Attempted Piperidine-Catalyzed Decarboxylations of α-Phenyl-*cis*- and *trans*-*p*-nitrocinnamic Acids.—After heating 3 g. of either acid[4e,15] with 7 ml. of piperidine for 1 hr. under reflux, no stilbene was found in the neutral fraction.

Ultraviolet and Infrared Spectra.—Ultraviolet spectra were recorded on a Carey Model 11 spectrophotometer and infrared spectra on a Beckman IR5 spectrophotometer.

(15) M. Bakunin, *Gazz. chim. ital.*, **25**, 137 (1895).

Acknowledgment.—This work was supported in part by Cancer Research funds of the University of California and by an American Cancer Society Institutional grant, 1N 33D. The authors wish to express their thanks to Dr. L. A. Strait for many helpful discussions and to Mr. Michael Hrenoff for determining the infrared and ultraviolet spectra.

Synthesis of 1,1-Dimethyl-*trans*-decalin-10-carboxylic Acid[1a,b]

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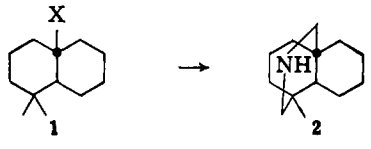
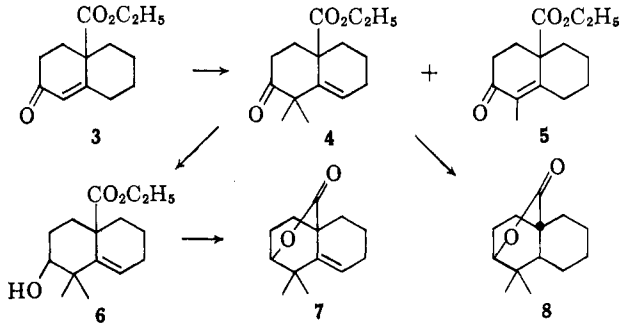
A convenient six-step stereoselective synthesis of 1,1-dimethyl-*trans*-decalin-10-carboxylic acid (**15**) from 6-carbethoxy-2,2-dimethylcyclohexanone (**9**) is described. This proceeds in 30% yield by condensation of the β-keto ester **9** with methyl vinyl ketone, catalytic reduction of the resulting 10-carbethoxy-1,1-dimethyl-Δ[8]-7-octalone (**11**), conversion of the saturated keto ester **13** into its thioketal, desulfurization, and cleavage of the resulting saturated ester **14** with lithium iodide. Attempts to prepare the acid **15** from 10-carbethoxy-1,1-dimethyl-Δ[8]-2-octalone (**4**) also are discussed.

In connection with an investigation of the structural selectivity of a variety of photochemical reactions which might afford derivatives of the tricyclic amine **2**,[2] we required a series of 1,1-dimethyl-*trans*-decalin derivatives (**1**) containing angular substituents (X) capable of undergoing suitable photolysis. It appeared that most of these would be readily accessible from 1,1-dimethyl-*trans*-decalin-10-carboxylic acid (**15**),[3] and thus a convenient synthesis of the latter was developed. This synthesis and several interesting observations on unsuccessful approaches to the problem are described in the present paper.



The 1,1-Dimethyl-Δ[8]-2-octalone Approach.—The most direct route to the acid **15** initially appeared to involve dimethylation of 10-carbethoxy-Δ[1,9]-2-octalone (**3**), followed by a suitable reductive sequence to remove the ketone and olefin from the product. Accordingly, the carbethoxyoctalone **3**[4] was treated with potassium *t*-butoxide and excess methyl iodide,[5] producing a major product readily recognized as the desired 10-carbethoxy-1,1-dimethyl-Δ[8]-2-octalone (**4**) by its lack of ultraviolet absorption in the 240-mμ region, its infrared absorption at 5.85 μ (ester and nonconjugated ketone), and its n.m.r. spectrum, which had a singlet at 8.82 τ (two quaternary C-methyl groups), a triplet at 4.27 τ (one vinyl proton), and the quartet (5.93 τ) and triplet (8.78 τ) from the ethoxyl group.[6] Unfortunately, however, none of the subsequent sequences which we examined for removal of nuclear functionality from the dimethyl enone **4** led efficiently to the desired acid **15**. Although unsuccessful for their intended synthetic purpose, certain of these results were not without interest, however, for they appear to be strikingly illustrative of the influence which the *gem*-dimethyl group can have on the behavior of the decalin system.



(1) (a) Abstracted in part from the Ph.D. dissertation of A. S. Levinson, Indiana University, 1963; (b) preliminary communication, W. L. Meyer and A. S. Levinson, *Proc. Chem. Soc.*, 15 (1963); (c) Communication no. 1140.

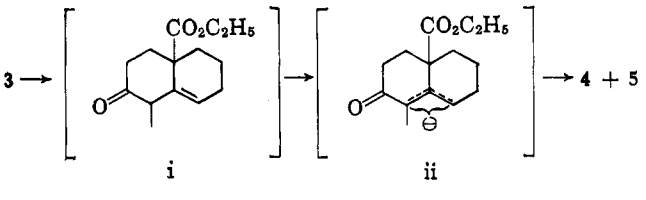
(2) W. L. Meyer and A. S. Levinson, *J. Org. Chem.*, in press.

(3) For the sake of clarity all *gem*-dimethyldecalins herein discussed are named with the methylated position as C-1. The configurational notations α and β are used in the steroid sense, *i.e.*, a β substituent is *cis* to the angular group. Although only one enantiomer is depicted in each of the structural formulas and the prefix *dl* is omitted, all compounds discussed are racemic.

(4) E. C. DuFeu, F. J. McQuillin, and R. Robinson, *J. Chem. Soc.*, 53 (1937); A. S. Hussey, H. P. Liao, and R. H. Baker, *J. Am. Chem. Soc.*, **75**, 4727 (1953); A. S. Dreiding and A. J. Tomasewski, *ibid.*, **77**, 411 (1955); M. Idelson, Ph.D. thesis, Brooklyn Polytechnic Institute, 1955; M. Idelson and E. I. Becker, *J. Am. Chem. Soc.*, **80**, 908 (1958).

(5) R. B. Woodward, A. A. Patchett, D. H. R. Barton, D. A. J. Ives, and R. B. Kelly, *J. Chem. Soc.*, 1131 (1953).

