column chromatography on silica gel (single spot on TLC).

Acetate (2a). From **1a** was obtained **2a**: 0.250 g (65% yield); IR (neat) 1735 cm^{-1}; NMR ($CDCl_3$) δ 1.2 (s, 6 H), 1.45 and 1.40 (s, 24 H), 1.95 (s, 3 H), 3.08 (s, 1 H), 5.67 (d, J = 16 Hz, 1 H), 5.9 (d, J = 16 Hz, 1 H).

Acetate (2b). From **1b** was obtained **2b** (0.160 g, 65% yield) after chromatography with ether–pentane (1:7): IR (neat) 2240, 1730 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.4 (s, 6 H), 2 (s, 3 H), 3.50 (s, 1 H), 5.61 (d, J = 16 Hz, 1 H), 5.94 (d, J = 16 Hz, 1 H).

Acetate (2c). From **1c** was obtained **2c** (0.380 g, 90% yield) after chromatography with ether–hexane (1:1): IR (neat) 1730 cm^{-1}; NMR (CCl_4) δ 1.2–1.5 (18 H, with d, J = 7 Hz, centered at 1.40, $(CH_3)_2CH$), 1.86 (s, 3 H), 3.23 (s, 3 H), 3.80 (s, 1 H, and m, 1 H), 5.73 (d, J = 16 Hz, 1 H), 5.78 (d, J = 16 Hz, 1 H), 7.4 (m, 3 H), 7.80 (br d, J = 8 Hz, 1 H).

Acetate (2d). From **1d** was obtained **2d** (0.240 g, 85% yield) after column chromatography with ether–hexane (1:1): IR (neat) 2240, 1730 cm^{-1}; NMR ($CDCl_3$) δ 1.27 (s, 6 H), 1.3 (t, J = 7Hz, 3 H), 1.50 (s, 6 H), 1.96 (s, 3 H), 3.32 (s, 1 H), 4.20 (q, J = 7 Hz, 2 H), 5.67 (d, J = 16 Hz, 1 H), 5.75 (d, J = 16 Hz, 1 H). Anal. Calcd for $C_{15}H_{23}O_3N$: C, 64.0; H, 8.24; N, 4.98. Found: C, 63.77; H, 8.11; N, 5.14.

Acetate (2e). From **1e** was obtained **2e** (0.298 g, 85% yield) by column chromatography with ether–hexane (3:1): oil; TLC [silica gel, ether–hexane (3:1)] R_f 0.37; IR (neat) 3060, 2240, 1730, 1580 cm^{-1}; ^1H NMR (CCl_4) δ 1.45 (s, 6 H), 1.52 (s, 6 H), 1.97 (s, 3 H), 3.87 (s, 1 H), 5.85 (s, 2 H), 7.55 (m, 3 H), 7.95 (m, 2 H); ^{13}C NMR ($CDCl_3$) δ 22.16, 25.6, 26.2, 26.7, 26.9, 40.9, 66.9, 79.9 (quaternary carbon, >COAc), 113.7, 129.4, 129.5, 132.5, 134.9, 138.6, 169.8. Anal. Calcd for $C_{18}H_{23}O_4SN$: C, 61.86; H, 6.83; N, 4.01; S, 9.17. Found: C, 61.68; H, 7.02; N, 4.25; S, 9.05.

General Procedure for the Synthesis of the Substituted Cyclopropanes. The appropriate acetate **2** (1 mmol) in THF solution (3 mL) was added at room temperature to a suspension of 1.1 mmol of NaH in 0.5 mL of THF. The mixture was stirred at 65 °C and monitored by TLC on silica gel. The reaction was quenched with dilute HCl (2%). The aqueous layer was extracted with ether or methylene chloride. The organic extracts were washed with water, dried over $MgSO_4$, and evaporated in vacuo. The residue was purifed by recrystallization or chromatography.

1,1-Dicyano-2,2-dimethyl-3-(2-methyl-1-propenyl)cyclopropane (6, A = X = CN). From the sodio derivative of **2b** (1.5 h at 65 °C) after chromatography with ether–pentane (1:9) was obtained **6**: 0.130 g (75% yield); mp 94 °C; IR ($CDCl_3$) 2230 cm^{-1}; NMR ($CDCl_3$) δ 1.35 (s, 3 H), 2 (s, 3 H), 1.83 (s, 3 H), 1.85 (br s, 3 H), 2.43 (d, J = 7 Hz, 1 H), 4.95 (br d, J = 7 Hz, 1 H); mass spectrum, m/e 174 (molecular ion). Anal. Calcd for $C_{11}H_{14}N_2$: C, 75.82; H, 8.10; N, 16.10. Found: C, 75.7; H, 8.09; N, 16.32.

