were added successively. The reaction mixture was allowed to warm to 0 °C, stirred for 24 h and then warmed to 20 °C. After stirring for an additional 24 h at 20 °C, the solution was quenched by 1 N HCl and the aqueous layer was extracted with Et_2O. The combined organic layers were washed with a saturated aqueous $NaHCO_3$ solution, water and brine, dried over anhydrous $MgSO_4$ and concentrated in vacuo. The residual oil was purified by flash chromatography eluting with pentane followed by 1% Et_2O/pentane to give vinylsilanes **4a−c** as pale yellow oils.

Typical Procedure for the Preparation of Vinylsilanes (4d−f): To a cooled (−80 °C) solution of vinyllithiums **2d−f** were added dropwise a cooled (−40 °C) solution of lithiated allyltrimethylsilane **1** and a 1 M solution of $ZnBr_2$ (3.0 equiv.) in Et_2O successively. After stirring at 0 °C for 24 h and then at room temperature for an additional 24 h, the solution was quenched with a 2:1 mixture of a saturated aqueous NH_4Cl solution and NH_3. Ethanolamine (1−2 mL) was added and, after being stirred for 1 h at room temperature, the aqueous layer was extracted with Et_2O and the combined organic layers were washed with water and brine, dried over anhydrous $MgSO_4$ and concentrated in vacuo. The residual oil was purified by flash chromatography eluting with pentane followed by 5% Et_2O/pentane to give vinylsilanes **4d−f** as pale yellow oils.

(4*R,5*R**)-(*E*)-5-*tert*-Butoxy-4-methyl-1-trimethylsilyloct-1-ene (4a):** Prepared by the typical procedure from vinyllithium **2a** (3.00 mmol) in 64% yield (520 mg, 1.92 mmol); *E*/*Z*: 95:5 and *syn*/*anti*: 95:5. − IR (NaCl film): $\tilde{\nu}$ = 1615, 1245, 1195, 835, 760 cm^{-1}. − ^1H NMR ($CDCl_3$): δ = 0.06/0.14* (s, 9 H), 0.83 (d, ^3J = 6.9 Hz, 3 H), 0.92 (m, 3 H), 1.20 (s, 9H), 1.21−1.45 (m, 4 H), 1.73 (m, 1 H), 1.85 (m, 1 H), 2.40 (ddd, ^2J = 13.5 Hz, ^3J = 1.3 and 5.8 Hz, 1 H), 3.36 (m, 1 H), 5.52* (d, ^3J = 14.0 Hz, 1 H)/5.64 (d, ^3J = 17.8 Hz, 1 H), 6.00 (ddd, ^3J = 5.8, 7.3 and 17.8 Hz, 1 H)/6.31* (ddd, ^3J = 6.0, 8.4 and 14.0 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.0/0.4*, 14.5/15.1*, 16.3, 19.5, 29.3, 34.3/35.6*, 37.2/38.0*, 39.5, 72.9, 74.1*/75.1, 129.4*/130.9, 147.1/148.0*. − $C_{16}H_{34}OSi$ (270.24): calcd. C 71.04, H 12.67; found C 71.03, H 12.67.

(4*R,5*R**)-(*E*)-5-*tert*-Butoxy-4-methyl-1-trimethylsilylhept-1-ene (4b):** Prepared by the typical procedure from vinyllithium **2b** (3.00 mmol) in 63% yield (482 mg, 1.88 mmol); *E*/*Z*: 95:5 and *syn*/*anti*: 95:5. − IR (NaCl film): $\tilde{\nu}$ = 1615, 1245, 1190, 835, 765 cm^{-1}. − ^1H NMR ($CDCl_3$): δ = 0.06/0.13* (s, 9 H), 0.83 (d, ^3J = 6.8 Hz, 3 H), 0.89 (t, ^3J = 7.3 Hz, 3 H), 1.20 (s, 9H), 1.35−1.50 (m, 2 H), 1.74 (m, 1 H), 1.80 (m, 1 H), 2.38 (ddd, ^2J = 13.5 Hz, ^3J = 1.3 and 5.8 Hz, 1 H), 3.28 (m, 1 H), 5.52* (d, ^3J = 13.9 Hz, 1 H)/5.64 (d, ^3J = 18.5 Hz, 1 H), 6.00 (ddd, ^3J = 5.8, 7.3 and 18.5 Hz, 1 H)/6.31* (ddd, ^3J = 5.7, 8.5 and 13.9 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.1, 10.6, 15.1, 24.6, 29.1, 36.6, 39.6, 72.9, 76.1, 130.8, 146.9. − $C_{15}H_{32}OSi$ (256.50): calcd. C 70.24, H 12.57; found 70.16, H 12.55.

