

vious procedure gave 0.66 g., 65%, of 2-naphthoic acid, m. p. 183°. 2-Naphthoic acid is recorded as melting at 185°.

Hydrolysis of α -(4-Nitrophenylsulfonyl)-4-chloro-acetophenone.—Hydrolysis of 2.34 g. (0.007 mole) of this compound gave 0.97% g., 90% of 4-chlorobenzoic acid, m. p. 238. The literature gives the melting point of this compound as 243°.

Summary

The synthesis of eight α -(4-nitrophenylmer-

capto)-acetophenones has been accomplished by one of two procedures and in some instances by both procedures. Each of the mercapto compounds was subsequently oxidized to the sulfone, then followed by reduction to the corresponding α -(4-aminophenylsulfonyl)-acetophenone.

None of the compounds tested were found to be active against tuberculosis.

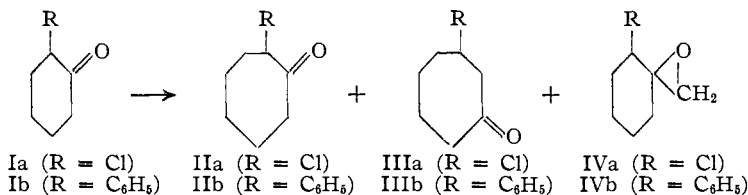
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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, WASHINGTON UNIVERSITY]

Ring Enlargements. I. The Ring Enlargement of 2-Chlorocyclohexanone and 2-Phenylcyclohexanone

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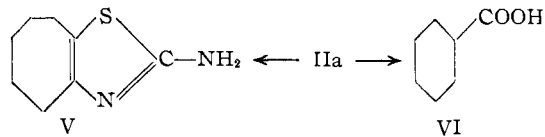
The ring enlargement of carbocyclic ketones by means of diazomethane has received occasional attention in the two decades since Mosettig and Burger¹ found that cyclohexanone could be smoothly converted to cycloheptanone through the action of this reagent. The synthetic value of these reactions, however, has been largely confined to the ring enlargement of symmetrical ketones, for unsymmetrically substituted ketones often yield mixtures of products.² The ratio of isomers present in such mixtures has in no case been accurately ascertained, as a consequence of which considerable confusion exists concerning the course of certain ring enlargements. The present communication discusses the ring enlargement of two 2-substituted cyclohexanones, (Ia) and (Ib), for which the ratio of isomers produced has been determined with fair accuracy.



Ring Enlargement of 2-Chlorocyclohexanone (Ia).—The reaction of Ia with ethereal diazomethane was reported by Giraitis and Bullock³ in a Communication to the Editor which has not been followed by a fuller exposition of their work. These experimenters claimed that the product from this reaction was pure 2-chlorocycloheptanone (IIa) and that it was obtained in practically quantitative yield. Steadman,⁴ using Meerwein's⁵ procedure for conducting diazomethane ring enlargements, later showed that chlorocycloheptanone was produced in only 50–60% yield and that the isomeric oxide (IVa) accounted for at

least 16% of the product. Steadman sought to prove the structure of the former by the base-catalyzed conversion to cyclohexanecarboxylic acid (VI), a reaction characteristic of cyclic 2-chloroketones.⁶ From the chlorocycloheptanone fraction he obtained, upon treatment with alcoholic sodium hydroxide, a 36% yield of "somewhat impure" VI which was identified by conversion to the known amide. The relatively low yield of VI was not rationalized and, as will be shown below, was actually due to the fact that the chlorocycloheptanone fraction consisted of a mixture of the 2- and 3-chloro compounds.

2-Chlorocyclohexanone was treated with nitrosomethylurethan according to the directions of Steadman⁴ and his reported yields were duplicated. Two reactions characteristic of the 2-chloroketo grouping were carried out with the chlorocycloheptanone fraction, and the results were compared with the same reactions in which authentic IIa was used as the starting material. In both reactions the material from the ring enlargement resembled the authentic 2-chloroketone qualitatively but not quantitatively. Authentic IIa could be converted by treatment with thiourea to 2-amino-4,5,6,7-tetrahydro-4-cycloheptathiazole, V, in 72% yield whereas the product of ring enlargement produced V in only 17.5% yield. Thus, on the basis of these data, the prod-



uct of ring enlargement is indicated to consist of 24% of IIa and 76% of IIIa. This ratio of isomers was closely substantiated in the base-catalyzed conversion of the chloroketone to cyclohex-

- (1) Mosettig and Burger, *THIS JOURNAL*, **52**, 3456 (1930).
- (2) Adamson and Kenner, *J. Chem. Soc.*, 181 (1939).
- (3) Giraitis and Bullock, *THIS JOURNAL*, **59**, 951 (1937).
- (4) Steadman, *ibid.*, **62**, 1606 (1940).
- (5) Meerwein, German Patent 579,309 [C. A., **27**, 4546 (1933)].

