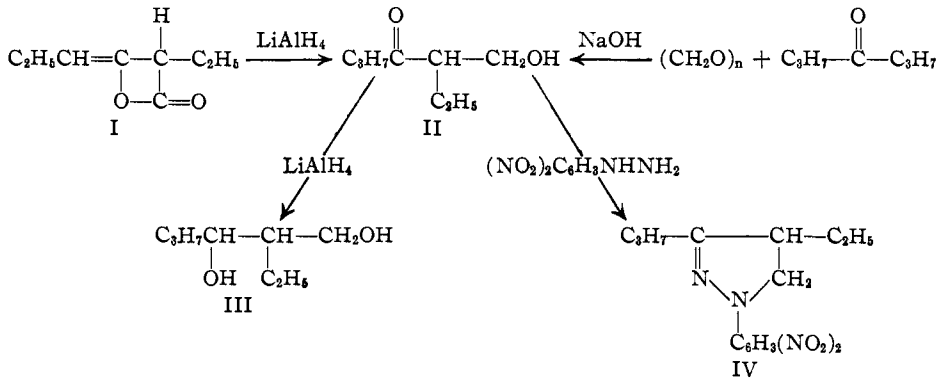
In this Laboratory it has been found that the lithium aluminum hydride reduction of ethylketene dimer (I) produced 3-(hydroxymethyl)-4-heptanone (II) in 55% yield. This result is consistent with the β,γ-unsaturated β-lactone structure for the dimers, but not with the 1,3-cyclobutanedione or acyl ketene structures.[3]

To identify II, it was reduced with lithium aluminum hydride. A high yield of 2-ethyl-1,3-hexanediol (III) was obtained; however, this is not an unequivocal proof of the identity of II. Therefore excess di-*n*-propyl ketone was condensed with paraformaldehyde in the presence of a small amount of methanolic sodium hydroxide, a general procedure stated to give monomethylol ketones.[4] The product was shown to be identical with II.



Experimental

Ethylketene Dimer (I).—The preparation was carried out as described by Sauer.[5] Eighty grams (0.75 mole) of butyryl chloride was dehydrohalogenated with 78 g. (0.77 mole) of triethylamine. A 65% yield of product (34.2 g.) was collected at 92–95° (31 mm.), $n^{24}D$ 1.4385.

Preparation of 3-(Hydroxymethyl)-4-heptanone (II) by **Lithium Aluminum Hydride Reduction of Ethylketene Dimer.**—The reaction was carried out in a 3-necked flask equipped with a gas inlet and dropping funnel, a ground-glass sealed stirrer and a condenser protected with a drying tube. The apparatus was dried several hours in a 125° oven before use. Powdered lithium aluminum hydride (3.0 g., 0.079 mole) was dissolved in 200 ml. of anhydrous ether. With a slow stream of nitrogen flowing through the apparatus, 14.0 g. (0.10 mole) of ethylketene dimer dissolved in 30 ml. of anhydrous ether was added dropwise. The mixture refluxed during the addition. Stirring was continued for an additional 30 minutes. The mixture was cooled with ice and cautiously hydrolyzed by slowly adding 15 ml. of methanol. Then 180 g. of 10% sulfuric acid was added, the ether layer separated and the aqueous layer extracted with two portions of ether. The combined ether layers were washed with saturated aqueous sodium bicarbonate and water, dried, and the ether flask distilled. The pleasant-smelling residual liquid was distilled from a Claisen flask. The material distilling at 70–76° (1 mm.) was collected. The yield was 8 g. (55%). Redistillation through a 10-plate column gave a high recovery of liquid distilling at 58.5–59° (0.5 mm.), 75° (1.5 mm.), $n^{23}D$ 1.4389. *Anal.* Calcd. for $C_8H_{16}O_2$: C, 66.62; H, 11.18. Found: C, 66.2; H, 11.0.

The reaction of this compound with 2,4-dinitrophenylhydrazine reagent produced a pyrazoline (IV), which is characteristic of methylol ketones.[6] The orange crystals melted at 118.5–119.5° after recrystallization from absolute ethanol. *Anal.* Calcd. for $C_{14}H_{18}N_4O_4$: C, 54.89; H, 5.92; N, 18.29. Found: C, 54.70; H, 5.99; N, 18.2.

