and −1006.6 ± 3.7 kJ/mol, respectively. From these values it can be calculated that the pyrimidine photodimer fragmentation reaction, in the standard state, is exothermic ($\Delta H°_r$ = −110.0 ± 5.2 kJ mol^{-1}). The exothermicity of this reaction, when compared with the endothermic fragmentation of cyclobutane[11] ($\Delta H°_r$ = +76.5 ± 0.8 kJ mol^{-1}), reflects both the release of the additional strain in the pyrimidine photodimer compared to the simple cyclobutane and the formation of the delocalized pyrimidine double bond. Although photoenzymes can catalyze strongly endergonic reactions due to the large amount of energy absorbed by the enzyme substrate complex, this study demonstrates that in the case of DNA photolyase, all of this energy is used for catalysis.

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Registry No. 3, 5236-60-2; 4, 135790-03-3; 5, 137394-53-7; 6, 137394-54-8; 1,3-dibromopropane, 109-64-8; 1-methyluracil, 615-77-0; DNA photolyase, 37290-70-3.

Supplementary Material Available: NMR spectrum for 4 and details of the calorimetric measurements (7 pages). Ordering information is given on any current masthead page.

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Diastereoselective Electrophilic Addition Reactions to Chiral β-Dimethylphenylsilyl Ester Enolates. Synthesis of 2,3-Anti-α-substituted-β-silyl-(*E*)-hex-4-enoates

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Current efforts in our laboratory are focusing on the development of optically active (*E*)-crotylsilane reagents for their use as carbon nucleophiles in asymmetric addition reactions.[1,2] In this regard, we have recently reported the stereoselective synthesis of α-substituted β-silyl-(*E*)-hex-4-enoates **3** through the use of the Ireland–Claisen rearrangement on esters of optically active (*E*)-vinylsilanes **1**.[3,4] The process is illustrated with the *R* stereoisomer in Scheme I. This strategy is particularly useful for the construction of the syn diastereomers $\mathbf{3}_{syn}$, derived from the corresponding glycolate (X = OMe, OH) and propionate esters (X = Me). Thus, by using enolization conditions that permit the near exclusive formation of the chelated *Z* O-enolate, high levels of syn diastereoselection (16 to >25:1 syn/anti) were achieved.

In connection with studies directed toward the asymmetric synthesis of trans olefin dipeptide isosteres we required functionalized β-dimethylphenylsilyl (*E*)-hex-4-enoates that possess large alkyl substituents (e.g., ^{i}Pr, benzyl, cyclohexylmethyl) and an amine precursor (azide) α to the ester group with anti stereochemistry relative to the silicon group. In these cases the Claisen strategy was plagued by the fact that the desired anti diastereomer could only be isolated in low yield with considerable amounts of 1-(dimethylphenylsilyl)-1-buten-3-ol produced presumably via the hydrolysis of the intermediate silylketene acetal. Furthermore, for cases employing glycolate esters of **1** (X = OR) the configuration of the enolate had to be reversed from *Z* O- to the *E* O-ester enolate, a situation where the strong chelating ability of the glycolate oxygen made it difficult to achieve useful levels of selectivity resulting in only moderate levels of diastereoselection for the anti product.[3] In an effort to develop a more efficient method for the production of $\mathbf{3}_{anti}$ with high levels of diastereoselection, we investigated the potential of the derived β-silyl ester enolate of **2** to participate in diastereoselective electrophilic addition reactions (Scheme I). As first documented by Fleming,[5a,b] useful levels of diastereoselection were achieved in alkylation reactions of racemic β-silyl enolates derived from the conjugate addition of a silyl cuprate to an α,β-unsaturated carbonyl compound. The sense of asymmetric induction is the same as the well-established anti stereospecifity observed in the addition of electrophiles to allylsilanes.[6]