- (6) Favorskii and Boshowski, *J. Russ. Phys.-Chem. Soc.*, **50**, 582 (1917) [C. A., **18**, 1476 (1924)].

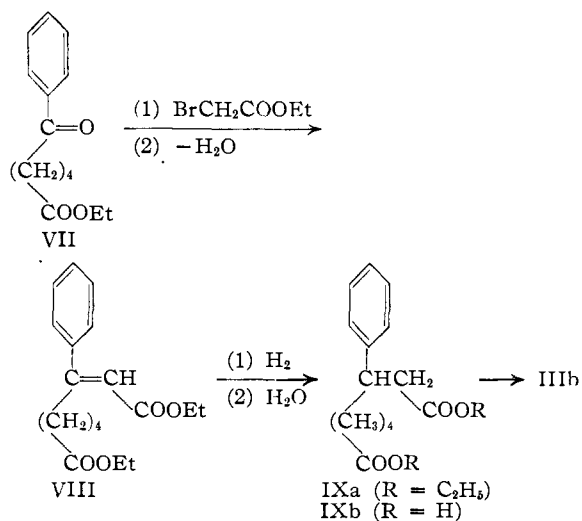
anecarboxylic acid (VI). The authentic material yielded VI in 69% yield whereas the ring enlargement product formed VI in only 15% yield. From these data the product of ring enlargement is indicated to consist of 22% of IIa and 78% of IIIa. That the product resulting from the treatment of IIa with potassium carbonate was indeed VI instead of 2-hydroxycycloheptanone, as previously reported by Kötzt and his co-workers,⁷ was proved by conversion to the known amide of VI. Meerwein⁸ has also cited this inconsistency in Kötzt's data.

Steadman⁴ subjected the chlorocycloheptanone obtained by ring enlargement of Ia to further reaction with nitrosomethylurethan and obtained a product to which the structure of 2-chlorocyclooctanone was assigned, the proof again depending upon a ring contraction to cycloheptanecarboxylic acid for which no yields were given. In view of the results of the present work it is quite probable that this chlorocyclooctanone was a mixture of the 2-, 3- and 4-chloro isomers containing very little of the 2-chloro isomer.

Ring Enlargement of 2-Phenylcyclohexanone (Ib).—The ring enlargement of Ib, which has not been previously carried out, was effected by two methods but only the diazomethane method was carefully investigated. A smooth reaction took place between Ib and nitrosomethylurethan in the presence of methanol and potassium carbonate, and fractional distillation of the product yielded two main fractions. The lower boiling material, obtained in 21.5% yield, was identified as 4-phenyl-1-oxaspiro[2,5]octane⁹ (IVb) from its failure to react with semicarbazide and from its reaction with piperidine to form an amino alcohol. The higher boiling fraction, representing a 49.5% yield, had an analysis compatible with phenylcycloheptanone and formed a semicarbazone in quantitative yield. The semicarbazone, however, melted over a wide range and consisted of a methanol-soluble and a methanol-insoluble component. From the latter there was obtained a pure semicarbazone which was shown to be identical with that of IIIb. The methanol-soluble fraction was difficult to purify but finally yielded a semicarbazone identical with that of I Ib. The presence of I Ib was also demonstrated by the isolation from the higher boiling fraction of a 2,4-dinitrophenylhydrazone identical with that from I Ib.