(*E*)- and (*Z*)-Methyl 2,2-Dimethyl-3-(2-methyl-1-propenyl)-1-[(*o*-isopropylphenyl)sulfonyl]carboxylates (11 and 12). From the sodio derivative of **2c** after 3 h at 65 °C was obtained a mixture of **11** and **12**: 0.320 g, (100% yield); TLC [silica gel ether–hexane (1:1)] R_f 0.35. For **11**: IR (Nujol) 1730 cm^{-1}; NMR ($CDCl_3$) δ 1–1.25 (m, 12 H), 1.5–1.8 (m, 6 H), 2.90 (d, J = 8 Hz, 1 H), 3.13 (s, 3 H), 3.5 (m, 1 H), 5.12 (d, J = 8 Hz, 1 H), 7.2 (m, 3 H), 7.73 (d, J = 8 Hz, 1 H). For **12**: NMR ($CDCl_3$) 1–1.25 (m, 12 H), 1.5–1.8 (m, 6 H), 2.73 (d, J = 8 Hz, 1 H), 3.13 (s, 3 H), 5.60 (d, J = 8 Hz), 7.2 (m, 3 H), 7.73 (d, J = 8 Hz, 1 H).

1-Cyano-2,2-dimethyl-3-(2-methylpropenyl)-1-(phenylsulfonyl)cyclopropane (13). From the sodio derivative of **2e** after 3 h at 65 °C and after recrystallization (hexane) was obtained **13**: mp 90 °C; 0.232 g (80% yield); IR ($CHCl_3$) 3060, 2230, 1580 cm^{-1}; NMR (CCl_4) δ 1.27 (s, 3 H), 1.60 (s, 3 H), 1.80 (s, 6 H), 2.85 (d, J = 8 Hz, 1 H), 4.89 (d, J = 8 Hz, 1 H), 7.6 (m, 3 H), 7.90 (m, 2 H); mass spectrum, m/e 289 (molecular ion). Anal. Calcd for $C_{16}H_{19}O_2SN$: C, 66.45; H, 6.62; N, 4.84; S, 11.08. Found: C, 66.65; H, 6.68; N, 4.9; S, 11.17.

(*E*)- and (*Z*)-Ethyl 1-Cyano-2,2-dimethyl-3-(2-methyl-1-propenyl)cyclopropanecarboxylates (14 and 15). (i) From the sodio derivative of **2d** after 2.5 h at 65 °C a 1:1 mixture of **14** and **15** was obtained after column chromatography on silica gel (eluting with pentane): 0.166 g (75% yield); TLC [silica gel, ether–pentane (1:1)] R_f 0.32.

(ii) From sodio derivative of **2d** (performed at 10 °C) and subsequent addition of 10% of tetrakis(triphenylphosphine)-palladium, with the reaction mixture being heated at 65 °C for 1.5 h, was obtained 0.150 g (70% yield, no optimization) of **14** as the major product (95%) with 5% of **15**.

For **14**: IR ($CDCl_3$) 2220, 1725 cm^{-1}; NMR ($CDCl_3$) δ 1.20–1.45 (m, 9 H, with 2 s at 1.34 and 1.36), 1.75 (s, 3 H), 1.80 (s, 3 H), 2.7 (d, J = 8 Hz, 1 H), 4.27 (q, J = 7 Hz, 2 H), 5.07 (br d, J = 7 Hz, 1 H).

For **15**: NMR ($CDCl_3$) δ 1.20–1.45 (m, 9 H, 2 s at 1.73 and 1.78), 2.45 (d, J = 8 Hz, 1 H), 4.18 (q, J = 7 Hz, 2 H), 5.28 (d, J = 8 Hz, 1 H).

Synthesis of *cis*-Chrysanthemonitrile (3).[4] A stirred mixture of –35 °C of 0.250 g (0.84 mmol) of **13** in dry methanol, 1.3 g of 6% Na/Hg, and 0.490 g of Na_2HPO_4 gave after a conventional workup 0.125 g (100% yield) of chrysanthemonitrile: bp 130–134 °C (15 mm); IR (neat) 2230 cm^{-1}; NMR ($CDCl_3$) δ 1.1–1.45 (7 H, with s at 1.25), 1.2–2 (7 H, with 2 br s at 1.75 and 1.82), 5.07 (d, J = 8 Hz, 1 H). Less than 10% of trans compound was detected: NMR δ 1.15 (s), 1.37 (s), 4.87 (d, J = 8 Hz); mass spectrum, m/e 149 (molecular ion).

