Cyclopropanes. XXXVI. Stereochemistry of the Decomposition of an Optically Active 1-Pyrazoline[1]

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Received January 8, 1975

The diastereomeric 3-carbomenthoxy-3-methyl-5,5-diphenyl-1-pyrazolines have been prepared and their absolute configurations established. Thermal and photochemical decomposition of the optically active pyrazoline produced the corresponding cyclopropane derivative with overall *retention of configuration* and in optical yields of 73 and 90%, respectively.

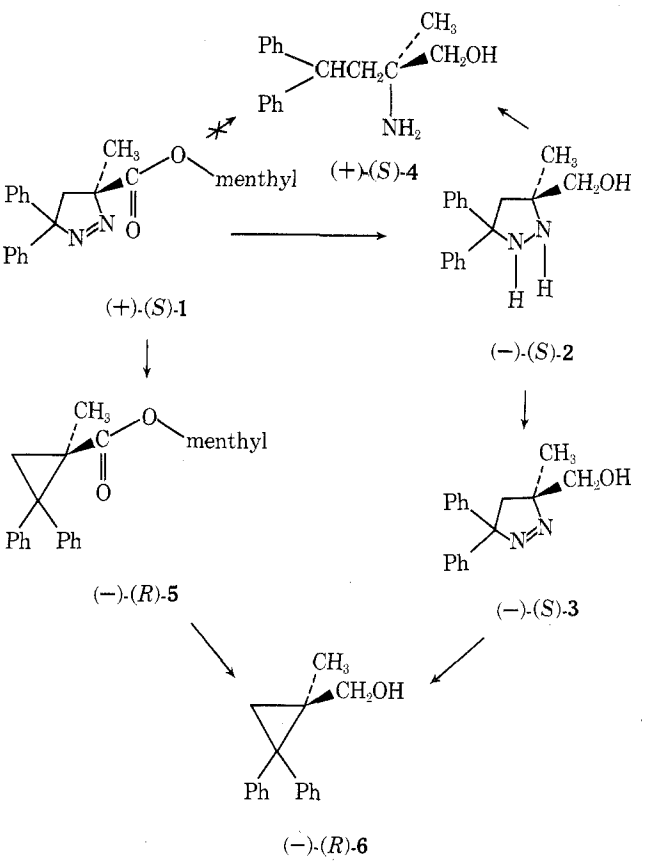
Previous work has indicated that a small amount of asymmetric synthesis occurs when diphenyldiazomethane is added to (−)-(1*R*,2*S*,5*R*)-menthyl methacrylate to produce in diastereomeric excess (−)-(1*R*,2*S*,5*R*)-menthyl (*R*)-1-methyl-2,2-diphenylcyclopropanecarboxylate.[2,3] It was postulated that the reaction proceeded by an initial 1,3-dipolar addition[4] to form a 1-pyrazoline intermediate which decomposed to the cyclopropyl derivative. The 1-pyrazoline was not isolated in this early work. In this article we will report on the synthesis, the determination of absolute configuration, and on the thermal and photochemical decomposition of the optically active 1-pyrazoline, (+)-(1*R*,2*S*,5*R*)-menthyl (*S*)-3-methyl-5,5-diphenyl-1-pyrazoline-3-carboxylate (**1**).

Synthesis and Absolute Configuration of 1. After a number of abortive attempts it was found that **1** could readily be obtained by mixing (−)-(1*R*,2*S*,5*R*)-menthyl methacrylate[2] with solid diphenyldiazomethane at subambient temperature and allowing this mixture to remain at −13° for 5 days. Purification of **1** led to some problems owing to heat sensitivity which caused decomposition at room temperature in a matter of hours. This necessitated working up the reaction mixture below 0°. Moreover, in order to prevent acid-catalyzed decomposition, all glassware was washed with a solution of alcoholic potassium hydroxide before use. Taking these precautions the method of synthesis developed was to treat the acrylate with excess diphenyldiazomethane and to successively wash the solid residue formed with cold methanol (−13°) until the diphenyldiazomethane color was removed. The resulting white solid, $[\alpha]_{Hg}^{23}$ 118.5°, melted sharply at 83–84° with loss of nitrogen and gave NMR and ir spectra consistent with the proposed structure (see Experimental Section).

The absolute configuration of (+)-**1** was established as *S*. The configurational assignment is based on two pieces of evidence. Neither datum by itself can be considered absolute but the internal consistency of both provides a convincing argument for the assignment.

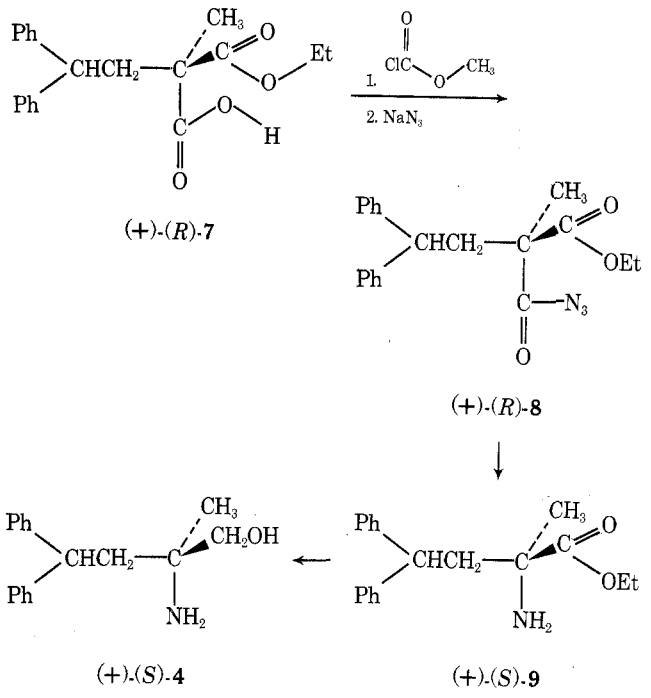
Applying the chiroptical correlations obtained by Snatzke and coworkers[5] for a number of 1-pyrazolines one would assign the *S* configuration to (+)-**1**. The pyrazoline (+)-**1** gave a positive CD band ($\Delta\epsilon$ +6.11) at 332 nm which corresponds to the n → π* absorption of the azo chromophore.[5,6] A positive Cotton effect was also observed. Reduction of **1** with lithium aluminum hydride[7] in tetrahydrofuran at −78° led to the formation of (−)-(*S*)-3-hydroxylmethyl-3-methyl-5,5-diphenylpyrazolidine (**2**) (Chart I). The configurational assignment for **2** as *S* is based on the configuration assigned to its precursor **1**. Air oxidation[8] of **2** produced (−)-(*S*)-3-hydroxylmethyl-3-methyl-5,5-diphenyl-1-pyrazoline (**3**), which gave a negative CD band ($\Delta\epsilon$ −3.32) at 332 nm as well as a negative Cotton effect. The change in sign and magnitude of the CD band in going from **1** to **3** is characteristic and consistent with the configurational assignments given.[5]

