Thus, we have evidence that the N-acylated intermediate in the acyl transfer mechanism does form in the quinine system. In addition (in the quinine system), there is apparently no evidence of an OH to N-1 hydrogen bond.[1] Finally, intramolecular acyl migrations from amide N to OH are well known in aliphatic systems[10] including peptides.[11]

In summary, with our present results, we provide what we believe to be the first example of regioselective esterification induced by intramolecular acyl transfer from a tertiary amine. Our opinion on this point is supported by a careful survey of *Chemical Abstracts*. Having established this mechanistic event, experiments are in progress with the design to prepare other quinine derivatives with electrophilic functionality at the desired C-10 position.

Experimental Section

IR spectra were run using a Perkin-Elmer 1310 spectrophotometer. NMR spectra were obtained on a JEOL JNM-PMX 60 instrument in $CDCl_3$ solution (internal TMS). Analytical TLC made use of Merck precoated silica gel plates (0.25 mm), and preparative TLC purifications were done using commercial AnalTech Si gel G (2 mm) plates. The solvent system was 20% MeOH in $CHCl_3$–2% NH_4OH in all cases, and visualization utilized UV or iodine vapor. Quinine, 2-pyridylcarbinol, benzyl alcohol, *N*,*N*-dimethylethanolamine, and isoamyl alcohol are all available from Aldrich Chemical Co. Organic solutions were dried over anhydrous $MgSO_4$.

OsO_4/$NaIO_4$ Oxidation of Quinine (1). In a 100-mL round-bottom flask 0.753 g of quinine (2.32 mmol) was added to 40 mL of 80% acetic acid with stirring. After cooling to 0 °C, 1.483 g of $NaIO_4$ (6.93 mmol) was added followed by a few crystals of OsO_4. The solution became opaque purple as it was stirred for 5 h on ice. The flask was refrigerated overnight, whereupon the now pale yellow solution was rotovaped. About 10 mL of water was added, and the mixture was rotovaped again. The resulting foam was dissolved in 50 mL of $CHCl_3$ and shaken with saturated $NaHCO_3$. The organic layer was separated, and the aqueous phase extracted with 25 mL of $CHCl_3$. The combined organic solution was dried, filtered, and evaporated to dryness to give 0.720 g (95%) of a yellow foam. **2**:[7] IR (neat) 3200 (OH), 1720 (C=O) cm^{-1}; NMR 9.73, 9.65 (CHO), 3.88, 3.83 (MeO) ppm. A 1:1 mixture of C-3 epimers was confirmed by examining the NMR of the acetate ester of **2**.

$NaBH_4$ Reduction of Aldehyde 2. The 0.720-g sample of **2** from the previous preparation was taken up in 30 mL of MeOH, and 0.536 g of $NaBH_4$ was added slowly at room temperature with stirring. After 1 h the reaction solution was diluted with 100 mL of water and extracted with 4 × 50 mL of $CHCl_3$. The combined organic solution was dried, filtered, and evaporated to dryness to give 0.573 g (79.6%) of a white foam. **3**: one spot on TLC (R_f 0.2); IR ($CHCl_3$) 3200 (OH), 1622, 1595, 1510 cm^{-1}; EI-MS *m*/*e* (% base peak) 328 (M^+) (8.3), 313 (3.7), 297 (30), 269 (50), 189 (90), 140 (100). Compound **3** was not soluble enough to obtain an NMR spectrum.

Cinnamoylation of Diol 3. A 0.231-g sample of the diol **3** (0.704 mmol) in 30 mL of benzene (2 mL of Et_3N) was heated at reflux to dissolve the starting material. After cooling, 0.129 g of cinnamoyl chloride (0.775 mmol) was added, and the reaction solution was stirred and refluxed for 1.5 h ($CaCl_2$ drying tube). Stirring continued overnight at room temperature, whereupon the mixture was shaken with 5% NaOH. The organic layer was separated, washed once with water, dried, filtered, and evaporated. The crude product **4** (0.261 g), a pale yellow foam, showed one major spot on TLC (R_f 0.6) with traces of starting **3** and a high R_f impurity (diester). Product **4** was easily purified by prep TLC as described. **4**: IR (neat) 3400 (OH), 1710 (C=O), 1625, 1590, 1505 cm^{-1}; EI-MS *m*/*e* (% base peak) 458 (M^+) (63), 444 (19), 327 (27), 311 (100), 188 (94), 140 (44), 131 (79); NMR 8.73 (d, 1 H) (H-2′), 8.08 (d, 1 H) (H-8′), 7.83 (d, 1 H, *J* = 16 Hz) (cinnamoyl β-H), 6.73 (d, 1 H, *J* = 8 Hz) (H-9), 6.60 (d, 1 H, *J* = 16 Hz) (cinnamoyl α-H), 3.93 (s, 3 H) OMe), 3.50 ppm (2 H) (CH_2O).

