g.) was pyrolyzed by the same method as its isomer. Decomposition of this xanthate did not set in until a temperature of 145° was reached. The distillate (6.75 g.) was crystallized from pentane, and the crystals obtained were recrystallized from pentane. By carrying through second crops, a total of 5.03 g. of *cis*-α-methylstilbene was obtained (65% yield), m.p. 47–48° (lit.[10] 48°).

Anal. Calcd. for $C_{15}H_{14}$: C, 92.74; H, 7.26. Found: C, 92.75; H, 7.23.

From the combined filtrates was isolated by distillation 1.65 g. of a yellow oil. This oil (1.4 g.) was heated with hydrobromic acid (1 ml. of 48%) and 50 ml. of glacial acetic acid for two hours at 100° and the resulting mixture was poured onto ice. From the oil that separated only 0.15 g. of *trans*-α-methylstilbene was isolated. The rest of the material was probably some sulfur-containing compound.

Since *cis*-olefin can be readily converted to the *trans* isomer by the above procedure,[10] this experiment demonstrates that the yellow oil contained only minor amounts of either *cis*- or *trans*-olefin.

The dibromide of *cis*-α-methylstilbene was prepared in the usual way (45% yield), m.p. 132–133° (dec.), m.p. with dibromide from the *trans*-olefin, 119–131°.

Anal. Calcd. for $C_{15}H_{14}Br_2$: C, 50.88; H, 3.99. Found: C, 50.86; H, 4.16.

LOS ANGELES, CALIF.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES]

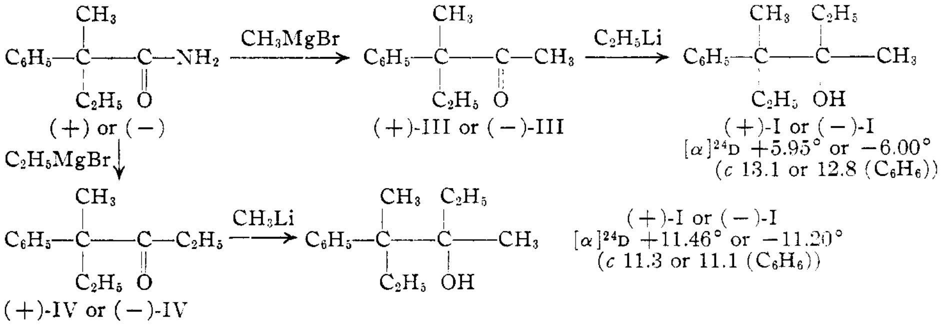
Studies in Stereochemistry. XI. The Preparation and Complete Resolution of the 3,4-Dimethyl-4-phenyl-3-hexanol System

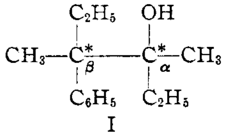
BY DONALD J. CRAM AND JACK D. KNIGHT

RECEIVED MARCH 12, 1952

Optically pure (+)- and (−)-methylethylphenylacetic acids were converted through their respective amides to the corresponding (+)- and (−)-3-methyl-3-phenyl-2-pentanones and (+)- and (−)-4-methyl-4-phenyl-3-hexanones. The addition of ethyl lithium to each of the methyl ketones gave carbinol in which one diastereomer predominated whereas the addition of methyl lithium to each of the ethyl ketones gave carbinol in which the other diastereomer predominated. All four isomers of 3,4-dimethyl-4-phenyl-3-hexanol as well as their *p*-bromobenzoates were isolated in optically pure state. Correlations of the configurations of these substances with their rotations and modes of preparation are made.

