8130); IR ($CHCl_3$) 2114, 1695 cm^{-1}, NMR ($CDCl_3$) δ 4.45 (s, 2 H, CH_2N), 6.06 (s, 2 H, OCH_2O), 6.80 (m, 2 H, aryl H's), 6.85 (d, 1 H, J_{ortho} = 7.5 Hz, H-5).

Preparation of the α-Amino Ketone Hydrochlorides 5. A solution of the azido ketone (400 mmol) in methanol (300 mL) containing hydrogen chloride (400 mmol) and suspended 10% palladium on charcoal catalyst (4 g) was hydrogenated at 45 psig at room temperature for 5 h. The mixture was filtered, the filtrate was evaporated in vacuo, and the residue was crystallized from a suitable solvent system. The yields and physical constants of these compounds are found in Table II.

1-Amino-4-phenyl-2-butanone hydrochloride (*5*, R = $PhCH_2CH_2$) was typical of this group of compounds: mp 136 °C (EtOAc); UV (MeOH) 242 nm, 247, 251, 260, 262, 266 (ϵ 1413, 676, 190, 224, 209, 190, 170); IR (KBr) 3448, 1718 cm^{-1}; NMR (Me_2SO-d_6) δ 2.86 (s, 4 H, CH_2CH_2) 3.91 (s, 2 H, CH_2), 7.26 (s, 5 H, aryl H's), 8.43 [s, 3 H, NH_3 (broad, exchanged with D_2O)].

Synthesis of the α-Formamido Ketones 6. Anhydrous sodium formate (15 g, 220 mmol) was suspended in acetic–formic anhydride (90 mL, prepared from acetic anhydride (60 mL) and 97% formic acid (30 mL) according to the procedure of Olah[13]) and stirred at room temperature for 10 min. The amino ketone hydrochloride (165 mmol) was added all at once and stirring at room temperature was continued for 1 h. The reaction mixture was poured into cold water (500 mL) and the product was extracted into dichloromethane. The extract was washed with water and then shaken with solid sodium carbonate (50 g, 470 mmol). The mixture was filtered and the filtrate was evaporated in vacuo to give the crude formamide. See Table II for yields and physical constants.

3,4-(Methylenedioxy)phenacylformamide (**6**, R = 3,4-$OCH_2OC_6H_3$) was typical of this class of compounds: mp 140–142 °C (acetone–hexane): UV (MeOH) 229 nm, 272, 307 (ϵ 18600, 7080, 8130); IR ($CHCl_3$) 3413, 1695, 1675 cm^{-1}; NMR ($CDCl_3$ + Me_2SO-d_6) δ 4.68 (d, 2 H, J = 3 Hz, CH_2N), 6.06 (s, 2 H, OCH_2O), 6.86 (d, 1 H, J = 9 Hz, H-6), 7.50 (m, 3 H, H-3, H-5, NH), 8.31 (s, 1 H, CHO).

Preparation of the α-Alkyl α-Formamido Ketones 7. The α-formamido ketone **6** (6 mmol) in anhydrous DMF (10 mL) was added to a stirred and cooled (0 °C) suspension of sodium hydride (60% in mineral oil; 0.257 g, 6.4 mmol) in dry DMF (20 mL) maintained in a nitrogen atmosphere. After 30 min the alkyl halide (8 mmol) was added slowly at 0 °C and 1 h thereafter the reaction mixture was poured into cold water. The product was extracted into ethyl acetate, and the extract was washed well with water, dried (Na_2SO_4), and evaporated in vacuo. The crude α-alkylated compounds were purified by the methods described in Table I.