(4*R,5*R**)-(*E*)-5-*tert*-Butoxy-4-methyl-1-trimethylsilylhex-1-ene (4c):** Prepared by the typical procedure from vinyllithium **2c** (3.01 mmol) in 60% yield (436 mg, 1.80 mmol); *E*/*Z*: 90:10 and *syn*/*anti*: 95:5. − IR (NaCl film): $\tilde{\nu}$ = 1615, 1245, 1195, 835, 765 cm^{-1}. − ^1H NMR ($CDCl_3$): δ = 0.06/0.14* (s, 9 H), 0.83 (d, ^3J = 6.9 Hz, 3 H), 1.05 (d, ^3J = 6.2 Hz, 3 H), 1.17 (s, 9H), 1.56 (m, 1 H), 1.82 (ddd, ^2J = 13.5 Hz, ^3J = 0.7 and 8.3 Hz, 1 H), 2.36 (ddd, ^2J = 13.5 Hz, ^3J = 1.4 and 5.4 Hz, 1 H), 3.43 (m, 1 H), 5.43* (d, ^3J = 13.8 Hz, 1 H)/5.57 (d, ^3J = 18.2 Hz, 1 H), 5.91 (ddd, ^3J = 5.4, 8.3

and 18.2 Hz, 1 H)/6.22* (ddd, ^3J = 6.3, 7.9 and 13.8 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.0/0.4*, 15.6*/15.8, 18.9*/19.2, 28.7*/28.8, 39.5, 39.7/40.4*, 70.5/70.7*, 73.1, 129.5*/131.0, 146.7/148.6. − $C_{14}H_{30}OSi$ (242.47): calcd. C 69.35, H 12.47; found C 69.36, H 12.44.

(4*R,5*R**)-(*E*)-5-Metoxymethoxy-4-methyl-1-trimethylsilyloct-1-ene (4d):** Prepared by the typical procedure from vinyllithium **2d** (3.00 mmol) in 61% yield (466 mg, 1.81 mmol); *E*/*Z*: 95:5 and *syn*/*anti*: 95:5. − IR (NaCl film): $\tilde{\nu}$ = 1615, 1245, 1040, 835, 765 cm^{-1}. − ^{1}H NMR ($CDCl_3$): δ = 0.05/0.13* (s, 9 H), 0.87 (d, ^3J = 6.8 Hz, 3 H), 0.93 (t, ^3J = 7.2 Hz, 3 H), 1.27−1.76 (m, 4 H), 1.91 (m, 1 H), 1.93 (ddd, ^2J = 13.7 Hz, ^3J = 0.7 and 7.7 Hz, 1 H), 2.33 (ddd, ^2J = 13.7 Hz, ^3J = 1.3 and 5.4 Hz, 1 H), 3.39 (s, 3 H), 3.44 (m, 1 H), 4.65 (s, 2 H), 5.55* (d, ^3J = 14.0 Hz, 1 H)/5.65 (d, ^3J = 18.4 Hz, 1 H), 5.99 (m, 1 H)/6.32* (ddd, ^3J = 6.0, 8.2 and 14.0 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.1/0.2*, 9.8*/10.3, 14.4/14.7*, 22.9*/23.9, 33.3, 35.7*/35.9, 40.0/40.4*, 55.6, 81.3, 96.0*/96.2, 130.0*/131.5, 145.8*/146.0. − $C_{14}H_{30}O_2Si$ (258.47): calcd. C 65.06, H 11.70; found C 64.97, H 11.60.