Chart I



It was hoped to convert the pyrazoline **1**, by chemical means, to a compound whose absolute configuration was either known or could be established. Attempts to reduce **1** directly to an acyclic derivative were futile since **1** decomposed to **5** so readily. The method which proved successful was to first reduce **1** to the pyrazolidine **2** and then to catalytically reduce **2** directly to **4**. This involved not only the reduction of the nitrogen–nitrogen bond but also the hydrogenolysis of the diphenyl carbinyl–nitrogen bond. This was finally achieved by using a large excess of 5% palladium on charcoal as the catalyst and carrying out the reduction in an autoclave which permitted rapid stirring. Under these conditions (−)-(*S*)-**2** was converted to (+)-2-amino-2-methyl-4,4-diphenyl-1-butanol (**4**). Since the reduction of **2** to **4** does not involve the asymmetric center the configuration of **4** is related to **2**. Optically active **4** was independently synthesized as shown in Chart II. The absolute configuration was determined by the Nakanishi and Dillon[9]

Chart II



correlation of CD for α-amino alcohols using $Pr(dpm)_3$ reagent. The α-amino alcohol (+)-**4** showed a $\Delta\epsilon$ +1.45 at 314 nm and a $\Delta\epsilon$ −1.45 at 293 nm[9] and on the basis of this CD the *S* configuration is assigned to (+)-**4**. This designation is consistent with the previous assignment of the *S* configurations to (+)-**1** and (−)-**2**.

Thermolysis. The thermal decomposition of optically active 3-carbomenthoxy-3-methyl-5,5-diphenyl-1-pyrazoline [(+)-(*S*)-**1**] was carried out at 50° in the dark under a nitrogen atmosphere for a period of 1 hr. To assess the effect of changing the polarity of the solvent on the stereochemical result two solvents of widely divergent polarity, cyclohexane and *N,N*-dimethylformamide, were used. The results showed that there was no significant difference in the product formed. In both cases 1-carbomenthoxy-1-methyl-2,2-diphenylcyclopropane [(−)-(*R*)-**5**] was produced as the sole product, in quantitative yield. Moreover, the optical rotation, $[\alpha]_{Hg}^{23}$ −64°, of **5** obtained from either solvent was identical, showing the absence of a solvent effect on the optical yield.

In order to determine the optical purity of the thermolysis product **5** a direct method was thought desirable.[10] This was achieved in the following manner. If a molecule contains two asymmetric centers, four diastereomers are possible: *R,R*, *R,S*, *S,S*, and *S,R*. If one center is held to one configuration, as in this case with (−)-(1*R*,2*S*,5*R*)-menthol, then only two diastereomers are possible, (*R,R*)-**5** and (*S,R*)-**5**. Since (*R*)-(+)-1-methyl-2,2-diphenylcyclopropanecarboxylic acid (**10**) was obtained[2] by the saponification of **5**, then the rotation of the mixture of diastereomeric esters should lie on the line between the rotation of (±)-(*RS*)-(−)-(*R*)- and pure (+)-(*R*)-(−)-(*R*)-**5**. The two menthyl esters were synthesized by converting (±)-**10** to the acid chloride followed by reaction with (−)-(*R*)-menthol to yield the (±)-(*RS*)-(−)-(*R*)-menthyl ester, $[\alpha]_{Hg}^{24}$ −58.1°. Repeating this process with optically pure (+)-(*R*)-**10** produced the (+)-(*R*)-(−)-(*R*) diastereomer, $[\alpha]_{Hg}^{24}$ −66.2°. Comparing the rotation of the ester obtained from the thermolysis, $[\alpha]_{Hg}^{24}$ −64°, with the above values gives an optical purity for the thermolysis product (**5**) of 73%.

In order to check the accuracy of the above method in one run the product was reduced with lithium aluminum hydride to give a mixture of 1-hydroxymethyl-1-methyl-2,2-diphenylcyclopropane (**6**) and menthol. Separation of this mixture by ordinary means proved difficult. The method which finally proved successful was to convert the mixture of alcohols to their trimethylsilyl derivative by reaction with *N*-trimethylsilylacetamide[11] and using GLC to separate them. The siloxane derivative was hydrolyzed to yield (−)-(*R*)-**6**, $[\alpha]_{Hg}^{23}$ −32.2° (*c* 2.1, $CHCl_3$), which corresponds to an optical purity[12] of 70% and agrees well with the value obtained from the previous method. The pyrolysis of **1** therefore proceeds with ~85% *retention of configuration.*

Pyrolysis of pyrazoline (−)-(*S*)-**3**, $[\alpha]_{Hg}^{23}$ −23.4°, produced (−)-(*R*)-**6**, $[\alpha]_{Hg}^{23}$ −25.5° (*c*, 2.0, $CHCl_3$), with an optical purity of 56% which represents 78% *retention of configuration.*

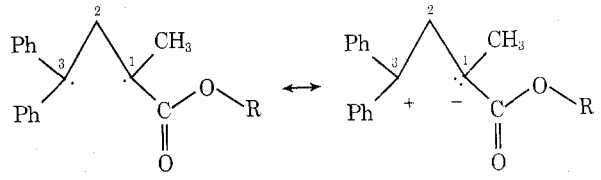
The direct photolysis of (+)-(*S*)-**1** was carried out to determine if there would be a change in stereochemistry of the product, **5**. The 1-pyrazoline **1** with λ_{max} 330 nm (N=N, ϵ 150) was dissolved in methylcyclohexane and irradiated at −4° using a high-pressure mercury lamp and a Pyrex filter. The main products obtained were (−)-(*R*)-**5** (79%) and 1,1-diphenylethylene[13] (13%). The rotation of the ester **5** produced was $[\alpha]_{Hg}^{24}$ −65.6° and **5** was shown to be stable under these irradiation conditions. This result shows that this reaction proceeds with over 95% *retention of configuration.*

Irradiation of (+)-(*S*)-**1** using benzophenone as a sensitizer[14] produced **5** in only trace amounts; the major products appeared to be formed by fragmentation.[15] No attempt was made to identify the many olefinic products produced.