Alkylation of **6** (R = Ph) with 2-bromopropane gave a 1:1 mixture of **7** (R = Ph; R′ = *i*-Pr) and the enol ether **9** (3:2 mixture of isomers) which was separated by TLC (see Table I). The enol ether mixture was a solid: UV (MeOH) 222 nm, 283 (ϵ 9550, 20400); NMR ($CDCl_3$) δ 1.24 (d, 6 H, J = 6 Hz, *i*-Pr), 4.11 (septet, 1 H, J = 6 Hz, CH), 6.90, 7.01 (singlets, total 1 H, CH), 7.34 (m, 5 H, aryl H's), 7.56 (broad, 1 H, NH), 8.22 (s, 1 H, CHO). The spectral characteristics of the desired α-alkylated compound **7** (R = Ph; R′ = *i*-Pr), an oil, were quite different: UV (MeOH) 245 nm (ϵ 12300); NMR ($CDCl_3$) δ 0.77 (d, 3 H, J = 6.7 Hz, Me_2CH), 1.04 (d, 3 H, J = 6.7 Hz, Me_2CH), 2.20 (m, 1 H, $CHMe_2$), 5.68 (dd, 1 H, J = 3.9, 10.1 Hz, CH), 6.50 (broad, 1 H, NH), 7.53 (m, 3 H, H-3,4,5), 8.02 (m, 2 H, H-2,6), 8.36 (s, 1 H, CHO).

Attempted Dialkylation of Formamidoacetophenone (6, R = Ph). Formamidoacetophenone (1.00 g, 6.1 mmol) was reacted with a suspension of 60% sodium hydride (0.539 g, 13.5 mmol) in anhydrous DMF (10 mL) and benzyl bromide (2.3 g, 13 mmol) at 0 °C as described above. After 1 h the reaction mixture was worked up in the usual way and the crude product was subjected to preparative thin layer chromatography on silica gel using hexane–ethyl acetate (70:30) as the developing solvent. There was thus obtained the mono- (0.15 g, 10%), di- (0.400 g, 19%), and tribenzyl (0.720 g, 27%) compounds **7** (R = Ph; R′ = $PhCH_2$), **11** and **12**, respectively. The monobenzyl compound was an oil: UV (MeOH) 245 nm, 280 (ϵ 12900, 1320); IR ($CHCl_3$) 3413, 1695, 1669 cm^{-1}; NMR ($CDCl_3$) δ 3.15 (m, 2 H, CH_2), 5.88 (m, 1 H, CH), 6.66 (broad, 1 H, NH), 7.06–7.50 (m, 8 H, aryl H's), 7.96 (m, 2 H, aryl H's), 8.20 (s, 1 H, CHO). The dibenzyl compound **11** was a solid which after crystallization from acetone–hexane had the following: mp 151 °C; UV (MeOH) 219 nm, 250 (ϵ 10200, 10100); IR ($CHCl_3$) 3367, 1668, 1689 cm^{-1}; NMR ($CDCl_3$) δ 3.75 (d, 2 H, J = 13.5 Hz, CH_2), 4.20 (d, 2 H, J = 13.5 Hz, CH_2), 6.63 (s, 1 H, NH), 7.50 (m, 13 H, aryl H's), 7.86 (m, 2 H, aryl H's), 8.16 (s, 1 H, CHO). The tribenzyl compound **12** also was an oil; UV (MeOH) 223 nm 2.45 (ϵ 11200, 9330); IR ($CHCl_3$) 1661 cm^{-1}; NMR ($CDCl_3$) δ 3.30 (q, 2 H, J = 13.5 Hz, CH_2), 3.50 (q, 2 H, J = 13.4 Hz, CH_2), 3.79, 4.75 (broad singlets, total 2 H, NCH_2), 7.03 (m, 2 H), 7.15–7.50 (m, 16 H), 7.58 (dd, 1 H), 7.84 (dd, 1 H), 7.89, 8.13 (singlets, total 1 H, CHO); mass spectrum, *m/e* (relative intensity) 342 (14, $M^+ - C_7H_7$), 328 (14, $M^+ - C_6H_5CO$), 314 (20, $M^+ - C_7H_7 - CO$), 300 (7, $M^+ - C_7H_7NCHO + H^+$), 91 (100, C_7H_7).

Synthesis of the α-Alkyl α-Amino Ketone Hydrobromides 8. Methanolic hydrogen bromide (16.7 mL of a 3 N solution, 50 mmol) was added to a solution of **7** (5 mmol) in methanol (50 mL) and the solution was heated at reflux temperature for 1 h. The solvent was removed in vacuo and the residue was crystallized from a methanol–ether solution. See Table II for yields and physical constants.