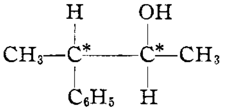
A considerable amount of interest has developed recently in the resolution of optically active tertiary alcohols for purposes of studying the stereochemistry and mechanism of the S_N1 reaction.[1,2] A number of other investigations of the effect of steric and electronic factors on the course of the solvolysis and rearrangement reactions in sterically strained tertiary systems have also been reported.[3] The 3,4-dimethyl-4-phenyl-3-hexanol system (I) combines the feature of asymmetry with that of steric strain at the two reactive centers (C_α and C_β) of this molecule. Moreover, this quaternary–tertiary system (I) is somewhat analogous to the tertiary–secondary 3-phenyl-2-butanol system (II), whose symmetry properties proved valuable in the study of the Wagner–Meerwein,[4] substitution[4] and elimination reactions.[5] This paper reports the preparation, resolution and characterization of I, and Paper XII in this series reports the results of the solvolysis of esters of this carbinol.





$$CH_3-\overset{C_2H_5}{\underset{C_6H_5}{\overset{*}{C}_\beta}}-\overset{OH}{\underset{C_2H_5}{\overset{*}{C}_\alpha}}-CH_3$$

I



$$CH_3-\overset{H}{\underset{C_6H_5}{\overset{*}{C}}}-\overset{OH}{\underset{H}{\overset{*}{C}}}-CH_3$$

II

Results

Methylethylphenylacetic acid[2] was resolved into its two optical antipodes, the (+)-isomer being separated as its brucine salt and the (−)-isomer as its quinine salt. Table I reports the rotations, physical properties and analyses of these acids as well as the other intermediates in the synthesis.[6,7] The amides of the (+)- and (−)-acids were each

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[1] (a) W. Doering and H. Zeiss, THIS JOURNAL, **72**, 147 (1950), Abstracts of Meeting of the American Chemical Society, Philadelphia, Pa., April, 1950, p. 7L. (b) H. Zeiss, Abstracts of Meeting of the American Chemical Society, Chicago, Ill., Sept., 1950, p. 50N; (c) H. Zeiss, THIS JOURNAL, **73**, 2391 (1951); (d) E. Hughes, C. Ingold, R. Martin and D. Meigh, *Nature*, **166**, 679 (1950).

[2] Probably the first tertiary system to be prepared in an optically active state is the methylethylbenzylcarbinyl chloride of E. Wallis and P. Bowman, *J. Org. Chem.*, **1**, 383 (1936).

[3] (a) P. D. Bartlett and A. Schneider, THIS JOURNAL, **67**, 141 (1945), and P. D. Bartlett, *Bull. soc. chim. France*, **18**, 100C (1951); (b) H. C. Brown and R. Fletcher, THIS JOURNAL, **71**, 1845 (1949); (c) F. Brown, T. Davis, I. Dostrovsky, O. Evans and E. Hughes, *Nature*, **167**, 987 (1951).

[4] D. J. Cram, THIS JOURNAL, **71**, 3863, 3875 (1949); **74**, 2129, 2159 (1952).

[5] D. J. Cram, *ibid.*, **71**, 3871 (1949); *ibid.*, **74**, 2149, 2152 (1952).

[6] E. Wallis and P. Bowman (ref. 2) prepared the (−)-isomer of this substance ($[\alpha]^{20}D$ −23.28°, benzene) but apparently did not obtain optically pure material.

[7] Evidence for the optical purity of all the active compounds reported in Table I is found in the facts that the magnitudes of the rotations of enantiomorphically related materials are in each case almost equivalent, and that samples of the same materials prepared in different runs had the same rotations.

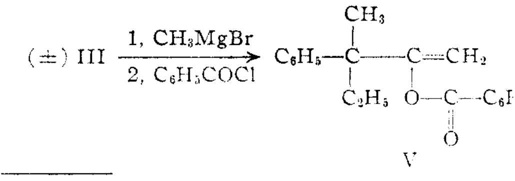
TABLE I

THE PHYSICAL PROPERTIES AND ANALYSES OF COMPOUNDS INVOLVED IN THE SYNTHESIS OF THE 3,4-DIMETHYL-4-PHENYL-3-HEXANOL SYSTEM

