in hexane and 0.53 mL of dicyclohexylamine) under an argon atmosphere was added dropwise a solution of 0.4 g (1.27 mmol) of (*S*)-(+)-**7** in 2.5 mL of THF. The mixture was stirred at −100 °C for 10 min and quenched with a cooled solution of 10% aqueous HCl (5 mL). Et_2O (15 mL) was added, the mixture warmed to room temperaure, and the organic layer separated, washed with brine (5 mL), and extracted with 10% $NaHCO_3$ solution (2 × 5 mL). The aqueous extract was acidified (cold 10% aqueous HCl) and extracted with Et_2O (2 × 10 mL). The Et_2O layer was washed with brine (2 × 4 mL), dried (Na_2SO_4), and concentrated in vacuo. Recrystallization of the residue from hexane/Et_2O afforded 0.11 g (30%) of colorless prisms, mp 124–125 °C. **9**: $[\alpha]^{22}_D$ +39.7° (*c* 1.00, MeOH); IR ν_{max}^{neat} 2920, 2680, 1735, 1650, 1390, 1340, 1140; ^1H NMR ($CDCl_3$, 250 MHz) δ 5.14 (d, 1 H, *J* = 11.4 Hz), 5.18 (d, 1 H, *J* = 11.4 Hz), 5.51 (s, 1 H), 7.08–7.12 (m, 2 H), 7.26–7.43 (m, 8 H). Anal. Calcd for $C_{17}H_{14}O_4$: C, 72.33; H, 5.00. Found: C, 72.54; H, 5.08.

(*S*)-(+)-3,4-Dihydroxy-5-phenyl-2(5*H*)-furanone (3). To a solution of (*S*)-(+)-**9** (0.04 g, 0.14 mmol) in EtOH (5 mL) were added 10% Pd/C (0.04 g) and cyclohexene (0.36 mL, 3.56 mmol). The mixture was refluxed for 1 h under argon, filtered, and concentrated in vacuo. Recrystallization of the residue from acetone/hexane afforded 0.01 g (40%) of colorless needles, mp 142–143 °C (lit.[23] mp for racemic **3** 150.5–152 °C dec). **3**: $[\alpha]^{22}_D$ +109.4° (*c* 0.80, MeOH); IR ν_{max}^{neat} 3300, 1740, 1640 cm^{-1}; ^1H NMR ($CDCl_3$ + d_6-DMSO, 250 MHz) δ 4.98 (s, 1 H), 7.23–7.41 (m, 5 H). Anal. Calcd for $C_{10}H_8O_4$: C, 62.50; H, 4.20. Found: C, 62.69; H, 4.25.

Acknowledgment. We are grateful to the U.S. Public Health Service National Heart, Lung and Blood Institute for support of this work through grant no. R01 HL-12740.

Registry No. (±)-**1**, 124400-07-3; (*S*)-**2**, 119006-88-1; (*S*)-**3**, 124400-08-4; (*S*)-**4**, 687-47-8; (*S*)-**5**, 124400-09-5; (*S*)-**6**, 21210-43-5; (*S*)-**7**, 124400-10-8; (*S*)-**8**, 124400-11-9; (*S*)-**8**·(*S*)-$PhCH(CH_3)NH_2$, 124400-13-1; (*S*)-**9**, 124400-12-0; $PhCH_2OCH_2C(O)Cl$, 19810-31-2.

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(27) Removal of the chiral auxilliary with $Mg(OCH_3)_2$[24] (0.02 M; 1.1 equiv) at −15 °C to −20 °C followed by deprotection via transfer hydrogenation yielded partially racemized α-hydroxy ester [(35% ee, $[\alpha]^{22}_D$ +49.1° (*c* 1.00, MeOH)] in 61% overall yield from the oxazolidinone carboximide.
(28) Dale, J. A.; Dull, D. L.; Mosher, H. S. *J. Org. Chem.* **1969**, *34*, 2543–2549.
(29) The racemic methyl α-hydroxyacetate, mp 104–105 °C, was prepared by CH_2N_2 esterification of the racemic acid, which was synthesized as follows: in situ cyanosilylation[30] [Me_3SiCl, KCN, $Zn(CN)_2$] of 4-biphenylcarboxaldehyde furnished trimethylsilyl cyanohydrin ether, which was hydrolyzed with HCl[31] to the hydroxy amide (mp 226–227 °C) and finally to racemic α-hydroxy acid (mp 201–202 °C, lit.[32] mp 201–203 °C) with KOH/MeOH in 56% overall yield.
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New Stereoselective Propanal/Propanoic Acid Synthons for Aldol Reactions[1]