1,5-Diphenyl-2-amino-3-pentanone hydrobromide (**8**, R = $PhCH_2CH_2$; R′ = $PhCH_2$): mp 197–199 °C; UV (MeOH) 220 nm, 248, 253, 258, 264, 267 (ϵ 3720, 229, 309, 398, 331, 251); IR (KBr) 3175, 1718 cm^{-1}; NMR (Me_2SO-d_6) δ 2.73 (s, 4 H, CH_2CH_2), 3.05 (d, J = 6 Hz, CH_2), 4.40 (t, 1 H, CH), 7.16 (m, 10 H, aromatic H's), 8.25 (broad, 3 H, NH_3, enchanged with D_2O).

Acknowledgment. The authors thank Dr. M. L. Maddox for helpful discussion of certain aspects of the NMR spectra and Dr. L. G. Partridge and J. Wong for their extra effort on our behalf in measuring the high-resolution mass spectra.

Registry No. **3** (R = Ph), 70-11-1; **3** (R = 3,4-$OCH_2OC_6H_3$), 40288-65-1; **3** (R = $PhCH_2CH_2$), 31984-10-8; **4** (R = Ph), 1816-88-2; **4** (R = 3,4-$OCH_2OC_6H_3$), 102831-07-2; **4** (R = $PhCH_2CH_2$), 102831-08-3; **5** (R = Ph), 5468-37-1; **5** (R = 3,4-$OCH_2OC_6H_3$), 38061-34-6; **5** (R = $PhCH_2CH_2$), 31419-53-1; **6** (R = Ph), 73286-37-0; **6** (R = 3,4-$OCH_2OC_6H_3$), 102831-09-4; **6** (R = $PhCH_2CH_2$), 102831-10-7; **7** (R = Ph, R^1 = Me), 102831-14-1; **7** (R = Ph, R^1 = Et), 102831-15-2; **7** (R = Ph, R^1 = Pr-*c*), 102831-16-3; **7** (R = Ph, R^1 = Bu), 102831-17-4; **7** (R = Ph, R^1 = CH_2Ph), 102831-18-5; **7** (R = 3,4-$OCH_2OC_6H_3$, R^1 = Me), 102831-19-6; **7** (R = 3,4-$OCH_2OC_6H_3$, R^1 = Bu), 102831-20-9; **7** (R = 3,4-$OCH_2OC_6H_3$, R^1 = CH_2Ph), 102831-21-0; **7** (R = CH_2CH_2Ph, R^1 = Me), 102831-22-1; **7** (R = CH_2CH_2Ph, R^1 = Bu), 102831-23-2; **7** (R = CH_2CH_2Ph, R^1 = CH_2Ph), 102831-24-3; **8** (R = Ph, R^1 = CH_2Ph), 102831-11-8; **8** (R = 3,4-$OCH_2OC_6H_3$, R^1 = CH_2Ph), 102831-12-9; **8** (R = CH_2CH_2Ph, R^1 = CH_2Ph), 102831-13-0; (*E*)-**9**, 102831-25-4; (*Z*)-**9**, 102831-28-7; **11**, 102831-26-5; **12**, 102831-27-6; MeI, 74-88-4; EtBr, 74-96-4; *i*-PrBr, 75-26-3; BuBr, 109-65-9; $PhCH_2Br$, 100-39-0.