Preparation of 3-(Hydroxymethyl)-4-heptanone (II) from **Di-*n*-propyl Ketone and Paraformaldehyde.**—Di-*n*-propyl ketone (45.7 g.), 3.0 g. of paraformaldehyde and a small amount of phenolphthalein indicator were heated to 50°. Small amounts of methanolic sodium hydroxide were added when necessary to keep the mixture slightly alkaline to the indicator. After several minutes the paraformaldehyde dissolved. The mixture was then cooled in ice for two hours and allowed to stand overnight. After neutralizing with acetic acid, the mixture was filtered and the filtrate distilled. Excess di-*n*-propyl ketone was collected up to 50° (20 mm.). The product then distilled at 72–73° (1.3 mm.), $n^{24}D$ 1.4387. The yield was 6.0 g. (42%). The pyrazoline derivative prepared from 2,4-dinitrophenylhydrazine reagent melted at 118–119.5°. A mixture of the two pyrazolines melted at 118.5–120°.

Preparation of 2-Ethyl-1,3-hexanediol (III) by **Lithium Aluminum Hydride Reduction of 3-(Hydroxymethyl)-4-heptanone** (II).—II (7.5 g.) was reduced with lithium aluminum hydride (1.5 g.) in a manner similar to that described above. Distillation of the crude product yielded 6.0 g. (79%) of III, b.p. 91–93° (1.5–2 mm.), $n^{16}D$ 1.4535. The bis-phenylurethan, fine white needles after recrystallization from benzene, melted at 130–131°. *Anal.* Calcd. for $C_{22}H_{28}N_2O_2$: N, 7.3. Found: N, 7.5.

The bis-phenylurethan prepared from a commercial sample of 2-ethyl-1,3-hexanediol gave a mixed m.p. of 129–130° with the above derivative.

Acknowledgment.—I wish to thank Messrs. B. W. Nippoldt, P. B. Olson and J. G. Gagnon of our Analytical Section for the analyses.

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(3) The lithium aluminum hydride reduction of γ-valerolactone gives 1,4-pentanediol: see R. F. Nystrom and W. G. Brown, THIS JOURNAL, **70**, 3738 (1948).

(4) W. M. Quattlebaum, Jr., U. S. Patent 2,064,564.

(5) J. C. Sauer, THIS JOURNAL, **69**, 2444 (1947).

(6) G. T. Morgan and E. L. Holmes, *J. Chem. Soc.*, 2667 (1932).

The Resolution of Methylethylphenylcarbinol

BY HAROLD H. ZEISS

The resolution of the mixed aliphatic–aromatic tertiary alcohol, methylethylphenylcarbinol (I),[1] is achieved by the methods employed in the separation of the enantiomorphs of methylethylisobutylcarbinol.[2] Past attempts to resolve I by other approaches are reported to be unsuccessful.[3] The carbinol is prepared by the reaction of methyl ethyl ketone with phenylmagnesium bromide and is converted to hydrogen 2-phenylbutyl-2-phthalate (II) by the addition of its potassium salt to phthalic anhydride in benzene solution. The acid ester is isolated easily and in pure form by crystallization from benzene.[4] When II and an equimolecular amount of brucine are combined in acetone, brucine 2-phenylbutyl-2-phthalate (III) crystallizes from solution as clusters of transparent prisms. A systematic fractional crystallization of III from acetone, according to the triangle

(1) An optical rotation of $\pm 14°$ is erroneously reported for I in "Beilstein," (1) Vol. VI, p. 258.

(2) W. von E. Doering and H. H. Zeiss, THIS JOURNAL, **70**, 3966 (1948); **72**, 147 (1950).

(3) E. S. Wallis and F. H. Adams, *ibid.*, **55**, 3838 (1933).