(6) The dimethyl enone **4** was accompanied by 10–15% of 10-carbethoxy-1-methyl-Δ[1,9]-2-octalone (**5**) [F. J. McQuillin and R. Robinson, *ibid.*, 586 (1941)], the product of monomethylation. Retreatment of this mixture of ketones with potassium *t*-butoxide and methyl iodide under the conditions of its formation resulted in no increase in the ratio of di- (**4**) to monomethylation product **5**, clearly demonstrating that the dimethyl enone **4** is produced without intermediacy of the conjugated monomethyl enone **5**, and providing insight into the sequence of steps involved in such methylations. The initial product of methylation of the enolate of **3** is, of course, the unconjugated 1-methyl-Δ[8]-2-ketone i, and it seems clear that this must be the intermediate from which the monomethyl enolate ii is formed. Enolate ii then undergoes the second methylation and, to a lesser extent, competitive protonation to produce the monomethyl ketone **5**. Proton abstraction from C-8 of the latter (to re-form the enolate ii) is apparently quite slow under these conditions. See H. J. Ringold and S. K. Malhotra, *J. Am. Chem. Soc.*, **84**, 3402 (1962), for other recent evidence supporting such a sequence in related dimethylations.

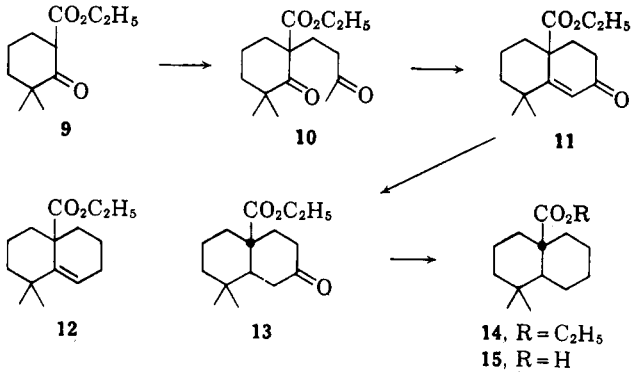


Considerable precedent exists for preparation of *trans*-decalin derivatives by stereoselective hydrogenation of the 8,9-olefin in analogous systems,[7] and thus our initial experiments for reduction of the bicyclic nucleus were directed along these lines. However, we did not find conditions which would effect only this transformation of the enone **4**. Use of palladium or nickel catalysts under various conditions either produced no change or led to mixtures which, from spectral and gas chromatographic examination (without fractionation), appeared to contain varying amounts of products from reduction of only the ketone, only the olefin, and both functions, perhaps including mixtures of stereoisomers. Catalytic reduction with platinum in ethanol occurred almost exclusively at the ketone function,[8] producing the unsaturated hydroxy ester **6** which was converted in good yield to the corresponding lactone **7**, m.p. 93–95°, during chromatography over neutral alumina. The same lactone was available by sodium borohydride reduction of the enone, but in this case the intermediate hydroxy ester **6** could not be isolated, even when the reaction mixture was processed without acidification or heating above room temperature. Formation of the lactone, of course, shows that both the catalytic and the borohydride reductions add hydrogen almost exclusively to the α-face of the molecule. The unusual ease with which the system lactonizes, doubtless by attack of the 2β-hydroxyl or its alkoxide on the ester without intermediacy of the hydroxy acid, is of considerable interest in its own right, however, for it appears qualitatively that this lactonization is more rapid than is that of the unmethylated decalin analog,[9] an effect which almost certainly originates with the steric requirement of the *gem*-dimethyl group.[10]

Platinum-catalyzed hydrogenation of the enone **4** in glacial acetic acid afforded after distillation the lactone of 10-carboxy-2β-hydroxy-1,1-dimethyl-*trans*-decalin (**8**), clearly a saturated derivative because it had no proton resonance below 5.8 τ. Under identical conditions the unsaturated lactone **7** was not further reduced, implying that platinum-catalyzed reduction of the double bond *follows* reduction of the carbonyl group but *precedes* lactonization. Since it seems likely that reduction of both the double bond and the carbonyl group took place from the same side of the molecule, the *trans* ring fusion is assigned to the lactone **8**, although the evidence is not yet rigorous. Arguments based on steric hindrance to catalyst approach or analogy,[7] of course, support the same conclusion.

Thus efficient stereoselective hydrogenation of the double bond required concomitant reduction of the ketone. This was at first sight not disturbing, however, for it appeared that the saturated lactone **8** could be as useful for removal of the C-2 oxygen as the ketone presumably would have been. For example, Dauben and his co-workers[9] were able to open the analogous 10-carboxy-2β-hydroxy-*trans*-decalin lactone with hydrogen bromide in glacial acetic acid to obtain a 10-carboxy-2-bromo-*trans*-decalin which they subsequently debrominated. Unfortunately, our corresponding dimethyl lactone **8** was recovered after such treatment, and methanolic hydrogen bromide, lithium bromide–pyridine,[11] and thiourea–hydriodic acid[12] also produced no change. It appears that these results are a consequence of a displacement of the lactone–halo acid equilibrium in favor of the lactone by 1,1-dimethyl substitution. Introduction of a *gem*-dimethyl group probably raises the energy of the halo acid, mainly due to the 1,3-diaxial interaction between the 1β-methyl and the angular carboxyl, more than it does that of the lactone, which is locked in nearly a boat conformation and gains no comparable interaction from methylation. This effect is also presumably responsible for the remarkably easy lactonization of the methylated hydroxy esters, and is the subject of a continuing study.

The 1,1-Dimethyl-Δ^8-7-octalone Sequence.—Several other sequences for conversion of the Δ^8-2-enone **4** to the saturated acid **15** were investigated and, although many intriguing results were obtained with functional groups in the methylated ring of the decalin system, they did not readily lead to the desired acid.[13] As it appeared likely that to some extent many of the difficulties originated with steric effects due to the juxtaposition on the same ring of the bulky *gem*-dimethyl group, the angular ester, and the C-2 function undergoing manipulation, in pursuit of the original synthetic goal we turned to intermediates which involved functionality only in the unmethylated ring.



Condensation of 2,2-dimethylcyclohexanone with ethyl oxalate followed by decarbonylation of the product conveniently affords 6-carbethoxy-2,2-dimethylcyclohexanone (**9**).[14] Indeed, the mixture obtained by methylation of 2-methylcyclohexanone[15] may be used in place of the pure dimethyl ketone in this sequence, for, although appreciable quantities of other methylation products are present, condensation proceeds selectively only with the small residual amount of 2-methylcyclohexanone and the 2,2-dimethyl derivative (see Experimental). Sodium ethoxide-catalyzed Michael addi-

(7) *Inter alia*, J. D. Cocker and T. G. Halsall, *J. Chem. Soc.*, 3441 (1957); F. Sondheimer and D. Elad, *J. Am. Chem. Soc.*, **79**, 5542 (1957); **80**, 1967 (1958); B. Gaspert, T. G. Halsall, and D. Willis, *J. Chem. Soc.*, 624 (1958); S. A. Narang and P. C. Dutta, *ibid.*, 2842 (1960).

(8) This reduction was not readily reproducible in our hands, apparently as a consequence of rather strict requirements as to catalyst activity.