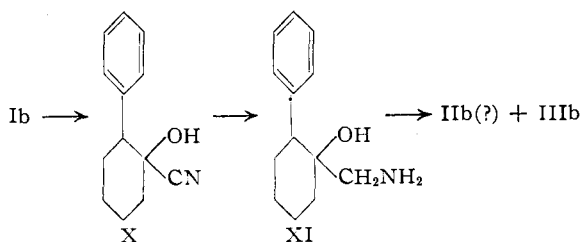
The most apparent method for the determination of the isomer ratio in the phenylcycloheptanone series depended upon a comparison of the physical characteristics of the mixture with pure I Ib and IIIb. 2-Phenylcycloheptanone (I Ib) had previously been prepared by Tiffeneau and his co-workers¹⁰ by the isomerization of 1-phenyl-1,2-

epoxycycloheptane. However, a less equivocal method, previously employed for the preparation of other 2-substituted cycloheptanones^{2,3} appeared to be the ring enlargement of cyclohexanone by means of phenyldiazomethane. Thus, when a mixture of cyclohexanone, methanol and potassium carbonate was treated with nitrosobenzylurethan a smooth reaction took place to yield 26% of I Ib. 3-Phenylcycloheptanone, IIIb, hitherto unknown, was synthesized from ethyl δ -benzoylvalerate (VII) in 23% over-all yield according to the method indicated below.



The ratio of the isomers I Ib and IIIb in the mixture produced by diazomethane ring enlargement of Ib was most satisfactorily ascertained by infrared analysis.¹¹ By a quantitative comparison at several wave lengths of the absorptions of I Ib, IIIb, and the mixture an average value was obtained (maximum deviation $\pm 3\%$) which indicated the mixture to contain 81% of I Ib and 19% of IIIb. The refractive indices also reflected this isomer ratio. That of the mixture (1.5387) indicated about 75% of I Ib (1.5389) and 25% of IIIb (1.5380).

A second method of ring enlargement of Ib was investigated and found to produce a mixture from which the semicarbazone of IIIb could be isolated. 2-Phenylcyclohexanone (Ib) was converted with hydrogen cyanide to 1-cyano-1-hydroxy-2-phenylcyclohexane (X). Hydrogenation to the amino alcohol (XI) followed by treatment



(7) Kötzt, Blendermann, Rosenbusch and Siringhaus, *Ann.*, **400**, 55 (1913).

(8) Meerwein, *Ann.*, **417**, 259 (1917).

(9) Nomenclature based on Patterson-Capell Ring Index Compound No. 474.

(10) Tiffeneau, Weill, Gutmann and Tchoubar, *Compt. rend.*, **201**, 277 (1935).

(11) Kindly performed by Dr. Ralph H. Munch of Monsanto Chemical Company, St. Louis.

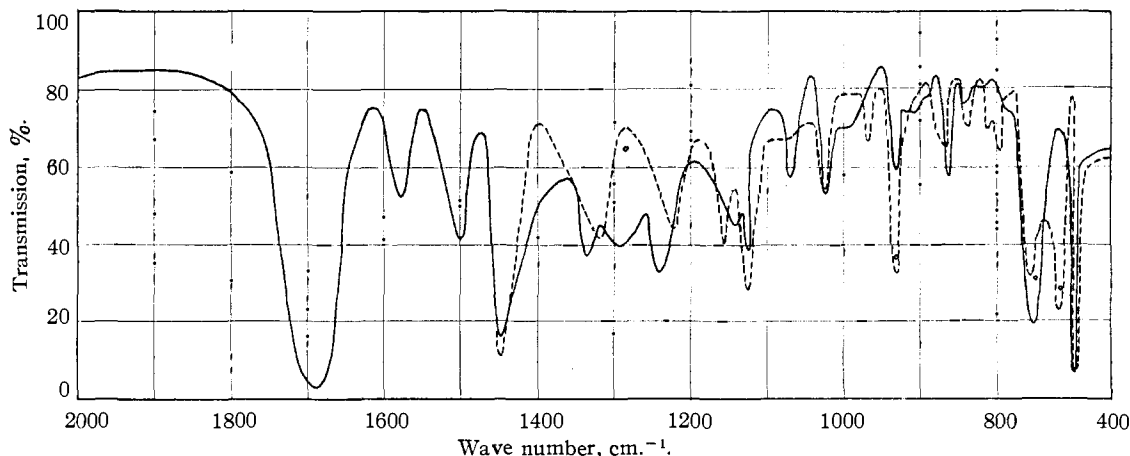


Fig. 1.—Infrared absorption spectra of phenylcycloheptanones: - - - - -, 2-phenylcycloheptanone; ———, 3-phenylcycloheptanone; o o o, points on the absorption curve of the mixture at which quantitative comparisons were made.

with nitrous acid gave a product containing approximately 84% of ketonic material which was a mixture probably containing IIb and IIIb. The semicarbazone of IIIb was isolated in a pure form but the residual semicarbazone could not be purified.