In this paper, we wish to report the results of our experiments on the electrophilic additions to chiral β-(dimethylphenylsilyl)lithium ester enolates of (*R*)-**2a** and (*S*)-**2b**. The reactions constitute a viable approach for the synthesis of the 2,3-anti diastereomers in nearly optically pure form. The (*E*)-crotylsilanes **2** are derived from an Ireland–Claisen reaction on the acetate of (*S*)-**1a** or (*R*)-**1b** (X = H) as previously reported.[3] A variety of carbon electrophiles and the azide doner, 2,4,6-triisopropylbenzenesulfonyl azide (trisyl-N_3),[7] were examined. The

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Scheme I. Comparison of Diastereoselection in the Ireland–Claisen Rearrangement of (*R*)-(*E*)-Vinylsilanes and Electrophilic Additions to β-Silyl Enolates

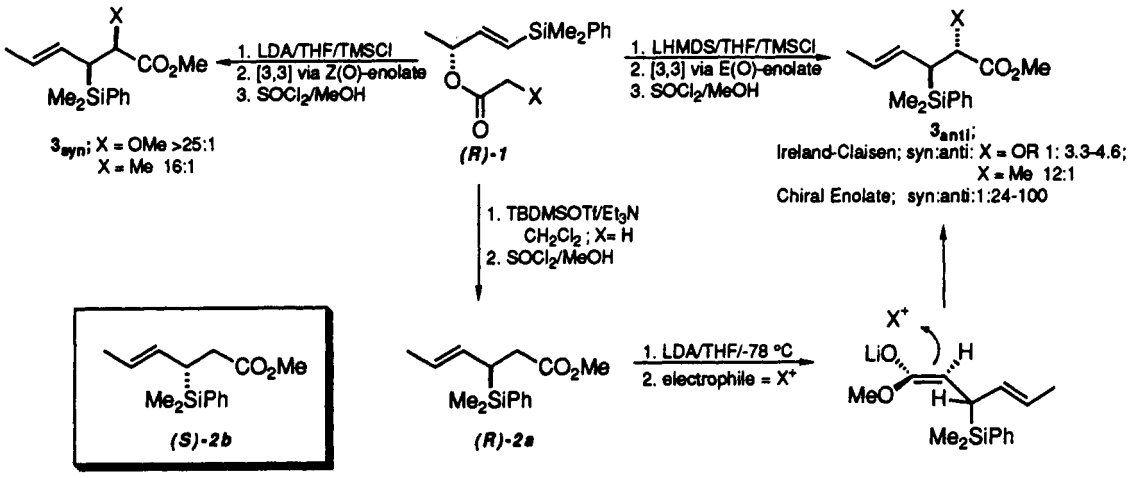
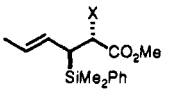
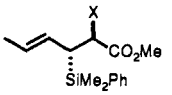


Table I. Electrophilic Addition Reactions to Optically Active β-Silyl Ester Enolates

entry	electrophile	structure	product X	product compd no.	yield,[a] %	anti/syn[b]
						
1	benzyl bromide	from (*R*)-**2a**	$PhCH_2$	**3a**	89	60:1
2	allyl bromide		allyl	**3e**	70	100:1
3	trisyl azide		N_3	**3g**	73	40:1
4	cyclohexylmethyl bromide[c]		c-$C_6H_{11}CH_2$	**3h**	76	50:1
						
5	benzyl bromide	from (*S*)-**2b**	$PhCH_2$	**3b**	85	75:1
6	2-bromopropane[c]		^iPr	**3c**	82	24:1
7	methyl iodide		Me	**3d**	91	100:1
8	trisyl azide		N_3	**3f**	73	40:1

[a] Yields refer to diastereomerically pure (*E*)-crotylsilanes after column chromatography on SiO_2. [b] Diastereomer ratios were determined by GLC and ^1H NMR spectroscopic analysis. [c] Reaction was carried out at a concentration of (0.2–0.3 M) with 20% HMPA/THF (v/v).