Discussion

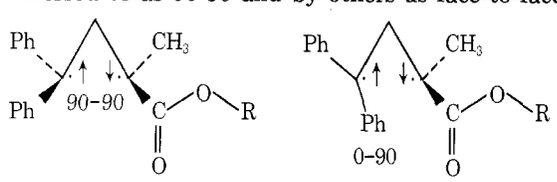
Our results show that in both the photolysis and pyrolysis of pyrazolines **1** and **3** the corresponding cyclopropane derivative is formed with a high retention of configuration and optical activity. Such results have been observed by other workers. Overberger[16] found that the thermal decomposition of *trans*-3,5-diphenyl-1-pyrazoline gave 89% *trans*-1,2-diphenylcyclopropane and that photolysis gave a similar result. Rinehart[17] showed that *cis*- and *trans*-1-carbomethoxy-3,4-dimethyl-1-pyrazoline produced cyclopropanes of corresponding stereochemistry and that photolysis was even more selective. Similar observations have been made by Nozaki[18] in the decomposition of *cis*- and *trans*-9,10-diazabicyclo[6.3.0]undec-9-ene. In an analysis of the stereochemistry of pyrazoline decomposition McGreer[19] has demonstrated that, in general, the decomposition proceeds with overall retention of configuration, although there are notable exceptions.[19,20]

It is generally believed that thermal and photochemical decomposition of a 1-pyrazoline leads to the formation of a cyclopropane by way of a trimethylene diradical intermediate.[21,22] The state of the diradical formed under these conditions is believed to be singlet. The amount of zwitterionic character associated with the singlet diradical, due to resonance, is not known but the amount would undoubtedly be structure dependent.[23] The diradical formed from **1** should



have an appreciable ionic contribution since it would have two phenyl groups at C-3 which would delocalize the positive charge and a carbomenthoxy at C-1 which would delocalize the negative charge. However, the absence of a solvent effect in the decomposition of 1 would indicate that the zwitterionic contribution is not very large.[23]

The high-temperature pyrolysis of cyclopropane derivatives presumably also results in the formation of singlet diradical intermediates. The stereochemistry of this ring opening–ring closing reaction has been studied by Berson,[24] Bergman,[25] and Cram[23] and has been the subject of a recent review.[21] The results show that the trimethylene radical produced under their conditions ring closes 5–11 times faster than it can rotate. In the case of the trimethylene radical produced in the decomposition of 1 and based on the percent retention of configuration observed, the rate of ring closure is seven times faster than rotation for the thermolysis and 19 times faster for the photolysis reaction. The configuration of the diradical that best accommodates our results is the one suggested by Bergman,[25] which has been referred to as 90-90 and by others as face-to-face.[23]



face-to-face edge-to-face

We cannot eliminate the 0-90 based on our observation but we can eliminate all intermediates which are achiral, such as 90-0 and 0-0. The small amount of inversion of confguration that is found is probably due to the latter type of intermediate, which is the result of rotation around the C_1–C_2 bond. Steric hindrance to such rotations is produced by the substituents at C_1 and C_3 which may enhance the rate of ring closure.[24,25] The rate of ring closure vs. rotation of the trimethylene radical would also be expected to be sensitive to temperature. The lower retention of configuration bound in the thermolysis of 1 (50°) to that of the photolysis of 1 (−3°) may well be due to a temperature effect. This effect may also account for the lowered retention of configuration in the pyrolysis of 3 (130°) although reduced steric interactions may also be playing a role.

Finally, it should be noted that our attempts to isolate cyclopropane derivatives from the benzophenone-sensitized photolysis of 1 were abortive and only a number of unsaturated compounds (not identified) were obtained. It was also shown that the cyclopropane 5 decomposed under these conditions. Apparently in this system the triplet diradical, presumably produced from 1 or 5, decomposed by other pathways[15] before triplet–singlet interconversion leading to ring closure could occur.

Experimental Section

Melting points were measured with a Mel-Temp apparatus and both melting and boiling points are uncorrected. Infrared spectra were determined using a Perkin-Elmer Model 257 spectrophotometer. Nuclear magnetic resonance spectra were recorded on a Varian A-60 or Bruker 90-MHz spectrophotometer; chemical shifts are reported in parts per million downfield from tetramethylsilane and coupling constants are in hertz. Optical rotatory and circular dichroism spectra were recorded with a Jasco 5 and optical rotations at 5461 Å with a Bendix-Ericson Model 143A polarimeter. Microanalyses were performed by the Beller Laboratories, Gottingen, Germany.

Synthesis of Optically Active 2-Amino-2-methyl-4,4-diphenyl-1-butanol. 2,2-Diphenylethanol. To a stirred solution of 17.9 g (0.46 mol) of lithium aluminum hydride in 250 ml of dry ether was added a solution of 100 g (0.46 mol) of diphenylacetic acid in 250 ml of dry ether at such a rate so as to maintain a steady reflux. After the completion of addition the reaction mixture was allowed to stir for 30 min, and was hydrolyzed with water and 150 ml of 10% sulfuric acid. The ether layer was separated and washed twice with water and finally with saturated salt solution and dried over anhydrous sodium sulfate. Evaporation of ether gave 85 g (91%) of 2,2-diphenylethanol. Recrystallization from *n*-hexane gave colorless crystals: mp 54–55°; ir ($CHCl_3$) 3588 (m), 3120–2980 (m), 1730 (s), 1607 (m), 1498 (s), 1458 (s), 1390 (m), 1025 cm^{-1} (s); NMR ($CDCl_3$) δ 1.7 (s, 1 H), 4.0 (s, 3 H), 7.1 (s, 10 H).

2,2-Diphenylethyl Toluenesulfonate. To a stirred solution of 40.0 g (0.20 mol) of 2,2-diphenylethanol in 150 ml of dry pyridine at 0° was added dropwise a solution of 44.7 g (0.20 mol) of *p*-toluenesulfonyl chloride in 150 ml of dry pyridine. After stirring the reaction mixture for 6 hr at 0°, it was poured into 1 l. of ice water and the product, 2,2-diphenylethyl toluenesulfonate, was filtered. Recrystallization from acetone–water gave colorless needles: mp 93–95°; ir ($CHCl_3$) 3010 (w), 1600 (m), 1495 (w), 1450 (w), 1370 (s), 1175 (s), 1100 (m), 970 (s), and 875 cm^{-1} (m); NMR ($CDCl_3$) δ 2.36 (s, 3 H), 4.4 (m, 3 H), 7.1–7.55 (m, 14 H).

Diethyl (2,2-Diphenylethyl)methylmalonate. Sodium hydride–mineral oil dispersion (5.0 g, 0.12 mol) was washed free of oil with dry diethyl ether, 150 ml of distilled dimethylformamide was added under a dry atmosphere, and 22 g (0.13 mol) of diethyl methylmalonate was added dropwise with stirring at 0° until gas evolution ceased. To this solution 40 g (0.114 mol) of 2,2-diphenylethyl toluenesulfonate in 150 ml of dimethylformamide was added dropwise and the reaction mixture was heated at 110° for 30 hr. Upon cooling, the reaction mixture was diluted with water and extracted with diethyl ether several times which, upon combination, was washed with saturated salt solution and dried over anhydrous sodium sulfate. Evaporation of ether gave 50 g of crude yellow oil. Vacuum distillation of this oil gave 13 g (0.03 mol) of diethyl (2,2-diphenylethyl)methylmalonate: bp 176° (0.5 mm); yield 31.6% (based on converted tosylate); ir (CCl_4) 3080–2980 (m), 1755 (shoulder), 1740 (s), 1600 (m), 1495 (m), 1452 (m), 1150 (s), 1030 (m), and 690 cm^{-1} (s); NMR ($CDCl_3$) δ 1.1 (t, 3 H), 1.36 (s, 3 H), 3.86 (m, 5 H), 7.1 (s, 10 H). The major side product was identified by infrared and NMR as 1,1-diphenylethylene.

