oxybenzyl chloride (8.80 g) in 25 mL of DMF was added for 30 min to a cooled (0 °C) suspension of NaH (2.36 g of 60% dispersion) in 75 mL of DMF and stirred at 25 °C. After 1 h 20% excess of 3,4-dimethoxybenzyl chloride (0.88 g) was added and left overnight. The reaction mixture was poured over ice and after usual workup the crude product was purified by passing through silica gel column with hexane–ether. Fractions corresponding to the pure product was collected to give racemic ester **2** as a colorless liquid (11.50 g, 95%): IR (film) 2900 (m), 1720, 1612, 1596, 1520, 1470, 1425, 1400–1040, 970–785 cm^{-1}; ^1H NMR (CCl_4, 60 MHz) 1.20 (s, 3 H), 1.25 (s, 3 H), 1.30 (s, 6 H), 1.35–2.00 (m, 4 H), 3.70 (m, 1 H), 3.75 (s, 12 H), 4.39 (s, 2 H), 5.07 (s, 2 H), 5.78 (s, 1 H), 6.60–6.80 (m, 6 H) ppm.

Reaction of Methyl (*S*)-(+)-(4-Hydroxy-2,2,6,6-tetramethylcyclohexylidene)-acetate with NaH in THF. A mixture of 226 mg of methyl (*S*)-(+)-(4-hydroxy-2,2,6,6-tetramethylcyclohexylidene)acetate ($[\alpha]^{25}_D$ +31.31 ± 0.20°, 37.52% ee) and 100 mg of NaH in 5 mL of THF was stirred overnight at 25 °C under N_2 atmosphere. The reaction mixture was diluted with wet ether (50 mL) and filtered through 5 g of silica gel to give mixture of several compounds. The crude mixture on radial chromatography separation using hexane–ether solvent mixtures gave two main fractions. The ^1H NMR spectrum of the less polar fraction (70 mg) showed signal corresponding to bridged bicyclic compounds (^1H NMR 1.00–1.50 (several methyl s), 1.50–2.00 (m), 2.80 (s), 2.84 (s), 3.68 (s), 3.71 (s), 3.72 (s), 4.30 (t), 5.20 (br), 5.81 (s), 5.85 (s) ppm). No further attempts was made to separate these compounds. The polar fraction (120 mg) was found to be racemic starting material methyl ester.

NaH Treatment of (*S*)-(+)-(4-Hydroxy-2,2,6,6-tetramethylcyclohexylidene)acetophenone (3) in THF. A mixture of 272 mg of (*S*)-(+)-(4-hydroxy-2,2,6,6-tetramethylcyclohexylidene)acetophenone (**3**) ($[\alpha]^{31}_D$ +65.63 ± 0.30°, 37.52% ee) and excess NaH (150 mg) in 5 mL of THF was stirred at 25 °C for 7 days. Water was added, and the mixture of products was extracted with ether (3 × 50 mL). The combined ether solution was washed with water, dried (Na_2SO_4), and evaporated. The crude mixture on separation by radial chromatography gave two fractions.

The less polar fraction I, 0.165 g (60%), solidified on standing to give 1-phenacyl-2,2,6,6-tetramethyl-7-oxabicyclo[2.2.1]heptane (**4**): mp 70–71 °C; IR (CCl_4) 3080 (w), 3060 (w), 3000 (w), 2980, 2950, 2880, 1950 (w), 1900 (w), 1810 (w), 1700, 1600, 1580 (w), 1480, 1460, 1430, 1400, 1390, 1380, 1370, 1115, 1230, 1200, 1130, 1055, 1005–900 cm^{-1}; ^1H NMR 1.03 (s, 6 H), 1.52 (s, 6 H), 1.40–1.60 (m, 2 H), 1.70–1.90 (dd, J = 6 Hz, J = 16 Hz, 2 H), 3.60 (s, 2 H), 4.23 (t, J = 6.10 Hz, 1 H), 7.40–7.60 (m, 3 H), 7.99 (m of d, J = 9 Hz, 2 H) ppm; ^{13}C NMR 26.43 (2 CH_3), 32.46 (2 CH_3), 38.96 (CH_2), 44.95 (2 C), 50.43 (2 CH_2), 74.95 (CH), 92.64 (C), 128.00 (2 CH), 128.59 (2 CH), 132.88 (CH), 138 (C), 197.39 (C=O) ppm; UV (c 9.19 × 10^{-5}, 9.19 × 10^{-3}, CH_3CN) λ 317 nm (ε 35), 287 (630), 278 (960), 270 (914), 241 (13 000).