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Improved Route to 3-Vinyl-Substituted Cyclopentanones. Synthesis of (±)-Mitsugashiwalactone†

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Recently we described[1] a simple route to 2,3-disubstituted cyclopentanones. The procedure utilizes an efficient catalytic dimerization[2,3] of methyl acrylate (eq 1) to afford

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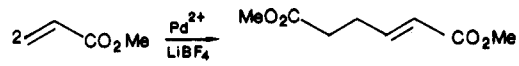
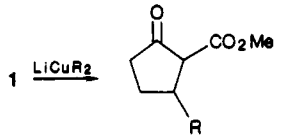
dimethyl (*E*)-2-hexenedioate (1). Tandem conjugate addition/cyclization[4,5] of 1 using a lithium diorganocuprate ("Gilman reagent") affords alkyl- and aryl-substituted cyclopentanones 2 in 60–80% yield. However, with vinyl



(1)



(2)

2a, R = vinyl
2b, R = isopropenyl

cuprates, significantly lower (ca. 40%) yields were observed. This was unfortunate because the vinyl and isopropenyl derivatives **2a** and **2b** have proven to be useful starting materials for natural product synthesis.[6-9] We now report that by using the corresponding higher order cyanocuprates[10] ("Lipshutz reagents") as the organometallic reactant in eq 2, both **2a** and **2b** can be obtained in high yield.

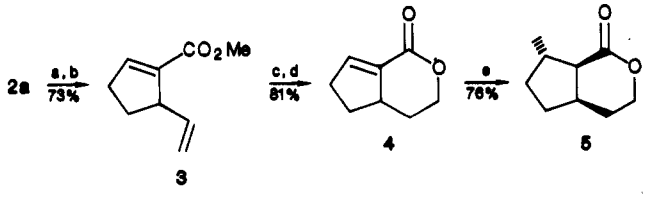
In our studies, vinyllithium was generated in ether solution by transmetalation of tetravinyltin with methyllithium[11] (eq 3). This procecure has the advantage of

$$Sn(CH{=}CH_2)_4 + 4MeLi \rightarrow 4LiCH{=}CH_2 + SnMe_4 \quad (3)$$

producing as coproduct volatile tetramethyltin which can be distilled away with solvent, obviating chromatographic purification. Addition of 1 to the cuprate prepared from vinyllithium and copper(I) cyanide (2 to 1 mol ratio) afforded after distillation **2a** in 77–85% yield. While the relative stereochemistry of **2a** will be of not consequence for most synthetic applications, ^{13}C NMR evidence suggests it contains ca. 94% of the trans isomer.[12] In a similar manner **2b** was prepared starting from tetraisopropenyltin in 74% yield.[13]

With this approach, compounds **2** are easily prepared in 10-g quantities. This should further increase their use as starting materials for the synthesis of cyclopentanoid natural products, of which many are known.[14] In this regard, we have carried out a short synthesis of the iridoid natural product mitsugashiwalactone[15,16] (**5**), which is summarized in Scheme I. Borohydride reduction of **2a** afforded a mixture of diasteromeric alcohols, which was

Scheme I[a]



[a] (a) $NaBH_4$; (b) MsCl and then DBU; (c) 9-BBN then H_O; (d) TsOH; (e) $LiCuMe_2$.

not separated but was converted to **3** by base-induced elimination of the methanesulfonates. Hydroboration of **3** with 9-BBN apparently occurred exclusively at the nonconjugated double bond; subsequent oxidation with basic hydrogen peroxide produced three types of products depending on the reaction conditions. Extended treatment (72 h) with hydrogen peroxide in saturated sodium bicarbonate afforded **4** as predominant product while in 1 N NaOH the product, upon acidic workup, was largely the corresponding hydroxy acid. Highest yields were obtained by oxidizing in half-saturated $NaHCO_3$ for 5 h to afford principally the corresponding hydroxy ester. The product was then converted to **4** in a separate acid-catalyzed lactonization step. Upon treatment with lithium dimethylcuprate, unsaturated lactone **4** afforded a 76% yield of a conjugate addition product which was greater than 95%, a single isomer according to TLC, GC, and 360-MHz ^1H NMR. Spectral data for **5** were in agreement with the values reported for mitsugashiwalactone isolated from *Boshniakia rossica* Hult.[15] Due to lack of an authentic sample or high-resolution spectral data derived therefrom, we are unable to conclusively prove that this product is identical with the natural product. However, assignment of structure **5** appears secure based on several lines of evidence.[17,19]