Anal. Calcd for $C_{22}H_{26}O_4$: C, 74.55; H, 7.39. Found: C, 74.99; H, 7.54.

(±)-2-Carbethoxy-2-methyl-4,4-diphenylbutanoic Acid. To a stirred solution of 14 g (0.039 mol) of diethyl (2,2-diphenylethyl)methylmalonate in 100 ml of 95% ethanol and 25 ml of water was added 2.2 g (0.039 mol) of potassium hydroxide and the solution was allowed to stir overnight at room temperature. The reaction mixture was then diluted with water and extracted several times with diethyl ether. The aqueous layer was acidified and extracted with diethyl ether, which, upon evaporation of ether extracts, gave 8.4 g (65%) of 2-carbethoxy-2-methyl-4,4-diphenylbutanoic acid: mp 90–92°; ir ($CHCl_3$) 3500–2500 (broad), 1725 (s), 1601 (w), 1495 (w), 1385 (w), 1115 cm^{-1} (m); NMR ($CDCl_3$) δ 1.1 (t, 3 H), 1.4 (s, 3 H), 2.75 (d, 2 H), 3.85 (q, 2 H, 2.05 (t, 1 H), 7.19 (s, 10 H), 10.25 (s, 1 H).

Anal. Calcd for $C_{20}H_{22}O_4$: C, 73.60; H, 6.79. Found: C, 73.72; H, 6.94.

(−)-(*S*)-Carbethoxy-2-methyl-4,4-diphenylbutanoic Acid.[26] To a solution of 19.7 g (0.056 mol) of (±)-2-carbethoxy-2-methyl-4,4-diphenylbutanoic acid in 50 ml of ethyl acetate was added a solution of 2.58 g (0.028 mol) of (−)-ephedrine in 50 ml of ethyl acetate and the solution was kept at 0 to −5° for 48 hr. The salt was recrystallized five more times from ethyl acetate to give $[\alpha]_{Hg}^{25}$ −14.1° (2.5%, EtOH). Another recrystallization from chloroform gave the value $[\alpha]_{Hg}^{25}$ −14.7° (2%, EtOH); mp 131–132°; ir and NMR spectra identical with those of racemic compound.

(±)-Ethyl 2-Carbazido-2-methyl-4,4-diphenylbutanoate. A solution of 2 g (0.0062 mol) of ethyl 2-carboxy-2-methyl-4,4-diphenylbutanoate in 12 ml of acetone and 2 ml of water was cooled to −15° and 0.72 g (1 ml, 0.007 mol) of triethylamine dissolved in 6 ml of acetone was added. To this mixture, 0.78 g (0.7 ml, 0.007 mol) of ethyl chlorocarbonate in 2 ml of acetone was added dropwise. The mixture was stirred for 30 min and then 0.6 g (0.01 mol) of sodium azide in 5 ml of water was added slowly and the reaction mixture was stirred overnight at room temperature. Dilution with water and extraction with several portions of diethyl ether followed by evaporation on an aspirator yielded 2.15 g (quantitative yield) of crude ethyl 2-carbazido-2-methyl-4,4-diphenylbutanoate: mp 72–74° dec; ir (CCl_4) 2140 (s), 1750 (s), 1720 (s), 1601 (w), 1499 (m), 1457 (m), 1182 (s), 1030 (m), 692 cm^{-1} (m); NMR ($CDCl_3$) δ

1.02 (t, 3 H), 1.33 (s, 3 H), 2.75 (d, 2 H), 3.80 (m, 2 H), 4.02 (t, 1 H), 7.18 (s, 10 H).

(−)-Ethyl (*S*)-2-Carbazido-2-methyl-4,4-diphenylbutanoate. A solution of 2 g (0.006 mol) of (−)-2-carbethoxy-2-methyl-4,4-diphenylbutanoic acid in 12 ml of acetone and 2 ml of water was cooled to −15° and 0.72 g (1 ml, 0.007 mol) of triethylamine in 5 ml of acetone was added with stirring. To this mixture, 0.78 g (0.7 ml, 0.007 mol) of ethyl chlorocarbonate in 2 ml of acetone was added dropwise. The reaction mixture was stirred for 30 min at −15° and then 0.6 g (0.01 mol) of sodium azide in 5 ml of water was added slowly and the reaction mixture was stirred overnight at room temperature. Dilution with water and extraction with diethyl ether followed by evaporation of diethyl ether gave 2.0 g (93%) of ethyl 2-carbazido-2-methyl-4,4-diphenylbutanoate as a yellow oil: ir ($CHCl_3$) 2145 (s), 1750 (s), 1720 (s), 1605 (w), 1499 (m), 1457 (m), 1178 (s), 1128 (m), 1025 cm^{-1} (m); NMR (CCl_4) δ 1.02 (t, 3 H), 1.33 (s, 3 H), 2.71 (d, 2 H), 3.90 (m, 3 H), 7.17 (s, 10 H); $[\alpha]_{Hg}^{23}$ −23.5° (2.4%, $CHCl_3$).

(±)-Ethyl 2-Isocyanato-2-methyl-4,4-diphenylbutanoate. Heating ethyl 2-carbazido-2-methyl-4,4-diphenylbutanoate neat on a steam bath gave a quantitative yield of ethyl 2-isocyanato-2-methyl-4,4-diphenylbutanoate as a yellow liquid: bp 353° dec; ir (CCl_4) 2255 (s), 1790 (s), 1601 (w), 1210 (s), 1110 (m), 695 cm^{-1} (m); NMR (CCl_4) δ 1.04 (t, 3 H), 1.3 (s, 3 H), 2.7 (d, 2 H), 3.8 (m, 3 H), 7.1 (s, 10 H).

Anal. Calcd for $C_{20}H_{21}NO_3$: C, 74.28; H, 6.55; N, 4.33. Found: C, 74.66; H, 6.73; N, 4.48.

(±)-Ethyl 2-Amino-2-methyl-4,4-diphenylbutanoate. A benzene solution (20 ml) of 1.8 g (0.005 mol) of ethyl 2-carbazido-2-methyl-4,4-diphenylbutanoate and 0.6 ml (0.58 g, 0.005 mol) of benzyl alcohol was refluxed for 48 hr, at which time the benzene was removed under vacuum, leaving a yellow, oily residue. This residue was dissolved in 50 ml of anhydrous diethyl ether and gaseous hydrogen bromide was passed through the stirred solution for 3 hr. The ether solution was then extracted several times with water and the water layers were combined and neutralized with solid sodium carbonate. Extraction with several portions of diethyl ether and evaporation of the combined ether layers after drying (Na_2SO_4) gave 1.27 g (86%) of ethyl 2-amino-2-methyl-4,4-diphenylbutanoate: bp 150° (0.5 mm); ir (CCl_4) 3382 (w), 3310 (w), 3100–2820 (broad), 1734 (s), 1610 (m), 1498 (m), 1456 (m), 1379 (m), 1200 (s), 1115 (s), 1080 (m), 1032 (m), and 693 cm^{-1} (s); NMR (acetone-d_6) 0.98 (t, 3 H), 1.21 (s, 3 H), 2.22 (s, 2 H), 2.49 (dd, 2 H), 3.64 (m, 2 H), 4.20 (1 H), 7.17 (m, 10 H).