Anal. Calcd for $C_{18}H_{24}O_2$: C, 79.41; H, 8.82. Found: C, 79.34; H, 8.84.

Fraction II, 70 mg (25%), was identified as (±)-(4-hydroxy-2,2,6,6-tetramethylcyclohexylidene)acetophenone (**3**).

Reaction of (±)-(4-Hydroxy-2,2,6,6-tetramethylcyclohexylidene)acetaldehyde (5) with NaH in the Presence of CH_3I. A mixture of (4-hydroxy-2,2,6,6-tetramethylcyclohexylidene)acetaldehyde (**5**) (392 mg), NaH (200 mg), and CH_3I (1 mL) in 10 mL of THF was stirred at 25 °C for 12 h. The reaction mixture was diluted with water and extracted with ether (three times). The ether layer washed with water, dried (Na_2SO_4), and concentrated. The ^1H NMR spectrum of the crude mixture showed the presence of two main components in the ratio of 65:35. Careful radial chromatography separation of the mixture using hexane–ether (10:1) gave two pure fractions.

The less polar fraction yielded 1-(2′-methoxy-*trans*-ethylene)-2,2,6,6-tetramethyl-7-oxabicyclo[2.2.1]heptane (**6**) (101 mg, 24%) as a solid: mp 68–70 °C; IR ($CHCl_3$) 2900 (m), 1695 (w), 1680, 1660, 1470, 1455, 1395, 1388, 1374, 1340, 1315, 1290, 1267, 1170, 1120, 1040–920, 872, 842 cm^{-1}; ^1H NMR 0.90 (s, 6 H), 1.23 (s, 6 H), 2.08 (d, J = 10.5 Hz, 2 H), 2.47 (dd, J = 6.10 Hz, J = 10.49 Hz, 2 H), 3.56 (s, 3 H), 4.35 (t, J = 5.86 Hz, 1 H), 4.70 (d, J = 12.69 Hz, 1 H), 6.47 (d, J = 12.69 Hz, 1 H) ppm; ^{13}C NMR 25.63 (2 CH_3), 33.27 (2 CH_3), 44.30 (2 C), 48.48 (2 CH_2), 56.15 (OCH_3), 75.05 (OCH), 97.53 (=CH), 113.70 (OC), and 147.86 (=$CHOCH_3$) ppm.

Anal. Calcd for $C_{13}H_{22}O_2$: C, 74.28; H, 10.47. Found: C, 74.30; H, 10.55.

More polar fraction gave 1-(2′-methoxy-*cis*-ethylene)-2,2,6,6-tetramethyl-7-oxabicyclo[2.2.1] heptane (**7**) (51 mg, 12%) as a colorless liquid: IR ($CHCl_3$) 2950 (m), 1678, 1470, 1405, 1385, 1370, 1285, 1155-1130, 1095, 1050–950, 870 cm^{-1}; ^1H NMR 1.01 (s, 6 H), 1.26 (s, 6 H), 1.33 (d, J = 10.74 Hz, 2 H), 1.75 (dd, J = 5.86 Hz, J = 10.50 Hz, 2 H), 3.58 (s, 3 H), 4.20 (d, J = 7.57 Hz, 1 H), 4.39 (t, J = 5.86 Hz, 1 H), 5.94 (d, J = 7.57 Hz, 1 H) ppm; ^{13}C NMR 25.52 (2 CH_3), 32.42 (2 CH_3), 45.24 (2 C), 48.08 (2 CH_2), 59.84 (OCH_3), 75.09 (OCH), 101.74 (=CH), 122.18 (OC), 146.07 (=C-$HOCH_3$) ppm.