Experimental Section

General Methods. ^1H NMR spectra were determined on a Nicolet NT 360WB spectrometer as solutions in $CDCl_3$. Chemical shifts are reported in parts per million downfield from internal reference tetramethylsilane. Couplings (*J*) are in hertz. Dimethyl (*E*)-2-hexenedioate (1) was prepared by our published procedure for acrylate dimerization[1-3] catalyzed by tetrakis(acetonitrile)-

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(11) Tin–lithium exchange under our conditioins was apparently complete since addition of *excess* benzaldehyde at this stage afforded 3-phenyl-1-propen-3-ol which contained <2% 1-phenylethan-1-ol by GC. (In the absence of tetravinyltin, only the latter product obtained.) This contrasts with the reaction of tetravinyltin with butyllithium in hydrocarbon solvents which stops at the stage of dibutyldivinyltin: Seyferth, D.; Weiner, M. A. *J. Am. Chem. Soc.* **1961**, *83*, 3583–3586.
(12) We thank Dr. David Wustrow and Professor Andrew S. Kende for obtaining the proton-decoupled ^{13}C NMR spectrum. The spectrum shows two sets of resonances in an approximately 94:6 ratio. Because **2a** is an easily enolizable system we assume that the major isomer is the thermodynamically preferred trans diastereomer.
(13) Attempts to extend this approach to the alkyl and aryl cyanocuprates have not generally resulted in increased yields. Compound **2**, R = butyl, was obtained in 95% yield by this approach but the product was contaminated with ca. 5% of 1. For **2**, R = methyl, contamination with 1 was even more extensive, while an attempt to prepare **2**, R = phenyl by the cyanocuprate route gave mainly 1,2-addition products.
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(17) (a) Highly stereoselective conjugate addition of a methyl group to **4** must take place on the exo face of the molecule thus placing the methyl group syn to the C6 hydrogen. (b) Protonation of the resulting enolate under several conditions affords a single product which appears to be the thermodynamically favored isomer since it does not isomerize in the presence of 10% DBU/toluene. Molecular mechanic calculations indicate that the cis-fused isomer is ca. 4.4 kcal/mol less strained than the alternative trans-fused isomer. Epimerizations reported in the original structure proof of mitsugashiwalactone[15] also indicate that this 6–5 ring system prefers to be cis-fused. (c) The carbonyl stretching absorption (1735 cm^{-1}) indicates that the lactone of **5** is no more strained than mitsugashiwalactone. (d) Our product is clearly different from the 3-epimer (onikulactone) in which the methyl resonance[16] is shifted significantly upfield at 0.97 ppm.

palladium tetrafluoroborate (Strem). Tetravinyltin (Columbia Organics) and all other chemicals were reagent grade chemicals used as received. Flash chromatography was carried out on 230–400 mesh silica (EM reagents) following the procedure of Still.[18] All isolated products 1–5 gave satisfactory C,H analyses (±0.40%).

Preparation of 2-Carbomethoxy-3-vinylcyclopentanone (2a). Low halide methyllithium in ether (266 mL, 1.5 M, 0.40 mol) was added via syringe to a stirred solution of tetravinyltin (24.96 g, 0.11 mol) in anhydrous ether (500 mL) at 0 °C. After 15 min, the mixture was cooled to −78 °C, and copper(I) cyanide (18.02 g, 0.215 mol), was added all at once. The mixture was allowed to warm to −30 °C, at which temperature a solution of 1 (13.78 g, 0.08 mol) in ether (40 mL) was added dropwise. After an additional 30 min, half-saturated aqueous ammonium chloride (400 mL) was added dropwise as the temperature was allowed to rise, and the mixture was stirred an additional 1 h. The mixture was filtered, and the ether layer was separated. The aqueous layer was extracted with ether (2 × 200 mL). The combined organics were washed with water and dried ($MgSO_4$), and the solvent was removed at reduced pressure. Distillation of the residue afforded **2a** (10.4–11.4 g, 77–85%) as a colorless liquid: bp 58–62 °C (0.25 torr); ^{1}H NMR δ 1.72 (m, 1 H), 2.1–2.6 (m, 3 H), 3.05 (d, J = 11, 1 H), 3.1–3.3 (m, 1 H), 3.75 (s, 3 H), 5.09 (d, J = 11, 1 H), 5.16 (d, J = 17, 1 H), 5.75–5.85 (m, 1 H). IR (cm^{-1}) ν (C=O) 1762 s, 1662 m, 1618 m, ν (C=C) 1644 w.