results of our investigation concerning this electrophilic addition reaction are summarized in Table I and are complementary to the Claisen strategy[3] discussed above and related alkylation reactions of β-silyl enolates.[5] In all cases, the ester enolates exhibited high levels of diastereoselection for the formation of the anti diastereomer (syn vs anti; 1:24–100) as determined by ^1H NMR analysis and capillary GLC.[10b] As expected, the reactions show complete chemoselectivity for addition to the lithium enolate with no indication of reaction with the sensitive allylsilane functionality. Although simply mixing the alkyl halide with the derived lithium enolate of **2**, together in THF at −78 °C and allowing the reaction to warm gradually to room temperature (4–10 h) was generally sufficient for complete reaction (entries 1, 2, 5, and 7, Table I), less reactive electrophiles required the use of HMPA (entries 4 and 6, Table I). The reaction of the lithium enolate derived from (*R*)-**2a** and (*S*)-**2b** with 2,4,6-triisopropylbenzenesulfonyl azide (trisyl-N_3, 1.05 equiv, then AcOH quench) according to the conditions described by Evans et al.[7b] afforded the anti azides (2*S*,3*R*)-**3f** and (2*R*,3*S*)-**3g** in 70 and 73% yield, respectively, as a 40:1 ratio of anti/syn diastereomers. This direct azide transfer reaction with trisyl-N_3 provides a highly stereoselective route to interesting and highly functionalized allylsilanes in nearly enantiomerically pure form. Asymmetric addition reactions to acetals and aldehydes with (*E*)-crotylsilanes **3f** and **3g** may provide a new approach to the construction of functionalized α-amino acids.[8]

Stereochemical Assignment. The assignment of relative stereochemistry for the major 2,3-anti-(*E*)-hex-4-enoates **3a–h** is based on the vicinal coupling constants between the C2/C3 stereogenic centers ($^3J_{H2,H3}$).[9] For three cases authentic samples were available from an Ireland–Claisen, which permitted the direct comparison of the three-bond coupling constant values between both 2,3-syn and 2,3-anti diastereomers. For these structural types, the measured $^3J_{H2,H3}$ values for the anti diastereomers (2*S*,3*R*)-**3d**, (2*S*,3*R*)-**3f**, and (2*R*,3*S*)-**3g** were smaller in magnitude than those for the 2,3-syn diastereomer.[3]

Conclusion

The diastereoselective electrophilic additions to optically active β-(dimethylphenylsilyl)lithium enolates derived through the low-temperature deprotonation of either (*S*)-**2a** or (*R*)-**2b** with lithium diisopropylamide (LDA, −78

(8) The potential of an α-azido-β-silyl-(*E*)-crotylsilane of structural type **3** to function as an effective chiral nucleophile in enantioselective addition reactions with acetals and aldehydes to produce homoallylic ethers and alcohols bearing an α-azido ester is currently under investigation (cf. ref 1a,b). This functional group arrangement is resistant to racemization and has been shown to be a useful precursor to α-amino acids; see ref 6b for a summary of established methods for the asymmetric synthesis of α-amino acids.

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°C, THF) provides access to the functionalized (*E*)-crotylsilanes with an anti disposition of the α- and β-substituents. The present study complements the Ireland–Claisen strategy described for reactions of optically active (*E*)-vinylsilanes[3,4] and generally proceeds with high levels of diastereoselection. It is worth pointing out that the selectivities observed in this study are comparable to those observed for methylation reactions of ester enolates derived by 1,4-addition of $(PhMe_2Si)_2CuLi$ or Me_3SnLi to the corresponding enoate.[5] The experiments support the notion that a trialkylsilicon group can function as an effective stereocontrolling element in electrophilic addition reactions to the derived chiral enolate. Further studies aimed at development of these reagents in asymmetric addition reactions are currently being carried out in these laboratories and will be reported in due course.

