Synthesis of *syn,syn*; *anti,syn*; *syn,anti*; and *anti,anti* Stereotriads from a Single Pair of Enantiomeric Reagents

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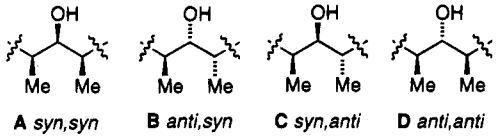
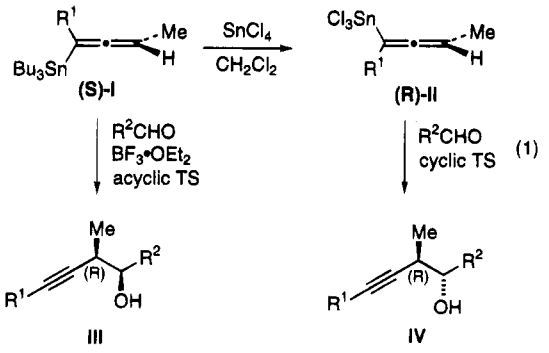
The stannanes (*S*)-**1a**, (*R*)-**1b**, and (*S*)-**1c** add to (*S*)- and (*R*)-2-methyl-3-(benzyloxy)propanal ((*S*)-**2** and (*R*)-**2**) to afford the *syn,syn* (BF_3•OEt_2 promotion), *syn,anti* ($MgBr_2$•OEt_2 promotion), *anti,anti* ($SnCl_4$-derived reagent in CH_2Cl_2), and *anti,syn* ($SnCl_4$-derived reagent in hexane) stereotriad adducts **3**, **4**, **6**, and **7**.

Several years ago, R. W. Hoffmann surveyed methodology under development for the synthesis of so-called stereotriads **A**–**D**, important subunits in a multitude of biologically active polyketide-derived natural products.[1]

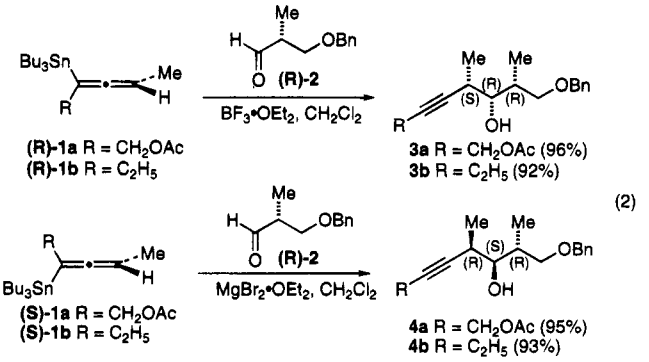


Of the four, **D** is the most arduously accessible. Heretofore there has been no single strategy that allows the synthesis of all four with equal efficiency. We now describe one.

We have previously shown that nonracemic allenylstannanes such as (*S*)-**I** add to aldehydes in the presence of BF_3•OEt_2 through an acyclic transition state to afford *syn* adducts **III**.[2] More recently we have found that premixing of such allenylstannanes with $SnCl_4$ followed by addition of the aldehydes leads to the *anti* adducts **IV** in high yield. The inverted allenyl chlorostannane (*R*)-**II** is thought to be an intermediate in the latter reaction which proceeds through a cyclic transition state (eq 1).[3,4]



With chiral α-methyl-β-alkoxy aldehydes, it is possible to control the facial selectivity of the addition through choice of Lewis acids. Aldehyde (*R*)-**2** and stannane (*R*)-**1a**, for example, give the *syn,syn* product **3a** in the presence of BF_3 with greater than 99:1 diastereoselectivity in over 90% yield.[2] When $MgBr_2$ is used to promote the reaction with stannane (*S*)-**1a**, the *syn,anti* adduct **4a** (>99:1) is produced in comparable yield (eq 2).[2] These reactions proceed through acyclic transition states under Cram (BF_3) and chelation ($MgBr_2$) control of diastereoselectivity. A similar outcome was observed with stannanes (*R*)-**1b** and (*S*)-**1b**.



The present work was undertaken to extend these earlier investigations[2,3] in an effort to define conditions for the efficient synthesis of the *anti,anti* and *anti,syn* isomers **6** and **7** (as in **D** and **C**). For these studies, we elected to employ the allenyl stannanes (*S*)-**1a**,[2] (*R*)-**1b**,[5] and (*S*)-**1c** with aldehyde (*R*)-**2** and its enantiomer (*S*)-**2**.