Anal. Calcd for $C_{19}H_{23}NO_2$: C, 76.73; H, 7.80; N, 4.71. Found: C, 76.83; H, 7.40; N, 5.04.

(−)-Ethyl (*R*)-2-Amino-2-methyl-4,4-diphenylbutanoate. A benzene solution (25 ml) of 1.8 g (0.005 mol) of ethyl-2-carbazido-2-methyl-4,4-diphenylbutanoate and 0.6 ml (0.58 g, 0.005 mol) of benzyl alcohol was refluxed for 48 hr. The reaction mixture was cooled and benzene was removed under reduced pressure to give yellow oil. This was dissolved in 50 ml of dry diethyl ether and gaseous hydrogen bromide was passed through the stirred solution for 3 hr. The ether solution was then extracted several times with water and combined water layer was neutralized with sodium carbonate. Extraction with several portions of diethyl ether and evaporation of combined ether layers after drying over anhydrous sodium sulfate gave 1.5 g (90.6%) of ethyl 2-amino-2-methyl-4,4-diphenylbutanoate. Recrystallization from diethyl ether–hexane gave colorless crystals: mp 101–103°; ir ($CHCl_3$) 3365 (w), 3310 (w), 3100–2800 (broad), 1733 (s), 1605 (m), 1085 (w), 1028 cm^{-1} (w); $[\alpha]_{Hg}^{25}$ −47.9° (2.06%, $CHCl_3$).

(±)-2-Amino-2-methyl-4,4-diphenylbutanoic Acid. Refluxing a solution of 9 g (0.03 mol) of α-amino ester with 4.2 g (0.075 mol) of potassium hydroxide in 20 ml of 50% ethanol–water overnight, followed by acidification and evaporation of solvent, yielded a yellow residue. Trituration with ethanol followed by removal of solvent gave 9 g of 2-amino-2-methyl-4,4-diphenylbutanoic acid hydrochloride as a yellow glass: ir (KBr) 3300–2600 (s, broad), 1740 (s, broad), 1600 (m), 1495 (s), 1455 (m), 1390 (w, broad), 1220–1180 (s, broad), 1130 (m), 1080 (w), 1032 (w), 740 (m), 693 cm^{-1} (m).

Neutralization of the hydrochloride using a slight excess of silver carbonate in ethanol, filtering, treatment with hydrogen sulfide, followed by filtration and evaporation gave 2-amino-2-methyl-4-diphenylbutanoic acid: mp >220° (sublimes); ir (KBr) 3200–2800 (broad, m), 2500 (broad, w), 1600 (broad, s), 1494 (m), 1452 (m), 1398 (m), 1360 (m), 1247 (w), 1231 (w), 1125 (w), 1080 (w), 1030 (w), 885 (w), 842 (w), 804 (w), 792 (w), 739 (m), 690 cm^{-1} (s).

Anal. Calcd for $C_{17}H_{19}NO_2$: C, 75.81; H, 7.11; N, 5.20. Found: C, 75.73; H, 7.04; N, 5.35.

(±)-2-Amino-2-methyl-4,4-diphenyl-1-butanol. Lithium aluminum hydride (1 g, 0.027 mol) was suspended in 15 ml of anhydrous diethyl ether and a solution of 0.8 g (0.0027 mol) of ethyl 2-amino-2-methyl-4,4-diphenylbutanoate in 15 ml of ether was slowly added. After refluxing for 4 hr the excess lithium aluminum hydride was hydrolyzed with saturated ammonium chloride solution and the ether layer was extracted several times with 10% hydrochloric acid. Neutralization of the combined water layers and extraction with diethyl ether, followed by drying over anhydrous sodium sulfate, gave upon evaporation 0.603 g (88%) of 2-amino-2-methyl-4,4-diphenyl-1-butanol: mp 108–110°; ir (CCl_4) 3640 (w), 3500–3200 (broad), 3100–2810 (broad m), 1601 (w), 1498 (m), 1457 (m), 1053 (m), 1034 (m), and 692 cm^{-1} (s); NMR (acetone-d_6) δ 0.86 (s, 3 H), 2.24 (d, 2 H), 3.20 (s, 2 H), 1.8–3.6 (m, 3 H), 4.26 (t, 1 H), and 6.9–4.5 (m, 10 H).

Anal. Calcd for $C_{17}H_{21}NO$: C, 79.96; H, 8.29; N, 5.49. Found: C, 80.01; H, 8.41; N, 5.51.

(−)-(*R*)-2-Amino-2-methyl-4,4-diphenyl-1-butanol. Lithium aluminum hydride (1 g, 0.027 mol) was suspended in 25 ml of dry diethyl ether and a solution of 1.2 g (0.004 mol) of ethyl 2-amino-2-methyl-4,4-diphenylbutanoate in 25 ml of dry diethyl ether was added slowly with stirring. After refluxing for 4 hr, the excess lithium aluminum hydride was hydrolyzed with saturated ammonium chloride solution and the ether layer was separated and washed several times with 10% hydrochloric acid. Neutralization of combined water layer and extraction with diethyl ether, followed by drying over anhydrous sodium sulfate, gave upon evaporation of diethyl ether 1.0 g (92%) of 2-amino-2-methyl-4,4-diphenyl-1-butanol. Recrystallization from diethyl ether–hexane gave colorless needles: mp 83–85°; ir and NMR identical with those of racemic compound, $[\alpha]_{Hg}^{24}$ −1.82 ± 0.8° (0.6%, EtOH).

(−)-Menthyl Methacrylate.[27] A mixture of 172 g (2 mol) of methacrylic acid and 90.8 g (0.66 mol) of phosphorus trichloride was heated at 65–70° for 75 min. After cooling to room temperature, the upper layer was distilled at atmospheric pressure to give 107 g (51.2%) of methacrylyl chloride as a colorless liquid, bp 96–98°.

This methacrylyl chloride (107 g, 1.02 mol) was added slowly to a solution of 160 g (1.03 mol) of (−)-1-menthol in 250 ml of dry pyridine at 0°. After stirring at room temperature overnight the reaction mixture was diluted with water and extracted several times with diethyl ether. The combined ether layers were washed twice with water and once with saturated sodium chloride solution and then dried over anhydrous sodium sulfate. Evaporation of the solvent gave crude menthyl methacrylate, which on vacuum distillation gave 106 g (46%) of pure menthyl methacrylate: bp 89–90° (2 mm); $[\alpha]_{Hg}^{24}$ −117.9° (0.78%, $CHCl_3$); ir (film) ν 2958 (s), 2930 (s), 2870 (s), 1645 (m), 1460 (m), 1325 (m), 1305 (m), 1175 (s), 1150 cm^{-1} (m); NMR (CCl_4) δ 0.81 (d, 3 H), 0.90 (d, 6 H), 0.6–2.3 (unresolved, 9 H), 1.92 (q, 3 H), 4.73 (m, 1 H), 5.48 (m, 1 H), and 6.03 (m, 1 H).