(9) W. G. Dauben, R. C. Tweit, and R. L. MacLean, *J. Am. Chem. Soc.*, **77**, 48 (1955).

(10) Quantitative comparison of the two systems is under study.

(11) F. Elsinger, J. Schreiber, and A. Eschenmoser, *Helv. Chim. Acta*, **43**, 113 (1960).

(12) A. Segre, R. Viterbo, and G. Parisi, *J. Am. Chem. Soc.*, **79**, 3503 (1957).

(13) Dr. R. F. C. Brown has recently informed us that he has succeeded in preparing the *trans* acid **15** and its *cis*-fused isomer through such intermediates. We are grateful to Dr. Brown for communications of his results prior to publication and permission to cite them here. Comparison of samples of his *trans* acid and ours has established their identity.

(14) G. Barraud, R. Cornubert, and A. M. Lemoine-Tressont, *Bull. soc. chim. France*, 1499 (1957); compare F. G. Fischer and K. Wunderlich, *Ber.*, **74**, 1544 (1941).

(15) A. Haller and R. Cornubert, *Bull. soc. chim. France*, **41**, 367 (1927); J. Meinwald and J. T. Ouderkirk, *J. Am. Chem. Soc.*, **82**, 480 (1960).

tion[16] of the β-keto ester **9** to methyl vinyl ketone smoothly gave 79% of the adduct **10**, and treatment of this diketone with pyrrolidine in refluxing benzene afforded 10-carbethoxy-1,1-dimethyl-Δ^8-7-octalone (**11**), m.p. 70–71°, in 71% yield. More than a trace of pyrrolidine was needed to effect ring closure[17] and triethylamine was not an efficient substitute. These facts suggest that an enamine intermediate is involved,[18] as is also implicit in the observation that gas chromatographic analysis of the reaction mixture showed the absence of enone **11** until *after* addition of aqueous acid, only a substance of considerably greater retention time (enamine?) being present before that point. The functionality of the Δ^8-7-enone **11** was apparent from its spectral properties, which established the presence of an α,β-unsaturated ketone [240 mμ[19] (ε 13,200), 6.02 μ, 6.23 μ], a saturated ester carbonyl (5.82 μ), an ethoxyl group (ABC_3 multiplet[20] with δ_A 5.80 τ, δ_B 5.90 τ, and δ_C 8.73 τ), one vinyl proton (4.10 τ), and two quaternary C-methyl groups (8.82 and 8.98 τ).

Hydrogenation of the Δ^8-7-enone **11** over palladium on carbon in ethanol at atmospheric pressure afforded a single saturated keto ester, m.p. 46.0–46.5°, in 91% yield. Careful scrutiny of the reaction mixture failed to reveal the presence of a second stereoisomer,[21] although small amounts of two by-products could be isolated. One of these was 10-carbethoxy-1,1-dimethyl-*trans*-decalin (**14**), identical with the sample obtained by the more efficient route to be described. It is presumably formed by initial reduction and hydrogenolysis of the C-7 oxygen function to produce the olefinic ester **12** which is then stereoselectively saturated. The second by-product was isolated in even smaller quantity and was not completely characterized, but its spectral properties, particularly the 4.38 τ triplet (one proton) in the n.m.r. spectrum, suggested that it was the intermediate olefinic ester **12** from this sequence.

The keto ester **13** is assigned the *trans* ring fusion in accordance with the specificity of the reduction. All known reductions of similarly located double bonds in the presence of an angular ester group have given rise to almost exclusively *trans*-decalin derivatives,[4,9,22] and nearly all Δ^8 systems having 1,1-dimethyl substituents and angular methyl groups have shown similar selectivity,[7] although a very few reports of *cis*-fused products from the latter type have appeared.[23] Since our compounds contain *both* of these structural units and since reduction of the corresponding olefin **12** gives the same steric result, it seems likely that the *trans* fusion is indeed produced. This result, of course, is also that expected in terms of steric hindrance to approach of the catalyst.

The keto ester **13** was readily converted to its thioketal, m.p. 55–56°, and Raney nickel desulfurization of this produced the saturated ester **14**, $n^{27}D$ 1.4769, in 67% yield over the two steps. Wolff–Kishner reduction of the keto ester was a considerably less efficient alternative, apparently because it is complicated by the expected transannular involvement of the angular carbethoxyl group.[9]

Treatment of the ester **14** with lithium iodide in refluxing *sym*-collidine[11] afforded 1,1-dimethyl-*trans*-decalin-10-carboxylic acid (**15**), m.p. 92.0–92.5° or 96–98° (polymorphs), in excellent yield, although a seventy-two-hour reaction period was required. This appears to be the method of choice for cleavage of esters such as this one which are severely hindered to nucleophilic attack at the carbonyl group. It is no doubt because of such hindrance[24] that alkaline saponification of the ester **14** in refluxing diethylene glycol proceeds in only moderate yield. "Reductive hydrolysis"[25] with various alkali metals in liquid ammonia, a reaction known for hindered *methyl* esters, produced the acid **15** in only 40% yield, together with varying proportions of the corresponding carbinol, m.p. 79–80° (also available by lithium aluminum hydride reduction of the ester), and starting ester. In contrast, considerably higher ratios of acid to carbinol are reported under similar conditions from methyl desoxypodocarpate and other systems in which (like **14**) an axial quaternary ester is hindered by an axial methyl group.[25] It is not at the moment clear whether the quantitative difference results from the nature of the alkoxyl group or from subtle differences in hindrance of axial ester groups at C-10 in this system and at C-4 in the terpenoid acids examined by Wenkert.

The most efficient sequence for its preparation, *i.e.*, **9** → **11** → **13** → thioketal → **14** → **15**, thus provides the acid **15** in 30% over-all yield. Preparation of various derivatives and their photolysis will be described elsewhere.

Experimental[26]

10-Carbethoxy-1,1-dimethyl-Δ^8-2-octalone (**4**).—This reaction was carried out by the general procedure of Woodward, Barton, and co-workers.[5] A solution of potassium *t*-butoxide, prepared from 29 g. of potassium and 600 ml. of *t*-butyl alcohol, was added to 55.5 g. of 10-carbethoxy-$\Delta^{1,9}$-2-octalone (**3**)[4] (estimated 90%

(16) A. L. Wilds and R. G. Werth, *J. Org. Chem.*, **17**, 1149 (1952).

(17) In contrast, S. Ramachandran and M. S. Newman, *Org. Syn.*, **41**, 38 (1961), found only small amounts of pyrrolidine to be required in a similar cyclization.

(18) G. Stork and H. K. Landesman, *J. Am. Chem. Soc.*, **78**, 5128 (1956).