Acknowledgment.—We gratefully acknowledge a generous Research Corporation grant which has made possible the purchase of certain equipment necessary for this work. We are indebted to Dr. Ralph H. Munch for performing the infrared measurements and quantitatively interpreting the infrared data and to Dorothy Kuenne for performing the micro-analyses.

Experimental¹²

Diazomethane Ring Enlargement of 2-Chlorocyclohexanone (Ia).—The directions of Steadman⁴ were precisely followed. From 76.0 g. of freshly distilled 2-chlorocyclohexanone, 57 cc. of methanol, 1.0 g. of finely powdered sodium carbonate and 84 g. of nitrosomethylurethan there was obtained, after fractionation through a thirty-four inch, glass helix-packed column, 12.1 g. (14%) of 4-chloro-1-oxaspiro[2,5]octane (IVa), b. p. 70–75° (14 mm.), 43.1 g. (51%) of chlorocycloheptanone, b. p. 92–95° (14 mm.), and 26.2 g. (32%) of an intermediate fraction, b. p. 75–90° (14 mm.). The major portion of the chlorocycloheptanone fraction had a b. p. of 94–95° (14 mm.), n_D^{25} 1.4824, and the following analysis.

Anal. Calcd. for $C_7H_{11}ClO$: C, 57.34; H, 7.56; Cl, 24.18. Found: C, 57.22; H, 7.57; Cl, 23.92.

2-Amino-4,5,6,7-tetrahydro-4-cycloheptathiazole (V).

(a) **From Authentic 2-Chlorocycloheptanone.**—Cycloheptanone¹³ was converted in 52% yield to 2-chlorocycloheptanone (b. p. 94–96° at 14 mm.; n_D^{25} 1.4836) by the method described for the chlorination of cyclohexanone.¹⁴ When a 1.00-g. sample of this material was treated with 0.52 g. of finely powdered thiourea and the mixture heated on the steam-bath for two hours, 1.49 g. (98%) of an almost colorless solid was obtained. This was dissolved in water (completely soluble), the solution made basic with potassium hydroxide, and the thiazole extracted into benzene. Evaporation of the benzene left 0.82 g. (72%) of

orange colored material; m. p. 65–70° (previous softening). Sublimation at 95° (0.05 mm.) followed by two recrystallizations from hexane containing a few drops of benzene yielded colorless, glistening prisms; m. p. 76.5–77.5°. Erlenmeyer and Schoenauer¹⁵ prepared the hydrochloride of V but did not convert it to the free base.

Anal. Calcd. for $C_8H_{12}N_2S$: C, 57.10; H, 7.19. Found: C, 57.08; H, 6.98.

(b) **From Chlorocycloheptanone Obtained by Ring Enlargement of 2-Chlorocyclohexanone.**—A 1.00-g. sample of the chlorocycloheptanone obtained by ring enlargement of 2-chlorocyclohexanone was treated with thiourea as described above. The red-brown product failed to solidify upon cooling and was only partially soluble in water. From the water-soluble portion there was obtained 0.20 g. (17.5%) of a material which solidified when seeded with authentic thiazole (V). The water-insoluble, benzene-soluble portion amounted to 0.80 g.

Cyclohexanecarboxylic Acid (VI): (a) **From Authentic 2-Chlorocycloheptanone.**—A 5.00-g. sample of authentic 2-chlorocycloheptanone was treated with 20 cc. of water and 15 g. of potassium carbonate.⁷ The mixture was stirred rapidly and heated at reflux for six hours and the product then separated into acidic and neutral fractions in the usual manner. From the acidic fraction there was obtained 3.00 g. (69%) of material melting at 22–26° from which an amide melting at 183–184° was prepared. Cyclohexanecarboxylic acid is reported to melt at 29° and its amide at 184°.¹⁶ The neutral fraction amounted to 0.76 g.

(b) **From Chlorocycloheptanone Obtained by Ring Enlargement of 2-Chlorocyclohexanone.**—A 5.00-g. sample of the chlorocycloheptanone obtained by ring enlargement of 2-chlorocyclohexanone was treated in the same fashion as described above to yield 0.65 g. (15%) of VI and 2.91 g. of a neutral, viscous oil.