Registry No. 1a, 77081-06-2; **1b**, 77081-07-3; **1c**, 77081-08-4; **1d**, 58773-90-3; **1e**, 77081-09-5; **2a**, 77081-10-8; **2b**, 77081-11-9; **2b** Na, 77081-12-0; **2c**, 77081-13-1; **2c** Na, 77081-14-2; **2d**, 77081-15-3; **2d** Na, 77081-16-4; **2e**, 77097-75-7; **2e** Na, 77097-76-8; **3**, 2198-88-1; **6**, 38111-13-6; **11**, 77081-17-5; **12**, 77081-18-6; **13**, 77081-19-7; **14**, 77081-20-0; **15**, 77081-21-1; sodium *tert*-butyl malonate, 55573-13-2; sodiomalononitrile, 20334-42-3; methyl [(*o*-isopropylphenyl)-sulfonyl]acetate, 77081-22-2; sodium methyl [(*o*-isopropylphenyl)-sulfonyl]acetate, 77081-23-3; sodium ethyl cyanoacetate, 18852-51-2; sodio(phenylsulfonyl)acetonitrile, 77081-24-4; **7**, 75646-37-6; tetrakis(triphenylphosphine)palladium, 14221-01-3.

Conversion of Lactones into Ethers

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Although tetrahydrofurans and tetrahydropyrans are important structural subunits of many classes of natural products,[1] comparatively few general synthetic methods are known.[2] Since γ- and δ-lactones are readily available,[3] an efficient and versatile transformation to the ether would significantly extend current methodology. The conversion of a lactone to an ether has been accomplished by hydride reduction to a diol followed by cyclization by way of a monotosylate[4] or other activated ester.[5] Certain Lewis acid–hydride complexes have also been employed.[6] This strategy has seen limited use due to the restrictions on the functional groups which are compatible with the reaction conditions. A clever method utilizing trichlorosilane has been developed independently by Baldwin[7] and Tsurugi.[8] Although lactones can be reduced in the presence of esters, there are some limitations on the types of lactones with which this method can be used. We report a mild, con-

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(5) VanTamelen, E. E.; Schnur, R. C. *J. Am. Chem. Soc.* **1975**, *97*, 465.
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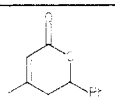
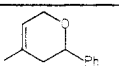
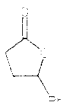
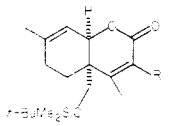
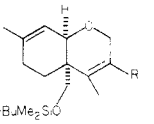
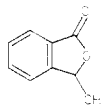
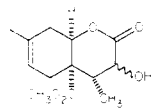
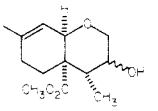
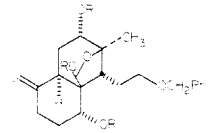
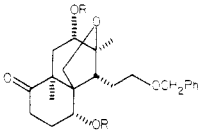
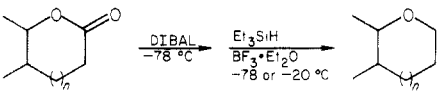
0022-3263/81/1946-2417$01.25/0

Table I. Conversion of Lactones to Ethers

reactant	temp, °C/time	% yield	product	
	−78/1 h	72		1
	−45/5 min	75		2
 R = CN, SPh, H	−78/30 min −78/30 min −78/30 min	75[a] 60 81		3, R = CN 4, R = SPh 5, R = H
	0/10 min	50		6[b]
	−78 to −45/1 h	53		7
 R = H, $COCH_3$	−20/24 h room temp/3 h	65[c] 88[c]		8, R = H 9, R = $COCH_3$

[a] 10% of the unsaturated aldehyde was also isolated. [b] Identical (NMR, IR, TLC) with an authentic sample. [c] Yield includes only silane reduction step.