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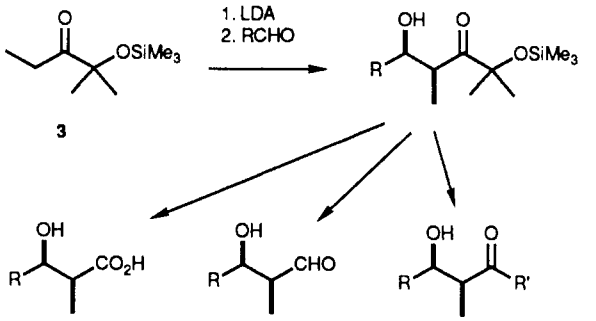
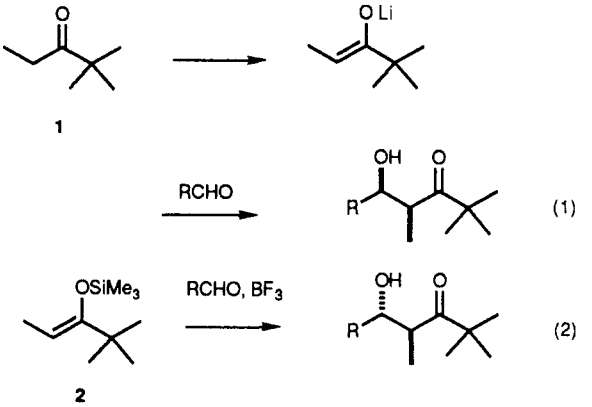
It has been well established that reactions of performed main-group metal enolates with aldehydes show a correlation between enolate geometry and aldol relative configuration if the nonreacting carbonyl ligand is sterically bulky.[2] For example, 2,2-dimethyl-3-pentanone undergoes deprotonation to give a *Z* enolate, which reacts with aldehydes to given syn aldols of high stereochemical purity (eq 1).[3] Conversely, the trimethylsilyl enol ethers of such ketones undergo anti-selective Lewis acid mediated aldol reactions (eq 2).[4]

Scheme I





To capitalize on this high aldol stereoeselectivy, we developed aldol reagent **3**.[3,5,6] Like 2,2-dimethyl-3-pentanone, ketone **3** gives a *Z* enolate that reacts with a variety of aldehydes to give syn aldols that can be cleaved by periodic acid to give β-hydroxy acids,[7] reduced and then cleaved by periodate to give β-hydroxy aldehydes,[8] or treated sequentially with an alkyllithium reagent and periodate to provide β-hydroxy ketones (Scheme I).[9]

Reagent **3** and its relatives have been employed in several syntheses as syn-selective propanal or propanoic acid synthons.[10] A structurally related synthon, ethyl trityl

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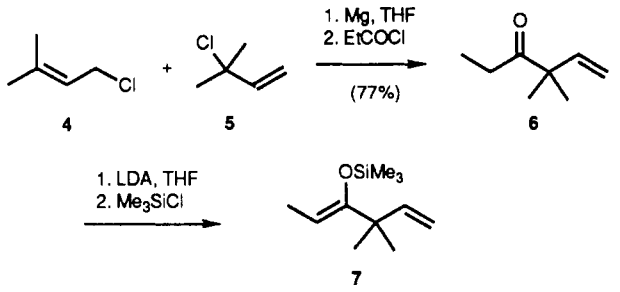
0022-3263/90/1955-1114$02.50/0

Scheme II

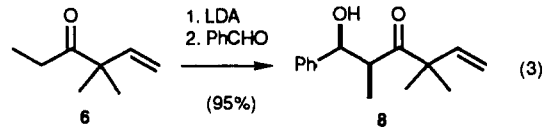


4 5 6 7

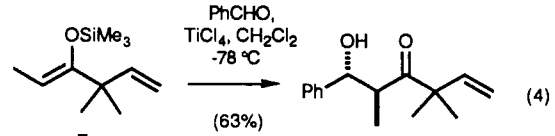
ketone, also undergoes highly syn-selective aldol reactions; the resulting trityl aldols may be reductively cleaved wtih lithium triethylborohydride, after protection of the secondary alcohol.[11]

In spite of its utility, however, ketone **3** has limitations. A case in point is in Lewis acid mediated additions of its (*Z*)-trimethylsilyl enol ether to aldehydes. Although this reagent is highly anti-selective with sample aldehydes, it is less selective with α-alkoxy aldehydes, perhaps because of unwanted coordination of the Lewis acid by the α-(trimethylsilyl)oxy group.[12] To remedy this deficiency, we have developed another 2,2-dimethyl-3-pentanone analogue that has all of the desirable properties of **3**, without the undesirable feature of a (trialkylsilyl)oxy group. The new reagent, ketone **6**, is simply prepared as shown in Scheme II by reaction of the Grignard reagent derived from prenyl chloride[13] with propanoyl chloride; ketone **6** is obtained in 77% yield.[14] Treatment of the derived lithium enolate with trimethylsilyl chloride affords the trimethylsilyl enol ether **7** in 75% yield.