Compound	M.p., °C.	B.p., °C.	Specific rotation			Mol. form	Carbon, %		Hydrogen, %	
			$[\alpha]_D$	Temp., °C.	c (benz.)		Calcd.	Found	Calcd.	Found
Methylethylphenylacetic acid										
Racemic	56–57	138–140 (3.5 mm.)	.....	..	.....	$C_{11}H_{14}O_2$	74.13	74.10	7.92	7.79
+	86–87[a]	....	+30.2°	23	4.5	$C_{11}H_{14}O_2$	74.13	74.18	7.92	8.20
−	86–87[a]	....	−30.0	23	4.8	....	...	...	..	..
Methylethylphenylacetamide										
Racemic	77[b]	....	.....	..	.....	$C_{11}H_{15}ON$	74.54	74.82	8.53	8.42
+	72–73	....	+18.7	25	4.1	$C_{11}H_{15}ON$	74.54	74.49	8.53	8.22
−	72–73[c]	....	−18.3	25	4.0	$C_{11}H_{15}ON$	74.54	74.72	8.53	8.84
3-Methyl-3-phenyl-2-pentanone										
Racemic[d]	....	149–151 (73 mm.)	.....	..	.....	$C_{12}H_{16}O$	81.75	81.74	9.15	9.38
+[e]	....	149–152 (72 mm.)	+70.0	23	Homog.	$C_{12}H_{16}O$	81.75	81.60	9.15	9.03
−[f]	....	149–153 (73 mm.)	−70.3	23	Homog.	$C_{12}H_{16}O$	81.75	81.67	9.15	9.19
4-Methyl-4-phenyl-3-hexanone										
Racemic[g]	....	159–161 (55 mm.)	.....	..	.....	$C_{13}H_{18}O$	82.06	82.12	9.53	9.80
+[h]	....	....	+73.7	23	Homog.	$C_{13}H_{18}O$	82.06	81.77	9.53	9.76
−[i]	....	....	−73.5	23	Homog.	$C_{13}H_{18}O$	82.06	81.87	9.53	9.53
3,4-Dimethyl-4-phenyl-3-hexanol										
threo + *erythro*[j]	....	108–109 (2 mm.)	.....	..	.....	$C_{14}H_{22}O$	81.49	81.68	10.75	10.52
(+)-*threo*	....	....	+12.30	23	11.8	$C_{14}H_{22}O$	81.49	81.20	10.75	10.76
(−)-*threo*	....	....	−12.45	22	12.1	$C_{14}H_{22}O$	81.49	81.45	10.75	10.99
(+)-*erythro*	32–34	....	+ 3.23	24	12.1	$C_{14}H_{22}O$	81.49	81.45	10.75	10.78
(−)-*erythro*[k]	32–34	....	− 3.34	24	12.2	$C_{14}H_{22}O$	81.49	81.44	10.75	10.78
3,4-Dimethyl-4-phenyl-3-hexyl *p*-bromobenzoate										
(+)-threo	62–63	....	+52.5	23	3.9	$C_{21}H_{25}O_2Br$	64.79	64.44	6.47	6.52
(−)-*threo*	63–64	....	−52.2	23	4.0	$C_{21}H_{25}O_2Br$	64.79	64.75	6.47	6.55
(+)-*erythro*	89–90	....	+13.3	23	9.1	$C_{21}H_{25}O_2Br$	64.79	64.49	6.47	6.51
(−)-*erythro*	90–91	....	−12.8	23	10.0	$C_{21}H_{25}O_2Br$	64.79	64.80	6.47	6.67

