Anal. Calcd for $C_{17}H_{11}N$: C, 89.05; H, 4.83; N, 6.11. Found: C, 89.02; H, 4.64; N, 5.87.

7-Methyl-3,9,11-trichlorobenz[c]acridine (14).—A solution of **12** (364 mg, 1.0 mmol) and potassium hydroxide (561 mg, 10 mmol) in absolute ethanol (60 ml) was refluxed for 3 hr. After about 1 hr a precipitate began to form. The mixture was cooled and the solid was filtered, washed with water, and dried, yield 300 mg, mp 208–213°. Two recrystallizations from benzene gave pale yellow needles, mp 234–237°, nmr (deuteriopyridine) δ 2.82 (s, CH_3).

Anal. Calcd for $C_{18}H_{10}Cl_3N$: C, 62.36; H, 2.91; N, 4.04; Cl, 30.69. Found: C, 62.17; H, 21.87; N, 3.93; Cl, 30.45.

The mother liquor from the first recrystallization, upon standing, deposited 20 mg of crystals, mp 215–220°. Further recrystallization from benzene gave pale yellow needles, mp 227–230°. This proved to be **8** (ir and mixture melting point).

Registry No.—**2**, 30885-38-2; **7**, 30885-39-3; **8**, 30885-40-6; **9**, 30885-41-7; **10**, 30885-42-8; **11**, 30885-43-9; **12**, 30885-44-0; **13**, 30885-45-1; **14**, 30953-15-2; **16**, 30885-46-2.

A New Method for the Controlled Hydroxymethylation of Ketones

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The attachment of a single hydroxymethyl substituent adjacent to a ketone or other electron-withdrawing function is most often accomplished by base-catalyzed aldol condensation of the active methylene compound and formaldehyde. Unfortunately, the process is usually difficult to control at the monoalkylation stage, resulting in complex mixtures containing polycondensation products as well as Cannizzaro-type reduction products.[1]

One well-used alternative to this process is the Mannich Reaction[2] which results in formation of the β-amino carbonyl derivative.

We now report a convenient two-step procedure capable of performing the desired transformation selectively and in high yield. The reaction sequence is illustrated by the conversion of 4-*tert*-butylcyclohexanone to 2-hydroxymethyl-4-*tert*-butylcyclohexanone.

Treatment of the ketone with sodium hydride and excess ethyl formate in dry dimethoxyethane (25°, 3–5 hr) gave the 2-hydroxymethylene derivative in 95% yield. This material was reduced, without further purification, by a method based on that suggested by Brown in his studies of aluminum hydride.[3] Generation of the sodium enolate by reaction with sodium hydride in tetrahydrofuran, followed by reaction with a tetrahydrofuran solution of aluminum hydride, furnished the desired 2-hydroxymethyl ketone in 90% yield. This material could be further purified by preparative layer chromatography on silica gel or short-path distillation.

The procedure may be varied by the substitution of dimethyl carbonate for ethyl formate, but there seems to be no particular advantage in this change. In fact, in some cases, only the more reactive formate was capable of acylating hindered ketones.

Experimental Section

Acylation with Ethyl Formate.—4-*tert*-Butylcyclohexanone (0.16 g, 1.04 mmol) in 2 ml of dry dimethoxyethane (distilled from lithium aluminum hydride) was added to a slurry of 4.1 mmol of sodium hydride (0.19 g of 55% mineral oil dispersion, washed three times with petroleum ether) in 3 ml of dry, alcohol-free ethyl formate (dried over potassium carbonate, distilled from phosphorus pentoxide) at 25° under argon. Ethanol (0.010 ml) was added, and the mixture was stirred for 5 hr and then poured into half-saturated aqueous ammonium chloride. Extraction with ether and drying of the ethereal extracts over sodium sulfate, followed by evaporation of the solvent, gave 0.18 g (95%) of the hydroxymethylene ketone: nmr (CCl_4) δ 0.92 (s, CH_3, 9 H), 1.0–2.6 (m, 7 H), 8.65 (s, olefinic, 1 H), 14.1 (m, OH, 1 H); ir $\lambda_{max}^{CCl_4}$ 2.7–4.0 (OH), 6.0–6.3 μ (keto enol ether).

Aluminum Hydride Reduction to 2-Hydroxymethyl-4-*tert*-butylcyclohexanone.—The hydroxymethylene ketone (0.17 g, 0.95 mmol) in 4 ml of tetrahydrofuran (distilled from lithium aluminum hydride) was added to a slurry of 1.07 mmol of sodium hydride (0.051 g of 55% mineral oil dispersion, washed three times with petroleum ether) in 2 ml of tetrahydrofuran. After 20 min at room temperature, 1.4 ml (1.05 mmol) of 0.75 *M* aluminum hydride in tetrahydrofuran (prepared from lithium aluminum hydride and 100% sulfuric acid by the method of Brown[3]) was added. After 1.25 hr the reaction mixture was poured into a mixture of ether and half-saturated aqueous ammonium chloride and filtered through Celite. Ether extraction of the filtrate, followed by drying (sodium sulfate) and evaporation of the solvent, gave 0.16 g (90%) of the desired hydroxymethyl ketone: nmr (CCl_4) δ 0.93 (s, CH_3, 9 H), 1.0–2.6 (m, 9 H), 3.65 (m, CH_2OH, 2 H); ir $\lambda_{max}^{CCl_4}$ 2.8 (OH), 5.85 μ (C═O). An analytical sample was prepared by bulb-to-bulb distillation at 90° (0.01 mm).

Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.58; H, 10.86.

Registry No.—Ethyl formate, 109-94-4; 2-hydroxymethylene-4-*tert*-butylcyclohexanone, 22252-96-6; 2-hydroxymethyl-4-*tert*-butylcyclohexanone, 31354-38-8.

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[1] *Cf.* H. O. House, "Modern Synthetic Reactions," W. A. Benjamin, New York, N. Y., 1965, p 230.

[2] F. F. Blicke, *Org. React.*, **1**, 303 (1942).

[3] N. M. Yoon and H. C. Brown, *J. Amer. Chem. Soc.*, **90**, 2927 (1968).