Experimental Section[10a]

Representative Procedure for the Diastereoselective Alkylation Reactions of Optically Active β-Silyl Ester Enolates. (2*R*,3*S*)-(*E*)-Methyl 2-Benzyl-3-(dimethylphenylsilyl)hex-4-enoate (3a). A solution of diisopropylamine (7.3 mmol, 1.01 mL, 1.4 equiv) in freshly distilled THF (8.0 mL) at −78 °C was treated with *n*-BuLi (7.3 mmol, 4.3 mL, 2.0 M, in hexanes). The solution was brought to 0 °C for 10 min then recooled to −78 °C. A solution of (3*R*)-(*E*)-β-silylhex-4-enoate[3] ((*R*)-**2a**, 2.32 g, 5.2 mmol) in THF (2.0 mL, 0.28 M) was added via syringe to the cooled solution (−78 °C) of LDA. The light yellow solution was stirred for 30 min, and benzyl bromide (1.44 g, 8.34 mmol, 1.2 equiv) in 1 mL of dry THF was added. The reaction mixture was allowed to warm to rt and stirred for 8 h before being diluted with saturated NH_4Cl (20 mL). The mixture was extracted with EtOAc (2 × 50 mL). The combined organic layers were washed with saturated brine and dried over $MgSO_4$, and the solvent was removed in vacuo to afford crude **3a** as a yellow oil. Purification on SiO_2 (100% PE–10% EtOAc–PE gradient elution) afforded pure **3a** as a colorless oil, 1.56 g (85%, 1.83 g theoretical): ^1H NMR (400 MHz, $CDCl_3$) δ 7.51–7.25 (m, 5 H), 7.21–6.98 (m, 5 H), 5.36–5.23 (m, 2 H), 3.20 (s, 3 H), 2.88–2.85 (m, 1 H), 2.69 (d, 2 H, *J* = 8.4 Hz), 2.19–2.14 (dd, 1 H, *J* = 10.0, 8.8 Hz), 1.70 (d, 3 H, *J* = 6.0 Hz), 0.33 (s, 3 H), 0.27 (s, 3 H); ^{13}C NMR (60 MHz, $CDCl_3$) δ 175.04, 139.88, 137.31, 134.26, 129.01, 128.73, 128.39, 128.15, 127.58, 126.24, 126.04, 50.91, 50.84, 48.44, 38.08, 36.15, 18.13, −3.23, −4.45; IR (neat) ν_{max} 3100–2800, 1710, 1410, 1230, 1150, 960, 680 cm^{-1}; CIMS (NH_3) 353.1, 275.1, 261.1, 135.0, 95.0; CIHRMS M + NH_4^+ (calcd for $C_{22}H_{28}O_2Si$) 370.2202, found 370.2199; $[\alpha]^{23}_D$ = +1.8° (*c* 1.7, CH_2Cl_2).

Representative Procedure for the Diastereoselective Azidation of Optically Active β-Silyl Ester Enolates. (2*R*,3*S*)-Methyl 2-Azido-3-(dimethylphenylsilyl)hex-4-enoate (3g). A solution of diisopropylamine (0.48 mmol, 60 μL, 1.2 equiv) in freshly distilled THF (8.0 mL) at −78 °C was treated with *n*-BuLi (0.34 mmol, 0.2 mL, 1.9 M, in hexanes). The solution was brought to 0 °C for 10 min then recooled to −78 °C. A solution of (*S*)-**2a**,[3] (0.27 mmol, 80 mg) in THF (2.0 mL, 0.28 M) was added to the cooled solution (−78 °C) of LDA. The light yellow solution was stirred for 30 min, and triisopropylbenzenesulfonyl azide[6] (86 mg, 0.28 mmol) in 1 mL dry THF was added via syringe. The reaction mixture was stirred for 10 min before quenching with acetic acid (1.22 mmol, 70 μL). The reaction mixture was allowed to warm to room temperature over 8 h before being diluted with saturated NH_4Cl solution. This solution was stirred for 5 min and extracted with Et_2O (2 × 15 mL). The combined organic layers were dried ($MgSO_4$), and the solvent was removed under reduced pressure. The crude oil was flash chromatographed on silica gel (3% EtOAc–hexanes eluant) to afford 67 mg (73% yield, theoretical 91 mg) of pure **3g** as a colorless oil: ^1H NMR (400 MHz, $CDCl_3$) δ 7.57–7.28 (m, 5 H), 5.40 (m, 2 H), 3.88 (d, 1 H, *J* = 5.6 Hz), 2.29 (dd, 1 H, *J* = 3.2, 9.2 Hz), 1.68 (d, 3 H, *J* = 5.4 Hz), 0.43 (s, 3 H), 0.33 (s, 3 H); ^{13}C NMR (60 MHz, $CDCl_3$) δ 170.74, 136.37, 134.00, 129.38, 127.84, 125.13, 63.59, 52.27, 36.26, 18.21, −16.45, −15.78; IR (neat) ν_{max} 3100–2800, 2140, 1760, 1450, 1270, 1130, 990, 860, 780, 720 cm^{-1}; CIMS (NH_3) 321.1, 261.0, 226.0, 152.0, 94.9; CIHRMS M^+ (calcd for $C_{15}H_{21}N_3O_2Si$) 303.4762, found 303.4872; $[\alpha]^{23}_D$ = −8.3° (*c* 1.5, $CHCl_3$).