[a] The melting point varied somewhat with the rate of heating. For value recorded, 1 deg./min. was employed. [b] J. Blondeaux [*Ann. chim.*, [10] 2, 5 (1924)] reported m.p., 74°. [c] E. Wallis and P. Bowman (ref. 2) reported m.p. 64.0–64.6° and $[\alpha]^{20}{}_{5893}$ −14.9° (benzene) for this amide. [d] $n^{25}\mathrm{D}$ 1.5081; $d^{25}{}_4$ 0.9715; *MR* calcd. 54.30, found 54.09. [e] $n^{25}\mathrm{D}$ 1.5081. [f] $n^{25}\mathrm{D}$ 1.5081. [g] $n^{25}\mathrm{D}$ 1.5059; $d^{25}{}_4$ 0.9616; *MR* calcd. 58.93, found 58.75. [h] $n^{25}\mathrm{D}$ 1.5045. [i] $n^{25}\mathrm{D}$ 1.5048. [j] $n^{25}\mathrm{D}$ 1.5209; $d^{25}{}_4$ 0.9634; *MR* calcd. 65.14, found 65.21. This material was prepared by the addition of methyl lithium to 4-methyl-4-phenyl-3-hexanone. [k] $n^{25}\mathrm{D}$ 1.5211.

submitted to the action of methyl magnesium bromide to give the (+)- and (−)-3-methyl-3-phenyl-2-pentanones (III), and to the action of ethylmagnesium bromide to give the (+)- and (−)-4-methyl-4-phenyl-3-hexanones (IV),[8] respectively. Although these ketones are too hindered to form the usual derivatives, the benzoyl derivative of racemic III was prepared by first treating the ketone with methylmagnesium bromide followed by benzoyl chloride. The resulting product probably possesses the enolate-ester structure (V) rather than the 1,3-diketone structure since the substance did not give any color tests characteristic of the latter class of compound.



$$(\pm)\ \text{III} \xrightarrow[2,\ C_6H_5COCl]{1,\ CH_3MgBr} C_6H_5-C(CH_3)(C_2H_5)-C(=CH_2)-O-C(=O)-C_6H_5$$

V

The (+)- and (−)-isomers of ketone III were treated with ethyl lithium in pentane to produce dextro- and levorotating mixtures, respectively, of 3,4-dimethyl-4-phenyl-3-hexanol (I). Similarly, the (+)- and (−)-isomers of ketone IV gave dextro- and levorotating mixtures of I, respectively, when mixed with methyl lithium. When these reactions were conducted at room temperature, less than half of the ketone was converted to carbinol, the enolization reaction predominating. At lower temperatures, however, the addition reaction predominated,[9] and good yields of carbinol could be obtained by recycling the reaction mixture once. Since a new asymmetric center was created in these reactions, mixtures of two diasteromers were produced, and the large differences in the magnitudes of the rotations of the mixtures obtained from the ketones of different structure suggest that the balance of the two diastereomers in the products vary widely depending on which alkyl group (methyl or ethyl) is introduced last into the molecule. Table II records the rotations of the diastereomeric mixtures obtained by each route as well as

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[8] P. Ramart-Lucas, M. Laclotre and A. Anagnostopoilus [*Compt. rend.*, **185**, 282 (1927)] reported that the reaction of the amide with phenylmagnesium bromide only produced methylethylphenylacetonitrile. In the present investigation the nitrile was once isolated when the reaction was run for insufficient time

[9] The use of a lower temperature was suggested by P. D. Bartlett, private communication.