In another run using 1.2 equiv of cinnamoyl chloride, the high R_f product was isolated and shown to be the corresponding diester of **3**: IR (neat) no OH, 1710 (C=O), 1634, 1620, 1590, 1575 cm^{-1}; NMR 8.75 (d, 1 H) H-2′), 8.08 (d, 1 H) (H-8′), 8.00–7.66 (2 doublets) (2 cinnamoyl β-H's), 6.70–6.30 (2 doublets) (2 cinnamoyl α-H's), 6.73 (d, 1 H, *J* = 8 Hz) (H-9), 4.16 (2 H) (CH_2O), 3.96 (s, 3 H) (OMe).

2-Pyridylcarbinol/Benzyl Alcohol: Competition Experiment. To a stirred solution of 0.311 g of **5** (2.85 mmol) and 0.314 g of **6** in 40 mL of benzene was added 0.470 g of cinnamoyl chloride (2.82 mmol). The reaction solution was stirred and refluxed ($CaCl_2$ drying tube) for 2 h then left in the refrigerator overnight. The resulting mixture was shaken thoroughly with 5% NaOH, and the organic layer was washed with water, dried, filtered, and evaporated to dryness (0.634 g, pale yellow, thick liquid). The NMR spectrum clearly indicated a 2.2:1 ratio of esters **7**:**8**, by integration of the signals at 5.37 and 5.17 ppm (CH_2O). These signals were shown to correspond to **7** and **8**, respectively, by comparison to authentic ester spectra.

***N*,*N*-Dimethylethanolamine/Isoamyl Alcohol: Competition Experiment.** An identical procedure was applied to alcohols **9** and **10** (3.4-mmol scale). The NMR of the ester product was nearly identical with that of authentic **11** and gave no indication of the presence of isoamyl cinnamoate.

Acknowledgment. We are grateful to the American Society of Pharmacognosy for financial support of this work through an Undergraduate Research Award. We also acknowledge the assistance provided by the UC Foundation Grote Chemistry Fund. Mass spectra were obtained through the generous help of the following colleagues: Alma Parker, Barry Henderson (Purdue University), Dr. Richard Pagni (University of Tennessee), Dr. W. Christie, R. Hettich (Oak Ridge National Lab.) Sunil Geevarghese provided technical assistance throughout the course of our work.

Registry No. **1**, 130-95-0; **2** (isomer 1), 127707-69-1; **2** (isomer 2), 127707-70-4; **3** (isomer 1), 127619-74-3; **3** (isomer 2), 127707-71-5; **4** (isomer 1), 127619-75-4; **4** (isomer 2), 127707-72-6; **4** (dicinnamate, isomer 1), 127619-76-5; **4** (dicinnamate, isomer 2), 127707-73-7; **5**, 586-98-1; **6**, 100-51-6; **7**, 127619-77-6; **8**, 78277-23-3; **9**, 108-01-0; **11**, 46742-18-1.

(10) Bernath, G.; Lang, K. L.; Tichy, M.; Pankova, M. *Acta Chim. Acad. Sci. Hung.* **1975**, *86*, 199.
(11) Iwai, K.; Ando, T. *Methods Enzymol.* **1967**, *11*, 263.

Synthesis of β-Methoxy Enones via a New Two-Carbon Extension of Carboxylic Acids

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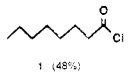
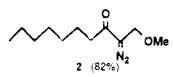
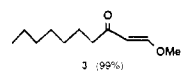
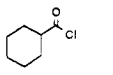
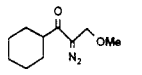
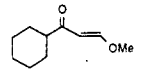
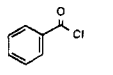
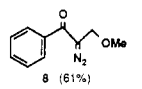
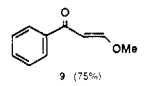
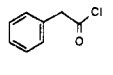
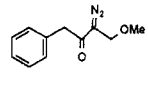
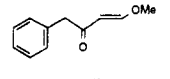
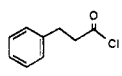
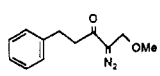
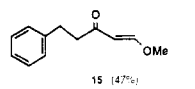
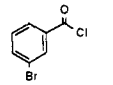
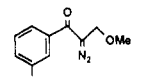
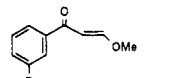
Received February 15, 1990

We report a new procedure for the synthesis of aliphatic and aromatic β-methoxy enones by a two-carbon homol-

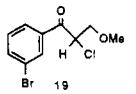
(1) Recipient of the Research Career Development Award (NIH-AI-00564), 1984–1989; to whom correspondance should be addressed.
(2) (a) We are indebted to CONACyT for financial assistance to H. F.O. during part of this work at Universidad Nacional Autonoma de Mexico and to Dr. Marta Albores-Velasco for her valuable guidance. (b) Partial effort from the Facultad de Quimica, Montevideo, resulted in the preparation of compounds **20**, **21**, **22**, and **23**. (c) Presented in part at the 3rd Brazilian Congress on Organic Synthesis, Sao Carlos, Brazil, January 1989.