(4) M. P. Balfe, M. A. Doughty, J. Kenyon and R. Poplett, *J. Chem. Soc.*, 605 (1942), have previously reported II without description of preparation or properties.

scheme, leads to an optically constant head fraction after six recrystallizations. This diastereoisomeric salt is apparently optically pure, for additional crystallization fails to alter its specific rotation, −14.0°, melting point and crystal habit. The salt from the mother liquors is dextrorotatory, $[\alpha]_D$ + 8.3°.

From the decomposition of the optically constant (−)-III with dilute hydrochloric acid the corresponding (−)-hydrogen phthalate is obtained as a colorless glass. The absence of racemization during this decomposition is demonstrated by the recombination of the acid ester with brucine to yield the salt with undiminished rotation.

Reductive cleavage of the optically active hydrogen phthalates with lithium aluminum hydride occurs smoothly to form the dextro- and levorotatory carbinols in excellent yields. From (−)-II there is obtained (+)-methylethylphenylcarbinol, $[\alpha]_D$ + 17.45°, which is presumed to be optically pure on the basis of the optical constancy of its hydrogen phthalate. Partially resolved (+)-II from the mother liquors is cleaved to (−)-I, $[\alpha]_D$ − 14.56°. Racemization of the hydrogen phthalates during treatment with lithium aluminum hydride is excluded by the reaction cycle in which II, + 11.8°, is cleaved to I, −4.53°, and (−)-I, when reacting with phthalic anhydride *via* its potassium salt, is reconverted to II, +11.6°. The infrared spectra of the dextrorotatory, levorotatory and racemic carbinols are identical in all essential details.[5]

Experimental[6]

Methylethylphenylcarbinol (I, 2-Phenylbutan-2-ol).—Methyl ethyl ketone (72 g.) in 150 ml. of ether was added to an iced solution of phenylmagnesium bromide in 350 ml. of ether (24.4 g. of magnesium and 160 g. of bromobenzene). After the mixture had stood overnight at room temperature, it was hydrolyzed with iced dilute hydrochloric acid and worked up in the usual fashion. Vacuum distillation of the carbinol yielded 123 g. (82%) of I: b.p. 90–91° (4 mm.): $n^{25}D$ 1.5189; d^{25}_4 0.984.[7] This carbinol still contained traces of diphenyl which could be effectively removed by conversion of the alcohol to its hydrogen phthalate followed by regeneration of I with lithium aluminum hydride as described below. Distillation of the carbinol at atmospheric pressure invariably results in dehydration.

Hydrogen 2-Phenyl-2-phthalate (II).[8]—Methylethylphenylcarbinol (150 g.) was added dropwise to a vigorously stirred suspension of 39 g. of potassium sand in 2.5 l. of dry benzene at 75°. After four hours the hot benzene solution of the potassium salt of I was pumped under nitrogen pressure into 1.5 l. of benzene containing 148 g. of phthalic anhydride. The crude acid ester was isolated as previously described[2] and then dissolved in benzene. This solution on concentration and cooling deposited three crops of crystalline II totalling 119 g. (40%), m.p. 111–112° (dec.).

Anal. Calcd. for $C_{18}H_{18}O_4$: C, 72.80; H, 6.08; neut. equiv., 298. Found: C, 72.97; H, 6.28; neut. equiv., 298.

Fractional Crystallization of Brucine 2-Phenylbutyl-2-phthalate (III).—A solution of 100.5 g. of II and 133 g. of anhydrous brucine in 300 ml. of hot acetone was cooled slowly to room temperature and then stored in the refrigerator overnight. The crystalline mass which had formed was filtered off and redissolved in 700 ml. of fresh acetone. A systematic fractional crystallization was thus initiated and continued in which the head fraction of the brucine salt was dissolved each time in just enough fresh acetone to effect solution, followed by cooling to room temperature and standing overnight. After six recrystallizations the melting point of the brucine salt comprising the head fraction had risen from 133–135° to a constant value of 139–140° and its specific rotation had increased from +0.6° to −14.0°. Two recrystallizations of the salt caused no change in rotation. Evaporation of the filtrate from the last crystallization gave brucine salt with identical rotation. The fractional crystallization was continued until 21 g. (9%) of optically constant III had been obtained: $\alpha^{27}D$ −0.71°, *c*, 5.07. The crystalline cake from the mother liquors, spontaneously formed, had the rotation $\alpha^{22}D$ +0.40°, *c*, 4.82.