TABLE II

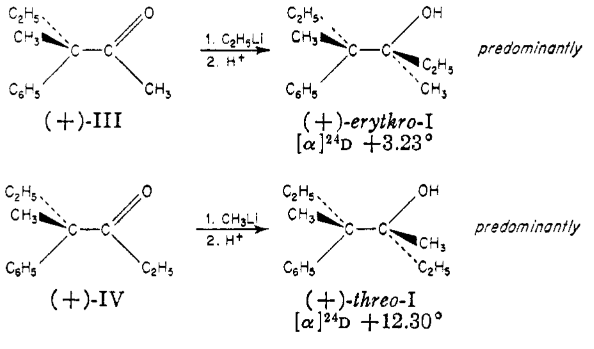
PROPERTIES OF THE DIASTEROMERIC MIXTURES OF I PREPARED BY DIFFERENT METHODS

Source	$n^{25}D$	$[\alpha]^{24}D$	c (C_6H_5)	Composition estim. from $[\alpha]D$ *threo*, %	Composition estim. from $[\alpha]D$ *erythro*, %	Composition correct. to known mixt. % *threo*/% *erythro*
(+)-Methyl ketone (III)	1.5209	+ 5.95°	13.1	30	70	0.51
(−)-Methyl ketone (III)	1.5208	− 6.00	12.8	29	71	.53
(+)-Ethyl ketone (IV)	1.5209	+11.46	11.3	91	09	4.5
(−)-Ethyl ketone (IV)	1.5210	−11.20	11.1	89	11	4.0
35% (−)-*threo*, 65% (−)-*erythro*	....	− 6.11	13.2	30	70	..
80% (+)-*threo*, 20% (+)-*erythro*	....	+11.26	11.7	89	11	..

the rotations of known synthetic mixtures prepared from pure carbinols whose compositions approximate those of the unknown mixtures. Utilizing these values, estimates of the composition of the unknown mixtures can be made (see Table II).

One of the diastereomers produced by the addition of ethyl lithium to the (−)-methyl ketone (III) crystallized with difficulty from the carbinol mixture. The other isomers were isolated through the use of their *p*-bromobenzoate derivatives, the mixtures of diastereomeric esters being separated by fractional crystallization. These esters were prepared by treating the potassium alcoholate[10] with *p*-bromobenzoic anhydride,[11] and the pure isomeric alcohols were recovered by reduction of these esters with lithium aluminum hydride. Figure 1 records the infrared absorption spectra of the (−)-*threo*- and (−)-*erythro*-isomers.

The Relative Configurations of the Diastereomeric Alcohols.—The stereospecificity observed in the preparations of I from the two ketones (III and IV) allows an application of the "rule of steric control of asymmetric induction"[12] to the 3,4-dimethyl-4-phenyl-3-hexanol system.[13] The rule predicts that the *erythro* diastereomer predominates when ethyl lithium is added to ketone III and the *threo* diastereomer predominates when methyl lithium is added to IV. Support is given to this tentative assignment of configuration by the fact that the magnitudes of the rotations of the members of the *threo* series are higher than those of the *erythro* series, a relationship observed in the 3-phenyl-2-butanol system (II)[4] whose symmetry properties are analogous to those of I. This assignment has also proved to be compatible with the stereochemistry of the Wagner–Meerwein rearrangements that occur in system I (see paper XII of this series).



(+)-III

(+)-*erythro*-I $[\alpha]^{24}D$ +3.23°

(+)-IV

(+)-*threo*-I $[\alpha]^{24}D$ +12.30°

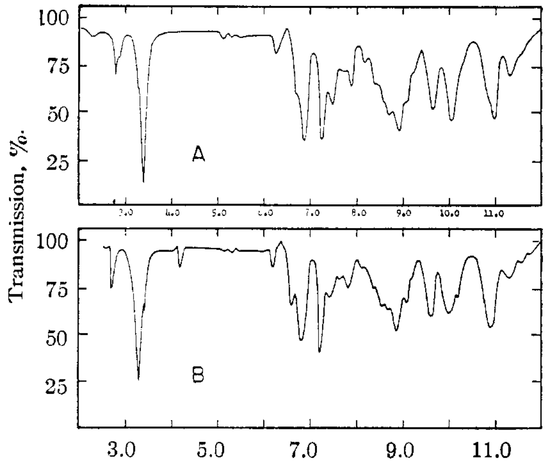


Fig. 1.—Infrared absorption spectra of diastereomeric 3,4-dimethyl-4-phenyl-3-hexanols: 10% solutions in CCl_4, Na prism, Beckman spectrophotometer (model I.R.2T). Curve A, (−)-*erythro* isomer; curve B, (−)-*threo* isomer.