Anal. Calcd for $C_{13}H_{22}O_2$: C, 74.28; H, 10.47. Found: C, 74.20; H, 10.61.

The Stereoselective Synthesis of Ethyl 2(*E*),4(*Z*)-Decadienoate

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Received December 3, 1985

Ethyl (2*E*,4*Z*)-decadienoate (**6**) is widely known as the chemical found in Bartlett pears (*Pyrus communis*) causing the characteristic taste.[1] Previous syntheses of **6** suffered from low yields[2] or low stereoselectivities.[3,4] Equally important is that the earlier work depended upon starting materials that were either expensive or not commercially available. We report a synthesis for ester **6** which alleviates the above shortcomings and provides a process versatile enough to accommodate the synthesis of other structurally similar compounds of interest to us.

The process (Scheme I) began with commercially available 1-heptyne (**1**), which was converted to the acetal 1,1-diethoxy-2-octyne (**2**). Acetal **2** was reduced stereoselectively to 1,1-diethoxy-2(*Z*)-octene (**3**), which was deprotected under mild conditions to 2(*Z*)-octenal (**4**). Reacting **4** with the carbanion generated from **5** gave the desired ester **6**.

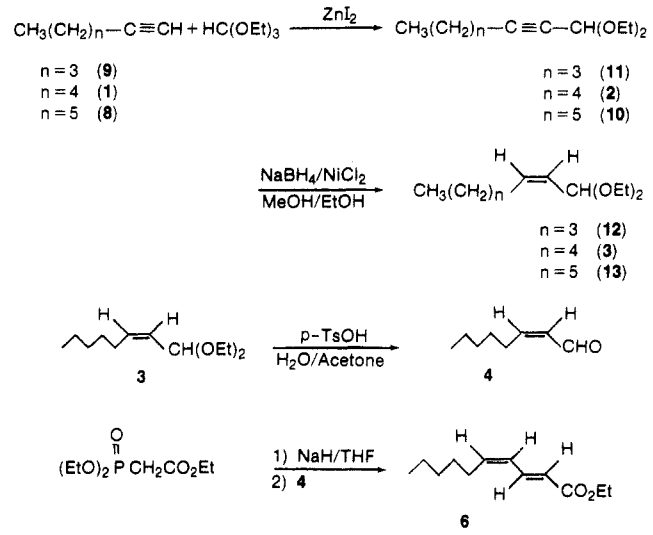
Preparation of Alkynal Acetals. Howk and Sauer[5] described the preparation of 1,1-diethoxy-3-phenyl-2-propyne (**7**) in good yields (72–78%) starting with phenylacetylene and triethyl orthoformate, using zinc iodide as a catalyst. However, when the authors extended the reaction to the lower boiling 1-hexyne under "autogeneous" pressure (190 °C for 3 h), acetal **11** was obtained in only a 32% yield.

We were able to improve the yield of **11** to 42.8% by azeotropically removing ethanol with 1-hexyne to drive the reaction toward completion. This required greater than stoichiometric amounts of alkyne. Similarly, 1-heptyne and 1-octyne gave the corresponding acetals **2** and **10** in 70.2% and 74.3% yields, respectively. The higher yields

(1) Heinz, D. E.; Jennings, W. G. *J. Food Sci.* **1966**, *31*, 81.
(2) Bestmann, H. J.; Suss, J. *Liebigs Ann. Chem.* **1982**, 363.
(3) Ohloff, G.; Pawlak, M. *Helv. Chem. Acta* **1973**, *56*, 1176.
(4) Sensory evaluations of ethyl 2(*E*),4(*E*)-decadienoate demonstrated the negative influence it has on flavors containing greater than 25% of the 2*E*,4*E* isomer.
(5) Howk, B. W.; Sauer, J. C. *Organic Syntheses*; Wiley: New York, 1963; Collect. Vol. 4, p 801.