Addition of aldehyde (*S*)-**2** to the chlorostannane reagent (*R*)-**5a**, derived *in situ* from stannane (*S*)-**1a** and $SnCl_4$, afforded the *anti,anti* adduct **6a** in 99% yield (eq 3). Use of the heptyl analogue (*S*)-**1c** similarly led to the *anti,anti* product **6c**, whereas aldehyde (*R*)-**2** and the reagent (*S*)-**5b**, derived *in situ* from stannane (*R*)-**1b**, yielded the enantiomeric product *ent*-**6b** . Although we have not been able to isolate the transient chlorostannanes **5a**–**c** presumed to be intermediates in these

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(1) Hoffmann, R. W. *Angew. Chem., Int. Ed. Engl.* **1987**, *26*, 489. Hoffmann, R. W.; Dahmann, G.; Andersen, M. W. *Synthesis* **1994**, 629. For other leading references to recent developments in this area, see: (a) Roush, W. R.; Palkowitz, A. D.; Ando, K. *J. Am. Chem. Soc.* **1990**, *112*, 6348. (b) Andersen, M. W.; Hildebrandt, B.; Hoffmann, R. W. *Angew. Chem., Int. Ed. Engl.* **1991**, *30*, 97. (c) Roush, W. R. *J. Org. Chem.* **1991**, *56*, 4151. (d) Evans, D. A.; Calter, M. A. *Tetrahedron Lett.* **1993**, *34*, 6871. (e) Evans, D. A. Gage, J. R.; Leighton, J. L. *J. Am. Chem. Soc.* **1992**, *114*, 9434.

(2) Marshall, J. A.; Wang, X-j. *J. Org. Chem.* **1992**, *57*, 1242.

(3) A portion of this work has appeared in preliminary form: Marshall, J. A.; Perkins, J. *J. Org. Chem.* **1994**, *59*, 3509.

(4) Boaretto, A.; Marton, D.; Tagliavini, G.; Gambro, A. *J. Organomet. Chem.* **1985**, *286*, 9.

(5) After the initial phase of this project was completed with stannanes (*S*)-**1a** and (*S*)-**1c**, an improved route to (*R*) allenylstannanes was developed by Shiping Xie of our laboratory starting from (*S*)-lactate. This methodology will be published in due course. As a result of this improved procedure we elected to carry out reactions in the **b** series with stannane (*R*)-**1b**. We apologize for any confusion this may cause for the reader.

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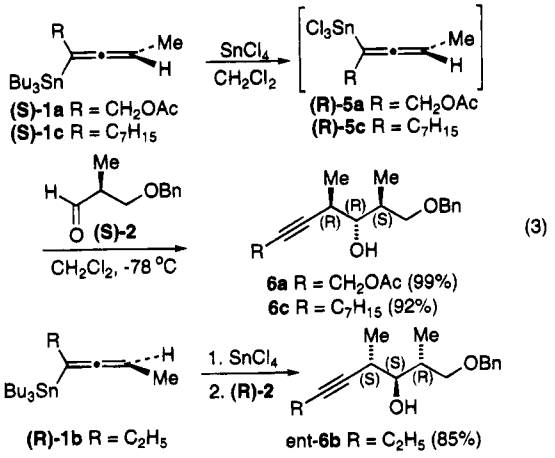
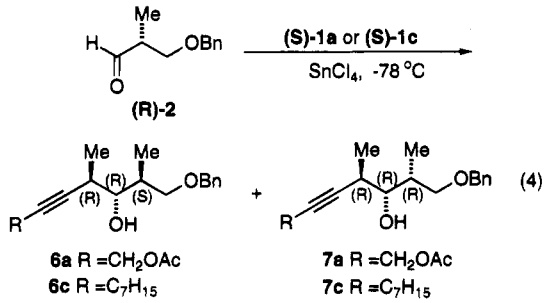
reactions, their presence is evident from the ^1H NMR spectrum, which changes in each case from that of the initial stannane **1** to one consistent with **5** upon addition of $SnCl_4$. The stereochemistry of the adducts **6a**, *ent*-**6b**, and **6c** is assigned by analogy to that established for the adducts **IV**, which we assume to arise through a cyclic six-center transition state as is found for racemic allenic and allylic chlorostannanes.[4] The facial selectivity is that expected from addition to a chelated aldehyde.



Adducts **3**, **4**, and **6** represent three of the four diastereomeric arrays found in stereotriads **A**–**D**. In an effort to secure the fourth, the *anti,syn* isomer **B**, we carried out the reaction of aldehyde (*R*)-**2** with the chlorostannane reagent ((*R*)-**5a**) formed *in situ* from stannane (*S*)-**1a** and $SnCl_4$. Surprisingly, this reaction afforded a mixture of adducts favoring the *anti,anti* diastereomer **6a** (eq 4). Analogous results were obtained with the stannane derived *in situ* from (*S*)-**1c** and $SnCl_4$.



series	solvent	yield, %	6:7[a]
a	CH_2Cl_2	90	67:33
a	hexane	91	7:93[b]
c	hexane	81	1:99