2b. The isopropenyl derivative was prepared in an analogous manner from tetraisopropenyltin. It was isolated in 74% yield by flash chromatography with 25% (v/v) ethyl acetate in hexane as eluant: ^{1}H NMR δ 1.7–1.8 (m, 1 H), 1.78 (s, 3 H), 2.22–2.52 (m, 3 H), 3.19 (d + q, 2 H total) 3.73 (s, 3 H), 4.81 (s, 1 H), 4.83 (s, 1 H).

2-Carbomethoxy-3-vinylcyclopentene (3). Sodium borohydride (0.31 g, 8.2 mmol) was added gradually over 10 min to a solution of **2a** (5.00 g, 29.7 mmol) in ethanol (50 mL) at 0 °C. After 30 min the mixture was added to water (25 mL) and was extracted with ether (3 × 25 mL). After removal of solvent, flash chromatography afforded, in addition to recovered starting material (0.50 g, fractions 10–13), a pair of products, presumed to be the isomeric alcohols (3.59 g, 81% based on recovered **2a**, fractions 15–21). A portion of this material (3.03 g, 17.8 mmol) was dissolved in a mixture of methylene chloride (100 mL) and triethylamine (4.72 g, 46.6 mmol). To this solution at 0 °C was added dropwise methanesulfonyl chloride (2.67 g, 23.3 mmol) in methylene chloride (50 mL). The ice bath was removed, and the mixture was stirred 30 min, whereupon 1,8-diazabicyclo[5,4.0]-undec-7-ene (8.20 g, 53.9 mmol) was added and stirring continued for 3 h. Extraction with aqueous ammonium chloride and water followed by removal of solvent afforded **3** (2.43 g, 90%), which was 97% pure by GLC: ^{1}H NMR δ 1.78–1.87 (m, 1 H), 2.14–2.25 (m, 1 H), 2.36–2.59 (m, 2 H), 3.56 (m, 1 H), 3.72 (s, 3 H), 4.97 (d, J = 10, 1 H), 5.05 (d, J = 16, 1 H), 5.8–5.9 (m, 1 H), 6.82 (m, 1 H).

Preparation of 4. A solution of 9-borabicyclo[3.3.1]nonane (2.22 g, 18.2 mmol) in THF (35 mL) was added dropwise to a solution of **3** (2.64 g, 17.3 mmol) in THF (35 mL) at 0 °C. After 30 min at 0 °C the solution was stirred overnight at room temperature. Half-saturated aqueous sodium bicarbonate (60 mL) was added dropwise. After 30 min, the mixture was cooled to 0 °C, and 30% hydrogen peroxide (8.7 mL) was added dropwise. The ice bath was removed, and the reaction was stirred 5 h and was then poured into 500 mL H_2O, extracted with ether (3 × 100 mL), and dried ($MgSO_4$). Removal of solvent followed by flash chromatography with 25% (v/v) isopropyl alcohol in hexane afforded in fractions 8–15 a mixture of **4** and the corresponding methyl hydroxy ester. This was taken up in toluene (100 mL) and heated with toluenesulfonic acid (0.02 g) with azeotropic removal of solvent until the upper hydroxy ester spot by TLC disappeared. Neutralization with solid potassium carbonate and removal of solvent afforded **4** (1.63 g, 81%) as a colorless liquid: ^{1}H NMR δ 1.56–1.72 (m, 2 H), 2.12 (m, 1 H), 2.33–2.50 (m, 3 H), 2.99 (m, 1 H), 4.32 (dt, J = 3, 13, 1 H), 4.45 (ddd, J = 2, 5, 12, 1 H), 6.97 (m, 1 H).