Experimental Part

Preparation and Resolution of Methylethylphenylacetic Acid.—This procedure is a modification of that employed by Wallis and Bowman.[2] From 1200 g. of acetophenone was prepared 1325 g. of methyl methylethylphenylcarbinyl ether, b.p. 55–56° (2 mm.), $n^{25}D$ 1.4999. Under an atmosphere of dry nitrogen, 400 g. of this ether was added to a vigorously stirred mixture of 268 ml. of sodium–potassium alloy (density = 0.86 g./ml. at 25°) and three liters of dry ether. After the addition (four hours) the mixture was allowed to stand ten hours at reflux temperature, after which dry carbon dioxide was passed into the mixture until the red color was discharged (30 minutes). The resulting mixture was hydrolyzed by first adding to it methanol and finally an excess of water. The aqueous phase was separated, acidified and the resulting organic layer was extracted with ether. The ether extracts were dried, the solvent was distilled and the resulting oil was distilled to give 307 g. (72% yield) of methylethylphenylacetic acid, b.p. 138–140° (3.5 mm.), m.p. 56.5–57.5°.

Quinine (1180 g.) and racemic acid (910 g.) were dissolved in four liters of ethanol, and water was added until the solution was almost turbid. Upon cooling, the solution deposited the quinine salt which after four recrystallizations and conversion to the acid gave 138 g. of pure (−)-product. The acid rich in the (+)-isomer was recovered from the filtrates and mixed with 1100 g. of anhydrous brucine and four liters of hot acetone. Upon cooling the solution deposited crystals which after ten recrystallizations gave salt that yielded 112 g. of pure (+)-acid. Repetition of the above scheme with acid recovered from the filtrates gave a total 286 g. of pure (−)-acid, 193 g. of pure (+)-acid, and 298 g. of acid, $[\alpha]^{23}D$ +8.2° (benzene, c 4.2).

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[10] The alcohol does not react with sodium or potassium but does react slowly with Na-K alloy.

[11] The acid phthalates of tertiary alcohols have been prepared successfully (ref. 1a and 1c) by treatment of the potassium alcoholate with phthalic anhydride.

[12] D. J. Cram and F. A. Abd Elhafez, THIS JOURNAL, **74**, 5828 (1952).

[13] In ketones III and IV, the groups on the β-C when arranged in order of decreasing bulk are C_6H_5 > C_2H_5 > CH_3.

Methylethylphenylacetamide.—To a solution of 20 g. of racemic acid and two drops of dry pyridine in 200 ml. of dry ether was added 20 ml. of thionyl chloride. The solution was allowed to stand at room temperature for 48 hours, after which time the solvent and excess thionyl chloride were removed by distillation. Without further purification the crude acid chloride was dissolved in 50 ml. of dry benzene and added to a mixture of ice and excess concentrated ammonia. The benzene layer was then separated, the solvent was removed, and the product was recrystallized from an ether–pentane mixture, wt. 14 g. (71%), m.p. 75–76°. Three recrystallizations from an ether–pentane mixture raised the m.p. to 77°. From 55 g. of the (–)-acid was obtained 38.4 g. of (–)-amide, and from 55 g. of the (+)-acid was produced 37.3 g. of the (+)-amide.

3-Methyl-3-phenyl-2-pentanone (III).—To a Grignard reagent (prepared from 24 g. of magnesium and excess methyl bromide) in 700 ml. of dry benzene was added 26 g. of the crude racemic amide. After the initial reaction had subsided, the reaction mixture was allowed to reflux under an atmosphere of dry nitrogen for 96 hours, after which time the mixture was hydrolyzed by pouring into cold 6 *N* sulfuric acid. After standing two days, the organic layer was separated and washed successively with dilute sodium hydroxide and water. After removing the solvent, the residue was distilled and the product was collected, b.p. 149–151° (73 mm.), weight 18.66 g. (74%).