[a] corrected for the ee of the stannane
[b] -40 °C

The minor *anti,syn* adducts **7a** and **7c**, which are the expected products of the foregoing reactions, are most likely formed through matched Cram addition to aldehyde (*R*)-**2** by the chlorostannane reagent *via* cyclic transition state **G** (Figure 1). The unexpected *anti,anti* adducts must arise by chelation-controlled addition to aldehyde (*S*)-**2**, as in **E**. Evidently, the conditions employed in this reaction are favorable both to chelation and to racemization of the starting aldehyde (*R*)-**2**.[6] Furthermore, reaction of stannane (*R*)-**5** (from (*S*)-**1**) with the inverted aldehyde (*S*)-**2** in the matched chelation pairing **E** must occur more readily than that of (*R*)-**5** with

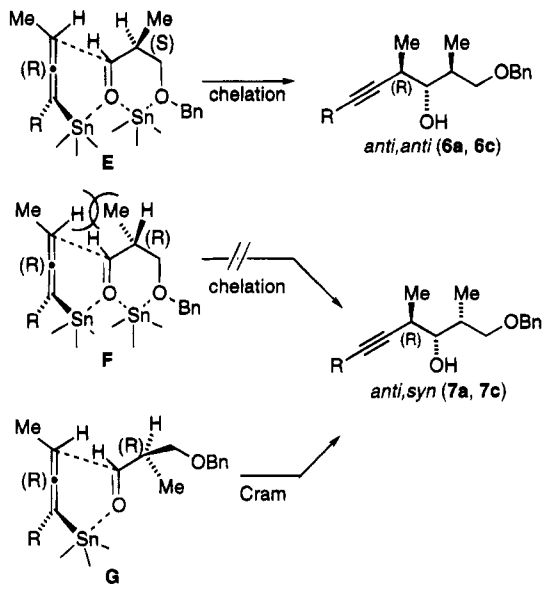
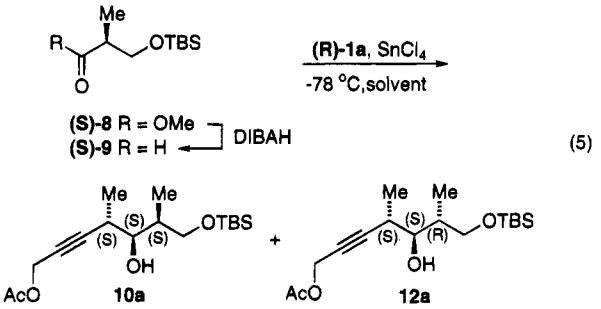


Figure 1. Transition state arrangements for additions of the (*R*)-(trichlorostannyl)allene derived from stannanes (*S*)-**1a**/**1c** to aldehydes (*S*)-2 and (*R*)-2. (The Cl ligands on the Sn atoms are not shown to improve clarity.) Additions of stannane (*R*)-**1b** would proceed through the enantiomeric transition states.

aldehyde (*R*)-**2** in the matched Cram pairing **G**. In fact, addition of 1 equiv of racemic aldehyde (*RS*)-**2** to the reagent derived from $SnCl_4$ and stannane (*S*)-**1a** in CH_2Cl_2 proceeds with significant "deracemization,"[7] affording an 87:13 mixture of *anti,anti* and *anti,syn* adducts **6a** and **7a** (see eq 4).

The TBS analogue (*S*)-**9** of aldehyde (*R*)-**2** showed a lesser tendency toward chelation/epimerization and gave a predominance of the Cram adduct **10a** with stannane (*S*)-**5a** (derived *in situ* from (*R*)-**1a**) in CH_2Cl_2 (eq 5).



solvent	yield, %	10a:12a
CH_2Cl_2	90	85:15
hexanes	84	97:3

However, the best solution to the chelation/epimerization problem came through use of hexane as solvent for the addition, whereupon the *anti,syn* adduct **10a** predominated 97:3. Under these conditions, aldehyde (*S*)-**2** afforded the *anti,anti* adducts **6a** and **6c** with premixed $SnCl_4$ and stannanes (*S*)-**1a** and (*S*)-**1c**, whereas (*R*)-**2** yielded the *anti,syn* adducts **7a** and **7c** (see Figure 2). Likewise, stannane (*R*)-**1b** yielded adducts *ent*-**6b** and *ent*-**7b**, via (*S*)-**5b**, with aldehydes (*R*)-**2** and (*S*)-**2**, respectively. In all cases, the reactions proceeded in high yield and excellent diastereoselectivity. Apparently, epimerization of aldehyde (*R*)-**2** does not take place in

(6) Possibly the combination of $SnCl_4$ and CH_2Cl_2 leads to trace quantities of HCl which catalyzes the epimerization.

(7) By "deracemization" we mean diastereomeric enrichment of a product through preferential reaction of one enantiomer of an equilibrating pair of enantiomeric reactants with a chiral reagent.