The reactions summarized in eq 3 and 4 were carried out to assess the simple diastereoselectivity of reagents **6** and **7**. As expected, reaction of the lithium enolate with benzaldehyde affords syn aldol **8**, whereas the $TiCl_4$-mediated reaction of **7** with the same aldehyde provides the anti aldol **9**. Both aldols are obtained in a diastereomeric purity of >97:3 (high-field ^1H NMR).

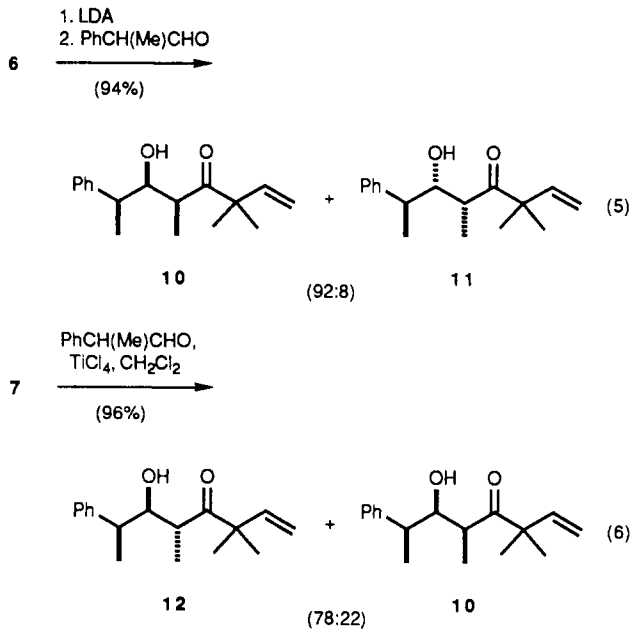


6 8 (3)



7 9 (4)

2-Phenylpropanal was used to examine the stereoselectivity of the aldol reactions of reagents **6** and **7** with a typical chiral aldehyde. The reaction of the lithium enolate of **6** with 2-phenylpropanal gives only the two syn aldols, and a rather high Cram/anti-Cram ratio of 92:8 is observed (eq 5). In the $TiCl_4$-mediated reaction of **7** with the same aldehyde (eq 6), the Cram/anti-Cram ratio is >97:3,[15] but the simple diastereoselectivity is unusually low; aldols **12** and **10** are produced in a ratio of 3.5:1.



6 → 10 + 11 (5)

7 → 12 + 10 (6)

Because it has been found that diastereofacial selectivity in additions to α-chiral thionium ions is enhanced when the sulfur substituent is more bulky,[16] we investigated the Lewis acid mediated nucleophilic substitution reactions of the pinacol acetal (**13**) of 2-phenyl-2-propanal. As shown in Scheme III, $TiCl_4$-mediated reaction of **13** with reagent **7** provides a 95:5 mixture of **14** and **15** if the reaction is carried out and quenched at −78 °C. To our pleasant surpise, we discover that aldols **12** and **10** are produced in 96% yield in a ratio of 94:6 if the aldol reaction mixture is warmed for −78 °C to 0 °C prior to the aqueous quench. The loss of the pinacol group presumably occurs by $TiCl_4$-promoted pinacol rearrangement of the intermediate ethers. Use of the pinacol ether is essential to obtain high diastereofacial selectivity; when the dimethyl acetal corresponding to **13** is used in this reaction, three β-methoxy ketones are obtained in a ratio of 5:4:1.

Finally, we have demonstrated the conversion of the new aldols to more useful β-hydroxy carbonyl compounds as shown in Scheme IV. Reduction of a 24:1 mixture of aldols **12** and **10** with lithium aluminum hydride provides a mixture of diols that is oxidized with lead tetraacetate to a mixture of β-hydroxy aldehydes.[17] Reduction of the latter mixture provides a mixture of diols **16** (57%) and **17** (5%). The transformation depicted in Scheme IX is impressively chemoselective, considering the fact that one of the secondary hydroxy groups is homoallylic and the other is homobenzylic. Other examples of the $Pb(OAc)_4$-mediated conversion of such homoallylic alcohols to aldehydes will be reported in connection with a paper

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(14) For a precedent for this reaction, see: Sato, F.; Inoue, M.; Oguro, K.; Sato, M. *Tetrahedron Lett.* **1979**, 4303.