The following compounds were prepared according to the representative procedures above. The amount of substrate (mg, mmol), number of equivalents of LDA, solvent (if different from THF), electrophile (equiv), reaction time (h), and product weight (% yield) are specified after the systematic names. **(2*S*,3*R*)-(*E*)-Methyl 2-Benzyl-3-(dimethylphenylsilyl)hex-4-enoate (3b).** Enolization conditions/electrophile: from (*S*)-**2b**; 305 mg, 1.16 mmol; LDA (1.4 equiv), benzyl bromide (1.6 equiv) −78 °C → rt, 8 h, 363 mg, (89%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.51–7.33 (m, 5 H), 7.20–6.98 (m, 5 H), 5.33–5.26 (m, 2 H), 3.19 (s, 3 H), 2.87–2.85 (m, 1 H), 2.69 (d, 2 H, *J* = 8.4 Hz), 2.16 (dd, 1 H, *J* = 10.0, 8.8 Hz), 1.69 (d, 3 H, *J* = 6.1 Hz), 0.33 (s, 3 H), 0.26 (s, 3 H); ^{13}C NMR (60 MHz, $CDCl_3$) δ 175.03, 139.88, 137.31, 134.25, 129.01, 128.72, 128.39, 128.13, 127.57, 126.24, 126.03, 50.89, 50.83, 48.24, 38.08, 36.15, 18.11, −3.23, −4.44; IR (neat) ν_{max} 3100–2800, 1710, 1410, 1230, 1150, 960, 680 cm^{-1}; CIMS (NH_3) 353.1, 275.1, 261.1, 135.0, 95.0; CIHRMS M + NH_4^+ (calcd for $C_{22}H_{28}O_2Si$) 370.2202, found 370.2206; $[\alpha]^{23}_D$ = −2.0° (*c* 1.6, CH_2Cl_2).

(2*S*,3*R*)-(*E*)-Methyl 2-Isopropyl-3-(dimethylphenylsilyl)hex-4-enoate (3c). Enolization conditions/electrophile: from (*S*)-**2b**; 400 mg, 1.52 mmol; LDA (1.4 equiv), THF/20% HMPA, 2-bromopropane (1.5 equiv), −78 °C → rt, 6 h, 400 mg, (82%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.49–7.30 (m, 5 H), 5.29–5.21 (m, 1 H), 5.04–4.98 (m, 1 H), 3.33 (s, 3 H), 2.43–2.38 (dd, 1 H, *J* = 4, 12.2 Hz), 2.22–2.14 (dd, 1 H, *J* = 11.0, 10.7 Hz), 1.91–1.86 (m, 1 H), 1.62 (d, 3 H, *J* = 6.2 Hz), 0.83 (d, 3 H, *J* = 7.0 Hz), 0.77 (d, 3 H, *J* = 7.0 Hz), 0.24 (s, 3 H), 0.197 (s, 3 H); ^{13}C NMR (60 MHz, $CDCl_3$) δ 174.23, 137.56, 134.38, 128.88, 128.78, 127.42, 127.34, 125.10, 50.58, 50.53, 50.26, 32.76, 28.87, 21.41, 18.05, 15.62, −3.67, −4.38; IR (neat) ν_{max} 3100–2850, 1750, 1540, 980, 850 cm^{-1}; CIMS (NH_3) 305.2, 304.2, 289.1, 261.1, 227.1, 152.1, 135.1, 95.0; CIHRMS M + NH_4^+ (calcd for $C_{18}H_{28}O_2Si$) 322.2202, found 322.2201; $[\alpha]^{23}_D$ = +32.1° (*c* 0.6, CH_2Cl_2).