0022-3263/90/1955-4767$02.50/0

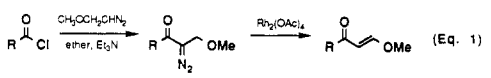
Table I. Conversion of Acids to β-Methoxy Enones

acid chloride[a]	diazo ketone (%)[b,c,e]	enol ether (%)[b]
 1 (48%)	 2 (82%)	 3 (99%)
 4 (99%)	 5 (64%)	 6 (95%)
 7	 8 (61%)	 9 (75%)
 10 (99%)	 11 (52%)	 12 (78%)
 13	 14 (52%)	 15 (47%)
 16[f]	 17[f] (86%)	 18[f] (99%); (82%)[c]

[a] Acid chlorides **1**, **4**, **10**, and **13** were prepared; the others were purchased from Aldrich and used without purification. [b] Isolated yields. [c] Crude diazo ketones can be used directly without isolation; the yields listed are those of analytical samples. [d] Overall yield from crude diazo ketone. [e] The yields of diazo ketone formation were not optimized. The mass balance of the reaction mixtures consisted of the corresponding α-chloro-β-methoxy ketones resulting from inefficient neutralization by Et_3N of HCl generated during the reaction. Chloro ketone **19** was characterized as a byproduct in the preparation of **17**. **19**: ^1H NMR ($CDCl_3$) δ 8.13 (t, J = 1.7 Hz, 1 H), 7.92 (m, 1 H), 7.74 (m, 1 H), 7.38 (t, J = 7.9 Hz, 1 H), 5.13 (t, J = 6.5 Hz, 1 H), 4.03 (d, d, J = 10.0, 10.1 Hz, 1 H), 3.80 (d, d, J = 10.0, 10.1 Hz, 1 H), 3.41 (s, 3 H). [f] Several additional derivatives of halobenzoic acids were prepared.[16]

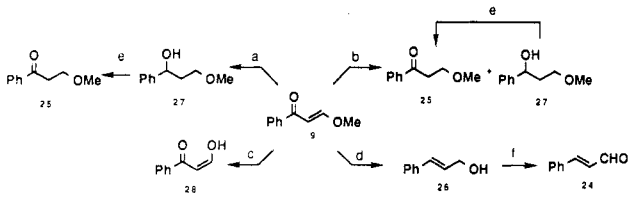

19

ogation of carboxylic acids using previously unknown methoxydiazoethane (eq 1). These substrates are of


(Eq. 1)

general interest as protected β-keto aldehydes,[3] substrates for hetero-Diels–Alder reaction,[4] reagents for the synthesis of γ-pyrones,[5] trans,trans-dienones,[6] or potential synthons for the direct preparation of regioselectively substituted ketones from carboxylic acids (by alkylation of the available α-position, hydrolysis, and deformylation). The

Scheme I[a]



[a] (a) $NaBH_4$, MeOH, rt; (b) H_2, Pd/C, MeOH; (c) $HClO_4$, THF/H_2O; (d) $LiAlH_4$, ether, HCl; (e) PCC, CH_2Cl_2; (f) CrO_3·Py (3 equiv), rt.

two-step procedure involves the conversion of a carboxylic acid to its acid chloride with either oxalyl chloride or Ghosez reagent[7] and formation of the corresponding 2-diazo-1-methoxyethyl ketones by the action of 2-diazo-1-methoxyethane[8] on the acid chloride, Table I. Exposure of the diazo ketones to $Rh_2(OAc)_4$[9] led to formation of trans-β-methoxy enones[10] in excellent yields, presumably via β-elimination of the intermediate metalocarbene.

Several simple transformations were performed with phenyl-β-methoxyvinyl ketone **9**, Scheme I, to illustrate the synthetic potential of β-methoxy enones. In addition to the published processes mentioned earlier, the enones can serve as convenient starting materials for the preparation of allylic alcohols, β-alkoxy ketones, β-keto aldehydes, or unsaturated aldehydes. In each of the cases listed in Scheme I the net transposition corresponds to a condensation of a carbonyl with β-alkoxycarbanion, a synthon that is not accesible in practice because of the more likely elimination process.

The β-methoxy enones listed in Table I are easily prepared in any quantity and are stable when stored at low temperature. On standing or storage at room temperature they tend to hydrolyze partially to β-keto aldehydes (this may be reflected in the elemental analytical results).[11]

(3) House, H. O.; Rasmusson, G. H. *J. Org. Chem.* **1963**, *28*, 27. Gannon, W. F.; House, H. O. *Organic Syntheses*; Wiley: New York, 1973; Collect. Vol. V, p 539.