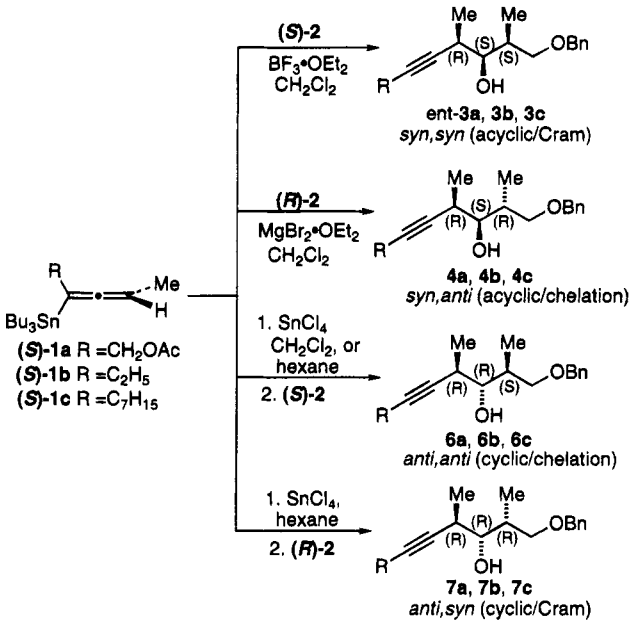
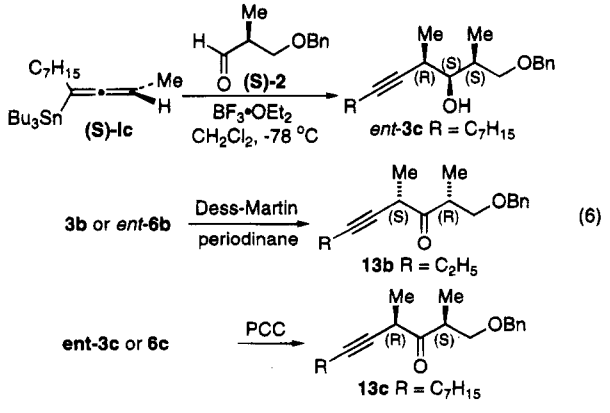


Figure 2. Combinations of stannanes (*S*)-**1** and aldehyde (*S*)-**2**/(*R*)-**2** leading to diastereomeric stereotriads. The enantiomers would arise from the enantiomeric pairings. Although neither **4c** nor its enantiomer have actually been prepared as of yet, there is little reason to doubt that the indicated transformation could actually be achieved.

hexane.[6] Fortunately, the Cram-selective pairing of aldehyde (*R*)-**2** with transient stannanes (*R*)-**5a**/(*R*)-**5c** and aldehyde(*S*)-**2** with (*S*)-**5b** proceeds with remarkable efficiency in this solvent.

The structure of adducts **3a**, **4a**, and **7a** has previously been established.[2] Adduct **6a** is clearly different from those isomers and the stereochemistry is assigned accordingly. Adducts *ent*-**3b** and **4b** are also known compounds.[2] Upon oxidation with the Dess–Martin periodinane reagent,[8] alcohols **3b** and *ent*-**6b** each afforded ketone **13b** of comparable optical rotation thus confirming the assignment for *ent*-**6b**. Similarly, oxidation of alcohol **6c** and *ent*-**3c** with PCC on alumina[9] yielded ketone **13c** (eq 6). The structure of adduct **6c** is thereby established; *ent*-**7b** and **7c** follow by default.



In summary, it is now possible to access the four stereotriads **A**–**D** with a single pair of enantiomeric reagents or aldehyde substrates (Figure 2). Although we have not done so, it is clear that all eight stereoisomers of each set could be prepared through variation of reagent or substrate configuration and reaction conditions. Set **a** represents an especially attractive array, as further elaboration of the triple bond through OH-directed hydrometalation and ensuing hydroxylation could afford various stereopentads.[1,10] Additional work along these lines is in progress.

Experimental Section[11]