(4*R,5*R**)-(*E*)-5-Methoxymethoxy-4-methyl-1-trimethylsilylhept-1-ene (4e):** Prepared by the typical procedure from vinyllithium **2e** (5.00 mmol) in 60% yield (724 mg, 2.97 mmol); *E*/*Z*: 95:5 and *syn*/*anti*: 95:5. − IR (NaCl film): $\tilde{\nu}$ = 1615, 1245, 1040, 835, 765 cm^{-1}. − ^{1}H NMR ($CDCl_3$): δ = 0.07/0.13* (s, 9 H), 0.88 (d, ^3J = 6.9 Hz, 3 H), 0.93 (t, ^3J = 7.4 Hz, 3 H), 1.54 (m, 2 H), 1.79 (m, 1 H), 1.95 (ddd, ^2J = 13.7 Hz, ^3J = 0.7 and 7.7 Hz, 1 H), 2.33 (ddd, ^2J = 13.7 Hz, ^3J = 1.3 and 5.4 Hz, 1 H), 3.35 (m, 1 H), 3.41 (s, 3 H), 4.67 (s, 2 H), 5.55* (d, ^3J = 14.0 Hz, 1 H)/5.67 (d, ^3J = 18.0 Hz, 1 H), 6.00 (m, 1 H)/6.32* (ddd, ^3J = 6.0, 8.2 and 14.0 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.1/0.2*, 9.8*/10.3, 14.4/14.7*, 22.9*/23.9, 35.5/36.3*, 40.2, 55.6, 83.0, 96.1*/96.2, 131.7/133.1*, 145.8*/146.0. − $C_{13}H_{28}O_2Si$ (244.44): calcd. C 63.87, H 11.55; found C 63.79, H 11.55.

(4*R,5*R**)-(*E*)-5-Methoxymethoxy-4-methyl-1-trimethylsilylhex-1-ene (4f):** Prepared by the typical procedure from vinyllithium **2f** (3.00 mmol) in 51% yield (352 mg, 1.53 mmol); *E*/*Z*: 73:27 and *syn*/*anti*: 95:5. − IR (NaCl film): $\tilde{\nu}$ = 1610, 1245, 1035, 835, 760 cm^{-1}. − ^{1}H NMR ($CDCl_3$): δ = 0.06/0.12* (s, 9 H), 0.89 (d, ^3J = 6.8 Hz, 3 H), 1.14 (d, ^3J = 6.4 Hz, 3 H)/1.29* (d, ^3J = 6.8 Hz, 3 H), 1.68 (m, 1 H), 1.90−2.02 (m, 1 H), 2.34 (ddd, ^2J = 13.8 Hz, ^3J = 1.1 and 5.4 Hz, 1 H), 3.38 (s, 3 H), 3.61 (m, 1 H), 4.53* (AB system, ^2J = 6.8 Hz, 1 H)/4.63 (AB system, ^2J = 6.6 Hz, 1 H), 4.70 (AB system, ^2J = 6.6 Hz, 1 H), 5.54* (d, ^3J = 14.0 Hz, 1 H)/5.66 (d, ^3J = 19.8 Hz, 1 H), 6.00 (m, 1 H)/6.31* (ddd, ^3J = 6.1, 8.2 and 14.3 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.1/0.3*, 14.7/16.8*, 17.1/20.4*, 35.9*/38.3*, 39.9*/40.0, 55.4, 76.4/76.5*, 95.2*/95.3, 130.0*/131.6, 145.8/147.8. − $C_{12}H_{26}O_2Si$ (230.42): calcd. C 62.55, H 11.37; found 62.67, H 11.21.

(1*R,2*R**)-2-Methyl-1-propylpent-4-enyl Acetate (6):** To a solution of vinylsilane **4a** (1−2 mmol scale) in CH_3CN (10 mL) was added PTSA monohydrate (1.0 equiv.) at 20 °C. The resulting mixture was stirred at room temperature for 20 h, at which time no starting material was detectable by TLC, and was concentrated in vacuo. The residue was dissolved in Et_2O (20 mL) and the resulting organic layer was washed with a saturated aqueous $NaHCO_3$ solution (20 mL). The aqueous layer was extracted with Et_2O (2 × 20 mL) and the combined organic layers were washed with water and brine, dried over anhydrous $MgSO_4$ and evaporated to dryness. The residual brownish oil was taken up in CH_2Cl_2 (10 mL) to which DMAP (0.1 equiv.) and Ac_2O (10.0 equiv.) were added successively. After being stirred at 20 °C overnight, the mixture was quenched with a saturated aqueous $NaHCO_3$ solution. The organic layer was washed with water and brine, dried over anhydrous $MgSO_4$ and concentrated in vacuo. The residue was purified by kugelrohr distillation (bp. = 180 °C/760) to give acetate **6** as a colorless liquid.