(4) (a) Some cycloadditions have been reported: reaction with ketenes to give (4 + 2) cycloaddition products and conversion to 2-pyranones on treatment with Zn and AcOH. Brady, W. T.; Agho, M. O. *J. Org. Chem.* **1983**, *48*, 5337. (b) Cycloaddition catalyzed with $ZnCl_2$ to give 2,2-dialkoxy-3,4-dihydropyrans: Bakker, C. G.; Nivard, R. J. F. *Recl. Trav. Chim. Pays-Bas* **1981**, *100*, 13. (c) Berti, G.; Catelani, G.; Colonna, F.; Monti, L. *Tetrahedron* **1982**, *38*, 3067. (d) Boger, D. L.; Weinreb, S. N. *Hetero Diels Alder Methodology in Organic Synthesis*, ORG. CHEM, a series of monographs, Vol. 47; Academic Press; New York 1987.

(5) (a) Condensation of the enolate with acid chlorides and treatment with TFA to give γ-pyrone: Koreeda, M.; Akagi, H. *Tetrahedron Lett.* **1980**, *21*, 1197. (b) Direct preparation of γ-pyrone: Morgan, T. A.; Ganem, B. *Tetrahedron Lett.* **1980**, *21*, 2773.

(6) Molander, G. A.; Singaram, B.; Brown, H. C. *J. Org. Chem.* **1984**, *49*, 5024.

(7) Devos, A.; Remion, J.; Frisque-Hesbain, A. M.; Colens, A.; Ghosez, L. *Chem. Commun.* **1979**, 1180. Haveaux, B.; Dekoker, A.; Rens, M.; Sidane, A. R.; Toye, J.; Ghosez, L. *Org. Synth.* **1979**, *59*, 26.

(8) (a) The procedures are similar to those for *N*-methyl-*N*-nitrosourea: Arndt, F. *Organic Syntheses*; Wiley: New York, 1943; Collect. Vol. II, p 165. (b). Arndt, F. ref 8a, p 461.

(9) For applications of $Rh_2(OAc)_4$-catalyzed reactions, see the following. (a) OH insertion of diazoesters: Paulissen, R.; Hayez, E.; Hubert, A. J.; Teyssie, P. *Tetrahedron Lett.* **1974**, 607. Noels, A. F.; Demonceau, A.; Petiniot, N.; Hubert, A. J.; Teyssie, Ph. *Tetrahedron* **1982**, *38*, 2733. (b) NH insertion: Salzmann, T. N.; Ratcliffe, R. W.; Christensen, B. G.; Bouffard, F. A. *J. Am. Chem. Soc.* **1980**, *102*, 6161. Mattingly, P. G.; Miller, M. J. *J. Org. Chem.* **1981**, 1557. (c) CH insertion: Taber, D. F.; Petty, E. H. *J. Org. Chem.* **1982**, *47*, 4808. (d) Cycloadditions: Petiniot, N.; Anciaux, A. J.; Noels, A. F.; Hubert, A. J.; Teyssie, Ph. *Tetrahedron Lett.* **1978**, *14*, 1239. Anciaux, A. J.; Hubert, A. J.; Noels, A. F.; Petiniot, N.; Teyssie, Ph. *J. Org. Chem.* **1980**, *45*, 695. (e) β-Keto esters: Pelliciari, R.; Fringuelli, R.; Ceccherelli, P.; Sisani, E. *J. Chem. Soc., Chem. Commun.* **1979**, 959. Holmquist, C. R; Roskamp, E. J. *J. Org. Chem.* Submitted for publication. (f) *cis*-α,β-Unsaturated esters: Ikota, N.; Takamura, N.; Young, S. D.; Ganem, B. *Tetrahedron Lett.* **1981**, *22*, 4163.

(10) The trans stereochemistry was assigned from the coupling constant of C-α and C-β hydrogens (12.5 Hz). The NOE experiment showed 16% enhancement (of the maximum theoretical value) of C-α hydrogen when the methoxy group hydrogens were irradiated.

(11) The results of combustion analyses of enones gave consistently erroneous results, low in carbon, due to either hydrate content or partial hydrolysis to aldehydes in transit. **1-Methoxy-1(*E*)-decen-3-one (3).** Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.70; H, 10.94. Found: C, 69.65; H, 10.92. **1-Cyclohexyl-3-methoxy-2(*E*)-propen-1-one (6).** Anal. Calcd for $C_{10}H_{16}O_2$: C, 71.38; H, 9.60. Found: C, 70.61; H, 9.65. **3-Methoxy-1-phenyl-2(*E*)-propenone (9).** Anal. Calcd for $C_{10}H_{10}O_2$: C, 74.04; H, 6.23. Found: C, 72.63; H, 5.86. **1-Phenyl-4-methoxy-3(*E*)-buten-2-one (12).** Anal. Calcd for $C_{11}H_{12}O_2$: C, 74.97; H, 6.86. Found: C, 73.51; H, 6.52. **1-Methoxy-5-phenyl-1(*E*)-penten-3-one (15).** Anal. Calcd for $C_{12}H_{14}O_2$: C, 75.70; H, 7.41. Found: C, 72.85; H, 7.02. **1-(3-Bromophenyl)-3-methoxy-2(*E*)-propenone (18).** Anal. Calcd for $C_{10}H_9BrO_2$: C, 49.82; H, 3.76. Found: C, 49.01; H, 3.70.