(19) This absorption, like that of the enones **3** and **5**, is at a slightly shorter wave length than is predicted by Woodward's Rules or observed in many analogs with angular *methyl* groups. *Cf.* L. F. Fieser and M. Fieser, "Steroids," Reinhold Publishing Corp., New York, N. Y., 1950, p. 15 ff.; L. Dorfman, *Chem. Rev.*, **53**, 47 (1953); N. W. Atwater, *J. Am. Chem. Soc.*, **82**, 2847 (1960). These compounds have in common the homoallylic angular carbethoxyl group. Compare P. N. Rao and L. R. Axelrod, *J. Org. Chem.*, **27**, 4694 (1962), however.

(20) The multiplets from the ethoxyl groups in n.m.r. spectra of many of the ethyl esters described herein clearly show that the two OCH_2 protons are not equivalent. This situation appears to be intimately related to structure and conformation and will be dealt with in detail elsewhere.

(21) In contrast, reduction at three atmospheres produced an approximately 3:1 mixture (gas chromatographic estimation) of the *trans*-keto ester **13** with another substance which may have been the isomeric *cis*-keto ester, as well as traces of **12** and **14**. This major by-product has not yet been isolated, however.

(22) L. S. Minckler, A. S. Hussey, and R. H. Baker, *J. Am. Chem. Soc.*, **78**, 1009 (1956); W. G. Dauben and J. B. Rogan, *ibid.*, **79**, 5002 (1957).

(23) T. G. Halsall, W. J. Rodewald, and D. Willis, *J. Chem. Soc.*, 2798 (1959); N. B. Haynes and C. J. Timmons, *Proc. Chem. Soc.*, 345 (1958).

(24) Even *trans*-decalin-10-carboxylic esters are quite hindered; *cf.* ref. 9.

(25) E. Wenkert and B. G. Jackson, *J. Am. Chem. Soc.*, **80**, 217 (1958).

(26) Infrared spectra were obtained on Perkin-Elmer, Models 21, 137, and 137G, spectrophotometers; ultraviolet spectra were taken using a Cary Model 14 ultraviolet spectrophotometer; and n.m.r. spectra were obtained from dilute solutions with tetramethylsilane as internal standard using a Varian A-60 spectrometer or a Varian DP-60 spectrometer operating at 60 Mc. and equipped with a Model 3506 Flux Stabilizer. Band positions in DP-60 spectra were determined by the audio side-band technique. N.m.r spectra are described by the use of abbreviations, (s) for singlet, (d) for doublet, (t) for triplet, (q) for quartet, and (m) for multiplets not otherwise described, with chemical shifts in τ units. Vapor phase chromatography (v.p.c.) was done on a Perkin-Elmer Model 154D vapor fractometer with helium as the carrier gas and a thermal conductivity detector, a 2-m. 20% Apiezon L grease column, designated Q, or a 2-m. 9% silicone gum (SE30) on Chromosorb W column, designated Z, being employed. Compositions of mixtures were estimated as the ratios of peak areas. Melting points (open capillary tubes) and boiling points are uncorrected. Microanalyses were by Alfred Bernhardt, Mulheim (Ruhr), Germany.

pure by v.p.c. analysis) in 1600 ml. of dry *t*-butyl alcohol at 40° in a dry nitrogen atmosphere. The solution turned red-orange and 213 g. of methyl iodide in 100 ml. of *t*-butyl alcohol was added. The cloudy yellow mixture was refluxed for 1 hr., concentrated to *ca.* 250 ml. *in vacuo*, diluted with 500 ml. of water, and extracted with methylene chloride. The organic material was washed with water, dried over calcium chloride, and concentrated *in vacuo* to a viscous oil. Distillation through a 10-cm. Vigreux column gave 50 g. of pale yellow oil, b.p. 127–117° (1.5–0.6 mm.); λ_{max}^{film} 5.8, 6.0 μ (weak); $\lambda_{max}^{95\%\ EtOH}$ 245 mμ (ϵ 2,125). V.p.c. (Q column, 225°) indicated the presence of three components in the approximate ratio 1:12:2 in order of emergence. The retention time of the second of these was identical with that of purified dimethyl enone **4** described subsequently, while that of the third corresponded exactly to authentic 10-carbethoxy-1-methyl-$\Delta^{1,9}$-2-octalone (**5**).[6] Redistillation did not appreciably alter the composition of this product.

A pure sample of the enone **4** was obtained by hydrolysis of the corresponding ketal by the procedure of Ireland and Marshall.[27] A solution of 0.9175 g. of the ketal, m.p. 71–72°, in 30 ml. of freshly distilled acetone and 30 ml. of 3 *N* hydrochloric acid was refluxed for 20 min. Acetone was removed *in vacuo* and the residue was extracted with ether, which was washed with water, dried over sodium sulfate, and distilled *in vacuo* to leave 0.6303 g. of colorless oil (81% based on the ketal). Distillation in a Hickman still at 1 mm. (bath 90°) afforded an analytical sample, $\lambda_{max}^{CHCl_3}$ 5.85, 7.26, 7.32 μ; $\lambda_{max}^{95\%\ EtOH}$ 290 mμ (ϵ 50); n.m.r. (CCl_4) 4.27 (t), 5.93 (q), 8.78 (t), 8.82 τ (s). Infrared and n.m.r. spectra of this sample were nearly identical with those of the distilled mixture described earlier, differences being ascribable to the known contaminants in the mixture.

Anal. Calcd. for $C_{15}H_{22}O_3$: C, 71.97; H, 8.86. Found: C, 71.7; H, 8.9.

A small portion of the once-distilled methylation product was chromatographed on Merck "suitable for chromatography" alumina. The fractions eluted with benzene–cyclohexane (10:90 through 40:60) were enriched in dimethyl enone **4** according to v.p.c. assay, and were converted to the semicarbazone,[28] m.p. 153–170° dec. The sample was recrystallized four times from benzene, once from 50% ethanol, twice from 95% ethanol, once from benzene, and finally from absolute ethanol to give colorless plates of the semicarbazone, m.p. 166–168°; $\lambda_{max}^{CHCl_3}$ 2.82, 2.87, 2.92, 2.95, 3.10 (broad), 5.85, 5.92, 6.40 μ; $\lambda_{max}^{95\%\ EtOH}$ 230 mμ (ϵ 11,700).

Anal. Calcd. for $C_{16}H_{25}N_3O_3$: C, 62.52; H, 8.20; N, 13.67. Found: C, 62.6; H, 8.1; N, 14.0.