A benzoyl derivative of this ketone was prepared by the following procedure. An ethereal solution containing 0.7 g. of racemic 3-methyl-3-phenyl-2-pentanone was added to an equimolar amount of methylmagnesium bromide in 50 ml. of dry ether, and the mixture was allowed to reflux for 20 minutes. A solution of 0.7 ml. of benzoyl chloride in 10 ml. of dry ether was then added, and the reaction mixture was allowed to reflux for three hours, after which time it was decomposed with 2 *N* sulfuric acid. The ether layer was washed with water, dried, and the solvent was removed to leave a white solid. After two crystallizations from an ether–pentane mixture, 0.17 g. of white needles were isolated, m.p. 135–136°. This solid gave a negative ferric chloride test and would not form a *p*-nitrophenylhydrazone.

Anal. Calcd. for $C_{19}H_{20}O_2$: C, 81.39; H, 7.19. Found: C, 81.11; H, 7.10.

By an analogous procedure, 38.4 g. of (–)-methylethylphenylacetamide gave 32.1 g. (83% yield) of (–)-ketone, and 37.3 g. of (+)-amide gave 25.67 g. (69% yield) of (+)-ketone.

4-Methyl-4-phenyl-3-hexanone (IV).—To an ethyl Grignard reagent (prepared from 9.6 g. of magnesium) in 300 ml. of dry benzene was added 11.0 g. of crude racemic methylethylphenylacetamide. After the initial reaction had subsided the reaction mixture was allowed to reflux under dry nitrogen for 100 hours, after which time the mixture was worked up as before (see previous procedure), wt. 10.1 g. (86%).

In a similar manner, 204 g. of (–)-methylethylphenylacetic acid (the amide intermediate was not isolated) gave 158 g. (72% yield based on acid) of (–)-ketone, and 120 g. of (+)-acid gave 99.7 g. (77% yield based on acid) of (+)-ketone.

3,4-Dimethyl-4-phenyl-3-hexanol (I) **from 4-Methyl-4-phenyl-3-hexanone.**—To an excess of methyl lithium (7 moles) dissolved in five liters of dry ether (the solution had been filtered) was added 145 g. of racemic 4-methyl-4-phenyl-3-hexanone. The addition was carried out under nitrogen and was accompanied by an evolution of gas. After the addition was complete the reaction mixture was stirred overnight, and decomposed by adding water. The solvent was removed from the dried ethereal layer and the resulting residue was distilled into two fractions on a fifty-plate center-rod column at 2 mm. The first fraction (81 g.) contained considerable unreacted ketone, while the second fraction was almost pure product. Redistillation of the second fraction afforded analytically pure product, wt. 42 g. By recycling the first fraction with methyl lithium three times (the ketone and alcohol were not separated until the end), an additional 75 g. of pure carbinol was obtained (total of 75% yield).

By a procedure the same as above except that the reaction product was recycled three times without separating ketone and alcohol, 32 g. of (–)-ketone produced 21 g. of carbinol. When 67 g. of (+)-ketone was added to the alkyl lithium solution at 0° and the product was not recycled, 49 g. of alcohol was isolated. The absence of ketonic impurities in these alcohol preparations was demonstrated by the absence of a carbonyl band in the infrared spectra of the substances.

3,4-Dimethyl-4-phenyl-3-hexanol (I) **from 3-Methyl-3-phenyl-2-pentanone** (III).—To a filtered (under nitrogen) solution of ethyl lithium (prepared from 20 g. of lithium) in two liters of dry pentane was added under nitrogen 26 g. of (–)-3-methyl-3-phenyl-2-pentanone. The reaction mixture was decomposed with water, the organic layer was dried, and the ether was removed. The resulting oil was again added to an excess of ethyl lithium. In this manner, the ketone was treated with ethyl lithium four times to give (after fractional distillation) 15.6 g. of alcohol, which partially solidified upon standing at 0° for five days. By systematic crystallization and recrystallization of the solid from pentane at –80°, 2.98 g. of (–)-*erythro*-I was isolated, m.p. 32–34°, $[\alpha]^{24}\text{D}$ –3.34° (benzene, *c* 12.2).