(2*S*,3*S*,4*R*)-(−)-1-(Benzyloxy)-2,4-dimethyl-5-tridecyn-3-ol (*ent*-3c). To a mixture of 135 mg (0.30 mmol) of allenylstannane (*S*)-**1c** and 107 mg (0.60 mmol) of aldehyde (*S*)-**2** in 2 mL of CH_2Cl_2 was added 0.15 mL (0.90 mmol) of BF_3•OEt_2 at −78 °C. The resulting mixture was stirred at −78 °C for 20 min, quenched with saturated aqueous $NaHCO_3$, and extracted with ether. The extracts were washed with brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was chromatographed on silica gel (hexanes:ether, 3:1) to afford 89 mg (89%) of alcohol *ent*-**3c**: $[\alpha]_D$ -4.7 (*c* 1.3, $CHCl_3$); IR (film) υ 3486, 2930, 1454 cm^{-1}; ^1H NMR δ 7.36–7.26 (m, 5H), 4.53–4.47 (ABq, J = 12.0 Hz, 2H), 3.65–3.51 (m, 3H), 2.49–2.44 (m, 1H), 2.22–2.20 (m, 1H), 2.11 (dt, J = 2.3, 7.0 Hz, 2H), 1.46–1.23 (m, 11H), 1.22 (d, J = 6.8 Hz, 3H), 1.00 (d, J = 7.1 Hz), 0.86 (t, J = 6.9 Hz, 3H); ^{13}C NMR δ 138.0, 128.4, 127.7, 127.5, 82.2, 81.9, 77.0, 76.7, 75.7, 73.4, 35.6, 31.8, 30.4, 29.0, 28.8, 28.8, 22.6, 18.7, 18.2, 14.1, 9.9.

(2*S*,3*R*,4*R*)-(−)-1-(Benzyloxy)-2,4-dimethyl-7-acetoxy-5-heptyn-3-ol (6a). A. From Aldehyde (*R*,*S*)-2. To a solution of 100 mg (0.23 mmol) of allenylstannane (*S*)-**1a** (ee 89%) in 0.5 mL of CH_2Cl_2 was added 0.23 mL (0.23 mmol) of a 1 M solution of $SnCl_4$ in CH_2Cl_2 at 0 °C. The mixture was stirred for 40 min and then cooled to −78 °C, and 37 mg (0.21 mmol) of racemic aldehyde (*RS*)-**2** was added in 0.2 mL of CH_2Cl_2. The reaction was quenched with dilute HCl after 4 h and then extracted with ether. The extracts were dried over $MgSO_4$, treated with 1 mL of Et_3N to remove tin byproducts, filtered, and concentrated. The residue was chromatographed on silica gel (hexane:ether, 1:1) to afford 55 mg (91%) of alcohols **6a** and **7a**/*ent*-**7a** as an 83:17 mixture (GC analysis; 88:12 after correction for the ee of the stannane).

B. From Aldehyde (*S*)-2. The above procedure was followed with 100 mg (0.23 mmol) of allenylstannane (*S*)-**1a** (ee 89%), 0.23 mL of 1 M $SnCl_4$ in CH_2Cl_2, and 34 mg (0.19 mmol) of aldehyde (*S*)-**2** to afford 60 mg (99%) of alcohols **6a** and *ent*-**7a** as a 94:6 mixture (GC analysis; 99:1 when corrected for the ee of the starting stannane): $[\alpha]_D$ −10.0 (*c* 0.6, $CHCl_3$); IR (film) υ 3483, 2361, 1746, 1228 cm^{-1}; ^1H NMR δ 7.36–7.26 (m, 5H), 4.66 (d, J = 2.0 Hz, 2H), 4.51 (s, 2H), 3.61–3.49 (m, 1H; and A of ABX, 2H), 3.35–3.32 (dd, B of ABX, J = 3.2, 2H), 2.06 (s, 3H), 2.06 (m, X of ABX, 1H), 1.26 (d, J = 7.1 Hz, 3H), 0.89 (d, J =7.0 Hz, 3H); ^{13}C NMR δ 170.4, 128.4, 127.7, 127.7, 126.9, 87.8, 78.2, 74.8, 73.4, 65.2, 52.8, 37.3, 30.5, 20.8, 17.7, 14.0.

(2*R*,3*S*,4*S*)-(+)-1-(Benzyloxy)-2,4-dimethyl-5-octyn-3-ol (*ent*-6b). To a solution of 245 mg (0.66 mmol) of allenylstannane, (*R*)-**1b**, (ee 98%) in 3 mL of CH_2Cl_2 was added 0.99 mL (0.99 mmol) of 1M $SnCl_4$ in CH_2Cl_2 at −78 °C. After 2 min, the mixture was warmed to 0 °C and allowed to stir for 1 h. The mixture was recooled to −78 °C, and 100 mg (0.56 mmol) of aldehyde (*R*)-**2** in 0.3 mL of CH_2Cl_2 was added dropwise. After 25 min, the reaction was quenched with saturated aqueous NH_4Cl and extracted with ether. The extracts were washed with brine and dried over $MgSO_4$, with addition of 0.41 mL (2.97 mmol) of Et_3N to precipitate the tin byproducts. Following filtration and concentration under reduced pressure, the crude residue was purified by flash chromatography on silica gel to afford 124 mg (85%) of a 99:1 mixture of alcohols *ent*-**6b** and **3b** (GC): $[\alpha]_D$ 1.38 (*c* 1.83,