Diazomethane Ring Enlargement of 2-Phenylcyclohexanone (Ib).—In a three-necked flask fitted with a stirrer, reflux condenser and dropping funnel was placed 50 g. (0.287 mole) of 2-phenylcyclohexanone,¹⁷ 150 cc. of methanol and 2 g. of finely powdered potassium carbonate. To the rapidly stirred suspension there was added, over a period of two hours, 43 g. (0.296 mole) of nitrosomethylurethan, the reaction temperature being held at 25–30° by means of a water-bath. After the addition of nitrosomethylurethan was completed, stirring was discontinued and the reaction mixture was allowed to stand at room temperature for ten hours. The potassium carbonate was

(12) All melting points are corrected.

(13) Kohler, Tishler, Potter and Thompson, *THIS JOURNAL*, **61**, 1057 (1939).

(14) Newman, Farbman and Hipsber, *Org. Syntheses*, **25**, 22 (1945).

(15) Erlenmeyer and Schoenauer, *Helv. Chim. Acta.*, **24**, 172E (1941).

(16) Lumsden, *J. Chem. Soc.*, 90 (1905).

(17) Newman and Farbman, *THIS JOURNAL*, **66**, 1550 (1944).

then removed by filtration, the volatile products evaporated under vacuum on the steam-bath and the residue fractionally distilled through a thirty-four inch, glass helix-packed column. The eight fractions collected were combined as follows: (a) 11.6 g. (21.5%), b. p. 114–117° (2.5 mm.), (b) 1.7 g., b. p. 117–123° (2.5 mm.), (c) 6.7 g., b. p. 123–131° (3 mm.), (d) 26.7 g. (49.5%), b. p. 131–133° (3 mm.).

4-Phenyl-1-oxaspiro[2,5]octane (IVb).—Fraction a from the diazomethane ring enlargement of 2-phenylcyclohexanone solidified after standing several hours, m. p. 53–55° after pressing on a porous plate. Two recrystallizations from petroleum ether (30–60°) gave the oxide (IVb) as colorless, large cubes, m. p. 60.5–62°.

Anal. Calcd. for $C_{13}H_{16}O$: C, 82.93; H, 8.57. Found: C, 82.87; H, 8.39.

The piperidino derivative of IVb was prepared by refluxing a 1.85-g. sample from fraction a with 2.0 cc. of piperidine for two and one-half hours and then allowing the mixture to stand at room temperature for two days. When a benzene extract of this reaction mixture was shaken with dilute hydrochloric acid there precipitated 1.60 g. of a white solid. This was removed by filtration and recrystallized twice from benzene containing a few drops of methanol to yield colorless, fine needles of the hydrochloride of the piperidino derivative of IVb, m. p. 225–226° (some previous softening).

Anal. Calcd. for $C_{13}H_{23}ClNO$: C, 69.76; H, 9.11. Found: C, 69.60; H, 9.06.

The crude free base, obtained by neutralization of the hydrochloride described above, was molecularly distilled at 100° (0.02 mm.) to yield a yellow oil which solidified after standing several hours. Recrystallization from petroleum ether (30–60°) cooled in an acetone–Dry Ice-bath yielded colorless crystals; m. p. 39–40°.

Anal. Calcd. for $C_{13}H_{21}NO$: C, 79.07; H, 9.95. Found: C, 79.09; H, 9.70.

Phenylcycloheptanones (IIb and IIIb) from Diazomethane Ring Enlargement of 2-Phenylcyclohexanone.—Fraction d from the diazomethane ring enlargement of 2-phenylcyclohexanone crystallized when it was cooled in an acetone–Dry Ice mixture and seeded with pure, crystalline 2- or 3-phenylcycloheptanone; m. p. 0–17°, n_D^{25} 1.5387.

Anal. Calcd. for $C_{13}H_{16}O$: C, 82.93; H, 8.57. Found: C, 82.94; H, 8.30.