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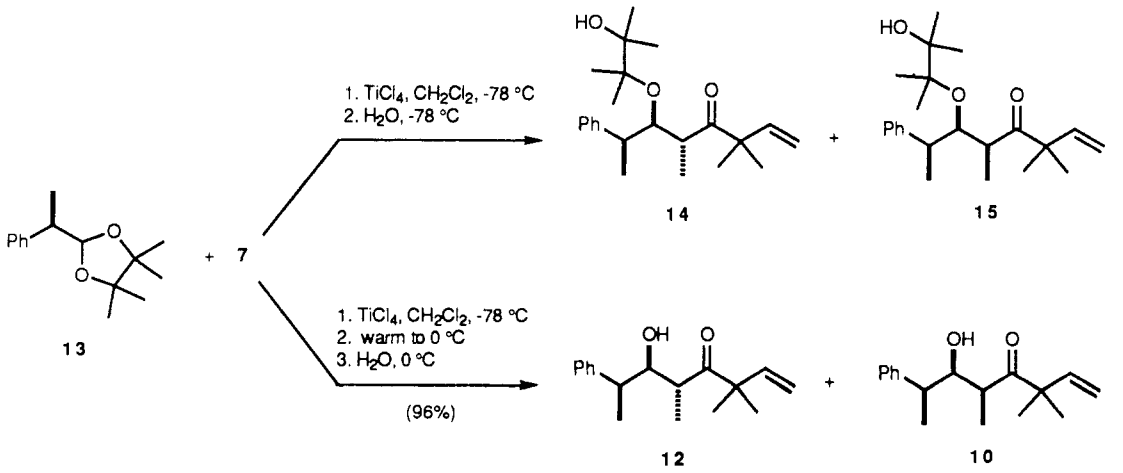
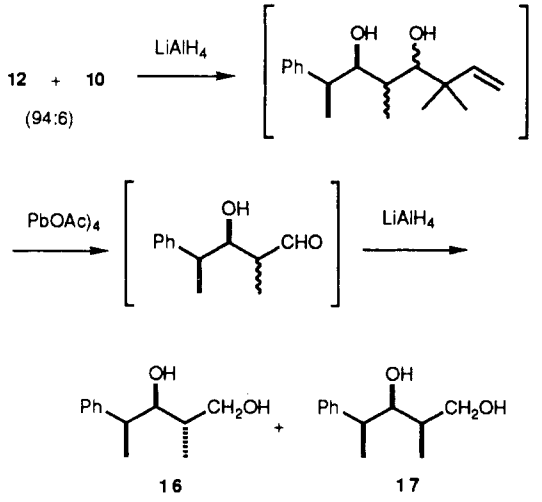
Scheme III



Scheme IV



detailing the use of **7** for an iterative thionium ion extension process.[18]

In conclusion, we have developed short, convenient syntheses of ketone **6** and the derived trimethylsilyl enol ether **7**, which may be used for stereoselective formation of syn and anti β-hydroxy carbonyl compounds. The obvious limitation of the new reagents is that other groups that react with lithium aluminum hydride or lead tetraacetate could provide avenues for side reactions.

Experimental Section

General. Unless otherwise noted, materials were obtained from commercial sources and used without further purification. All reactions were performed under a dry N_2 atmosphere. Tetrahydrofuran (THF), diethyl ether, and benzene were distilled from sodium/benzophenone ketyl immediately prior to use. Dichloromethane was distilled from calcium hydride. Chromatography was performed with silica gel 60 (E. Merk, Darmstadt), 100–120 mesh, with the indicated solvents. Analytical thin-layer chromatography was performed on precoated glass plates (250 m, silica gel 60, E. Merk, Darmstadt). ^1H NMR and ^{13}C NMR spectra were measured in $CDCl_3$ solution. J values are in hertz.