(8) Dess, D. B.; Martin, J. C. *J. Org. Chem.* **1983**, *48*, 4155. Ireland, R. E.; Liu, L. *J. Org. Chem.* **1993**, *58*, 2899.
(9) Cheng, Y.-S.; Liw, W.-L.; Chen, S. H. *Synthesis* **1980**, 223.
(10) For a recent review of substrate-directed organic reactions appropriate to such transformations, see Hoveyda, A. H.; Evans, D. A.; Fu, G. C. *Chem. Rev.* **1993**, *93*, 1307.
(11) Unless otherwise specified, ^1H and ^{13}C NMR spectra were determined in $CDCl_3$ at 300 or 100.6 MHz, respectively. For typical experimental protocols, see Marshall, J. A.; Wang, X-j. *J. Org. Chem.* **1991**, *56*, 960.

$CHCl_3$); IR (film) ν 3494 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.34–7.25 (m, 5H), 4.51 (s, 2H), 3.56 (d, J = 5.9 Hz, 2H), 3.36 (m, 1H), 3.0 (d, J = 5.5 Hz, 1H), 2.7 (m, 1H), 2.16 (dq, J = 2.2, 7.5 Hz, 2H), 2.05 (m, 1H), 1.22 (d, J = 7.0 Hz, 3H), 1.10 (t, J = 3.8 Hz, 3H), 0.92 (d, J = 6.9 Hz, 3H); ^{13}C NMR δ 138.1, 128.4, 127.6, 84.3, 79.5, 78.1, 74.6, 73.4, 37.6, 30.4, 18.4, 14.4, 14.1, 12.5. Anal. Calcd for $C_{17}H_{24}O_2$: C, 78.42; H, 9.29. Found: C, 78.31; H, 9.23.

(2*S*,3*R*,4*R*)-(−)-1-(Benzyloxy)-2,4-dimethyl-5-tridecyn-3-ol (6c). To a solution of 250 mg (0.400 mmol) of allenylstannane (*S*)-**1c** (ee 84%) in 2 mL of CH_2Cl_2 was added 0.6 mL (0.6 mmol) of 1 M $SnCl_4$ in CH_2Cl_2 at −78 °C. After 10 min, 47 mg (0.27 mmol) of aldehyde (*S*)-**2** in 0.5 mL of CH_2Cl_2 was added dropwise. After 15 min, the reaction was quenched with saturated aqueous NH_4Cl and extracted with ether. The extracts were washed with brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was chromatographed on silica gel (hexanes:ether, 1:1) to afford 85 mg (92%) of alcohols **6c** and *ent*-**7c** as a 95:5 mixture (GC analysis; >99:1 when corrected for the ee of the starting stannane. Evidently, some racemization of aldehyde (*S*)-**2** must have taken place to yield *ent*-**6c**, thus enhancing the ratio of **6**:**7** over that predicted (92:8) by the ee of the starting stannane: $[\alpha]_D$ -3.71 (*c* 1.1, $CHCl_3$); IR (film) ν 3486 cm^{-1}; ^1H NMR δ 7.33–7.25 (m, 5H), 4.51 (s, 2H), 3.5 (d, J = 5.91 Hz, 2H), 3.26–3.25 (dd, J = 3.23 Hz,1H), 2.65 (m, 1H), 2.15 (dt, J = 2.24, 6.94 Hz, 2H), 2.08–2.03 (m, 1H), 1.49–1.23 (m, 11H), 1.22 (d, J = 7.05 Hz, 3H), 0.91 (d, J = 6.93 Hz, 3H), 0.86 (t, J = 6.50 Hz, 3H); ^{13}C NMR δ 138.1, 128.4, 128.4, 127.6, 127.6, 127.5, 82.9, 80.1, 78.1, 77.3, 74.6, 73.5, 73.4, 31.8, 30.4, 29.1, 28.8, 22.6, 18.8, 18.4, 14.1.

(2*R*,3*R*,4*R*)-(−)-1-(Benzyloxy)-2,4-dimethyl-7-acetoxy-5-heptyn-3-ol (7a). The procedure for *ent*-**7b** was followed with 100 mg (0.23 mmol) of allenylstannane (*S*)-**1a** (ee 89%), 0.23 mL (0.23 mmol) of 1 M $SnCl_4$ in heptane, and 37 mg (0.21 mmol) of aldehyde (*R*)-**2** in 1 mL of hexanes at −40 °C for 48 h to afford 60 mg (91%) of alcohols **7a** and *ent*-**6a**/**6a** as an 88:12 mixture (GC analysis; 93:7 when corrected for the ee of the starting stannane): $[\alpha]_D$ −6.7 (*c* 1.4, $CHCl_3$); IR (film) ν 3486 cm^{-1}; ^1H NMR δ 7.36–7.26 (m, 5H), 4.65 (d, J = 2.0 Hz, 2H), 4.49 (s, 2H), 3.60–3.55 (m, A of ABX, 1H), 3.45 (dd, B of ABX, J = 5.1 Hz, 1H), 2.67 (m, 1H), 1.27 (m, X of ABX, 1H), 1.17 (d, J = 7.0 Hz, 3H), 0.95 (d, J =7.0 Hz, 3H); ^{13}C NMR δ 170.4, 138.3, 128.4, 127.6, 127.5, 90.0, 76.4, 75.6, 73.9, 73.2, 52.7, 36.2, 30.8, 20.8, 17.6, 10.9.