According to this procedure, from vinylsilane **4a** (455 mg, 1.68 mmol, *syn*/*anti*: 95:5) acetate **6** was prepared in 76% yield (250 mg, 1.27 mmol, *syn*/*anti*: 95:5); from vinylsilane **4a** (540 mg, 2.00 mmol, *syn*/*anti*: 83:17) acetate **6** was prepared in 66% yield (259 mg, 1.32 mmol, *syn*/*anti*: 83:17). The spectral data are as reported in the literature.[7] − IR (NaCl film): $\tilde{\nu}$ = 3075, 1735, 1640, 1240 cm^{-1}. − ^{1}H NMR ($CDCl_3$): δ = 0.89 (d, ^3J = 6.9 Hz, 3 H), 0.91 (t, ^3J = 7.2 Hz, 3 H), 1.29 (m, 2 H), 1.49 (m, 2 H), 1.87 (m, 1H), 1.89 (m, 1 H), 2.06 (s, 3 H), 2.16 (m, 1 H), 4.82* (td, ^3J = 5.4 and 7.3 Hz, 1 H)/4.89 (dt, ^3J = 4.4 and 8.5 Hz, 1 H), 5.01 (d, ^3J = 10.5 Hz, 1 H), 5.02 (d, ^3J = 15.8 Hz, 1 H), 5.77 (m, 1 H). − ^{13}C NMR ($CDCl_3$): δ = 14.4, 14.5/15.5*, 19.1*/19.3, 21.5, 33.1*/33.9, 36.5*/36.7, 37.3*/37.9, 76.9, 116.5, 137.2, 171.3.

(3*R,4*R**)-(*Z*)-7-Chloro-4-methylhept-6-en-3-ol (8):** To a stirred solution of vinylsilane **4e** (223 mg, 0.91 mmol, *E*/*Z*: 95:5 and *syn*/*anti*: 95:5) in CH_2Cl_2 (7 mL) was added in one portion at 0 °C *m*-CPBA (675 mg, 70−75% balance with water and 3-chlorobenzoic acid, 2.75 mmol). The mixture was allowed to warm to room temperature and, after being stirred for 1 h, was diluted with Et_2O. The organic layer was washed with a saturated aqueous Na_2SO_3 solution, a saturated aqueous $NaHCO_3$ solution and brine, and then concentrated in vacuo.

The residual yellow oil was taken up in MeOH (5 mL) to which concentrated HCl (1 mL) was added. The resulting solution was refluxed overnight, cooled to room temperature and diluted with Et_2O (30 mL). The aqueous layer was extracted with Et_2O (10 mL) and the combined organic layers were washed with a saturated aqueous $NaHCO_3$ solution, water and brine, dried over $MgSO_4$ and concentrated to dryness. The crude product was purified by flash chromatography eluting with 5% Et_2O/pentane followed by 10% Et_2O/pentane to give vinyl chloride **8** in 59% yield (88 mg, 0.54 mmol); *E*/*Z*: <5:95 and *syn*/*anti*: 95:5. Yellow oil. − IR (NaCl film): $\tilde{\nu}$ = 3370, 1630, 745 cm^{-1}. − ^{1}H NMR ($CDCl_3$): δ = 0.93 (d, ^3J = 6.9 Hz, 3 H)/0.94* (d, ^3J = 6.9 Hz, 3 H), 0.98 (t, ^3J = 7.4 Hz, 3 H), 1.42 (broad s, 1 H), 1.50 (m, 2 H), 1.69 (m, 1 H), 2.18 (m, 1 H), 2.38 (m, 1 H), 3.46 (m, 1 H), 5.81 (q, ^3J = 7.3 Hz, 1 H), 6.10 (dt, ^3J = 7.3 and ^4J = 1.5 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = 11.0, 13.8, 27.6, 31.4, 37.9, 76.1, 119.4, 130.8. − MS (C.I., NH_3): *m*/*z* (%) = 180 (100) [M + NH_4^+ for ^{35}Cl], 182 (33) [M + NH_4^+ for ^{37}Cl].