0022-3263/86/1951-2607$01.50/0

Scheme I



are attributed to the elevated reaction temperatures inherent to the higher molecular weight 1-alkynes. The azeotropic mixtures were washed with water, dried, and distilled to give recovered 1-alkynes. When accounting for the recovered alkynes, the yields were somewhat higher. The yield for acetal **2**, for example, increased to 77% based on recovered 1-heptyne. The alternative catalyst system of zinc chloride/sodium iodide was also employed without affecting the yields.

Selective Formation of (*Z*)-Alkenal Acetals. Natural products often contain the (*Z*)-alkene functionality. As the *E* isomer is thermodynamically more stable, any synthesis of a (*Z*)-alkene requires that conditions be sufficiently mild to retain the *Z* configuration. In the case of the conjugated 2(*Z*)-alkenals the propensity to isomerize is exceptionally high.[6] Although many catalytic semihydrogenation methods exist for selectively reducing alkynes to (*Z*)-alkenes,[7] an alternative route has been developed in order that large-scale reactions could be readily run independent of an autoclave.

Caubere found that $Ni(OAc)_2$ and NaH plus *t*-AmONa in THF created a stereoselective catalyst for semihydrogenating alkynes.[8] He observed that this catalysis compared favorably with Brown's[9,10] P-2 nickel catalyst for semihydrogenating alkynes, with a low proclivity toward isomerization of the product alkene. Our objective was to achieve the selectivity of the above exogenously generated catalysts but to generate the catalyst in situ. This goal was achieved by treating $NiCl_2$ with a large excess of sodium borohydride under a nitrogen atmosphere. The excess sodium borohydride was used to generate hydrogen in the mixed solvent of methanol/ethanol.

The stereoselective catalyst was generated by the addition of $NiCl_2$ (19 mmol) to a mixture of $NaBH_4$ (140 mmol) in absolute ethanol (210 g). The immediate formation of a black granular precipitate indicated that the catalyst had formed.

The alkyne (300 mmol) was next introduced as a solution in methanol (30 g). The in situ generation of hydrogen was then initiated by the addition of methanol (189 g) over 1 h. After three additional hours (greater than 95% conversion), the reaction was stopped by stirring air into the vessel, thus deactivating the catalyst. After workup and fractional distillation good yields of (*Z*)-alkenes were obtained. In this manner alkyne **2** gave alkene **3** in 64% yield with an *Z*/*E* ratio of 97.1/1.1.

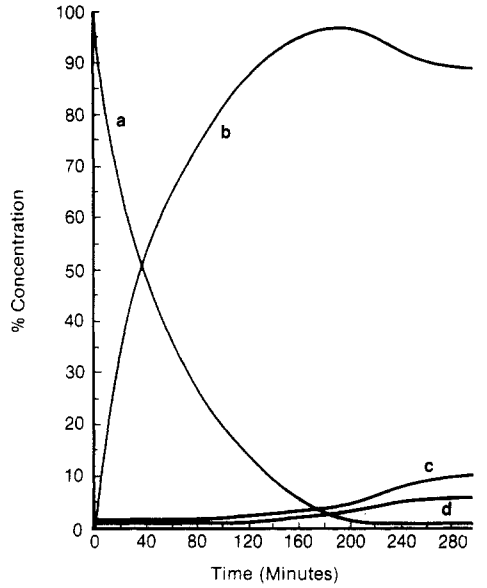


Figure 1. Reduction of 1,1-diethoxy-2-octyne (**2**) with $NaBH_4/NiCl_2$: (a) disappearance of starting material (**2**); (b) appearance of **4**; (c) appearance of 1,1-diethoxy-2(*E*)-octene; (d) appearance of 1,1-diethoxyoctane.

The reduction was stopped short of completion because two competing reactions become important with decreasing alkyne concentration. The first is the reduction of the alkene to alkane, and the second is the isomerization of the *Z* to the *E* isomer. The relative importance of the side reactions is illustrated in Figure 1.

Using the same procedure as for **2**, reduction of alkynes **11** and **10** gave (*Z*)-alkenes **12** and **13** with high stereoselectivity. Gas chromatographic ratios of the crude reaction mixtures after workup routinely were 2.6/93.5/3.3/0.6 for the alkane/*Z* isomer/*E* isomer/alkyne, respectively.