4,4-Dimethyl-5-hexen-3-one (6).[14] In a 500-mL, three-necked, round-bottomed flask equipped with a thermometer, a reflux condenser, and a magnetic stirring bar were placed magnesium turnings (21.6 g, 0.9 mol) and 100 mL of THF under N_2. A small piece of iodine and ca. 0.2 mL of prenyl chloride[13] were added at 25 °C. After 10 min, the disappearance of iodine color indicated the initiation of the reaction. The reaction mixture was cooled to −10 to −15 °C and then was diluted with 60 mL of THF. A solution of prenyl chloride (31.5 g, 0.3 mol) in 200 mL of THF was added dropwise over a period of 3 h with vigorous stirring. The reaction mixture was allowed to warm to room temperature and was stirred for 30 min. The solution of the Grignard reagent was transferred dropwise over a period of 1 h at −78 °C, via cannula, into a 1000-mL flask containing 52.5 mL (0.6 mol) of propanoyl chloride in 200 mL of THF. The resulting mixture was allowed to warm to room temperature, stirred for 2 h, and poured into 1 L of water. The organic layer was removed and the aqueous layer was extracted with two 100-mL portions of ether. The combined organic layers were washed with 1 L of 2 M NaOH and 500 mL of brine. After drying, the solvent was removed by distillation through a 10-in. Vigreux column at atmospheric pressure. The residual oil was distilled at reduced pressure to give 29.0 g (77% yield) of ketone **6** as a colorless oil, bp 72–74 °C/40 Torr. IR (film): 3100, 2980, 1720, 1630, 1460, 1100, 980, 920 cm^{-1}. ^1H NMR (250 MHz): δ 5.93 (dd, 1, J = 10.5, 17.4), 5.14 (dd, 1, J = 17.4, 0.7), 5.13 (d, 1, J = 10.5, 0.7), 2.49 (q, 2, J = 7.2), 1.23 (s, 6), 1.00 (t, 3, J = 7.2). ^{13}C NMR (50.78 MHz): δ 213.6, 142.6, 113.8, 50.6, 30.4, 23.5, 8.1. Anal. Calcd for $C_8H_{14}O$: C, 76.14; H, 11.18. Found: C, 75.95; H, 11.27.

(*Z*)-3,3-Dimethyl-4-[(trimethylsilyl)oxy]-1,4-hexadiene (7). To a solution of diisopropylamine (15.4 mL, 110 mmol) in 200 mL of THF was added 53 mL of n-C_4H_9Li (105 mmol, 1.98 M in hexane) in 10 min at 0 °C. After being stirred for 15 min, the solution was cooled to −78 °C and 12.6 g (100 mmol) of ketone **6** was added over a period of 10 min. After being stirred for 1.5 h, $(CH_3)_3SiCl$ (13.9 mL, 110 mmol) was added at −78 °C, and the mixture was allowed to warm to 25 °C and stirred overnight. The reaction mixture was poured into 400 mL of pH 7 phosphate buffer and extracted with three 50-mL portions of pentane. The combined organic layers were washed with two 200-mL portions of the phosphate buffer, dried over $MgSO_4$, concentrated with a rotary evaporator, and distilled to give 17.8 g (90% yield) of ether **7**, bp 103–106 °C/45 Torr. IR (film): 3090, 2960, 1660, 1640, 1250, 1140, 1080, 900, 905, 845 cm^{-1}. ^1H NMR (250 MHz): δ 5.87 (dd, 1, J = 10.6, 17.5), 5.05 (dd, 1, J = 17.5, 1.3), 4.98 (dd, 1, J = 10.6, 1.3), 4.64 (q, 1, J = 6.7), 1.52 (d, 3, J = 6.7), 1.13 (s, 6), 0.21 (s, 9). ^{13}C NMR (50.78 MHz): δ 157.1, 146.3, 111.2, 99.4, 42.6, 25.5, 11.7, 1.1. Anal. Calcd for $C_{11}H_{22}OSi$: C, 66.60; H, 11.80. Found: C, 66.64; H, 11.54.

(1*S,2*S**)-1-Hydroxy-2,4,4-trimethyl-1-phenylhex-5-en-3-one (8).** To a stirring solution of 1.55 mL (11 mol) of diisopropylamine in 35 mL of THF was added 5.5 mL (11 mmol) of a 2 M solution of n-C_4H_9Li in hexane at 0 °C. After 15 min, the solution was cooled to −78 °C and 1.26 g (10 mmol) of ketone **6** was added over 5 min. After being stirred for 30 min, 1.06 g (10 mmol) of benzaldehyde was added dropwise, and the solution was stirred for 30 min. The reaction was quenched with 50 mL of saturated NH_4Cl and extracted with three 20-mL portions of ether. The combined ether layers were dried over Na_2SO_4 and concentrated to give 2.21 g (95%) of the title compound as a colorless oil. ^1H NMR (250 MHz): δ 7.28 (m, 5), 5.76 (dd, 1, J = 10.5, 17.5), 5.18 (dd, 1, J = 17.5, <1.0), 5.16 (dd, 1, J = 10.5, <1.0), 4.84 (d,

(18) Mori, I.; Bartlett, P. A.; Heathcock, C. H., manuscript in preparation.