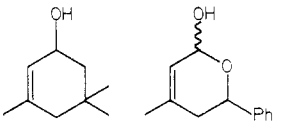
venient, two-step procedure by which this conversion may be effected. The basic plan is outlined below.



n = 0, 1

The first step, reduction with diisobutylaluminum hydride (DIBAL), is well-known. A comprehensive review has been written by Winterfeldt.[9] Precedent for the second step can be found in the reductive deoxygenation chemistry of Doyle,[10] Fry,[11] and Carey.[12] The overall yields obtained by our procedure range from 50% to 88%. Examples of this reduction technique are illustrated in Table I. It can be seen that benzyl ethers, hindered esters, and unprotected alcohols are compatible with the mild reduction conditions. Notably, the reduction of unsaturated lactones affords only the product in which the position of the double bond remains unchanged. In the last entry the slow reduction rate is primarily due to the partial insolubility of the triol at low temperature. However, acetylation with acetic anhydride generated a triacetate which could be rapidly reduced.

In a competition experiment between 3,5,5-trimethylcyclohex-2-enol (8) and lactol 9, using 1 mol of triethylsilane and borontrifluoride etherate at −78 °C, the lactol is reduced to the ether while the allylic alcohol is recovered unchanged. Interestingly, alcohol 8 could be deoxygenated



8 9

to a mixture of isomeric alkenes at −20 °C. The rate of deoxygenation is much slower (24 h). In this case the trisubstituted alkene is the major product.

The two-step procedure described below features a low-temperature reduction followed by a highly chemoselective deoxygenation. The use of this method in complex systems is demonstrated in several examples in Table I. It compares favorably in terms of operational simplicity and overall yields with present methods.

Experimental Section

Unless otherwise noted, materials were obtained from commercial suppliers and were used without further purification. Diethyl ether, THF, benzene, and toluene were distilled from $LiAlH_4$ prior to usage. Dichloromethane was distilled from P_2O_5. All organic extracts were dried over Na_2SO_4, except where otherwise noted. Melting points were determined on a Fisher-Johns melting-point apparatus and are uncorrected. Infrared spectra were determined on a Beckman IR-4250 spectrometer. Nuclear magnetic resonance spectra were determined on either a Hitachi Perkin-Elmer R-20B 60-MHz or a Varian HA-100 100-MHz instrument. Carbon-13 NMR spectra were determined on a JEOL FX-90Q Fourier transform spectrometer. Both proton and carbon chemical shifts are expressed in parts per million downfield from internal tetramethylsilane. High-resolution mass spectra were recorded on an AEI MS-902 high-resolution mass spectrometer. Elemental analyses were performed by Galbraith Laboratories, Inc.

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General Procedure. Diisobutylaluminum hydride (1.0 M, hexanes) was added portionwise to a 0.3 M toluene solution of the unsaturated lactone (7.0 mmol) cooled to −78 °C (dry ice–CH_3OH bath) until TLC analysis judged the reaction complete. It was then poured into a rapidly stirred mixture of ice (25 g) and acetic acid (7 mL). Chloroform (50 mL) was added and the two-phase system stirred vigorously for 10 min. Another 100-mL portion of chloroform was added and vigorous stirring continued until two distinct layers formed when the stirring was halted (typically 30–60 min). The layers were separated, and the organic layer was washed with bicarbonate (2 × 100 mL) and brine (75 mL). Drying and removal of the solvents afforded a colorless oil which was used without purification.

The crude lactol and triethylsilane (1.22 g, 10.5 mmol) in dichloromethane (25 mL) were cooled under nitrogen. Dropwise addition of boron trifluoride etherate (0.95 mL, 7.7 mmol) gave a solution which was stirred until TLC indicated that no lactol was present and then quenched by addition of ca. 10 mL of aqueous bicarbonate. The cooling bath was removed and the solution allowed to warm to room temperature with vigorous stirring. After the mixture was transferred to a separatory funnel, ether (100 mL) was added and the whole washed with bicarbonate (20 mL) and brine (20 mL). Drying and removal of the solvents afforded an oil which was chromatographed (silica gel, hexanes–EtOAc).

1: IR (film) 2070, 3040, 2930, 2830, 1490, 1455, 1380, 1120, 750, 695 cm^{-1}; NMR ($CDCl_3$) δ 1.74 (m, 3 H), 2.20 (m, 4 H), 4.34 (m, 2 H), 4.55 (dd, J = 5, 9 Hz), 5.52 (m, 1 H), 7.40 (s, 5 H).