(2*S*,3*S*,4*S*)-(−)-1-(Benzyloxy)-2,4-dimethyl-5-octyn-3-ol (*ent*-7b). To a solution of 279 mg (0.80 mmol) of allenylstannane (*R*)-**1b** (ee 98%) in 0.9 mL of hexanes was added 0.80 mL (0.80 mmol) of 1 M $SnCl_4$ in heptane at 0 °C. After stirring for 3h at 0 °C, the mixture was cooled to −78 °C, and 125 mg (0.70 mmol) of aldehyde (*S*)-**2** in 1.3 mL of hexanes was added dropwise. After stirring at −78 °C for 3 h, the reaction was quenched with 1 N HCl and extracted with ether. The extracts were washed with brine and dried over $MgSO_4$, with addition of 3 mL of Et_3N to precipitate the tin byproducts. Following filtration and concentration under reduced pressure, the crude residue was purified by flash chromatography on silica gel to afford 151 mg (83%) of alcohols *ent*-**7b** and *ent*-**6b**/**6b** as a 93:7 mixture (GC): $[\alpha]_D$ −10.3 (*c* 0.57, $CHCl_3$); IR (film) ν 3489 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.35–7.25 (m, 5H), 4.50 (ABq J = 12.0 Hz 2H), 3.53 (dd, J = 9.2, 6.3 Hz, 1H) 3.47 (m, 1H), 3.42 (dd, J = 9.1, 5.6 Hz, 1H), 2.60 (m, 1H), 2.34 (d, J = 5.2 Hz, 1H), 2.17 (dq, J = 7.5, 2.2 Hz, 2H), 1.95 (m, 1H), 1.14 (d, J = 7.0 Hz, 3H), 1.10 (t, J = 7.5 Hz, 3H), 0.96 (d, J = 7.0 Hz, 3H); ^{13}C NMR δ 138.5, 128.3, 127.5, 84.6, 80.6, 75.6, 73.9, 73.2, 36.3, 30.8, 18.2, 14.3, 12.4, 10.9. Anal. Calcd for $C_{17}H_{24}O_2$: C 78.42, H 9.29. Found: C 78.31, H 9.25.

(2*R*,3*R*,4*R*)-(+)-1-(Benzyloxy)-2,4-dimethyl-5-tridecyn-3-ol (7c). The above procedure for *ent*-**7b** was followed with 200 mg (0.27 mmol) of allenylstannane (*S*)-**1c** (ee 84%), 0.27 mL (0.27 mmol) of 1 M $SnCl_4$ in heptane, and 48 mg (0.27 mmol) of aldehyde (*R*)-**2** in 0.5 mL of hexanes. The product was chromatographed on silica gel (hexanes:ether, 4:1) to afford 75 mg (81%) of alcohols **7c** and *ent*-**6c**/**6c** as a 93:7 mixture (GC analysis; >99:1 when corrected for the ee of the starting stannane): $[\alpha]_D$ 6.9 (*c* 1.0, $CHCl_3$); ^1H NMR δ 7.31–7.25 (m, 5H), 4.48 (d, J = 1.4 Hz, H), 3.56–3.41 (m, 4H), 2.60 (m, 1H), 2.15 (dt, J = 4.9, 7.1 Hz, 2H), 1.97–1.60 (m, 1H), 1.49–1.18 (m, 10H), 1.13 (d, J = 7.0 Hz, 3H), 0.96 (d, J = 6.9 Hz, 3H), 0.86 (t, J = 6.9 Hz, 3H); ^{13}C NMR δ 138.5, 128.3, 127.5, 75.5, 73.8, 73.2, 36.4, 31.7, 30.9, 29.0, 28.8, 28.78, 22.6, 18.7, 18.2, 14.1, 11.0.