1, J = 4.2), 3.48 (br s, 1), 3.20 (dq, 1, J = 4.2, 6.9), 1.17 (s, 3), 1.08 (s, 3), 1.02 (d, 3, J = 6.9). ^{13}C NMR (50.78 MHz): δ 217.4, 141.1, 140.4, 127.4, 126.6, 125.4, 114.6, 51.0, 46.4, 22.2, 22.0, 11.6.

(1*S,2*R**)-1-Hydroxy-2,4,4-trimethyl-1-phenylhex-5-en-3-one (9).** To a mixture of 106 mg (1.0 mmol) of benzaldehyde and 291 mg (1.5 mmol) of ether **7** in 5 mL of CH_2Cl_2 at −78 °C was added dropwise 0.11 mL (1.0 mmol) of $TiCl_4$. After 30 min the reaction mixture was poured into 20 mL of 1 N HCl, the organic layer was separated, and the aqueous layer was washed with two 10-mL portions of CH_2Cl_2. The combined organic layers were washed with 20 mL of brine, dried ($MgSO_4$), and concentrated to give an oil. This crude product was chromatographed on silica gel, using 5:1 hexane/ethyl acetate as eluant, to obtain 136 mg (63%) of aldol **9** as a colorless oil. IR (film): 3500, 2980, 1710, 1635, 1500, 1015, 995, 925, 775, 710 cm^{-1}. ^{1}H NMR (250 MHz): δ 7.28 (m, 5), 5.80 (dd, 1, J = 17.4, 0.8), 5.14 (dd, 1, J = 10.6, 0.8), 5.11 (dd, 1, J = 10.6, 0.8), 4.71 (d, 1, J = 7.4), 3.27 (dq, 1, 7.4, 7.0), 3.05 (br s, 1), 1.16 (s, 3), 0.94 (d, 3, J = 7.0). ^{13}C NMR (50.78 MHz): δ 217.7, 142.8, 141.6, 128.2, 127.6, 126.4, 114.4, 72.2, 51.5, 47.5, 22.9, 22.8, 16.6. Anal. Calcd for $C_{15}H_{20}O_2$: C, 77.55; H, 8.68. Found: C, 77.17; H, 8.66.

Reaction of the Lithium Enolate of Ketone 6 with 2-Phenylpropanal. A solution of LDA, prepared from 0.24 mL (1.70 mmol) of diisopropylamine and 0.62 mL of a 2.42 M solution of n-C_4H_9Li (1.50 mmol) in hexane, in 10 mL of THF was cooled to −78 °C and 189 mg (1.5 mmol) of ketone **6** was slowly added. After stirring for 30 min at −78 °C, 0.134 g (1.0 mmol) of 2-phenylpropanal was added. After 15 min at −78 °C, water was added and the solution was worked up in the usual manner to provide 249 mg (95%) of a 92:8 mixture of aldols **10** and **11**, as shown by ^{1}H NMR spectroscopy. The pure aldols were isolated by gravity chromatography on silica gel.

(2*R,3*S**,4*R**)-3-Hydroxy-4,6,6-trimethyl-2-phenyloct-7-en-5-one (10).** TLC: R_f = 0.44 (5.1 hexane/ethyl acetate). ^{1}H NMR (250 MHz): δ 5.61 (dd, 1, J = 10.5, 17.3), 5.01 (d, 1, J = 10.5), 4.89 (d, 1, J = 17.3), 3.69 (dd, 1, J = 0.8, 9.8), 3.50 (d, 1, J = 0.8), 2.68–2.84 (m, 2), 1.36 (d, 3, J = 6.8), 1.06 (s, 3), 1.03 (s, 3), 1.00 (d, 3, J = 7.0). ^{13}C NMR (50.78 MH): δ 219.1, 143.9, 140.5, 128.3, 127.3, 126.4, 115.2, 75.7, 51.3, 42.8, 40.1, 22.5, 18.7, 10.1.