Isolation of 10-Carbethoxy-1-methyl-$\Delta^{1,9}$-2-octalone (5).—Later fractions from a chromatogram similar to that described before had gradually increasing ultraviolet absorption at 247 mμ. One fraction with ϵ 10,300 at 247 mμ had an infrared spectrum (film) superimposable on that of authentic 10-carbethoxy-1-methyl-$\Delta^{1,9}$-2-octalone in terms of band positions but with minor differences in relative intensities of a few peaks in the fingerprint region. The authentic sample was prepared by condensation of 2-carbethoxycyclohexanone with 1-diethylamino-3-pentanone methiodide,[6] and had $\lambda_{max}^{95\%\ EtOH}$ 247 mμ (ϵ 13,500).

10-Carbethoxy-1,1-dimethyl-2,2-ethylenedioxy-Δ^8-octalin.—A mixture of 25.0 g. of 10-carbethoxy-1,1-dimethyl-Δ^8-2-octalone (**4**) (once distilled, 80% pure by v.p.c.), 6.21 g. of ethylene glycol, 50 ml. of benzene, and a trace of *p*-toluenesulfonic acid was refluxed under an azeotropic separator for 15 hr., 0.62 g. of ethylene glycol was added, and reflux was continued for 3 hr. The cooled solution was shaken with 5 g. of potassium bicarbonate and solvent was removed *in vacuo* to give 29.2 g. of orange oil. Distillation through a 10-cm. Vigreux column afforded 23.5 g. of the ketal, b.p. 167–170° (7 mm.). This crystallized and was recrystallized from aqueous methanol to give a first crop of 12.17 g., m.p. 65–70°, and a second crop of 1.10 g. Recrystallization from 2-propanol, aqueous 2-propanol, four times from 2-propanol, and finally from methanol gave colorless plates, m.p. 71–72°; $\lambda_{max}^{CHCl_3}$ 5.86 μ; n.m.r. (CCl_4) 4.33 (t), 5.87 and 6.00 (m),[29] 6.17 (s), 8.76 (t), 9.04 (s), 9.11 τ (s).

Anal. Calcd. for $C_{17}H_{26}O_4$: C, 69.36; H, 8.90. Found: C, 69.4; H, 8.9.

Lactone of 10-Carboxy-2β-hydroxy-1,1-dimethyl-Δ^8-octalin (7). (A) By Sodium Borohydride Reduction.—To 375 ml. of 95% ethanol was added 3.78 g. of sodium borohydride and 2.50 g. of 10-carbethoxy-1,1-dimethyl-Δ^8-2-octalone (**4**) (once distilled, 80% pure by v.p.c.). The mixture was stirred at room temperature for 1.5 hr., poured into 1500 ml. of water, and extracted thoroughly with methylene chloride. The organic solution was washed with water, dried over sodium sulfate, and evaporated *in vacuo* at room temperature to give 2.14 g. of an oil which partially crystallized during storage overnight in a refrigerator. This crude product had infrared absorption at 5.7 and 6.0 μ (weak). Recrystallization from aqueous ethanol gave 1.45 g. (70%) of the lactone **7**, m.p. 82–91°. Five recrystallizations from 2-propanol gave large colorless prisms, m.p. 93–95°; $\lambda_{max}^{CHCl_3}$ 5.75, 6.01 μ (weak); n.m.r. ($CDCl_3$) 4.25 (t), 5.80 (m), 8.85 τ (s).

Anal. Calcd. for $C_{13}H_{18}O_2$: C, 75.69; H, 8.80. Found: C, 75.7; H, 8.6.

(B) By Catalytic Reduction.—A solution of the enone **4** in absolute ethanol was shaken under hydrogen at 3-atm. pressure with platinum oxide in a Parr low-pressure hydrogenation apparatus. On two occasions starting material (characterized by infrared spectroscopy and v.p.c.) was recovered. On one occasion 2.5 g. of 10-carbethoxy-1,1-dimethyl-Δ^8-2-octalone (**4**) (once distilled, 80% pure by v.p.c.) in 50 ml. of absolute ethanol with 0.1864 g. of Adams' catalyst after 12 hr. at 51.5-lb. pressure of hydrogen gave by filtration and evaporation 1.8 g. of oily hydroxy ester **6**, λ_{max}^{film} 2.9 to 3.0 (broad), 3.26 (weak), 5.81, 5.87 (sh), 6.06 μ; n.m.r. ($CDCl_3$) 4.17 (t), 6.73 (m), 8.75 (t), 8.87 (s), 9.32 τ (s). The O–CH_2 multiplet appeared near 235 c.p.s.[20]

A sample of this material was chromatographed on Woelm neutral alumina (activity grade II). The predominant product, which was eluted in the cyclohexane through benzene fractions, had a v.p.c. retention time and infrared spectrum (film) identical with those of the authentic lactone **7** previously prepared. A small amount of material eluted in later fractions had infrared absorption (film) at 2.9 and 5.8 μ.

Lactone of 10-Carboxy-2β-hydroxy-1,1-dimethyl-*trans*-decalin (8).—A solution of 42.0 g. of 10-carbethoxy-1,1-dimethyl-Δ^8-2-octalone (**4**) (once distilled, 80% pure by v.p.c.) in 250 ml. of glacial acetic acid containing 1 g. of platinum oxide was shaken under 3 to 4 atm. of hydrogen pressure in a Parr apparatus. After 16 hr. at room temperature no hydrogen had been consumed. The catalyst was removed by filtration, 1 g. of fresh catalyst was added, and shaking was continued for 36 hr., *ca.* 0.2 mole of hydrogen being consumed. An additional 1 g. of catalyst was added and after 20 hr. another 0.1 mole of hydrogen was absorbed. The temperature was raised to 54° for 3 hr., and then the mixture was cooled and filtered. Evaporation of most of the solvent *in vacuo* left 40.5 g. of an oil which was distilled to give 27.3 g. of colorless liquid, b.p. 100–124° (0.4–0.5 mm.); λ_{max}^{film} 2.75 (weak), 5.7 μ; n.m.r. ($CDCl_3$) 5.93 (m), 8.92 (s), 8.98 τ (s). Redistillation at 10 mm. gave 15.8 g., b.p. 162–170°, and 6.1 g., b.p. 172–178°. Both fractions had infrared spectra identical with that of once-distilled material and consisted mainly of one component according to v.p.c. analysis, although small amounts of three impurities were present which were not removed by redistillation, precluding preparation of an analytical sample.

6-Carbethoxy-2,2-dimethylcyclohexanone (9).—This three-step sequence was carried out without purification of intermediates. The alkylation procedure was similar to that employed by Meinwald and Ouderkirk[15] except that sodium hydride was used as the base. Under a dry nitrogen atmosphere 342 g. of 2-methylcyclohexanone (Aldrich Chemical Co.) was added dropwise over 3.5 hr. to a stirred refluxing slurry of 148 g. of a 53.7% sodium hydride dispersion in mineral oil[29] in 1800 ml. of anhydrous ether. Reflux was continued for 1 hr., 510 g. of methyl iodide was added during 1.5 hr., and this mixture was stirred and refluxed for 4 hr. Unchanged sodium hydride was decomposed by cautious addition of water to the cooled mixture, 200 ml. of 5% sodium thiosulfate solution was added, phases were separated, and the aqueous phase was washed with ether. The combined organic extract was washed with saturated sodium chloride solution, dried over sodium sulfate, and distilled through a 6-in. Vigreux column to afford 336 g. of colorless liquid, b.p.