(2*S*,3*R*)-(*E*)-Methyl 2-Methyl-3-(dimethylphenylsilyl)-hex-4-enoate (3d). Enolization conditions/electrophile: from (*S*)-**2b**; 200 mg, 0.76 mmol; LDA (1.3 equiv), methyl iodide (2.0 equiv), −78 °C → rt, 10 h, 191 mg, (91%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.50–7.48 (m, 2 H), 7.36–7.33 (m, 3 H), 5.31–5.21 (m, 2 H), 3.45 (s, 3 H), 2.55–2.52 (m, 1 H), 2.14 (dd, 1 H, *J* = 7.2, 10.4 Hz), 1.65 (d, 3 H, *J* = 5.2 Hz), 1.06 (d, 3 H, *J* = 6.8 Hz), 0.31 (s, 3 H), 0.26 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.82, 137.67, 134.23, 129.04, 127.71, 127.66, 126.11, 51.34, 39.86, 36.12, 18.22, 16.04, −3.29, −4.19; IR (neat) ν_{max} 2995, 1700, 1450, 1250, 900, 800 cm^{-1}; CIMS (NH_3 gas) 296, 277; CIHRMS M + NH_4^+ (calcd for $C_{16}H_{24}O_2Si$) 294.4931, found 294.4930; $[\alpha]^{23}_D$ = −30° (*c* 1, CH_2Cl_2).

(2*R*,3*S*)-(*E*)-Methyl 2-Propenyl-3-(dimethylphenylsilyl)hex-4-enoate (3e). Enolization conditions/electrophile: from (*R*)-**2a**; 200 mg, 0.76 mmol; LDA (1.3 equiv), allyl bromide (2.0 equiv), −78 °C → rt, 10 h, 160.6 mg, (70%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.50–7.48 (m, 2 H), 7.36–7.33 (m, 3 H), 5.69–5.62 (m, 1 H), 5.32–5.30 (m, 1 H), 5.17–5.13 (m, 1 H), 4.97–4.92 (m, 2 H), 3.37 (s, 3 H), 2.53–2.47 (m, 1 H), 2.29–2.12 (m, 2 H), 2.09–2.07 (m, 1 H), 1.67 (d, 3 H, *J* = 6.4 Hz), 0.31 (s, 3 H), 0.26 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.33, 137.44, 135.88, 134.34, 129.04, 128.47, 127.60, 126.14, 116.41, 51.05, 46.02, 36.42, 35.49, 18.15, −3.27, −4.33; IR (neat) ν_{max} 3000, 1700, 1500, 1350, 1200, 1000, 900, 800 cm^{-1}; CIMS (NH_3 gas) 437.2, 397.1, 303.1, 261.1,