(2*R,3*R**,4*S**)-3-Hydroxy-4,6,6-trimethyl-2-phenyloct-7-en-5-one (11).** TLC: R_f = 0.38 (5.1 hexane/ethyl acetate). ^{1}H NMR (250 MHz): δ 7.21–7.34 (m, 5), 5.93 (dd, 1, J = 10.0, 17.8), 5.26 (d, 1, J = 10.5), 5.25 (d, 1, J = 17.0), 3.77 (d, 1, J = 9.0), 3.31 (dq, 1, J = 1.8, 7.3), 3.25 (s, 1), 2.76–2.83 (m, 1), 1.28 (s, 3), 1.25 (s, 3), 1.19 (d, 3, J = 7.3), 1.09 (d, 3, J = 7.0).

$TiCl_4$-Promoted Reaction of Ether 7 with 2-Phenylpropanal. To a mixture of 0.134 g (1.0 mmol) of 2-phenylpropanal and 0.238 g (1.2 mmol) of ether **7** in 11 mL of CH_2Cl_2 was added 0.13 mL (1.2 mmol) of $TiCl_4$ slowly at −78 °C. After being stirred for 15 min, the bright yellow reaction mixture was quenched at −78 °C by rapid addition of 10 mL of saturated $NaHCO_3$. The mixture was extracted with two 50-mL portions of ether and the combined ether layers were dried and concentrated to obtain 251 mg (96%) of a 78:22 mixture of aldols **12** and **10**, as judged from the ^{1}H NMR spectrum. The pure aldols were obtained by chromatography on silica gel.

(2*R,3*S**,4*S**)-3-Hydroxy-4,6,6-trimethyl-2-phenyloct-7-en-5-one (12).** TLC: R_f = 0.38 (5.1 hexane/ethyl acetate). IR (film): 3520, 2950, 1710, 1460, 1000, 715 cm^{-1}. ^{1}H NMR (250 MHz): δ 7.16–7.34 (m, 5), 5.88 (dd, 1, J = 10.5, 17.5), 5.12 (d, 1, J = 16.5), 5.11 (d, 1, J = 11.5), 3.75 (dd, 1, J = 6.8, 12.3), 3.00–3.14 nm, 1), 2.79–2.93 (m, 1), 2.38 (d, 1, J = 6.8), 1.30 (d, 3, J = 7.0), 1.19 (s, 3), 1.17 (s, 3), 1.10 (d, 3, J = 7.0). ^{13}C NMR (50.78 MHz): δ 218.2, 144.5, 128.3, 127.6, 126.2, 113.9, 51.1, 42.9, 23.5, 16.0, 14.5. Anal. Calcd for $C_{14}H_{24}O_2$: C, 78.40; H, 9.31. Found: C, 78.12; H, 8.99.

(2*R,3*S**,4*R**)-3-Hydroxy-4,6,6-trimethyl-2-phenyloct-7-en-5-one (10).** TLC: R_f = 0.44 (5.1 hexane/ethyl acetate). This material was identical by ^{1}H NMR with the sample obtained as the major product in the foregoing lithium enolate reaction.

2-(1-Phenylethyl)-4,4,5,5-tetramethyl-1,3-dioxolane (13). A mixture of 0.670 g (5.0 mmol) of 2-phenylpropanal and 0.590 g (5 mmol) of pinacol in 25 mL of benzene was heated under reflux while water was continuously removed with a Dean–Stark trap. After 1 h the solution was cooled to room temperature and 0.2 g of $NaHCO_3$ was added. The solvent was removed under vacuum and the residue purified by flash chromatography[19] on silica gel, eluting with 20:1 hexane/ethyl acetate, to obtain 1.02 g (87%) of the pure acetal. IR (film): 2980, 1605, 1500, 1450, 1370, 1100, 980, 770, 700 cm^{-1}. ^{1}H NMR (250 MHz): δ 7.27 (m, 5), 5.08 (d, 1, J = 5.4), 2.87 (dq, 1, J = 5.4, 7.2), 1.32 (d, 3, J = 7.2), 1.18 (s, 3), 1.14 (s, 3), 1.08 (s, 6). ^{13}C NMR (50.78 MHz): δ 142.4, 128.5, 127.9, 126.4, 103.6, 81.7, 81.6, 45.1, 24.11, 24.06, 22.2, 22.1, 16.2. Anal. Calcd for $C_{15}H_{22}O_2$: C, 76.88; H, 9.46. Found: C, 77.04; H, 9.34.