(+)-(*S*)-3-Carbomenthoxy-3-methyl-5,5-diphenyl-1-pyrazoline. Freshly prepared diphenyldiazomethane (30 g, 0.15 mol) was added to 22.4 g (0.1 mol) of (−)-menthyl methacrylate at 0°. After thorough mixing the reactants were allowed to stand at −10 to −15° for 5 days, yielding a red gum. This gum was triturated repeatedly with cold absolute methanol at −10 to −15° until all trace of pink color was removed. Approximately 50–60% of the crude mixture was lost during this process. Upon drying the residue under vacuum, 14 g (25%) of white solid 3-carbomenthoxy-3-methyl-5,5-diphenyl-1-pyrazoline was obtained: mp 83–83.5° dec; $[\alpha]_{Hg}^{23}$ +111.7 ° (0.75%, $CHCl_3$) [optically pure pyrazoline has $[\alpha]_{Hg}^{23}$ +118.46° (2%, $CHCl_3$); this represents an optical purity of 94.3%]; ir (CCl_4) ν 3080 (w), 3060 (w), 3025 (w), 2960 (s), 2930 (s), 2875 (m), 1737 (s), 1595 (w), 1560 (broad, w), 1500 (m), 1455 (m), 1395 (w), 1377 (w), 1315 (m), 1270 (m), 1185 (s), and 700 cm^{-1} (s); NMR (CCl_4) δ 0.66 (d, 3 H), 0.90 (d, 3 H), 1.45 (s, 3 H), 0.45–1.9 (broad, no fine structure), 2.45 (dd, 2 H), 4.57 (broad, 1 H), 7.23 (d, 10 H); ORD (*c* 0.68, $CHCl_3$), 23° $[\Phi]_{400}$ +789.8°, $[\Phi]_{343}$ +5346.5°, $[\Phi]_{315}$ −3706.1°, $[\Phi]_{280}$ −972.1°; CD (*c* 0.40, dioxane), 23° $[\theta]_{360}$ 0, $[\theta]_{332}$ +20,180, $[\theta]_{280}$ 0 ($\Delta\epsilon$ 6.11).

(−)-(*S*)-3-Hydroxymethyl-3-methyl-5,5-diphenylpyrazolidine. To 3.0 g (0.079 mol) of lithium aluminum hydride slurried in 200 ml of dry tetrahydrofuran at −78° under nitrogen atmosphere was added 13.2 g (0.032 mol) of 1-pyrazoline in 125 ml of dry tetrahydrofuran. The solution was stirred and allowed to come to room temperature overnight, after which the solution was dark

green. Excess lithium aluminum hydride was hydrolyzed with saturated ammonium chloride solution. The solution was then filtered and diluted with 500 ml of water, which was extracted with three 100-ml portions of diethyl ether. The combined ether layers were extracted with three 50-ml portions of 5% hydrochloric acid which upon treatment with potassium hydroxide and extraction with diethyl ether followed by evaporation of solvent gave 6.7 g (85%) of 3-hydroxymethyl-3-methyl-5,5-diphenylpyrazolidine as an oil: $[\alpha]_{Hg}^{24}$ −31.57° (0.98%, EtOH); ir (CCl_4) ν 3620 (w), 3060 (w), 3030 (w), 2980 (s), 2880 (m), 1600 (w), 1498 (m), 1455 (m), 1080 (m), 1060 (m), and 705 cm^{-1}; NMR (acetone-d_6) δ 0.90 (s, 3 H), 2.80 (s, 3 H), 3.37 (s, 2 H), 4.0 (broad s, 3 H), 7.43 (m, 10 H).

Anal. Calcd for $C_{17}H_{20}ON_2$: C, 76.09; H, 7.51; N, 10.44. Found: C, 76.39; H, 7.62; N, 10.33.

(+)-(*S*)-2-Amino-2-methyl-4,4-diphenyl-1-butanol. A mixture of 6.7 g (0.025 mol) of pyrazolidine and 7.0 g of 5% palladium on charcoal catalyst in 200–300 ml of 95% ethyl alcohol was changed into a 1-l. Magnadash autoclave. The autoclave was then flushed six times with hydrogen at 500 psi, pressurized to 900 psi with hydrogen, heated at 60°, and stirred for 24 hr. Cooling and venting followed by filtration and evaporation of solvent gave 5.7 g (90%) of yellow, oily residue. Thin layer chromatography on a 1 mm × 20 cm × 40 cm silica gel plate with diethyl ether as eluent gave three bands. The band with lowest R_f value yielded 40% of oily material which had has an ir and NMR identical with those of authentic 2-amino-2-methyl-4,4-diphenyl-2-butanol, $[\alpha]_{Hg}^{24}$ +2.28 ± 0.8° (0.6%, EtOH). The other bands corresponded to starting material and oxidized starting material.

(−)-(*S*)-3-Hydroxymethyl-3-methyl-5,5-diphenyl-1-pyrazoline. A 4.0-g portion (0.015 mol) of 3-hydroxymethyl-3-methyl-5,5-diphenyl-1-pyrazoline, $[\alpha]_{Hg}^{24}$ +113.7° (0.7%, $CHCl_3$), was dissolved in 50 ml of tetrahydrofuran. This solution was exposed to atmospheric oxygen for 3 days by allowing it to stand at room temperature. Evaporation of solvent gave an almost quantitative yield of 3-hydroxymethyl-3-methyl-5,5-diphenyl-1-pyrazoline as a yellowish residue. Preparative thin layer chromatography on a 20 cm × 40 cm × 1 mm plate of silica gel with diethyl ether as eluent gave 3.0 g (75%) of pure 1-pyrazoline: mp 98–99° dec; $[\alpha]_{Hg}^{24}$ −26.3° (0.92%, $CHCl_3$); ir (CCl_4) ν 3600 (w), 3400 (w, broad), 3060 (w), 3030 (m), 1455 (m), 1390 (w), 1315 (w), 1060 (m), 1040 (w), 890 (w), 705 cm^{-1} (s); NMR ($CDCl_3$) δ 1.11 (s, 3 H), 2.29 (dd, 2 H), 3.20 (s, broad, 1 H), 3.81 (dd, 2 H), and 7.3 (s, 10 H); ORD (*c* 0.1, $CHCl_3$), 23° $[\Phi]_{400}$ −4522°, $[\Phi]_{340}$ −16,492°, $[\Phi]_{302}$ +16,359°, $[\Phi]_{270}$ +14,098°; CD (*c* 0.04, dioxane), 23° $[\theta]_{280}$ 0, $[\theta]_{332}$ −10,970, $[\theta]_{360}$ 0 ($\Delta\epsilon$ −3.32).