In a similar manner (except that the ketone was not recycled), 25 g. of (+)-ketone-(III) afforded 7.0 g. of carbinol (I). This material could not be induced to crystallize until seeded with crystalline (+)-*erythro*-I. The absence of ketonic impurities in these alcohol preparations was demonstrated by the absence of a carbonyl band in the infrared spectra of the substances.

Preparation of the Four Isomeric *p*-Bromobenzoates of 3,4-Dimethyl-4-phenyl-3-hexanol.—The following procedure was conducted under dry, pure nitrogen. To 500 ml. of dry benzene stirred in a flask whose floor consisted of a sintered glass plate (the solution was held in place by a positive pressure from below) was added 16 ml. of sodium–potassium alloy (density, 0.86 g./ml. at 25°). Tertiary alcohol (21.9 g., $[\alpha]^{24}\text{D}$ +11.26°, prepared from (+)-III) was then added and the mixture was stirred for five hours (continued stirring results in decreased yields). The light yellow solution was then allowed to pass through the sintered glass plate into a lower flask fitted with a stirrer. To the clear stirred solution was added rapidly 10.0 g. of pure *p*-bromobenzoic anhydride (m.p. 220°). The reaction mixture was cooled to 0° before and after the anhydride was added. The mixture was stirred for three hours, the solid was filtered and washed with dry benzene. The combined filtrates were washed with dilute sodium bicarbonate, dried over potassium carbonate, and the solvent was removed by distillation at reduced pressure to yield 33 g. of a brown oil. When dissolved in pentane and cooled to –80° this material crystallized, and ten recrystallizations from pentane of the solid produced 3.2 g. of pure ester of (+)-*erythro*-I.

When cautiously heated at 100° (0.3 mm.), the oil from the bottom filtrates of the above fractional crystallization produced 8.0 g. of recovered I. The pot residue crystallized when dissolved in pentane and cooled to –80°, and fractional crystallization of this material from pentane (about twenty stages were needed) at –80° yielded 1.9 g. of white needles of pure ester of (+)-*threo*-I.

In a similar manner, 36.3 g. of I ($[\alpha]^{24}\text{D}$ –11.20°) gave 61.0 g. of a brown oil from which was obtained 8.2 g. of the pure ester of (–)-*erythro*-I. From the bottom filtrates was obtained 6.3 g. of the pure ester of (–)-*threo*-I. The properties of these compounds are recorded in Table I.

Preparation of the Four Isomeric 3,4-Dimethyl-4-phenyl-3-hexanols (I) by Reduction of Their *p*-Bromobenzoates.—To 1.0 g. of the *p*-bromobenzoate of (+)-*erythro*-3,4-dimethyl-4-phenyl-3-hexanol (I) in 25 ml. of dry ether was added excess lithium aluminum hydride, and the mixture was allowed to reflux for one hour. The excess lithium aluminum hydride was destroyed by adding water. The organic layer was washed with water, dried, and the solvent was removed. When a pentane solution of the residue was cooled, most of the *p*-bromobenzyl alcohol separated in needles and was removed by filtration. The filtrate was dissolved in pentane and adsorbed on 4.0 g. of activated alumina. Elution of the column with pentane afforded 380 mg. of an oil that crystallized when cooled. Recrystallization of this solid from pentane produced 100 mg. of pure (+)-*erythro*-I, m.p. 32–34°.

A similar reduction of 1.0 g. of the *p*-bromobenzoate of (+)-*threo*-I, afforded 0.30 g. of pure (+)-*threo*-I. From 0.35 g. of the ester of (–)-*erythro*-I was obtained 100 mg. of pure (–)-*erythro*-I, m.p. 32–34°, not depressed by admixture with the sample of (–)-*erythro*-I obtained by direct crystallization of the original alcohol mixture. Similarly, 1.0 g. of (–)-*threo*-ester gave 430 mg. of (–)-*threo*-I.

LOS ANGELES, CALIFORNIA