was obtained from petroleum ether as white needles, m.p. 76–76.5°.

Anal. Calcd. for $C_{16}H_{18}O$: C, 84.91; H, 8.02. Found: C, 84.66; H, 8.01.

The compound gave chemical tests similar to those obtained with the lower homologs.

2-Methoxyfluorene.—A diazonium chloride solution was prepared from 7.7 g. of 2-aminofluorene[27] and was treated with 8 g. of zinc chloride. The resulting precipitates, dried *in vacuo*, weighed 9.5 g. This complex salt was refluxed for 36 hours in 100 ml. of methanol. The resulting mixture was filtered while still warm and the filtrate chilled yielding 5.5 g. (66%) of a white solid, m.p. 98–102°. Upon recrystallization this product melted at 106–108° (lit.[27] 106–108°).

2-Hydroxyfluorene.—A solution containing 1 g. of 2-methoxyfluorene in a mixture of glacial acetic acid (20 ml.) and 48% hydrobromic acid (12 ml.) was refluxed for 36 hours. The phenolic material was separated from the reaction mixture in the usual way giving 0.5 g. (54%) of a cream-colored solid, m.p. 160–164°. Recrystallization of this product from dilute acetic acid gave material melting at 167–169° (lit.[27] sintering at 166°, m.p. 168° uncor.).

Biological Testing.—The testing procedure was essentially that of Leonard and Blackford.[2] Measurement was made of the inhibition of the rate of radial growth of test cultures of *Aspergillus niger*[28] caused by dispersion of known concentrations of the test compound in the agar medium.

---

[27] O. Diels, *Ber.*, **34**, 1758 (1901).

[28] T. C. 215-4247 Steinberg. We are indebted to Mrs. Rita S. Kardon and Mrs. Barbara S. Bayless for carrying out these tests.

DURHAM, N. C.

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

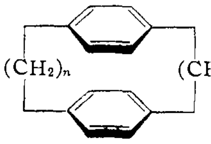
Macro Rings. IV. The Preparation of Three New Paracyclophanes[1]

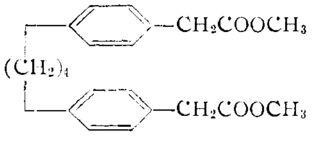
BY NORMAN L. ALLINGER AND DONALD J. CRAM[2]

RECEIVED DECEMBER 15, 1953

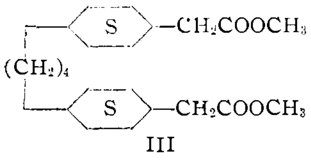
The three paracyclophanes (I) with the 3- and 4-, 4- and 5-, and 5- and 5-membered methylene bridges have been prepared. These syntheses further illustrate the generality of the method involving hydrogenation of the benzene rings prior to an acyloin ring closure followed by dehydrogenation at a later stage. The stereochemistry of the fully hydrogenated paracyclophanes is discussed.

The preceding paper in this series[3] reported the synthesis and properties of the paracyclophane (I) with $n = m = 4$. The acyloin ring closure fails on esters of the phenylacetic type,[4] such as II, but if the benzene rings of II are hydrogenated, the resulting dicyclohexyl compounds can be closed to give an acyloin ultimately convertible to I with $n = m = 4$. The method is obviously applicable to the synthesis of compounds having methylene bridges of this size or larger, but smaller only to the limit where steric factors prohibit ring closure.


I


II

In the previously reported synthesis of I with $n = m = 4$, the saturated ester III underwent acyloin ring closure only if the groups on the cyclohexane rings were oriented *cis–cis*, polymer resulting from starting materials of other configurations.


III

In the present investigation three new paracyclophanes were prepared by the general sequence formulated. The appropriate hydrocarbon IV was acetylated to give the corresponding diketone V, and in one case a mixture of the mono- and diketone ($n = 5$). This monoketone VI was propionylated to give VII, and along with the other two homologous diketones was submitted to the modified Willgerodt reaction.[5] The resulting thiomorpholides were hydrolyzed to the corresponding acids which were subsequently esterified. The over-all yields of ester from diketone were satisfactory (40–60%) except in the case of the unsymmetrical diketone, VII, which gave only a 15% yield of ester The aromatic rings were then hydrogenated to give the corresponding cyclohexyl compounds IX as *cis–cis*, *cis–trans* and *trans–trans* mixtures. The mixtures obtained were used directly in the acyloin ring closure,[3] no separation of isomers being attempted. Only one acyloin XB was obtained in a crystalline state, the others being isolated as oils which appeared to decompose appreciably when distilled. Therefore the crude acyloins were subjected directly to a modified[6] Clemmensen reduction followed by a catalytic reduction which converted olefinic by-product to the desired saturated material.[3]

The saturated hydrocarbon XIB ($n = 5, m = 4$) was obtained as a single pure compound in a yield of 19% (based on diester IXB), which is comparable to that obtained in the previous preparation[3] of the analogous substance with $n = m = 4$ (22%). The configuration of XIB was demonstrated to be *cis–cis* by its preparation from the parent paracyclophane (XIIB) by hydrogenation, a single isomer being obtained. Scale molecular models of XIB and XIIB indicate that neither can one ring of XIIB turn to right angles to the other ring nor is there room in between the two rings for catalyst with its absorbed hydrogen. The same considerations apply to the partially reduced intermediates in XIIB → XIB. Therefore XIB must possess the *cis–cis*

---

[1] This work was sponsored by the Office of Naval Research.