(27) R. E. Ireland and J. A. Marshall, *J. Org. Chem.*, **27**, 1620 (1962).

(28) R. L. Shriner, R. C. Fuson, and D. Y. Curtin, "The Systematic Identification of Organic Compounds," 4th Ed., John Wiley and Sons, Inc., New York, N. Y., 1956, p. 218.

(29) The activity of the sodium hydride is important. N. G. Schnautz in our laboratory has encountered some lots which are ineffective, apparently due to slow formation of the enolate. Potassium *t*-butoxide appears to be the preferred base for this alkylation.

165–172°. Gas chromatographic analysis (Q column, 150°) showed this to be 13% 2-methylcyclohexanone, 57% 2,2-dimethylcyclohexanone, and 30% other methylation products.

This mixture was condensed with 362 g. of ethyl oxalate and the resulting ethoxalyl derivative was decarbonylated by the method of Barraud, Cornubert, and Lemoine-Tressont.[14] Distillation of the products through a 1-ft. packed column gave 111 g. of a forerun which contained nearly all of the methylated cyclohexanones from the starting ketone mixture except for the 2-methyl and 2,2-dimethyl derivatives, according to v.p.c. analysis. This was followed by 271 g. of liquid, b.p. 127–130° (26 ± 2 mm.), which was estimated to be *ca.* 80% 6-carbethoxy-2,2-dimethylcyclohexanone and 20% 6-carbethoxy-2-methylcyclohexanone. Redistillation of the main fraction gave 227 g. (73% based on available 2,2-dimethylcyclohexanone) of colorless keto ester **9**, b.p. 125–127° (20 ± 2 mm.); $n^{24}D$ 1.4777 [reported[14] b.p. 117–120° (15 mm.), $n^{17}D$ 1.4762, and b.p. 114–116° (14 mm.)].

2-Carbethoxy-2-(γ-ketobutyl)-6,6-dimethylcyclohexanone (10).—Conditions employed in this experiment were based on those described by Wilds and Werth[16] for a similar system. To a solution prepared under nitrogen by dissolving 0.5085 g. of sodium in 500 ml. of absolute ethanol was added 800 ml. of dry benzene and 100 g. of 6-carbethoxy-2,2-dimethylcyclohexanone (**9**), b.p. 125–127° (20 ± 2 mm.). A solution of 70 g. of methyl vinyl ketone[30] in 140 ml. of absolute ethanol and 400 ml. of benzene was added with stirring over 0.5 hr. A slight exothermic reaction occurred and the mixture turned purple. Stirring was continued for 5 hr., the solution was poured into 1 l. of saturated salt solution, and the product was isolated by extraction with benzene, drying over sodium sulfate, evaporation of solvent *in vacuo*, and distillation through a 6-in. Vigreux column. After a forerun of 11 g., b.p. 130–132° (1 mm.), 106 g. (79%) of colorless diketo ester **10** (96% pure by v.p.c.) was collected at 132–140° (1 mm.); $\lambda_{max}^{CHCl_3}$ 5.8–5.9 μ. The analytical sample had b.p. 183–184° (5 mm.), $n^{22.5}D$ 1.4709.

Anal. Calcd. for $C_{15}H_{24}O_4$: C, 67.13; H, 9.02. Found: C, 67.3; H, 8.8.

10-Carbethoxy-1,1-dimethyl-Δ⁸-7-octalone (11).—A solution of 53.67 g. of 2-carbethoxy-2-(γ-ketobutyl)-6,6-dimethylcyclohexanone (**10**), b.p. 132–140° (1 mm.), and 28.45 g. of pyrrolidine in 100 ml. of benzene was refluxed for 24 hr. under an azeotropic distilling head. V.p.c. at this point showed the presence of no starting material, some product, and two substances (approximate ratio 15:1) with much longer retention times than either product or starting material.

The mixture was poured into 300 ml. of saturated sodium chloride and the benzene phase was isolated and washed with 4% hydrochloric acid and saturated sodium chloride. The aqueous washings were combined, acidified with 20 ml. of concentrated hydrochloric acid, and extracted with benzene. The organic phases were combined, washed with saturated sodium chloride, dried over sodium sulfate, and the solvent was removed *in vacuo* to give 43.0 g. of brown oily solid. V.p.c. showed the complete absence of materials with the long retention times. Attempted decolorization with Norit in ethanol was not visibly beneficial and the product was recrystallized from 75 ml. of cyclohexane to give 33.04 g. of large yellow prisms, m.p. 69–70°. Concentration of the mother liquors and recrystallization afforded an additional 2.48 g. of enone **11**, m.p. 66–69° (71% total). The analytical sample (large colorless prisms from cyclohexane) had m.p. 70–71°; $\lambda_{max}^{CHCl_3}$ 5.82, 6.02, 6.23 μ; $\lambda_{max}^{95\%\ EtOH}$ 240 mμ (ε 13,200); n.m.r. (CCl_4) 4.05 (s), 5.80 and 5.90 (m),[20] 8.73 (t), 8.82 (s), 8.98 τ (s).

Anal. Calcd. for $C_{15}H_{22}O_3$: C, 71.97; H, 8.86. Found: C, 72.2; H, 8.7.

The semicarbazone, prepared by the method of Shriner, Fuson, and Curtin,[28] was recrystallized from 95% ethanol to give white prisms which showed variation of melting point with rate of heating, decomposition starting at 221° with a temperature rise of 1°/min. from 200°; $\lambda_{max}^{CHCl_3}$ 2.84, 2.94, 2.96, 5.84, 5.92, 6.42 μ; $\lambda_{max}^{95\%\ EtOH}$ 270 mμ (ε 31,000).

Anal. Calcd. for $C_{16}H_{25}N_3O_3$: C, 62.52; H, 8.20; N, 13.67. Found: C, 62.65; H, 8.3; N, 13.5.

10-Carbethoxy-1,1-dimethyl-*trans*-7-decalone (13).—A solution of 17.53 g. of 10-carbethoxy-1,1-dimethyl-Δ⁸-7-octalone (**11**), m.p. 69–70°, in 300 ml. of 95% ethanol was stirred for 1.5 hr. with 0.4969 g. of 30% palladium on carbon under 1 atm. of hydrogen at room temperature. The catalyst was filtered and washed thoroughly with 95% ethanol, and the filtrate was concentrated *in vacuo* to provide 17.35 g. of partially crystalline material. V.p.c. indicated the presence of a small amount of a substance with retention time 6.3 min. in addition to the main product at retention time 14 min. (Z column, 200°). Recrystallization from 40 ml. of petroleum ether (b.p. 30–60°) gave 14.94 g. (85%) of the keto ester **13** as large white prisms, m.p. 45–46.5°.