Anal. Calcd for $C_{17}H_{18}ON_2$: C, 76.69; H, 6.78; N, 10.52. Found: C, 76.58; H, 6196; N, 10.35.

(−)-(*R*)-1-Hydroxymethyl-1-methyl-2,2-diphenylcyclopropane. Heating 0.5 g (0.0019 mol) of 3-hydroxymethyl-3-methyl-5,5-diphenyl-1-pyrazoline at 130° until bubbling ceased (about 10 min) gave a quantitative yield of 1-hydroxymethyl-1-methyl-2,2-diphenylcyclopropane. This product was sublimed at 60° and reduced pressure (0.25 mm) to give pure compound: mp 98–99°; $[\alpha]_{Hg}^{23}$ −25.3° (0.82%, $CHCl_3$); ir (CCl_4) ν 3630 (m), 3090 (w), 3070 (m), 3030 (m), 2960 (w), 2940 (m), 2880 (m), 1605 (m), 1500 (s), 1455 (s), 1398 (w), 1385 (w), 1090 (w), 1050 (s), 1025 (s), and 705 cm^{-1} (s); NMR (CCl_4) δ 1.06 (s, 3 H), 1.18 (dd, 2 H), 1.43 (s, 1 H), 3.28 (d, 2 H), 7.26 (m, 10 H).

Synthesis of Menthyl 1-Methyl-2,2-diphenylcyclopropanecarboxylate. From Racemic Acid. A catalytic amount of anhydrous *N,N*-dimethylformamide (2 drops) was added to a solution of 1 g (0.004 mol) of 1-methyl-2,2-diphenylcyclopropanecarboxylic acid in 2 ml (0.027 mol) of thionyl chloride and allowed to react at room temperature for 3 hr. The excess thionyl chloride was removed under vacuum and the yellow oil was crystalized from pentane to give 0.83 g of light yellow solid acid chloride. This material was added to a solution of 0.54 g (0.003 mol) of (−)-1-menthol in 25 ml of dry benzene and the mixture was refluxed overnight. Removal of solvent and preparative thin layer chromatography on two 2 cm × 40 cm × 1 mm silica gel plates with 1:1 ether–hexane eluent gave 1.049 g of menthyl 1-methyl-2,2-diphenylcyclopropanecarboxylate, an overall yield of 67% from starting acid: mp 88–90°; $[\alpha]_{Hg}^{24}$ −58.07° (1%, $HCCl_3$); ir (CCl_4) 3070 (w), 3050 (w), 3015 (w), 2945 (s), 2920 (s), 2860 (m), 1720 (s), 1497 (w), 1495 (m), 1446 (m), 1385 (w), 1368 (w), 1315 (m), 1255 (m), 1160 (s), 1145 (s), 695 (m), 686 cm^{-1} (m); NMR ($CDCl_3$) δ 0.83 (m, 9 H), 1.20 (s, 3 H), 1.37 (d, 1 H), 0.4–2.0 (unresolved m, 9 H), 2.30 (poorly resolved m, 1 H), 7.30 (m, 10 H).

Anal. Calcd for $C_{27}H_{34}O_2$: C, 83.03; H, 8.77. Found: C, 82.92; H, 8.74.

From Optically Active Acid. The same procedure as above was used starting with 0.160 g (6.3×10^{-4} mol) of (−)-*R*-1-methyl-2,2-diphenylcyclopropanecarboxylic acid, $[\alpha]_{Hg}^{24}$ +41.8° (2.2%, $HCCl_3$). Optically pure acid has $[\alpha]_{Hg}^{25}$ +43.5° (2.2%, $HCCl_3$). This represents an optical purity of 96%. The ester was isolated following the above procedure in 70% overall yield, mp 120–122°, $[\alpha]_{Hg}^{24}$ −65.89° (1%, $HCCl_3$). Correcting for optical purity gives a maximum rotation of $[\alpha]_{Hg}^{24}$ −66.2°; ir same as mixture but C=O at 1710 cm^{-1}; NMR better resolved.

Anal. Calcd for $C_{27}H_{34}O_2$: C, 83.03; H, 8.77. Found: C, 83.01; H, 8.80.

Pyrolysis of Purified 1-Pyrazoline. In Methylcyclohexane. A cold solution of 1 g (0.0024 mol) of 1-pyrazoline ($[\alpha]_{Hg}^{23}$ 118.48) in 20 ml of methylcyclohexane was injected by syringe into 100 ml of methylcyclohexane at 50° under a nitrogen atmosphere in the dark. Removal of solvent under vacuum after 1 hr gave 0.935 g (quantitative yield) of 1-carbomethoxy-1-methyl-2,2-diphenylcyclopropane, mp 115–117°, $[\alpha]_{Hg}^{24}$ −64.06 ± 0.25° (1%, $HCCl_3$). This represents an optical purity of 73.5%. Ir and NMR are essentially identical with that of pure diastereomer reported earlier. Repeat of this run gave $[\alpha]_{Hg}^{24}$ −63.94 ± 0.25° (1%, $HCCl_3$). To check these results the ester was reduced with excess lithium aluminum hydride in ether reflux for 3 hr. Hydrolysis with saturated ammonium chloride solution, dilution with water, and extraction with ether gave a mixture of 1-menthol and 1-hydroxylmethyl-1-methyl-2,2-diphenylcyclopropane. Treatment of this mixture with excess *N*-bis(trimethylsilyl)acetamide in hexane at room temperature followed by gas–liquid chromatography with a 0.25 in. × 4 ft 20% SE-30 on 60/80 Chromosorb P at 190° gave 1-methyl-1-trimethylsiloxymethyl-2,2-diphenylcyclopropane in approximately 80% yield overall: ir (CCl_4) 3100 (m), 3000 (m), 2900 (m), 1600 (w), 1495 (m), 1443 (m), 1248 (s), 1100 (m), 1078 (s), 880 (s), 846 (s), 707 (s), 696 cm^{-1} (m); NMR (CCl_4) δ 0.0 (s, 9 H), 1.0 (s, 3 H), 1.09 (dd, 2 H), 3.16 (dd, 2 H), 7.0 (m, 10 H). Hydrolysis of this material by refluxing in methanol–water with a catalytic amount of potassium hydroxide followed by dilution with water and extraction with ether gave a quantitative yield of 1-hydroxymethyl-1-methyl-2,2-diphenylcyclopropane, mp 101–103°, $[\alpha]_{Hg}^{23}$ −32.13 ± 0.12° (2%, $HCCl_3$). Alcohol prepared from optically pure acid has a rotation of $[\alpha]_{Hg}^{24}$ −45.54 ± 0.12° (2%, $HCCl_3$) and this represents an optical purity of 70.3%. Ir and NMR are identical with those of authentic alcohol. This material was shown not to racemize under these conditions.