(3*R,4*R**)-(*E*)-4-Methyl-7-trimethylsilylhept-6-en-3-ol (9):** To a stirred solution of vinylsilane **4e** (573 mg, 2.35 mmol; *E*/*Z*: 95:5 and *syn*/*anti*: 95:5) in MeOH (10 mL) was added concentrated HCl (1 drop) at 20 °C and the mixture was refluxed for 1 h. After cooling to room temperature, the solution was quenched with a saturated aqueous $NaHCO_3$ solution (10 mL), extracted with Et_2O (5 × 20 mL) and the combined organic layers were washed with water and brine, dried over anhydrous $MgSO_4$ and concentrated to dryness. The residue was purified by flash chromatography eluting with 5% Et_2O/pentane followed by 25% Et_2O/pentane to give alcohol **9** in 80% yield (376 mg, 1.88 mmol); *E*/*Z*: 95:5 and *syn*/*anti*: 95:5. Colorless viscous oil. − IR (NaCl film): $\tilde{\nu}$ = 3380, 1615, 1245, 835, 765 cm^{-1}. − ^{1}H NMR ($CDCl_3$): δ = 0.06/0.14* (s, 9 H), 0.87 (d, ^3J = 6.8 Hz, 3 H), 0.98 (t, ^3J = 7.2 Hz, 3 H), 1.35 (broad s, 1 H), 1.49 (m, 2 H), 1.67 (m, 1 H), 2.03 (m, 1 H), 2.27 (m, 1 H), 3.37*/3.45 (m, 1 H), 5.69 (d, ^3J = 18.5 Hz, 1 H), 6.03 (dt, ^3J = 6.7 and 18.5 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = −1.1, 10.7, 13.4, 27.4, 37.7, 41.2,

76.2*/76.4, 132.0, 145.8. − $C_{11}H_{24}OSi$ (200.39): calcd. C 65.93, H 12.07; found C 65.77, H 12.01.

(5*R,6*R**)-6-Ethyl-5-methyltetrahydropyran-2-one (10):** Under Ar, to a solution of alcohol **9** (100 mg, 0.50 mmol; *E*/*Z*: 95:5 and *syn*/*anti*: 95:5) in glacial AcOH (1 mL) were added concentrated H_2SO_4 (1 drop) and peracetic acid (0.33 mL of a 39% solution in AcOH, 2.00 mmol) at 0 °C. The mixture was warmed to 20 °C, stirred overnight at this temperature, and then poured into a saturated aqueous $NaHCO_3$ solution (10 mL). The aqueous layer was extracted with Et_2O (4 × 10 mL) and the combined organic layers were washed with a saturated aqueous Na_2SO_3 solution, water and brine, dried over anhydrous $MgSO_4$ and concentrated in vacuo to dryness. The crude oil was purified by flash chromatography eluting with Et_2O/pentane (gradient of Et_2O from 5% to 30%) to lead to valerolactone **10** in 45% yield (32 mg, 0.22 mmol); *cis*/*trans*: 92:8. Colorless viscous oil. The spectral data are as reported in the literature.[12f] − IR (NaCl film): $\tilde{\nu}$ = 1735 cm^{-1}. − ^1H NMR ($CDCl_3$): δ = 0.97 (d, ^3J = 7.0 Hz, 3), 1.02 (t, ^3J = 7.5 Hz, 3 H), 1.57 (m, 1 H), 1.71 (m, 2 H), 2.00−2.08 (m, 2 H), 2.55 (dd, ^3J = 6.6 and 8.0 Hz, 2 H), 3.91* (ddd, ^3J = 3.1, 7.5 and 9.7 Hz, 1 H)/4.22 (ddd, ^3J = 3.0, 5.4 and 8.5 Hz, 1 H). − ^{13}C NMR ($CDCl_3$): δ = 8.9/9.2*, 12.4, 17.4*/25.1, 26.2, 26.8, 29.0, 84.6/87.3*, 172.3. − MS (C.I., NH_3): *m*/*z* (%) = 160 (100) [M + NH_4^+], 143 (86) [M + H^+].

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