2: IR (film) 2980, 2895, 1065; NMR ($CDCl_3$) δ 1.52–2.42 (m, 4 H), 3.70–4.18 (m, 2 H), 4.68–4.94 (m, 1 H), 7.03–7.30 (m, 5 H); ^{13}C NMR 143.315, 128.146, 126.954, 125.492, 80.527, 68.446, 34.534, 25.919. The boiling point [105–107 °C (15 mmHg)] was identical with the literature[13] boiling point.

3 (R = CN): mp 75–76 °C; IR (film) 2980, 2880, 2205, 1120 cm^{-1}; 100-MHz NMR ($CDCl_3$) δ 0.10 (s, 6 H), 0.91 (s, 9 H), 1.72 (br s, 3 H), 1.8–2.0 (m, 4 H), 2.07 (t, J = 2 Hz, 3 H), 3.57, 3.70 (AB q, J = 10 Hz, 2 H), 4.15 (m, 3 H), 5.44 (m, 1 H); high-resolution mass spectrum for $C_{15}H_{22}O_2NSI$ (P − 57) requires m/e 276.15103, found m/e 276.14199.

4 (R = SPh): IR (film) 3035, 2970, 2940, 2870, 1685, 1480, 1445, 1260, 1105, 1070, 740, 690 cm^{-1}; 100-MHz NMR ($CDCl_3$) δ 0.06 (s, 6 H), 0.92 (s, 9 H), 1.75 (m, 3 H), 1.90 (m, 4 H), 1.97 (t, 3 H, J = 2 Hz), 3.60 and 3.80 (AB q, 2 H, J = 10 Hz), 4.07 (m, 2 H), 4.30 (m, 1 H), 5.47 (m, 1 H).

5 (R = H): IR (film) 2980, 2970, 2870, 1110 cm^{-1}; 100-MHz NMR ($CDCl_3$) δ 0.10 (s, 6 H), 0.90 (s, 9 H), 1.7–2.0 (m, 10 H), 3.50 and 3.72 (AB q, 2 H, J = 10 Hz), 4.02 (q, J = 2.5 Hz, 2 H), 4.20 (m, 1 H), 5.44 (m, 2 H); 90-MHz ^{13}C NMR ($CDCl_3$) δ 18.314, 23.135, 25.579, 25.898, 27.523, 41.124, 62.469, 65.511, 70.917, 121.353, 123.412, 134.517, 139.014; high-resolution mass spectrum for $C_{18}H_{32}O_2Si$ requires m/e 308.21717, found 308.21645.

7: IR (film) 3460, 2970, 2920, 1730, 1205; NMR ($CDCl_3$) δ 0.82–0.97 (m, 3 H), 1.60 (br s, 3 H), 1.73–2.63 (m, 5 H), 2.87 (br s, 1 H, OH), 3.30–3.82 (m, 6 H), 3.91–4.11 (m, 1 H), 5.14–5.43 (m, 1 H); mass spectrum for $C_{13}H_{20}O_4$ requires m/e 240.1361, found m/e 240.1369.

8 (R = H): NMR ($CDCl_3$) 1.31 (s, 3 H), 1.44 (m, 2 H), 1.80–2.48 (envelope, 7 H), 2.98 (m, 1 H), 3.40 (m, 3 H), 3.74 (m, 3 H), 4.60 (s, 2 H), 7.34 (s, 5 H); ^{13}C NMR ($CDCl_3$) 21.718, 22.433, 29.003, 30.954, 35.636, 41.099, 52.544, 53.324, 70.882, 71.857, 72.117, 73.548, 73.743, 82.782, 127.849, 128.434, 136.823, 213.039; IR ($CHCl_3$) 3400, 3040, 3005, 2980, 2880, 1700, 1450, 1090, 1050 cm^{-1}. Anal. Calcd for $C_{21}H_{28}O_5$: C, 69.98; H, 7.83. Found: C, 70.14; H, 8.05.

9 (R = $COCH_3$): NMR ($CDCl_3$) 1.24 (s, 3 H), 1.34 (m, 2 H), 1.86 (m, 2 H), 2.02 (s, 3 H), 2.14 (s, 3 H), 2.18–2.66 (envelope, 5 H), 3.02 (dd, 1 H, J = 7, 12 Hz), 3.50 (m, 4 H), 4.52 (s, 2 H), 4.84 (d, 1 H, J = 6 Hz), 5.02 (m, 1 H), 7.34 (s, 5 H); ^{13}C NMR ($CDCl_3$) 21.133, 21.263, 22.108, 24.126, 25.752, 28.418, 35.831, 41.944, 50.723, 51.178, 70.101, 71.987, 73.223, 73.808, 73.938, 82.522, 127.784, 128.434, 138.124, 169.404, 169.794, 209.788; IR (film) 3040, 2980, 2880, 1735, 1710, 1450, 1370, 1230, 1100, 1040, 1010, 940, 860, 735, 695 cm^{-1}. Anal. Calcd for $C_{25}H_{32}O_7$: C, 67.55; H, 7.26. Found: C, 67.52; H, 7.31.