(12) Shono, T.; Nishiguchi, I.; Komamura, T.; Sasaki, M. *J. Am. Chem. Soc.* **1979**, *101*, 984.

Experimental Section

Analytical TLC was performed on silica gel 60F-254 plates. Flash chromatography was performed on kieselgel 60 (EM Reagents, 230–400 mesh). Melting points are uncorrected. Infrared spectra were recorded on neat samples (NaCl plates). Proton and carbon NMR spectra were obtained on a Bruker WP-270 instrument. The purity of enol ethers **3**, **6**, **9**, **12**, **15**, and **18** was judged to be greater than 95% by GC (HP-5 capillary column) determinations.

***N*-(Methoxyethyl)-*N'*-nitrosourea.**[8a] A solution of 130.2 mL (112.5 g, 1.5 mol) of methoxyethylamine in 250 mL of water was cooled in an ice bath and neutralized (methyl red) by the addition of concentrated hydrochloric acid (127 mL). Then, 300 g (5.0 mol) of urea was added to this solution and refluxed for 3 h. The solution was cooled to room temperature and 110 g (1.6 mol) of sodium nitrite was dissolved in it; the solution was cooled in an ice bath and transferred slowly to a mixture of 600 g of ice and 100 g (1 mol) of concentrated sulfuric acid in an ice–salt bath. The temperature was not allowed to rise above 0 °C. The product was filtered with suction and washed with 50 mL of cold water; 44 g (0.3 mol, 20%) of *N*-methoxyethyl-*N'*-nitrosourea was obtained: mp = 78-79 °C; IR (KBr disk) 3400, 3250, 1737, 1600, 1485, 1420. *Caution*: this compound may be a cancer-suspect agent and protective clothing and ventilation are required when handling it.

1-Diazo-2-methoxyethane.[8b] To a stirred mixture of 3.0 mL of a 50% KOH solution and 10.0 mL of ether was added slowly 1.0 g (6.8 mmol) of *N*-(methoxyethyl)-*N'*-nitrosourea at room temperature. Stirring was continued for 15 min. The yellow ethereal solution was separated and the alkaline solution was extracted with more ether (5 × 2.5 mL). The ethereal solution was dried over KOH pellets at 0 °C for 1.5 h. This solution was ready for immediate use. *Caution*: all work should be performed in a well-ventilated hood.[15]

General Procedure for the Preparation of Diazo Ketones. The freshly prepared ethereal solution of 1-diazo-2-methoxyethane was stirred with 0.14 mL (1 mmol) of triethylamine at 0 °C. To this solution was added the acid chloride (1 mmol) slowly. Stirring was continued for 1 h at 0 °C and then overnight at room temperature. The resulting mixture was filtered and the precipitate washed with 20 mL of dry ether. The solvent was removed under reduced pressure. A pure sample of diazo ketone was obtained by column chromatography (alumina [Act.I]; hexane/ethyl acetate, 8:2).

2-Diazo-1-methoxydecan-3-one (2): IR (neat) 2950, 2080, 1650, 1080 cm^{-1}; ^1H NMR ($CDCl_3$) δ 4.28 (s, 2 H), 3.26 (s, 3 H), 2.42 (t, J = 7.5 Hz, 2 H), 1.57 (m, 2 H), 1.53 (m, 8 H), 0.81 (t, J = 6.6 Hz, 3 H).

1-Cyclohexyl-2-diazo-3-methoxypropan-1-one (5): IR (neat) 3000, 2920, 2140, 1670, 1480, 1365, 1110, 1020 cm^{-1}; ^1H NMR ($CDCl_3$) δ 4.36 (s, 2 H), 3.32 (s, 3 H), 2.59 (m, 2 H), 1.9–1.08 (m, 10 H).

2-Diazo-3-methoxy-1-phenylpropanone (8): IR (neat) 1960, 2090, 1670, 1230 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.8–7.3 (m, 5 H), 4.61 (s, 2 H), 3.49 (s, 3 H).

3-Diazo-4-methoxy-1-phenylbutan-2-one (11): IR (neat) 2940, 2080, 1630, 1085 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.4–7.2 (m, 5 H), 4.3 (s, 2 H), 3.8 (s, 2 H), 3.3 (s, 3 H).

2-Diazo-1-methoxy-5-phenylpentan-3-one (14): IR (neat) 2090, 1640, 1090 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.4–7.1 (m, 5 H), 4.3 (s, 3 H), 3.3 (s, 3 H), 3.0 (t, 2 H), 2.8 (t, 2 H).

1-(3-Bromophenyl)-2-diazo-3-methoxypropan-1-one (17): IR (neat) 2070, 1620, 1330 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.81 (s, 1 H), 7.66–7.65 (m, 2 H), 7.35–7.26 (m, 1 H), 4.42 (s, 2 H), 3.41 (s, 3 H).