Pyrolysis in *N,N*-Dimethylformamide. The same procedure was used as above. Two runs gave ester of $[\alpha]_{Hg}^{23}$ −64.00 ± 0.25° (1%, $HCCl_3$), mp 114–117°. Conversion of one run to 1-hydroxymethyl-1-methyl-2,2-diphenylcyclopropane gave $[\alpha]_{Hg}$ −31.60 ± 0.12° (25%, $HCCl_3$). This represents an optical purity of 69.3%. Ir and NMR are identical with those of authentic materials.

Photolysis of Purified 1-Pyrazoline. The equipment for these experiments was a Pyrex reactor with a glass frit gas inlet at the base and fitted with a water-jacketed Pyrex probe into which a 450-W Hanovia high-pressure mercury lamp was inserted. Nitrogen gas, which was prepurified and bubbled through a solution of benzophenone ketyl, was passed through a solution of 0.50 g (0.0012 mol) of 3-carbomenthoxy-3-methyl-5,5-diphenyl-1-pyrazoline in 120 ml of purified methylcyclohexane at −3° for 1 hr. Irradiation for 9 hr gave nearly complete reaction as indicated by the disappearance of N=N absorbance at 330 mμ. Evaporation of the solvent in vacuo left behind 0.3859 g of white solid. Thin layer chromatography on a 1 mm × 20 cm × 40 cm silica gel plate gave four bands which were isolated. In increasing order of R_f band 3 gave 0.3148 g of 1-carbomenthoxy-1-methyl-2,2-diphenylcyclopropane, mp 116–118°, $[\alpha]_{Hg}^{24}$ −65.72 ± 0.25° (1%, $HCCl_3$). This represents an optical purity of 93.8%. Ir and NMR are identical with those of pure diastereomeric ester. Band 4 consisted of 0.0245 g of colorless liquid identified by ir and NMR as 1,1-diphenylethylene. Ester accounts for 79.1% of starting pyrazoline and 1,1-diphenylethylene accounts for 13.3%. The remaining products were not identified.

A repeat of this experiment with 0.51 g of 3-carbomenthoxy-3-methyl-5,5-diphenyl-1-pyrazoline in 150 ml of methylcyclohexane irradiating for 3 hr gave 1-carbomenthoxy-1-methyl-2,2-diphenylcyclopropane (0.2791 g): $[\alpha]_{Hg}^{24}$ −65.42 ± 0.25° (1%, $HCCl_3$); optical purity 90.4%; mp 117–118°; major side product was 1,1-diphenylethylene.

Registry No.—(+)-(*S*)-**1**, 55124-19-1; (−)-(*S*)-**2**, 55124-20-4; (−)-(*S*-**3**, 55124-21-5; (±)-**4**, 55124-22-6; (−)-(*R*)-**4**, 55156-06-4; (+)-(*S*)-**4**, 55156-07-5; (±)-**5**, 55124-23-7; (*R*)-**5**, 55124-24-8; (−)-

(*R*)-**6**, 55124-25-9; (±)-**7**, 55124-26-0; (−)-(*S*)-**7**, 55156-08-6; (±)-**8**, 55124-27-1; (−)-(*S*)-**8**, 55156-09-7; (±)-**9**, 55124-28-2; (−)-(*R*)-**9**, 55156-10-0; 2,2-diphenylethanol, 614-29-9; 2,2-diphenylacetic acid, 117-34-0; 2,2-diphenylethyl toluenesulfonate, 6944-27-0; *p*-toluenesulfonyl chloride, 98-59-9; diethyl (2,2-diphenylethyl)methylmalonate, 55124-29-3; diethyl methylmalonate, 609-08-5; ethyl (±)-2-isocyanato-2-methyl-4,4-diphenylbutanoate, 55124-30-6; (±)-2-amino-2-methyl-4,4-diphenylbutanoic acid, 55124-31-7; (±)-2-amino-2-methyl-4,4-diphenylbutanoic acid hydrochloride, 55124-32-8; (−)-menthyl methacrylate, 2231-91-6; methacrylic acid, 79-41-4; phosphorus trichloride, 7719-12-2; methacrylyl chloride, 920-46-7; (−)-*l*-menthol, 2216-51-5; (±)-1-methyl-2,2-diphenylcyclopropanecarboxylic acid, 35389-12-9; (*R*)-1-methyl-2,2-diphenylcyclopropanecarboxylic acid, 4542-84-1; (*R*)-1-methyl-1-trimethylsiloxymethyl-2,2-diphenylcyclopropane, 55124-33-9.

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Synthesis of Stereoisomeric 4-Hydroxymethyl-4-methyl-3β-hydroxycholestanes, -androstanes, and -10-methyl-*trans*-decalins

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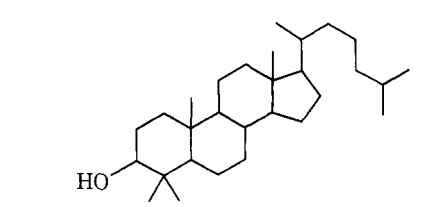
Received January 17, 1975

Reductive carbomethoxylation of enones **8**, **9**, and **10** was used as the key step in the preparation of 3β-hydroxycholestanes, 3β-hydroxyandrostanes, and 3β-hydroxy-10β-methyl-*trans*-decalins with 4α-hydroxymethyl-4β-methyl and 4β-hydroxymethyl-4α-methyl substituents (compounds **2**–**7**). Alkylation of the β-keto esters (**11**–**13**) resulting from reductive carbomethoxylations of enones **8**–**10** led to both 4β- and 4α-methyl compounds with the 4β isomer as the major product (~55%) in each case. Stereochemical assignments were made principally on the basis of the shielding effect that a 4β-carbomethoxyl group has on the NMR signal of the 10β-methyl group. Reduction of the methylated β-keto esters led to diols **2**–**7**, which were desired for study as possible intermediates in enzymic oxidative demethylation.

As part of a study of oxidative demethylation at C-4 during steroid biosynthesis,[1-3] we required derivatives of 4,4-dimethylcholestan-3β-ol (**1**) with the 4α or 4β methyl group in various stages of oxidation, particularly 4α-hydroxymethyl and 4β-hydroxymethyl compounds **2** and **3**.[1] The analogous derivatives **4** and **5** in the androstane series and **6** and **7** in the 10-methyl-*trans*-decalin[4] series were also needed for studies intended to determine the effect which substrate truncation would have on the enzymic demethylation process.[5] In this paper the details of the syntheses of these six diols and several related compounds are described.

Scheme I shows the pathway used for preparation of each of the three sets of diols. The same approach had been used previously for the synthesis of naturally occurring di-



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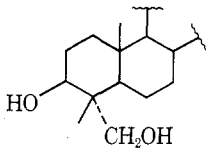

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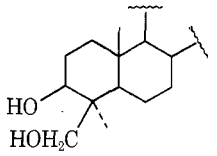

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