The mother liquor was concentrated *in vacuo* to 2.33 g. of pale yellow oil which showed v.p.c. retention times 6.3 min. (*ca.* 10%), 11.5 min. (*ca.* 1%), and 14 min. (*ca.* 90%). Chromatography on 40 g. of Woelm neutral alumina (activity grade II) gave a first fraction (cyclohexane) of 0.75 g., 37% of which consisted of substances with the shorter retention times. Later fractions (cyclohexane through benzene) contained 1.31 g. of keto ester **13** free of the contaminants with short retention times.

The first fraction from this chromatogram was rechromatographed on 20 g. of Woelm neutral alumina (activity grade II). Elution with cyclohexane gave in three fractions 0.25 g. of material, *ca.* 90% of which had a 6.2 min. retention time. Elution with 50:50 benzene–cyclohexane and with benzene gave 0.40 g. of keto ester **13** uncontaminated by substances with shorter retention times.

The later fractions from both chromatography experiments were combined and recrystallized from 5 ml. of petroleum ether (b.p. 30–60°) to give 0.97 g. of large white prisms of keto ester **13**, m.p. 45–46.5° (total yield 91%). The analytical sample from petroleum ether (b.p. 30–60°) had m.p. 45–46.5°; $\lambda_{max}^{CHCl_3}$ 5.85–5.90 μ; n.m.r. (CCl_4) 5.82 and 5.89 (m),[20] 8.70 (t), 9.12 (s), 9.23 τ (s).

Anal. Calcd. for $C_{15}H_{24}O_3$: C, 71.39; H, 9.59. Found: C, 71.55; H, 9.4.

The semicarbazone[28] (from 95% ethanol) had m.p. 196.5–197° dec. when the bath was heated at 0.5°/min. When the bath was heated at 1°/min., it had m.p. 199.5–200.5° dec.; $\lambda_{max}^{CHCl_3}$ 2.84, 2.94, 5.84, 5.94, 6.32 μ; $\lambda_{max}^{95\%\ EtOH}$ 230 mμ (ε 12,650).

Anal. Calcd. for $C_{16}H_{27}N_3O_3$: C, 62.11; H, 8.80; N, 13.58. Found: C, 62.3; H, 9.2; N, 13.3.

Isolation of 10-Carbethoxy-1,1-dimethyl-*trans*-decalin (14) and 10-Carbethoxy-1,1-dimethyl-Δ⁸-octalin (12) from Catalytic Reduction of the Enone 11.—The three cyclohexane fractions from the second chromatogram of the catalytic reduction product (just described) contained, respectively, 0.17 g., 0.05 g., and 0.03 g. of oil. The second fraction, mainly the unsaturated ester **12**, had λ_{max}^{film} 3.28, 5.82, 6.10 (weak), and 12.35 μ; n.m.r. (CCl_4) 4.40 (t), *ca.* 5.97 (m),[20] 8.80 (t), 8.97 (s), 9.15 τ (s).

The first fraction was chromatographed on 5 g. of Florisil to give 0.06 g. of oil with an infrared spectrum (film) superimposable on that of authentic 10-carbethoxy-1,1-dimethyl-*trans*-decalin (**14**), several mixed fractions (infrared spectra contain peaks of **14** and of **12**), and finally *ca.* 0.025 g. of oil with an infrared spectrum (film) the same as that of **12**.

10-Carbethoxy-1,1-dimethyl-7,7-ethylenedithio-*trans*-decalin.—The procedure of Sondheimer[31] was used. A solution of 11.0282 g. of 10-carbethoxy-1,1-dimethyl-*trans*-7-decalone (**13**), m.p. 45–46.5°, in 11 ml. of ethanedithiol was cooled to 0° and 11 ml. of boron fluoride etherate was added. The mixture was maintained at 0° for 0.5 hr., 10 ml. of methanol was added, and the two-phase mixture was cooled in a Dry Ice–acetone bath, seeded, and stored in a freezer. The 5.9196 g. of white solid, m.p. 55–56°, which precipitated was collected, and the filtrate was diluted with 15 ml. of methanol, cooled, and seeded. An additional 4.1523 g. of white prisms, m.p. 55–56°, was obtained in a few days and another 1.7566 g. of prisms, m.p. 55–56.5°, came down during 2 months, bringing the total yield to 11.83 g. (82%). Recrystallization from methanol produced large colorless prisms of the thioketal, m.p. 55–56°; $\lambda_{max}^{CHCl_3}$ 5.86 μ; n.m.r. (CCl_4) 5.86 and 5.96 (m),[20] 6.77 (s), 8.73 (t), 9.10 (s), 9.28 τ (s).

Anal. Calcd. for $C_{17}H_{28}O_2S_2$: C, 62.15; H, 8.59; S, 19.52. Found: C, 62.0; H, 8.6; S, 19.7.

10-Carbethoxy-1,1-dimethyl-*trans*-decalin (14).—A mixture of 11.15 g. of 10-carbethoxy-1,1-dimethyl-7,7-ethylenedithio-*trans*-decalin (crude crystalline product, m.p. 53–55.5°) and *ca.* 150 g. of W-2 Raney nickel (1 day old) in 1 l. of absolute ethanol was refluxed for 24 hr. The nickel was filtered and washed thoroughly with absolute alcohol, and solvent was distilled through a 6-in. Vigreux column to leave 6.87 g. of pale green oil.

(30) Matheson Coleman and Bell methyl vinyl ketone was dried overnight over calcium chloride in the refrigerator and filtered before use.

(31) F. Sondheimer and S. Wolfe, *Can. J. Chem.*, **37**, 1870 (1959).

This was distilled to afford 6.66 g. (82%) of colorless ester **14**, b.p. 74–79° (0.1 mm.). The analytical sample distilled at 87° (1 mm.); $n^{27}D$ 1.4769; $\lambda_{max}^{CHCl_3}$ 5.85 μ; n.m.r. (CCl_4) 5.89 and 5.97 (m),[20] 8.75 (t), 9.13 (s), 9.28 τ (s).

Anal. Calcd. for $C_{15}H_{26}O_2$: C, 75.58; H, 11.00. Found: C, 75.8; H, 11.0.