Mitsugashiwalactone (5). Methyllithium in ether (23.3 mL, 1.8 M, 42 mmol) was added to a suspension of copper(I) iodide (4.0 g, 21 mmol) in ether (50 mL) at −25 °C. A solution of **4** (0.97 g, 7.0 mmol) in ether (25 mL) was added dropwise, and stirring was continued for 30 min at −25 °C. After being quenched with 10% aqueous acetic acid (50 mL) the mixture was added to water (100 mL) and extracted with ether (2 × 50 mL). Removal of the solvent from the dried ($MgSO_4$) mixture afforded the crude product, which was purified by flash chromatography with 35% (v/v) ethyl acetate in hexane. Fractions 14–19 afforded **5** (0.82 g, 76%) as a colorless liquid with NMR essentially identical with that reported[16] for the natural product: ^{1}H NMR δ 1.13–1.26 (m, 1 H), 1.18 (d, J = 7, 3 H), 1.27–1.38 (m, 1 H), 1.47–1.57 (m, 1 H), 1.86–1.94 (m, 1 H), 1.98–2.08 (m, 2 H), 2.15–2.27 (m, 1 H), 2.37 (t, J = 11, 1 H), 2.53–2.65 (m, 1 H), 4.21 (ddd, J = 3, 9, 11, 1 H), 4.32 (ddd, J = 3, 7, 11, 1 H); IR [film, cm^{-1} (% transmission)] 2953 (2.8), 2968 (10.4), 1736 (0.9), 1479 (25.4), 1459 (22.1), 1391 (11.8), 1257 (4.8) 1224 (21.5), 1202 (12.4), 1179 (6.8), 1141 (22.1), 1120 (27.1), 1074 (2.8).

Registry No. 1, 70353-99-0; **2a**, 75351-19-8; **2b**, 68151-48-4; **2** (R = butyl), 87682-82-4; (±)-**3**, 102979-48-6; (±)-**4**, 102979-49-7; (±)-4 (methyl hydroxy ester), 102979-50-0; (±)-**5**, 60363-05-5; $(H_2C{=}CH)_4Sn$, 1112-56-7; $(H_3C(CH_2)_{34}Sn$, 1461-25-2; $(H_2C{=}C(CH_3))_4Sn$, 64503-52-2.

(18) Still, W. C. *J. Org. Chem.* **1978**, *43*, 2923–2925.

(19) **Note added in proof.** The IR spectrum of **5** was identical with that of material prepared by ref 16. We thank Professor T. Fujisawa for providing a copy of the IR spectrum.

Methyl 9,14-Didehydro-4,5-epoxy-3-methoxy-17-methyl-α-methylene-6-oxothebinan-8β-acetate[1]

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Hayakawa et al.[3] and we[4] have reported that thebaine and methyl propiolate form an adduct which on mild hydrolysis is transformed to the ketone **1** whose structure was secured by NMR spectroscopy and single-crystal X-ray analysis.

We reported earlier[4] that reduction of **1** with $NaBH_4$ gave the alcohol **2** characterized as the acetate, **3**, which on catalytic hydrogenation furnished the dihydro acetate **4**, (Scheme I). We now find that **4** is also obtained in modest yield by hydrogenation of **1** in acetic acid for 25 h followed by treatment with acetic anhydride in pyridine solution. If the reduction is carried out for a short time and the crude base dissolved in CH_3OH and the solution allowed to stand in air for about 2 days, a crystalline compound separates from solution which was shown to be **6** by means of single-crystal X-ray analysis (Figure 1).[5] In the NMR spectrum the signals at H-18 (δ 7.28) and H-5 (δ 5.06) of **1** were replaced by signals at δ 5.83 and 6.22 which were assigned to the vinylic protons at C-18 of compound **6**.

Recently, Theuns et al.[6] reported the isolation of the base **7** from *Papaver bracteatum* and commented that it may be an artifact since it was obtained by decomposition of one of the two thebaine *N*-oxides which are also present in the same plant. The acrylate ester **6** could arise by a process similar to the one suggested by Theuns et al. to

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