General Procedure for the Preparation of Enol Ethers. To a solution of diazo ketone (1 mmol) in benzene (10 mL) was added 1.0 mL of a well-stirred suspension of 20 mg of $Rh_2(OAc)_4$ in 50.0 mL of benzene at room temperature. Stirring was continued overnight. The solvent was evaporated and the mixture was filtered through a small column of silica gel (Davisil 60).

1-Methoxy-1(*E*)-decen-3-one (3): IR (neat) 2929, 2859, 1687, 1655, 1622, 1598, 1458, 1311, 1244, 1218, 1135, 1071 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.5 (d, J = 12.7 Hz, 1 H), 5.5 (d, J = 12.7 Hz, 1 H), 3.6 (s, 3 H), 2.38 (t, 2 H), 1.57 (m, 2 H), 1.23 (m, 8 H), 0.81 (t, J = 4.6 Hz, 3 H); ^{13}C NMR ($CDCl_3$) δ 200.0 (C), 162.3 (CH), 105.5 (CH), 57.3 (CH_3), 41.3 (CH_2), 31.6 (CH_2) 29.3 (CH_2), 29.0 (CH_2), 24.6 (CH_2), 13.9 (CH_3); MS (CI), m/e (relative intensity) 185 (100), 127 (8), 100 (12), 85 (11). Anal. Calcd for $C_{11}H_{21}O_2$: 185.1541. Found: 185.1557.

1-Cyclohexyl-3-methoxy-2(*E*)-propen-1-one (6): IR (neat) 2960, 2900, 1630, 1610, 1460, 1240 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.54 (d, J = 12.5 Hz, 1 H), 5.5 (d, J = 12.5 Hz, 1 H), 3.6 (s, 3 H), 2.3 (m, 1 H), 1.8–1.1 (m, 10 H); ^{13}C NMR ($CDCl_3$) δ 202.4 (C), 162.3 (CH), 103.6 (CH), 57.4 (CH_3), 49.8 (CH), 28.8 (CH_2, double intensity), 25.9 (CH_2), 25.7 (CH_2, double intensity); MS (Cl), m/e (relative intensity) 168 (6), 137 (8), 111 (15), 100 (8), 85 (100), 83 (37), 71 (12), 55 (22). Anal. Calcd for $C_{10}H_{16}O_2$: 168.1150. Found: 168.1159.

3-Methoxy-1-phenyl-2(*E*)-propen-1-one (9): IR (neat) 1645, 1600, 1585, 1205 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.91–7.87 (m, 2 H), 7.78 (d, J = 12.2 Hz, 1 H), 7.52–7.41 (m, 3 H), 6.33 (d, J = 12.2 Hz, 1 H), 3.8 (s, 3 H), ^{13}C NMR ($CDCl_3$) δ 190.5 (CO), 164.8 (CH), 138.7 (C), 128.3 (2CH), 127.9 (2CH), 101.6 (CH), 57.9 (CH_3); MS (EI), m/e (relative intensity) 162 (33), 147 (8), 133 (9), 105 (100), 85 (86), 77 (81), 51 (25). Anal. Calcd for $C_{10}H_{10}O_2$: 162.0681. Found: 162.0686.

4-Methoxy-1-phenyl-3(*E*)-buten-2-one (12): IR (neat) 1690, 1660, 1220 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.62 (d, J = 12 Hz, 2 H), 7.4–7.2 (m, 5 H), 5.6 (d, J = 12 Hz, 2 H), 3.72 (s, 2 H), 3.62 (s, 3 H); ^{13}C NMR ($CDCl_3$) δ 196.6 (C), 163.2 (CH), 135.0 (C), 129.3 (CH, double intensity), 128.6 (CH, double intensity), 126.8 (CH), 104.6 (CH), 57.5 (CH_3), 48.8 (CH_2); MS (EI), m/e (relative intensity) 176 (7), 91 (98), 85 (100), 77 (20), 69 (25), 65 (55). Anal. Calcd for $C_{11}H_{12}O_2$: 176.0837. Found: 176.0840.

1-Methoxy-5-phenyl-1(*E*)-penten-3-one (15): IR (neat) 1620, 1600, 1090 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.60 (d, J = 12.7 Hz, 1 H), 7.32–7.22 (m, 5 H), 5.59 (d, J = 12.7 Hz, 1 H), 3.69 (s, 3 H), 2.98–2.92 (t, J = 6.8 Hz, 2 H), 2.81–2.75 (t, J = 6.8 Hz, 2 H); ^{13}C NMR ($CDCl_3$) δ 198.4 (C), 162.7 (CH), 141.4 (C), 128.5 (4CH), 126.1 (CH), 105.6 (CH), 57.5 (CH_3), 42.8 (CH2), 30.4 (CH_2).

1-(3-Bromophenyl)-3-methoxy-2(*E*)-propen-1-one (18): IR (neat) 1650, 1560, 1200 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.01 (t, J = 1.6 Hz, 3 H), 7.78 (d, J = 12.2 Hz, 1 H), 7.8–7.6 (m, 2 H), 7.31 (t, J = 7.85 Hz, 1 H), 6.26 (d, J = 12.2 Hz, 1 H), 3.82 (s, 3 H); ^{13}C NMR 188 (C), 165 (CH), 141 (C), 135 (CH), 131 (CH), 129 (CH), 122 (C), 101 (CH), 59 (CH_3).