A 10.1-g. portion of fraction d was converted to 13.4 g. (101%) of a white, powdery semicarbazone, m. p. approximately 120–140°. After trituration with boiling methanol, a residue of 1.70 g. (13%) remained, m. p. 212–214° (dec., previous softening), which, after several recrystallizations from absolute ethanol, gave colorless, glistening blades melting at 219–220° (dec.) and showing no depression in m. p. when admixed with the semicarbazone of 3-phenylcycloheptanone. Repeated recrystallization of the methanol-soluble fraction from methanol cooled to –5° yielded a compound melting at 155–156° (dec.) and showing no depression in m. p. when admixed with authentic semicarbazone of 2-phenylcycloheptanone.

A 0.500-g. sample of fraction d was converted to a mixture of 2,4-dinitrophenylhydrazones which solidified only after standing for several hours and which was completely soluble in ether. The ether solution, after standing at room temperature for several days, however, deposited 0.10 g. of a yellow solid; m. p. 166–169.5° (dec.). Two recrystallizations from ethanol furnished yellow, fine needles melting at 170.5–172° (dec.) which did not depress the m. p. of authentic 2,4-dinitrophenylhydrazone of 2-phenylcycloheptanone.

The infrared data for the mixture of IIb and IIIb were obtained from a sample of fraction d.

2-Phenylcycloheptanone (IIb).—A stirred mixture of 66 g. (0.675 mole) of cyclohexanone, 100 cc. of methanol, and 2 g. of finely powdered potassium carbonate was treated, over a period of seven hours, with 141 g. (0.675 mole) of nitrosobenzylurethan,¹⁸ the reaction temperature

being maintained at 25–30°. The mixture was stirred overnight at room temperature and then worked up as described above. The crude product was fractionated through a thirty-four inch, glass helix-packed column to yield 33.2 g. (26%) of material boiling at 133–137° (4 mm.) and melting at 11–19°. Two recrystallizations from petroleum ether (30–60°), the entire operation performed in a refrigerator, yielded the pure ketone as colorless, very long needles; m. p. 21–23°, n_D^{25} 1.5389, $\mu_{\text{max}}^{\text{liquid}}$ cm.^{-1} 700, 717, 756, 795, 840, 867, 934, 967, 1027, 1125, 1154, 1223, 1317, 1450, 1500, 1576, 1688.

Anal. Calcd. for $C_{13}H_{16}O$: C, 82.93; H, 8.57. Found: C, 82.79; H, 8.41.

The semicarbazone of 2-phenylcycloheptanone, prepared from 1.00 g. of the oil described above, consisted of 1.17 g. (90%) of slightly tacky, colorless material. Trituration with ether left 0.57 g. (44%) of a white solid, m. p. 133–136°, which, after two recrystallizations from methanol, produced colorless, glistening plates; m. p. 155–156°. Tiffeneau¹⁹ has reported the m. p. as 156°.

Anal. Calcd. for $C_{14}H_{19}N_3O$: C, 68.54; H, 7.81. Found: C, 68.73; H, 7.85.

The 2,4-dinitrophenylhydrazone of 2-phenylcycloheptanone was obtained in the usual manner and recrystallized from ethanol to yield yellow crystals, m. p. 138.5–142.5°. A second recrystallization from ethanol produced yellow needles, m. p. 171–172° (dec.).

Anal. Calcd. for $C_{19}H_{20}N_4O_4$: C, 61.94; H, 5.47. Found: C, 61.94; H, 5.38.

With both the semicarbazone and the 2,4-dinitrophenylhydrazone of 2-phenylcycloheptanone it appears that a conversion to a higher melting form takes place during recrystallization. This anomalous behavior of derivatives of 2-substituted cyclic ketones has also been observed by other workers.²

2-Phenyl-1,6-dicarbethoxyhexene-1 (VIII).—To a three-necked flask fitted with a stirrer, a reflux condenser and a dropping funnel was added 36 g. (0.155 mole) of ethyl δ -benzoylvalerate (VII),¹⁹ 27 g. (0.162 mole) of ethyl α -bromoacetate, 180 cc. of dry, thiophene-free benzene, 10.5 g. (0.162 mole) of granulated, activated²⁰ zinc and a few crystals of iodine. The reaction mixture was stirred and refluxed for two hours, 12.5 g. (0.075 mole) of ethyl α -bromoacetate and 4.9 g. (0.075 mole) of zinc then added, and stirring and refluxing continued for another hour. The mixture was cooled, treated with 80 cc. of ethanol followed by water, and the organic material was then extracted into benzene. After washing with dilute hydrochloric acid and water, the benzene solution was distilled until no more water appeared in the distillate and the dehydration of the hydroxy ester then carried out with 2.0 cc. of phosphorus oxychloride according to the method of Lipkin and Stewart.²¹ The dehydration required five and one-half hours during which time 2.0 cc. (74%) of water was collected. The reaction mixture was then cooled, extracted several times with water, the benzene removed by evaporation under vacuum and the residue fractionally distilled through a ten-inch Vigreux column. The major fraction consisted of 31.7 g. (67.5%) of a yellow oil, b. p. 149–155° (0.1 mm.). A middle fraction taken for analysis had the b. p. 152–153° (0.1 mm.) and n_D^{25} 1.5121.