(10) (a) All reactions were run in oven-dried glassware, sealed with a rubber septa, and stirred with a magnetic stirring bar under N_2. Unless otherwise noted commercial reagents were purchased and used without further purification. HMPA was distilled from CaH_2. Diisopropylamine was distilled from NaOH. THF was distilled from sodium benzophenone ketyl under N_2 just prior to use. All extraction and chromatographic solvents (ethyl acetate (EtOAc), petroleum ether (PE)) were distilled prior to use. TLC plates used for determining reaction progress were plastic sheets precoated with SiO_2 60 F_{254} as purchased from E. Merck, Darmstadt. Flash chromatography (cf. Still, W. C.; Khan, M.; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923) was performed on E. Merck silica gel 230–400 mesh. (b) Capillary GLC analyses were performed with a 30 m × 0.25 mm fused-silica DB-1701 column on products that were filtered through a silica gel plug to remove debris from the reaction. No separation of diastereomers could be detected as ^1H NMR ratios (crude products) confirmed the ratios obtained by GLC analysis. The minor diastereomers were identified by capillary GC and/or ^1H NMR comparisons with authentic samples obtained from Ireland enolate–Claisen rearrangements (cf. ref 3).

225.1, 135.0, 95.0; CIHRMS M + NH_4^+ (calculated for $C_{18}H_{26}O_2Si$) 320.2046, found 320.2046; $[\alpha]^{23}_D$ = +7° (c 0.25, CH_2Cl_2).

(2S,3R)-Methyl 2-Azido-3-(dimethylphenylsilyl)hex-4-enoate (3f). Enolization conditions/electrophile: from (S)-**2b**; 1.04 mg, 0.4 mmol, LDA (1.2 equiv), trisyl azide (1.0 equiv), -78 °C → rt, 10 h, 88 mg, (73%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.57-7.28 (m, 5 H), 5.40 (m, 2 H), 3.88 (d, 1 H, J = 5.6 Hz), 2.29 (dd, 1 H, J = 3.2, 9.2 Hz), 1.68 (d, 3 H, J = 5.4 Hz), 0.43 (s, 3 H), 0.33 (s, 3 H); ^{13}C NMR (60 MHz, $CDCl_3$) δ 170.74, 136.37, 134.00, 129.38, 127.84, 125.13, 63.59, 52.27, 36.26, 18.21, -16.45, -15.78; IR (neat) ν_{max} 3100-2800, 2140, 1760, 1450, 1270, 1130, 990, 860, 780, 720 cm^{-1}, CIMS (NH_3) 321.1, 261.0, 226.0, 152.0, 94.9; CIHRMS M^+ (calcd for $C_{15}H_{21}N_3O_2Si$) 303.4762, found 303.4562; $[\alpha]^{23}_D$ = +7.1° (c 1.4, $CHCl_3$).

(2R,3S)-(E)-Methyl 2-(Cyclohexylmethyl)-3-(dimethylphenylsilyl)hex-4-enoate (3h). Enolization conditions/electrophile: from (R)-**2a**; 1.0 g, 3.80 mmol; LDA (1.3 equiv), THF/20% HMPA, cyclohexylmethyl bromide (2.0 equiv), -78 °C → rt, 10 h, 1.03 g, (76%); ^1H NMR (400 MHz, $CDCl_3$) δ 7.49-7.33 (m, 5 H), 5.22-5.14 (m, 2 H), 3.40 (s, 3 H), 2.56-2.52 (m, 1 H), 2.05-2.00 (dd, 1 H, J = 10.0, 9.1 Hz), 1.65 (d, 3 H), J = 5.6 Hz), 1.60-1.45 (m), 1.29-0.55 (m), 0.31 (s, 3 H), 0.25 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.16, 137.62, 134.22, 128.86, 128.44, 127.45, 125.52, 50.99, 50.92, 43.20, 38.97, 36.31, 35.99, 34.22, 32.19, 26.49, 26.27, 26.11, 18.05, -3.26, -4.32; IR (neat) ν_{max} 3060-2850, 1760, 1470, 1450, 1280, 1030, 840 cm^{-1}; CIMS (NH_3) 359.1, 358.1, 282.1, 281.1, 261.0, 152.0, 135.0; CIHRMS M + NH_4^+ (calcd for $C_{22}H_{34}O_2Si_1$) 376.2672, found 376.2679; $[\alpha]^{23}_D$ = +3.3° (c 0.7, CH_2Cl_2).