(2*S*,3*S*,4*S*)-(−)-1-[(*tert*-Butyldimethylsilyl)oxy]-2,4-dimethyl-7-acetoxy-5-heptyn-3-ol (10a). The above procedure for *ent*-**7b** was employed with 100 mg (0.23 mmol) of allenylstannane (*R*)-**1a** (ee 89%), 0.23 mL (0.23 mmol) of 1 M $SnCl_4$ in heptane, and 47 mg (0.23 mmol) of aldehyde (*S*)-**9** in 0.5 mL of hexane to afford 86 mg (84%) of alcohols **10a** and **12a** as a 93:7 mixture (GC analysis; 98:2 when corrected for the ee of the starting stannane): $[\alpha]_D$ −3.2 (*c* 1.0, $CHCl_3$); ^1H NMR δ 4.66 (d, J = 2.0 Hz, 2H), 3.65 (d, J = 4.6, 2H), 3.57 (dd, J = 3.7, 3.3 Hz, 1H), 2.67, m, 1H), 2.06 (s, 3H), 1.75 (m, 1H), 1.15 (d, J = 7.0 Hz, 3H), 0.92 (d, J = 7.0 Hz, 3H), 0.87 (s, 9H), 0.03 (s, 6H); ^{13}C NMR δ 170.4, 89.2, 76.1, 67.2, 52.8, 37.5, 30.8, 25.8, 20.9, 18.2, 17.4, 10.3. When this experiment was conducted in CH_2Cl_2 as the solvent an 85:15 mixture of adducts **10a** and **12a** was obtained.

(2*R*,4*S*)-(+)-1-(Benzyloxy)-2,4-dimethyl-5-octyn-3-one (13b). A. From Alcohol *ent*-6b. To a solution of 50 mg (0.19 mmol) of alcohol *ent*-**6b** in 1 mL of CH_2Cl_2 was added 165 mg (0.39 mmol) of the Dess–Martin periodinane reagent.[8] After stirring at rt for 30 min, the solution was filtered through a plug of silica gel and concentrated under reduced pressure to give 45.9 mg (94%) of ketone **13b**: $[\alpha]_D$ 24.2 (*c* 1.67, $CHCl_3$); IR (film) ν 1720 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.34–7.23 (m, 5H), 4.48 (ABq, J = 12.0 Hz, 2H), 3.71 (dd, J = 8.8, 7.1 Hz, 1H), 3.58–3.34 (m, 3H), 2.16 (dq, J = 7.5, 2.4 Hz, 2H), 1.28 (d, J = 7.1 Hz, 3H), 1.14 (d, J = 6.8 Hz, 3H), 1.10 (t, J = 7.5 Hz, 3H); ^{13}C NMR δ 210.1, 138.3, 128.3, 127.5, 85.5, 77.4, 73.2, 72.1, 43.6, 38.4, 16.9, 14.7, 13.9, 12.4.

B. From Alcohol 3b. The same procedure was employed with 30 mg (0.115 mmol) of alcohol **3b** and 97 mg (0.23 mmol) of the Dess–Martin periodinane reagent[8] to afford 20 mg (67%) of ketone **13b**: $[\alpha]_D$ 24.9 (*c* 0.44, $CHCl_3$).

(2*S*,4*R*)-(−)-1-(Benzyloxy)-2,4-dimethyl-5-tridecyn-3-one (13c). A. From Alcohol 6c. To a rapidly stirred suspension of 240 mg (0.24 mmol) of PCC on alumina[9] in 1.5 mL of CH_2Cl_2 was added 50 mg (0.15 mmol) of alcohol **6c** in 0.5 mL of CH_2Cl_2 at rt. The mixture was stirred overnight, 1 mL of acetone was added, and stirring was continued for a further 30 min. The mixture was then rapidly flushed through a pad of Celite, concentrated under reduced pressure, triturated with hexanes, filtered, and concentrated again to afford 41 mg (82%) of ketone **13c** as a pale yellow oil: $[\alpha]_D$ −12.9 (*c* 1.7, $CHCl_3$); IR (film) ν 1796 cm^{-1}; ^1H NMR δ 7.31–7.24 (m, 5H), 4.48 (d, J = 3.2 Hz, 2H), 3.71 (m, 1H), 3.5–3.37 (m, propargylic 3H), 2.14 (dt, J = 2.4, 7.1 Hz, 1H), 2.65 (m, 1H), 2.15 (dt, J = 2.2, 6.9 Hz, 2H), 2.08–2.03 (m, 2H), 1.6–1.2 (m, 10H), 1.28 (d, J = 7.1 Hz, 3H), 1.13 (d, J = 6.8 Hz, 3H), 0.86 (t, J = 6.9 Hz, 3H); ^{13}C NMR δ 210.2, 138.3, 128.3, 127.5, 127.5, 84.3, 78.0, 73.1, 72.0, 43.6, 38.5, 31.7, 28.8, 28.8, 22.6, 18.8, 16.9, 16.0, 14.7, 14.1.

B. From Alcohol *ent*-3c. The same procedure was employed with 20 mg (0.06 mmol) of alcohol *ent*-**3c** and 200 mg (0.20 mmol) of PCC on alumina[9] to afford 16 mg (80%) of ketone **13c**: $[\alpha]_D$ −13.1 (*c* 0.97, $CHCl_3$).

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