Anal. Calcd. for $C_{13}H_{20}O_4$: C, 71.02; H, 7.95. Found: C, 70.82; H, 7.70

2-Phenyl-1,6-dicarbethoxyhexane (IXa).—A solution of 30.7 g. of 2-phenyl-1,6-dicarbethoxyhexene-1 (b. p. 149–155° at 0.1 mm.) in 100 cc. of ethyl acetate was treated with 2.00 g. of 10% palladium on charcoal (Baker Co.) and submitted to hydrogenation at room temperature and atmospheric pressure. After the required volume of hydrogen had been absorbed (five hours), the catalyst was removed by filtration, the solvent evaporated under vac-

(19) Papa, Schwenk and Hankin, *THIS JOURNAL*, **69**, 3018 (1947).

(20) Fieser and Johnson, *ibid.*, **62**, 575 (1940).

(21) Lipkin and Stewart, *ibid.*, **61**, 3295 (1939).

uum and the residue distilled through a ten-inch Vigreux column to yield 26.4 g. (85%) of a colorless oil, b. p. 139–141° (0.08 mm.), n_D^{25} 1.4870.

Anal. Calcd. for $C_{18}H_{26}O_4$: C, 70.56; H, 8.55. Found: C, 70.53; H, 8.30.

2-Phenyl-1,6-dicarboxyhexane (IXb).—A 25.4-g. sample of 2-phenyl-1,6-dicarboxyhexane (b. p. 139–141° at 0.08 mm.) was refluxed for seven hours with 100 cc. of ethanol and 100 cc. of 30% potassium hydroxide solution. The crude product, obtained in the usual manner, consisted of a slightly sticky, yellow solid. One recrystallization from benzene followed by drying under high vacuum yielded 19.3 g. (93%) of product; m. p. 79–82°. Three recrystallizations from benzene yielded glistening, short blades, m. p. 86–86.5°.

Anal. Calcd. for $C_{14}H_{18}O_4$: C, 67.18; H, 7.25. Found: C, 67.07; H, 7.08.

3-Phenylcycloheptanone (IIIb).—An 18.5-g. sample of 2-phenyl-1,6-dicarboxyhexane (m. p. 79–82°) was dissolved in 100 cc. of ethanol, neutralized to phenolphthalein with 1 *N* sodium hydroxide solution and converted with thorium tetrachloride to 27.5 g. (102%) of the thorium salt.²² Pyrolysis of the thorium salt at 400° and 0.5 to 2 mm. afforded 8.40 g. (60%) of a dark green oil which, upon fractionation through an eight-inch Vigreux column, yielded 6.10 g. (44%) of a yellow-green oil, b. p. 131–134° (2 mm.). The oil was crystallized twice from petroleum ether (30–60°) (the entire operation carried out in the refrigerator) to produce colorless, long needles, m. p. 17–18°, n_D^{25} 1.5380, μ_{max}^{liquid} cm.⁻¹ 700, 751, 840, 862, 934, 1027, 1070, 1125, 1141, 1241, 1287, 1338, 1450, 1500, 1576, 1688.

Anal. Calcd. for $C_{13}H_{18}O$: C, 82.93; H, 8.57. Found: C, 82.76; H, 8.36.

The semicarbazone of 3-phenylcycloheptanone was prepared in the usual manner and obtained, after several recrystallizations from ethanol, as colorless, glistening blades, m. p. 220–221° (dec.).

Anal. Calcd. for $C_{14}H_{19}N_3O$: C, 68.54; H, 7.81. Found: C, 68.68; H, 7.61.