Optically Active Methylethylphenylcarbinol.—Optically constant III (20.5 g.) was dissolved in 80 ml. of ethanol and shaken with ether and 1% aqueous hydrochloric acid. The acidic aqueous layer was extracted with fresh ether, and the combined ether extracts were washed four times with water and dried over magnesium sulfate. The major part of the solvent ether was distilled on the steam-bath, and the remainder was removed by evaporation under reduced pressure: 8.5 g. (88%). Owing to the tendency of tertiary hydrogen phthalates to hydrolyze on standing in the presence of moisture, 3.1 g. of this acid ester was immediately added to 3 g. of lithium aluminum hydride in 200 ml. of anhydrous ether. The mixture was stirred for six hours at room temperature and then hydrolyzed with 40 ml. of water. The clear, supernatant ethereal solution of the carbinol was decanted from the precipitated salt, and the salt was washed several times with fresh ether. The combined ether solutions were washed with water, with two portions of dilute sodium hydroxide, again with water and then were dried over potassium carbonate. The ether was removed at the aspirator and (+)-methylethylphenylcarbinol was obtained by evaporative distillation[9] at 35° (1 mm.): 1.2 g. (77%); $[\alpha]^{22}D$ +17.45° (α = +17.18, *l* = 1); $[M]^{22}D$ 26.21°; $n^{25}D$ 1.5160; d^{25}_4 0.984.

Anal. Calcd. for $C_{10}H_{14}O$: C, 79.95; H, 9.39. Found: C, 79.81; H, 9.31.

Partially Resolved (−)-Methylethylphenylcarbinol.—The brucine salt of the mother liquors was decomposed with dilute hydrochloric acid, and the resulting hydrogen phthalate was obtained in a viscous form (37 g.) which slowly crystallized. This was taken up in benzene from which on standing at room temperature there was deposited 13 g. of crystalline acid ester: m.p. 114–115°; $[\alpha]^{24}D$ +4.44°. Cooling and concentration gave two additional crops of crystalline material totalling 7 g. whose specific rotation, when combined, was +11.84°. The hydrogen phthalate (19.5 g.) remaining in solution could not be crystallized and was cleaved with 10 g. of lithium aluminum hydride in 450 ml. of ether. Evaporative distillation of the carbinol from this reaction gave 6.5 g. (66%) of (−)-I: $[\alpha]^{26}D$ −14.56°; $n^{25}D$ 1.5169.

(5) These spectra were obtained through the generous coöperation of Professor Ralph S. Halford of Columbia University.

(6) All melting points are corrected. Optical rotations of carbinols were measured without solvent. The rotations of the hydrogen phthalates and of the brucine salts were determined in absolute ethanol.

(7) A. Klages, *Ber.*, **35**, 3506 (1902), reported b.p. 102° (14 mm.); $n^{20}D$ 1.5158; d^{22}_4 0.9845 for I.

(8) Note added in proof: M. P. Balfe, J. Kenyon and E. M. Thain, *J. Chem. Soc.*, **386** (1951), have currently reported m.p. 113–115° for the racemic hydrogen phthalate.

(9) Evaporative distillations of the carbinols were carried out in a modified Hickman still equipped with a cold finger and central take-off well, in order to avoid any decomposition into olefin.

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On Cyclic Intermediates in Substitution Reactions. II. Steric Effects in the Alkaline Hydrolysis of the Epimeric 3-Chloro-6//7-cholestanedicarboxylic Acids[1]

BY DONALD W. WUJCIAK,[2] ROBERT L. FELLER[3] AND JOHN F. LANE

Part I[4] of this series presented a study of the

(1) Taken, in part, from a thesis submitted by Donald W. Wujciak to the School of Chemistry, Rutgers University, in partial fulfillment of the requirements for the Senior Honors Program, 1950.

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(3) The Mellon Institute, Pittsburgh, Penna.

(4) J. F. Lane and H. W. Heine, THIS JOURNAL, **73**, 1348 (1951).