1,1-Dimethyl-*trans*-decalin-10-carboxylic Acid (15). (A) By Lithium Iodide Cleavage.—This experiment is based on the procedure of Elsinger, Schreiber, and Eschenmoser.[11] A solution of 1.3395 g. of 10-carbethoxy-1,1-dimethyl-*trans*-decalin (**14**), b.p. 74–79° (0.1 mm.), in 100 ml. of *sym*-collidine (freshly distilled from potassium hydroxide) containing 7.0969 g. of lithium iodide[32] was refluxed under nitrogen for 72 hr. The cooled golden yellow solution was diluted with 100 ml. of ether and 50 ml. of chloroform and was washed thoroughly with 7% hydrochloric acid. The washings were combined, acidified with 30 ml. of concentrated hydrochloric acid, and extracted with a 2:1 ether–chloroform mixture. The organic extracts were combined, washed with saturated salt solution, and extracted with 5% potassium hydroxide.[33] The basic extract was acidified with concentrated hydrochloric acid and extracted with chloroform, which was dried over magnesium sulfate and concentrated *in vacuo* to 1.1020 g. (94%) of white plates, m.p. 89–90°; λ_{max}^{KBr} 3.2–3.9 (broad), 5.9 μ. Recrystallization from aqueous methanol gave 0.9893 g. of the acid **15** as white prisms, m.p. 93–97°, and then 0.0423 g. as white plates, m.p. 88.5–91°. Infrared spectra of potassium bromide pellets or chloroform solutions of both forms were identical. Further recrystallization from aqueous methanol gave white prisms with m.p. 96–98° and after cooling and resolidification, m.p. 92–92.5°; $\lambda_{max}^{CHCl_3}$ 3.2–3.8 (broad), 5.92 μ; n.m.r. (CCl_4) −2.31 (s), 9.12 (s), 9.20 τ (s).

Anal. Calcd. for $C_{13}H_{22}O_2$: C, 74.24; H, 10.54. Found: C, 74.4; H, 10.6.

(B) By "Reductive Hydrolysis".—This experiment was based on the procedure of Wenkert and Jackson.[25] A solution of 0.203 g. of 10-carbethoxy-1,1-dimethyl-*trans*-decalin (**14**), b.p. 74–79° (0.1 mm.), in 25 ml. of tetrahydrofuran was added to *ca.* 75 ml. of liquid ammonia, and small bits of lithium were added over a 3-hr. period to maintain a blue color. The solution was allowed to evaporate at room temperature, the residue was diluted with 25 ml. of chloroform and 35 ml. of 10% hydrochloric acid, and the products were isolated by chloroform extraction. The chloroform solution was extracted with 5% potassium hydroxide, dried over magnesium sulfate, and concentrated *in vacuo* to 0.1203 g. of yellow amorphous material, λ_{max}^{KBr} 3.0 μ. Chromatography on Woelm neutral alumina (activity grade III) gave 60 mg. (30%) of crystalline carbinol, m.p. 78–79°, the melting point of which was undepressed on admixture with authentic 1,1-dimethyl-*trans*-10-decalylcarbinol.

The basic aqueous phase was acidified with 10 ml. of concentrated hydrochloric acid and the acid **15** was isolated by chloroform extraction, drying over magnesium sulfate, and concentration *in vacuo*, which gave 0.0711 g. (40%) of yellow plates, m.p. 86–88°, having an infrared spectrum identical with that of the analytical sample previously described.

The yield of acid was reproducible to within a few per cent, but the neutral fraction contained varying proportions of alcohol and starting ester.

1,1-Dimethyl-*trans*-10-decalylcarbinol.—To a slurry of 0.38 g. of lithium aluminum hydride in 15 ml. of dry tetrahydrofuran was added a solution of 0.238 g. of 10-carbethoxy-1,1-d methyl-*trans*-decalin (**14**), b.p. 74–79° (0.1 mm.), in 5 ml. of dry tetrahydrofuran. The slurry was stirred and refluxed for 18 hr., while protected with a calcium sulfate drying tube. A few drops of water and then 2 ml. of 20% sodium hydroxide were added to the cooled mixture. The mixture was filtered, the precipitate was washed with ether, and the filtrate was concentrated *in vacuo* to 0.182 g. of waxy solid. Recrystallization from aqueous methanol gave 0.144 g. (73%) of the carbinol as white fibrous crystals, m.p. 75–77°. The analytical sample (from aqueous ethanol) had m.p. 79–80°; $\lambda_{max}^{CHCl_3}$ 2.76 (sharp), 2.90 μ (broad); n.m.r. (CCl_4) 6.30 (s) 9.17 (s), 9.27 τ (s).

Anal. Calcd. for $C_{13}H_{24}O$: C, 79.53; H, 12.32. Found: C, 79.4; H, 12.15.

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(32) Mallinckrodt Chemical Co. lithium iodide trihydrate was heated with a free flame at *ca.* 0.5 mm. for 2 hr. immediately before use.

(33) In one experiment with 3.00 g. of **14**, 5% sodium hydroxide was employed for this extraction, but the sodium salt precipitated from the aqueous phase.

Stereoisomeric 3β,17β-Dihydroxyandrostan-16-ylacetic Acids

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A careful study of the catalytic hydrogenation of 3β,17β-diacetoxy-5-androsten-16-ylidenacetic acid afforded an improved yield of the selective hydrogenation product, 3β,17β-diacetoxy-5-androsten-16β-ylacetic acid, and permitted stereochemical assignments to the four possible tetrahydro products.

Partial hydrogenation of 3β,17β-diacetoxy-5-androsten-16-ylidenacetic acid (I) in glacial acetic acid in the presence of a 2% ratio of platinum oxide gave a 48% yield of the desired 3β,17β-diacetoxy-5-androsten-16β-ylacetic acid (II) when the reaction was stopped after 110–120% of the calculated amount of hydrogen was absorbed.[1] In an attempt to improve this yield, palladium-on-charcoal as well as rhodium-on-alumina catalysts were used in the reductions. The results with these catalysts were less satisfactory. Best results were finally obtained when the reduction of I was carried out with platinum in a solution of methanol containing 5% of water to yield 63% of the desired compound II.

(1) P. Kurath and W. Cole, *J. Org. Chem.*, **26**, 1939 (1961).

The complete reduction of I over a 10% ratio of platinum oxide in acetic acid solution gave 3β,17β-diacetoxy-5α-androstan-16β-ylacetic acid (III) in 65% yield.[1] Since this yield appeared to be maximum, an investigation was made of the by-products. During the catalytic hydrogenation of I, two new asymmetric centers at C-5 and C-16 were introduced. Thus, we could expect the possible formation of the main product III and three similar structures isomeric at C-5 and/or C-16. Chromatography of the mixture obtained from the above mother liquors resulted in the isolation of a small additional amount of III; however, a considerable amount of material remained still unidentified.

In a later experiment, a corresponding mixture was hydrolyzed in the presence of potassium hydroxide and