Hydrogenation of 3-Methoxy-1-phenyl-2-propen-1-one. A benzene solution (2 mL) of 39.7 mg (0.24 mmol) of 3-methoxy-2-propen-1-one (**9**) and 15 mg of palladium over charcoal (10%) was added. The mixture was shaken in a Parr hydrogenator for 3 h at 30 psi of H_2. The mixture was then filtered and two compounds were separated in a column with silica gel (hexane-

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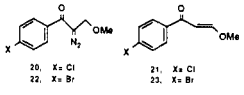

20, X = Cl 21, X = Cl
22, X = Br 23, X = Br

1-(4-Chlorophenyl)-2-diazo-3-methoxypropan-1-one (20): IR (neat) 3080, 2175, 1780, 1710, 1600, 1450, 1210, 1020, 1000, 850, 820 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.90–7.70 (d, 2 H), 7.45–7.35 (m, 2 H), 4.40 (s, 2 H), 3.33 (s, 3 H).

1-(4-Chlorophenyl)-3-methoxy-2(*E*)-propen-1-one (21): IR (neat) 3080, 1830, 1700, 1450, 1440, 1250, 1120, 1080, 850, 820 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.90–7.80 (d, J = 8 Hz, 2 H), 7.58 (d, J = 10 Hz, 1 H), 7.45–7.25 (d, J = 8 Hz, 2 H), 6.30 (d, J = 10 Hz, 1 H), 3.80 (s, 3 H).

1-(4-Bromophenyl)-2-diazo-3-methoxypropan-1-one (22): IR (neat) 3080, 2100, 1725, 1600, 1450, 1210 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.00–7.80 (d, 2 H), 7.45–7.32 (d, 2 H), 4.40 (s, 2 H), 3.33 (s, 3 H).

1-(4-Bromophenyl)-3-methoxy-2(*E*)-propen-1-one (23): IR (neat) 3026, 2937, 1660, 1592, 995, 818, 740 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.76 (d, J = 12 Hz, 1 H), 7.78 (d, J = 8.5 Hz, 2 H), 7.51 (d, J = 8.5, 2 H), 3.8 (s, 3 H); ^{13}C NMR 189.3 (C), 165.2 (CH), 137.5 (C), 131.8 (CH, double intensity), 129.6 (CH, double intensity), 127.2 (C), 101.2 (CH), 58.3 (CH_3); MS m/e (relative intensity) 242 (37), 240 (M^+, 39), 227 (10), 225 (39), 184 (39), 183 (40), 157 (25), 155 (25), 85 (100), 76 (35), 69 (20).

/ethyl acetate, 9:1); 18 mg (0.11 mmol, 45.7%) of 3-methoxy-1-phenylpropanone (**25**)[12] and 10 mg (0.06 mmol, 25%) of 3-methoxy-1-phenylpropanol (**27**)[13] were obtained. The mixture could be titrated with Jones reagent to afford only **25**.

3-Methoxy-1-phenylpropan-1-one (25).[12] To a dichloromethane solution (3 mL) of 60.3 mg (0.36 mmol) of 3-methoxy-1-phenyl-1-propanol (**27**) was added 110 mg of pyridinium chlorochromate (PCC). After 2 h the mixture was filtered through a small plug of Florisil; 46.4 mg (0.28 mmol, 78%) of 3-methoxy-1-phenylpropan-1-one (**25**) was obtained after the solvent was evaporated: IR (neat) 3061, 2893, 1685, 1597, 1449, 1118, 750, 691 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.96 (d, J = 7.8 Hz, 2 H), 7.57 (m, 1 H), 7.46 (m, 2 H), 3.83 (t, J = 6.4 Hz, 2 H), 3.38 (s, 3 H), 3.25 (t, J = 6.4 Hz, 2 H); ^{13}C NMR 198.2 (C), 137.0 (C), 133.1 (CH), 129.0 (2CH), 128.1 (2CH), 67.9 (CH_2), 58.8 (CH_3), 38.6 (CH_2).

3-Methoxy-1-phenyl-1-propanol (27).[13] A methanol solution (1 mL) of 82.7 mg (0.51 mmol) of enone **9** was treated with sodium borohydride (5 mg). The mixture was stirred for 1 h at room temperature and quenched with 10% NaOH solution (3 mL). Dichloromethane (1 mL) was added and the organic layer was separated. The aqueous layer was extracted twice with 1 mL of dichloromethane. The combined organic layers were evaporated. A pure sample of alcohol **27** (60.3 mg, 0.36 mmol, 71%) was obtained by column chromatography (silica gel, hexane/ethyl acetate, 9.5:0.5): IR (neat) 3416, 3062, 2924, 1493, 1453, 1117, 758, 701 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.25 (m, 5 H), 4.9 (m, 2 H), 3.55 (m, 2 H), 3.35 (s 3 H), 1.95 (m, 2 H).