It should be noted that even when the catalyst is deactivated but not removed, the (*Z*)-alkene is isomerized to significant amounts of the *E* isomer.

Hydrolysis to 2(*Z*)-Alkenals. The hydrolyses of the 1,1-diethoxy-2(*Z*)-alkenes were optimized to achieve the lowest levels of isomerization to the *E* isomer. The optimum system was acetone/water at 0 °C, with *p*-toluenesulfonic acid catalyst.[2] Under these conditions, a 91/9 ratio of (*Z*)/(E)-2-octenal (**4**) was obtained, starting with an acetal *Z*/*E* ratio of 95/5. After fractional distillation, higher ratios were obtained. A 1.5 mol hydrolysis gave **4** in an isolated yield of 93%, with a *Z*/*E* ratio of 98.4/0.8 after fractional distillation.

Formation of Ethyl 2(*E*),4(*Z*)-Decadienoate. To complete the reaction sequence, a Wittig–Horner reaction was chosen because of the high *E* stereoselectivity associated with this reaction.

The product ester was obtained by first generating the triethyl phosphonate carbanion in toluene with sodium hydride followed by the addition of **4**. A 76.9% yield of ester **6** was obtained after workup and fractional distillation. The isomer ratio of the products was 88/12 of 2*E*,4*Z* and 2*E*,4*E*.

Conclusions. Ethyl 2(*E*),4(*Z*)-decadienoate was made in a four-step process in an overall yield of 35%. A

(6) Heilbron, I.; Jones, E. R. H.; Toogood, J. B.; Weedon, B. C. L. *J. Chem. Soc.* **1949**, 1827.
(7) Marvell, E. N.; Li, T. *Synthesis* **1973**, 457.
(8) Caubere, P.; Brunet, J. J.; Gallois, P. *Tetrahedron Lett.* **1977**, 3955; Caubere, P.; Brunet, J. J.; Gallois, P. *J. Org. Chem.* **1980**, *45*, 1946.
(9) Brown, H. C.; Brown, C. A. *J. Am. Chem. Soc.* **1963**, *85*, 1005.
(10) Brown, C. A.; Ahuja, V. K. *J. Org. Chem.* **1973**, *38*, 2226. Brown, C. A.; Ahuja, V. K. *J. Chem. Soc., Chem. Commun.* **1973**, 553.
(11) Arbuzov, A. E.; Durin, A. A. *Zh. Russ. Phys.-Chem. O-va.* **1914**, *46*, 295; *Chem. Abstr.* **1914**, *8*, 2551.

modification of the Howk and Sauer method gave ready access to acetal **2** and was successfully applied to the formation of other alkynal acetals. The $NiCl_2/NaBH_4$ reducing systems allowed the stereoselective formation of (*Z*)-alkenal acetal **3** on a large scale independent of autoclaves or hydrogenators.

Experimental Section

The IR spectra were recorded on a Perkin-Elmer Model 782 spectrophotometer. ^1H NMR spectra were obtained with a Varian EM-360A spectrometer with Me_4Si as the internal standard. GLC analyses were carried out on Hewlett-Packard 5840H and 5710A gas chromatographs with 15% Carbowax-20M on 80/100 Chromasorb W ($^1/_8$ in. × 6 ft) columns. A standard program of 100–210 °C and 8 deg/min was used for all analyses. Samples of 1-heptyne, 1-hexyne, and 1-octyne were graciously provided by Heico Division, Whittaker Corp. All were used without further purification.

1,1-Diethoxy-2-octyne (2). 1-Heptyne (1100 g, 11.46 mol), triethyl orthoformate (1100 g, 7.5 mol), sodium iodide (73.9 g, 0.49 mol), and zinc chloride (44.9 g, 0.33 mol) were heated to reflux, removing the ethanol/1-heptyne azeotrope by distillation. When the reaction was complete by GC, heating was stopped (pot temperature 195 °C, 4 h). The cooled reaction mixture was washed with a 2.4% sodium bicarbonate solution (1400 g) and the aqueous phase extracted with hexane (350 g). The organic phases were combined and the hexane removed in vacuo. The crude product was distilled through a 1-ft Goodloe column to give a 70.2% yield (1052.6 g) of **2**: bp 87 °C (2.8 torr); IR (neat, film) 2975, 2930, 2870, 1122, 1052 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.90 (m, 3 H), 1.22 (t, *J* = 7 Hz, 6 H) [superimposed on δ 1.40 (m, 6 H)], 2.18 (m, 2 H), 3.62 (m, 4 H), 5.22 (m, 1 H).