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Registry No. (R)-**2a**, 136174-52-2; (S)-**2b**, 136314-66-4; **3a**^{anti}, 136824-13-0; **3a**^{syn}, 136824-14-1; **3b**^{anti}, 136824-15-2; **3b**^{syn}, 136824-16-3; **3c**^{anti}, 136824-17-4; **3c**^{syn}, 136824-18-5; **3d**^{anti}, 134451-72-2; **3d**^{syn}, 136235-01-3; **3e**^{anti}, 136824-19-6; **3e**^{syn}, 136824-20-9; **3f**^{anti}, 136824-21-0; **3f**^{syn}, 136824-22-1; **3g**^{anti}, 136824-23-2; **3g**^{syn}, 136824-24-3; **3h**^{anti}, 136824-25-4; **3h**^{syn}, 136824-26-5; allyl bromide, 106-95-6; trisyl azide, 36982-84-0; cyclohexylmethyl bromide, 2550-36-9; 2-bromopropane, 75-26-3.

Supplementary Material Available: Spectral data for all reaction products **3a-h** in the form of ^1H NMR and ^{13}C NMR spectra (16 pages). Ordering information is given on any current masthead page.

Syntheses of Destomic Acid and Anhydrogalantinic Acid from L-Serinal

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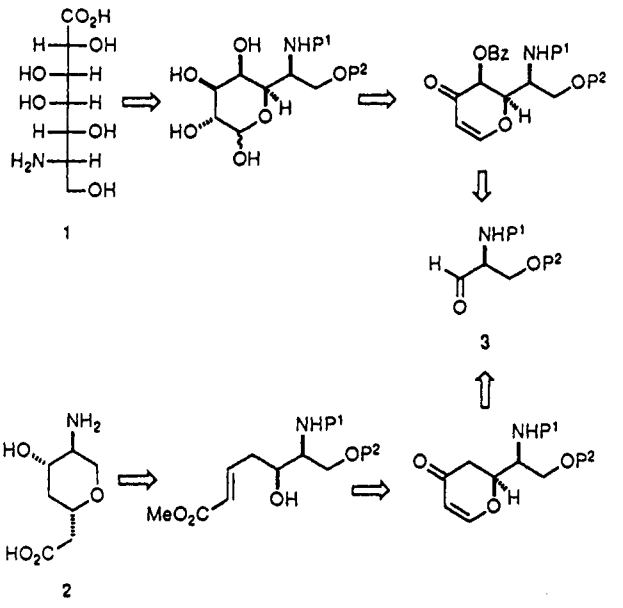
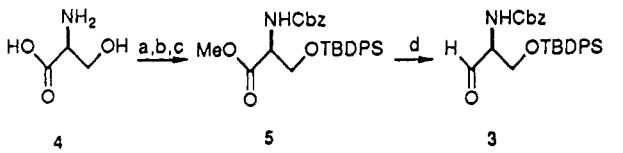
A few years ago we began a program to examine applications of α-amino aldehydes in total syntheses of natural products.[1,2] We found such aldehydes to be very convenient and versatile heterodienophiles under high-pressure[1-5] and/or Lewis acid catalysis[6-9] conditions. [4 + 2] Cycloadditions of 1,3-dienes to N-protected α-amino aldehydes offered an easy access to respective optically active cycloadducts which were readily transformed into several natural products.[10]

Scheme I



Scheme II[a]



[a] (a) MeOH, $SOCl_2$; (b) CbzCl, $NaHCO_3$; (c) TBDPSCl, Imd, DMF; (d) DIBAL, -78 °C, Et_2O.

Now we present in detail the formal syntheses of two natural products: destomic acid[11] and anhydrogalantinic acid,[12] both based on methodology involving [4 + 2] cycloadditions of Danishefsky's type dienes to *N*-protected α-amino aldehydes.[6-9]

Destomic acid (6-amino-6-deoxy-L-*glycero*-D-*galacto*-heptonic acid) (1) is a component of the aminocyclitol antibiotics: destomycin A,[13,14] B,[14,15] C,[16] hygromycin B,[17]

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