Cinnamyl Alcohol (26). An ether solution (2 mL) of 92.5 mg (0.57 mmol) of 3-methoxy-1-phenyl-2-propen-1-one (**9**) was treated with 43.2 mg (1.14 mmol) of $LiAlH_4$. The mixture was stirred for 2 h and quenched with 1 mL of water and then 1 mL of 10% solution of HCl. The organic layer was separated and the aqueous layer extracted with ether (2 × 1 mL). The combined organic layers were washed with 2 mL of brine solution and dried with $MgSO_4$. Evaporation of the solvent yielded 59.4 mg (0.44 mmol, 77%) of cinnamyl alcohol (**26**): IR (neat) 3356, 3026, 2926, 2862, 1598, 1494, 1449, 1217, 1093, 1012, 967, 750, 693 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.45–7.15 (m, 5 H), 6.65 (d, 1 H), 6.35 (dt, 1 H), 4.35 (d, 2 H). The oxidation of **26** to cinnamaldehyde **24** is known.[17]

Hydrolysis of Enone 9. A THF solution (5 mL) of 106.6 mg (0.6 mmol) of enone **9** was treated with 5 mL of 3% $HClO_4$, and the mixture was stirred for 2 h at room temperature; 5 mL of ether was added. The organic extract was washed with 2 mL of brine solution. The solution was filtered and 87.6 mg (90%) of benzoyl acetaldehyde was obtained:[14] ^1H NMR ($CDCl_3$) δ 8.1–7.2 (m, 5 H), 8.27 (d, J = 4.4 Hz, 1 H), 6.39 (d, J = 4.4 Hz, 1 H).

Acknowledgment. We express our gratitude to the following agencies for their generous financial support: the Petroleum Research Fund, administered by the American Chemical Society, National Institute of Health (AI-00564, AI-19749), and the Jeffress Trust Fund. The Fullbright Commission (Montevideo) is gratefully acknowledged for its continuing support of collaborative research program between Virginia Tech and Montevideo, established in 1984.

Registry No. **1**, 111-64-8; **2**, 127618-29-5; **3**, 118452-44-1; **4**, 2719-27-9; **5**, 127618-30-8; **6**, 127618-31-9; **7**, 98-88-4; **8**, 127618-32-0; **9**, 40685-20-9; **10**, 103-80-0; **11**, 127618-33-1; **12**, 127618-34-2; **13**, 645-45-4; **14**, 127618-35-3; **15**, 127618-36-4; **16**, 1711-09-7; **17**, 127618-37-5; **18**, 127618-38-6; **19**, 127618-39-7; **20**, 127618-40-0; **21**, 60390-86-5; **22**, 127618-41-1; **23**, 23632-42-0; **24**, 14371-10-9; **25**, 55563-72-9; **26**, 4407-36-7; **27**, 13125-59-2; **28**, 18609-60-4; *p*-ClC_6H_4COCl, 122-01-0; *p*-BuC_6H_4COCl, 586-75-4; methoxyethylamine, 109-85-3; urea, 57-13-6; *N*-methoxyethyl-*N'*-nitrosourea, 127618-42-2; 1-diazo-2-methoxyethane, 59712-30-0.

Supplementary Material Available: ^1H NMR spectra of the diazo ketones and methoxy enones shown in Table I (12 pages). Ordering information is given on any current masthead page.

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Activation and Synthetic Applications of Thiostannanes. Deprotection and Transformations of Tetrahydropyranyl Ethers

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Received December 27, 1989

Protection of functional groups is encountered quite frequently in organic synthesis, and new, more effective methodologies are still highly desired.[1] Another important synthetic operation is functional group transformation. In particular, direct transformations from the protected forms into other functionalities are extremely useful.[2-11] It, therefore, would meet a variety of synthetic demands if deprotection and chemical transformation are achievable from a common protecting form. To realize this idea, however, one must overcome the contradiction that the protection is a process which *deactivates* functional groups while the transformation requires *activation* of these groups. In this paper, we disclose that tetrahydropyranyl (THP) ethers **1** serve this purpose quite well when treated with thiostannanes **2** in the presence of $BF_3{\cdot}OEt_2$ (**3**). Thus, alcohols are regenerated under extremely mild conditions, and various functionalities are produced in one-pot from **1** without passing through the free alcohols.[12]

In general, THP ethers are deblocked under acidic conditions. To improve this disadvantage, dimethylaluminum chloride (2 equiv)[13] and magnesium bromide (3 equiv)[14] were found to be effective even in the presence of a *tert*-butyldimethylsiloxy group. We reported that distannoxanes[15] and organotin phosphate condensates[16] catalyzed deprotection of **1** compatible with various acid-labile groups. On the other hand, a THP group was replaced by an acyl group on treatment with acid chlorides

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