The 2,4-dinitrophenylhydrazone of 3-phenylcycloheptanone was prepared in the usual manner and obtained, after three recrystallizations from ethanol, as yellow-orange needles, m. p. 145–146° (dec.).

Anal. Calcd. for $C_{19}H_{20}N_4O_4$: C, 61.94; H, 5.47. Found: C, 62.12; H, 5.47.

Infrared Analysis.¹¹—The infrared spectra were measured in a Perkin-Elmer model 12 C instrument on the pure materials in layers 0.02 mm. thick. The data are given in Table I.

TABLE I

μ cm. ⁻¹	Log of ratio of % transmissions	% 2-Isomer	% 3-Isomer
717	0.412/0.492	83.5	(16.5)
751	.056/ .292	(81.0)	19.0
862	.013/ .075	(83.0)	17.0
934	.266/ .340	78.5	(21.5)
1287	.050/ .263	(81.0)	19.0

1-Cyano-1-hydroxy-2-phenylcyclohexane (X).—To a stirred, ice-cold mixture of liquid hydrogen cyanide (pre-

pared from 20 g. of potassium cyanide²³) containing five drops of piperidine was added, over a period of ten minutes, 10.0 g. of 2-phenylcyclohexanone. The reaction mixture was stirred for one hour at ice-bath temperature and the excess hydrogen cyanide then removed to leave 11.4 g. (99%) of a white solid melting at 87–94° (some previous softening) and probably consisting of a mixture of epimeric cyanohydrins. A 10.0-g. portion of the product was dissolved in benzene, the solution washed with dilute hydrochloric acid and water, and then concentrated by boiling. From the cooled solution there precipitated 4.50 g. of colorless crystals, m. p. 105–110° (previous softening). A portion of this material was sublimed at 100° (0.01 mm.) and recrystallized twice from benzene to give colorless, felted needles, m. p. 112–113°.

Anal. Calcd. for $C_{13}H_{15}NO$: C, 77.58; H, 7.51. Found: C, 77.48; H, 7.28.

3-Phenylcycloheptanone from Ring Enlargement of 1-Cyano-1-hydroxy-2-phenylcyclohexane.—The reduction of the cyanohydrin (X) to the amino alcohol (XI) and subsequent rearrangement with nitrous acid was carried out by a method patterned after that described by Goldberg and Studer.²⁴ A 1.52-g. sample of sublimed cyanohydrin (m. p. 105–110° with previous softening) was dissolved in 25 cc. of glacial acetic acid, treated with 0.200 g. of Adams catalyst (Baker Co.) and subjected to hydrogenation at room temperature and atmospheric pressure. When the required amount of hydrogen had been absorbed (twelve hours) the catalyst was removed by filtration and the filtrate diluted to 250 cc. with water. This solution was then cooled to 0° and treated, over a period of ten minutes, with 20 cc. of an aqueous solution containing 1.57 g. of sodium nitrite. The reaction mixture was stirred for four hours at 0° and then allowed to stand for five hours at room temperature. Several extractions of the reaction mixture with ether–benzene yielded, after evaporation of the solvent, 1.07 g. of a yellow oil which was converted to 1.18 g. (84%) of a sticky semicarbazone. Trituration of the crude semicarbazone with ether left 0.25 g. of a white powder melting at 212–217° (dec.) which, after several recrystallizations from ethanol, produced colorless, glistening blades, m. p. 219–220° (dec.). No depression in m. p. was observed when this material was admixed with authentic semicarbazone of 3-phenylcycloheptanone.

Summary

The ratio of the 2- and 3-substituted cycloheptanones formed by diazomethane ring enlargement of 2-substituted cyclohexanones has been investigated for two series. 2-Chlorocyclohexanone yields a mixture containing approximately 23% of the 2-isomer and 77% of the 3-isomer; 2-phenylcyclohexanone yields a mixture containing approximately 81% of the 2-isomer and 19% of the 3-isomer. The ratio of isomers in the chlorocycloheptanone series was determined by chemical means and in the phenylcycloheptanone series by infrared analysis.

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(23) Wade and Panting, *J. Chem. Soc.*, 255 (1898).

(24) Goldberg and Studer, *Helv. Chim. Acta*, **24**, 478 (1941).

(22) Cf. Ruzicka and Brugger, *Helv. Chim. Acta*, **9**, 339 (1926).