1,1-Diethoxy-2-heptyne (11). **11** was synthesized as above. The reaction was quenched after 4.5 h, pot temperature 120 °C, to give a 42.8% yield of **11**: bp 50 °C (0.5 torr); IR (neat, film) 2975, 2030, 1151, 1052 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.92 (m, 3 H), 1.27 (t, *J* = 7 Hz, 6 H) [superimposed on δ 1.45 (m, 4 H)], 2.21 (m, 2 H), 3.65 (m, 4 H), 5.23 (m, 1 H).

1,1-Diethoxy-2-nonyne (10). **10** was synthesized as above. The reaction was quenched after 5 h, pot temperature 180 °C, to give a 74.3% yield of **10**: bp 85 °C (1 torr); IR (neat, film) 2940, 1156, 1048 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.90 (m, 3 H), 1.23 (t, *J* = 7 Hz, 6 H) [superimposed on δ 1.35 (m, 8 H)], 2.22 (m, 2 H), 3.68 (m, 4 H), 5.25 (m, 1 H).

1,1-Diethoxy-2(*Z*)-octene (3). To anhydrous denatured ethanol (210 g) at 0 °C and under nitrogen atmosphere were added sodium borohydride (5.2 g, 0.14 mol) and nickel(II) chloride (2.4 g, 0.019 mol). A solution of **1** (60 g, 0.30 mol) in 30 g of methanol was added over 20 min, keeping the reaction temperature below 5 °C. Methanol (189.0 g) was then added over 1 h, keeping the temperature below 5 °C. The reaction mixture was stirred at 0 °C and the progress followed by GLC. When the reaction was 95% complete (approximately 3 h), the catalyst was deactivated by stirring air into the system for 5 min. Water (750.0 g) was added, and the reaction mixture was extracted twice with hexane (150 mL). The organic layer was filtered through diatomaceous earth and the hexane removed in vacuo. The crude was distilled through a 6-in. Goodloe column to give a 64.3% yield (39.0 g) of **3** (alkane/*Z*/*E* ratio, 0.1/97.1/1.1): bp 45 °C (0.07 torr); IR (neat, film) 2972, 2922, 2870, 1122, 1055, 995 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.90 (t, *J* = 5 Hz, 3 H), 1.2 (t, *J* = 8 Hz, 6 H), 1.35 (m, 6 H), 2.21 (m, 2 H), 3.6 (m, 4 H), 5.25 (m, 1 H), 5.60 (m, 1 H), 5.65 (m, 1 H).

1,1-Diethoxy-2(*Z*)-heptene (12). **12** was synthesized as above: IR (neat, film) 2972, 2922, 2870, 1122, 1055, 995 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.90 (t, *J* = 5 Hz, 3 H), 1.2 (t, *J* = 8 Hz, 6 H), 1.35 (m, 4 H), 2.21 (m, 2 H), 3.6 (m, 4 H), 5.25 (m, 1 H), 5.60 (m, 1 H), 5.65 (m, 1 H).

1,1-Diethoxy-2(*Z*)-nonene (13). **13** was synthesized as above: IR (neat, film) 2972, 2922, 2870, 1122, 1055, 995 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.90 (t, *J* = 5 Hz, 3 H), 1.2 (t, *J* = 8 Hz, 6 H), 1.35 (m, 8 H), 2.21 (m, 2 H), 3.6 (m, 4 H), 5.25 (m, 1 H), 5.60 (m, 1 H), 5.65 (m, 1 H).