(13) Loewen, P. C.; Makhubu, L. P.; Brown, R. K. *Can. J. Chem.* **1972**, *50*, 1502.

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Registry No. 1, 60335-71-9; 2, 16133-83-8; 3, 77256-27-0; 4, 77256-28-1; 5, 77256-29-2; 6, 87-41-2; 7, 77256-30-5; 8, 77256-31-6; 9, 77256-32-7; 5,6-dihydro-4-methyl-6-phenyl-2*H*-pyran-2-one, 29643-79-6; dihydro-5-phenyl-2(3*H*)-furanone, 1008-76-0; *cis*-3-cyano-4,7-dimethyl-4a-[[[(1,1-dimethylethyl)dimethylsilyl]oxy]methyl]-4a,5,6,8a-tetrahydrobenzopyran-2-one, 77256-33-8; *cis*-4,7-dimethyl-4a-[[[(1,1-dimethylethyl)dimethylsilyl]oxy]methyl]-3-(phenylthio)-4a,5,6,8a-tetrahydrobenzopyran-2-one, 77256-34-9; *cis*-4,7-dimethyl-4a-[[[(1,1-dimethylethyl)dimethylsilyl]oxy]methyl]-4a,5,6,8a-tetrahydrobenzopyran-2-one, 77256-35-0; 3-hydroxy-1-(3*H*)-isobenzofuranone, 16859-59-9; methyl 4,7-dimethyl-3,4,4a,5,8,8a-hexahydro-3-hydroxy-2-oxo-4a-benzopyrancarboxylate, 77256-36-1; hexahydro-1,4,9-trihydroxy-3-methyl-10-[2-(phenylmethoxy)ethyl]-1*H*-3,9a-methano-2-benzoxepin-6(7*H*)-one, 77256-37-2; 1,4,9-tris(acetyloxy)hexahydro-3-methyl-10-[2-(phenylmethoxy)ethyl]-1*H*-3,9a-methano-2-benzoxepin-6(7*H*)-one, 77256-38-3.

p-Methoxyacetophenone Dimethyl Ketal and α,*p*-Dimethoxystyrene. Efficient and Useful Reagents for 1,2- and 1,3-Diol Protection†

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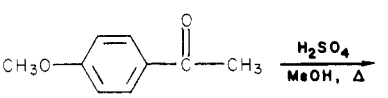
The use of carbohydrates as chiral templates in syntheses of complex natural products continues to attract an increasing amount of attention.[1] Selective derivatization of these optically pure building blocks plays a major role both in total synthesis and in the preparation of novel analogues of sugar-containing natural products (e.g., anthraquinones, aureolides, aminoglycosides, etc.).[2]

A key feature in most synthetic schemes involves control of the polyhydroxyl functionality present in the starting sugar. Need for the selective manipulation of these groups has led to a variety of 1,2- and 1,3-diol protecting groups,[3] perhaps the most common being acetals derived from benzaldehyde.[4,5] These derivatives, however, oftentimes require fairly strong (aqueous) acid for hydrolysis[6] or large quantities of an expensive hydrogenation catalyst[7] to effect cleavage. Hence, it was felt that an alternative protection/deprotection procedure which avoids these somewhat limiting conditions yet is highly efficient, rapid, and mild would be particularly useful. We now report our results from a study in this area which provide new methodology for a mild, nonaqueous 1,2- and 1,3-diol protection/deprotection sequence.

Conversion of *p*-methoxyacetophenone (**1**) to its dimethyl ketal **2** was readily performed in 81% distilled



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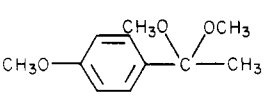

2

yield, using concentrated H_2SO_4 in MeOH at room tem-

† Dedicated to Professor Harry H. Wasserman on the occasion of his sixtieth birthday.

‡ Recipient of an American Cancer Society Junior Faculty Research Award, 1981–1983.

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