$TiCl_4$-Promoted Reaction of Acetal 13 with 2-Phenylpropanal. To a stirring solution of 0.234 g (1.0 mmol) of acetal **13** and 0.238 g (1.2 mmol) of ether **7** in 11 mL of CH_2Cl_2 was added dropwise 0.13 mL (1.2 mmol) of $TiCl_4$ at −78 °C. After 15 min, the mixture was allowed to warm to 0 °C and stirred 30 min, and the bright yellow mixture was quenched by rapid addition of 10 mL of saturated $NaHCO_3$ at 0 °C. The mixture was extracted with two 50-mL portions of ether. The combined organic layers were dried and concentrated to obtain 251 mg (96%) of a 94:6 mixture of aldols **12** and **10**, as judged by ^{1}H NMR. The pure aldols were obtained by chromatography on silica gel.

Conversion of Aldols 12 and 10 to Diols 16 and 17. To a solution of 260 mg (1.0 mmol) of a 94:6 mixture of aldols **12** and **10** in 10 mL of ether was added 38 mg (1.0 mmol) of $LiAlH_4$ at 0 °C. The solution was stirred for 5 min and allowed to warm to room temperature. After 30 min, the mixture was quenched at 0 °C by the slow addition of 10 mL of 1 N HCl. The mixture was extracted with two 20-mL portions of ether, and the combined ether layers were dried ($MgSO_4$) and concentrated to obtain 253 mg (96%) of a diastereomeric mixture of diols. To a solution of this material in 10 mL of CH_2Cl_2 was added 443 mg (1.0 mmol) of $Pb(OAc)_4$ at −78 °C under N_2. The mixture was stirred for 2 h at −78 °C and allowed to warm to room temperature. After 1.5 h, ca. 0.5 g of silica gel was added (for filtration aid), the mixture was filtered, and the filtrate was concentrated to obtain a diastereomeric mixture of β-hydroxy aldehydes as an oil. This crude material was dissolved in 10 mL of ether and 38 mg (1.0 mmol) of $LiAlH_4$ was added at 0 °C. The solution was stirred for 5 min and allowed to warm to room temperature. After 30 min the mixture was quenched at 0 °C by the slow addition of 10 mL of 1 N HCl. The resulting mixture was extracted with two 20-mL portions of ether and the combined organic layers were dried and concentrated to obtain a solid. Flash chromatography on silica gel, using 5:2 hexane/ethyl acetate as eluent, gave 111 mg (57%) of diol **16**, mg 54–55 °C, and 10 mg (5%) of diol **17**, oil.

(2*R,3*S**,4*R**)-2-Methyl-4-phenylpentane-1,3-diol (16).** TLC: R_f = 0.14 (2:1 hexane/ethyl acetate). ^{1}H NMR (250 MHz): δ 7.21–7.32 (m, 5), 3.73–3.77 (m, 1), 3.56–3.61 (m, 2), 3.12 (br s, 1), 3.01 (dq, 1, J = 4.6, 7.0), 2.47 (br s, 1), 1.71–1.88 (m, 1), 1.31 (d, 3, J = 7.0), 0.96 (d, 3, J = 7.0).

(2*R,3*S**,4*S**)-2-Methyl-4-phenylpentane-1,3-diol (17).** TLC: R_f = 0.09 (2:1 hexane/ethyl acetate). ^{1}H NMR (250 MHz): δ 7.16–7.30 (m, 5), 3.96 (dd, 1, J = 1.9, 9.6), 3.57–3.70 (m, 2), 2.82 (dq, 1, J = 9.8, 6.8), 2.48 (br s, 1), 1.65 (br s, 1), 1.35–1.50 (m, 1), 1.37 (d, 3, J = 6.8), 0.94 (d, 3, J = 7.0).

The spectral data for these two diols are in agreement with data reported by Matsumoto and co-workers[20] and were found to be identical with the spectra of samples previously prepared in this laboratory.[21]

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Registry No. **4**, 503-60-6; **5**, 2190-48-9; **6**, 78186-80-8; (*Z*)-**7**, 124400-14-2; **8**, 124400-15-3; **9**, 124400-16-4; **10**, 124400-17-5; **11**, 124509-16-6; **12**, 124509-17-7; **13**, 124400-18-6; **14**, 124400-19-7; **15**, 124508-29-8; **16**, 124508-30-1; **17**, 124508-31-2; $CH_3CH_2C(O)Cl$, 79-03-8; $CH_3CH(Ph)CHO$, 93-53-8; $PhCH(CH_3)CH(OH)CH(CH_3)CH(OH)C(CH_3)_2CH{=}CH_2$, 124400-20-0; $PhCH(CH_3)CH(OH)CH(CH_3)CHO$ (stereoisomer 1), 124400-21-1; $PhCH(CH_3)CH(OH)CH(CH_3)CHO$ (stereoisomer 2), 124508-32-3; pinacol, 76-09-5.

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