2(*Z*)-Octenal (4). To a solution of acetone (1000 g, 17.22 mol), water (500 g, 27.76 mol), and *p*-toluenesulfonic acid (4.0 g, 0.023 mol) at 0 °C was added **3** (300 g, 1.50 mol). The reaction mixture was stirred at 0 °C for 15 min and then neutralized with sodium bicarbonate (5.0 g, 0.059 mol). It was then extracted five times with hexane (150 mL) at 0 °C, concentrated in vacuo, and distilled through a short-path still to yield 93.1% (176.2 g) of **4** (97.6% *Z* isomer): bp 51 °C (1.8 torr); IR (neat, film) 1678, 1621, 1609 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.91 (t, *J* = 8 Hz, 3 H), 1.41 (m, 6 H), 2.62 (m, 3 H), 5.98 (ddt, *J* = 11, 8, 1 Hz, 1 H), 6.68 (dt, *J* = 11, 8 Hz, 1 H), 10.12 (d, *J* = 8 Hz, 1 H).

Ethyl 2(*E*),4(*Z*)-Decadienoate (6). To toluene (1500 g) at 0 °C was added with mechanical stirring sodium hydride (32.8 g, 0.68 mol) as a 50% mineral oil dispersion. Under nitrogen, ethyl (diethoxyphosphinyl)acetate[8] (150 g, 0.67 mol) was added dropwise over 30 min, maintaining 0 °C during the addition. Aldehyde **4** (80.1 g, 0.63 mol) was then added over 75 min at 0 °C. After being stirred for 30 min, the reaction mixture was washed with water (350 g). The crude product was distilled through a 1-ft Goodloe column to give a 76.9% yield (94.9 g) of ester **6** (purity; 88% 2*E*,4*Z* and 12% 2*E*,4*E*): bp 86 °C (0.9 torr); IR (neat, film) 2940, 2860, 1710, 1635, 1605, 1270, 1175, 1140 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.91 (m, 3 H), 1.31 (br t, *J* = 7 Hz, 9 H), 2.28 (m, 2 H), 4.24 (q, *J* = 7 Hz, 2 H), 5 .66–6.35 (m, 2 H), 5.82 (d, *J* = 11 Hz, 1 H) 7.61 (dd, *J* = 11, 15 Hz, 1 H).

Registry No. **1**, 628-71-7; **2**, 16387-55-6; **3**, 16387-56-7; **4**, 20664-46-4; (2*E*,4*Z*)-**6**, 3025-30-7; (2*E*,4*E*)-**6**, 7328-34-9; **8**, 629-05-0; **9**, 693-02-7; **10**, 79496-57-4; **11**, 18232-30-9; **12**, 81149-92-0; **13**, 91043-38-8; $(EtO)_2P(O)CH_2CO_2Et$, 867-13-0.

Stereodivergent Syntheses of *threo*- and *erythro*-6-Amino-6-deoxyheptosulose Derivatives via an Optically Active Oxazolidine Aldehyde

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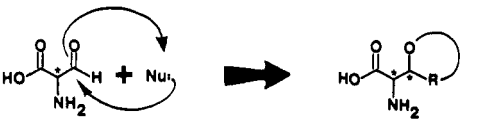
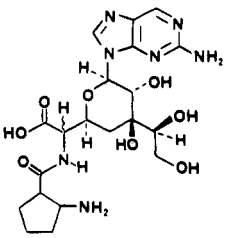
Received December 12, 1985

The stereocontrolled assembly of complex amino sugars is today an area of intense research effort. Introduction of nitrogen onto a pyranose or furanose ring can often be done specifically but similar control of acyclic side chain stereochemistry remains a less secure issue. Furthermore, it is desirable to form optically pure products—i.e., to exert *absolute* as well as relative stereocontrol.[1]

We began investigating nucleophilic (cyclo)additions to penaldic acid equivalents (vis., I → II) in connection with a projected synthesis of amipurimycin (1) and related amino sugar antibiotics.[2] One requirement of such a



I II



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(1) For a review of carbohydrate syntheses with an emphasis on acyclic stereocontrol, see: McGarvey, G. J.; Kimura, M.; Oh, T.; Williams, J. M. *J. Carbohydr. Chem.* **1984**, *3*, 125.

0022-3263/86/1951-2609$01.50/0