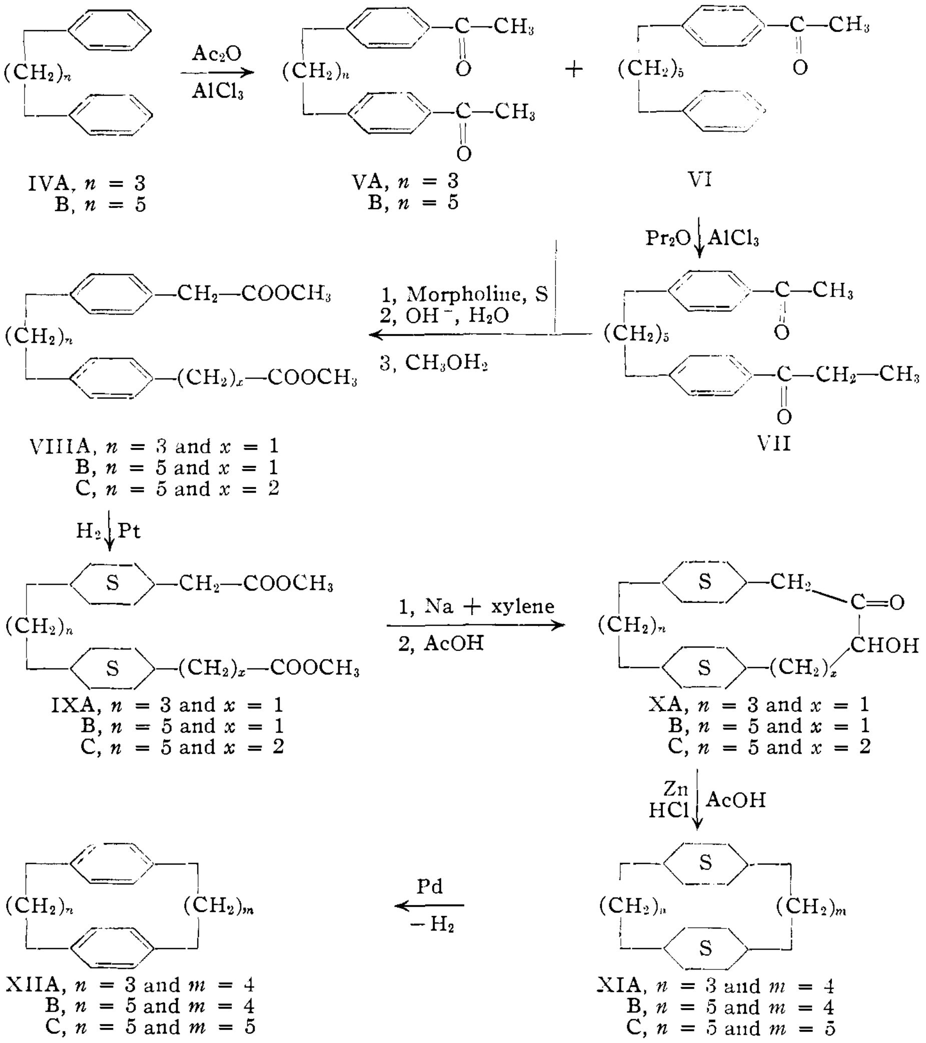
[2] Requests for reprints should be addressed to this author.

[3] D. J. Cram and N. L. Allinger, THIS JOURNAL, **76**, 726 (1954).

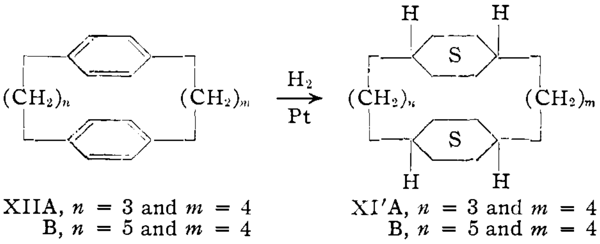
[4] D. J. Cram and H. Steinberg, *ibid.*, **73**, 5691 (1951).

[5] E. Schwenk and D. Papa, *J. Org. Chem.*, **11**, 798 (1946).

[6] K. Wiesner, D. M. MacDonald, R. B. Ingram and R. B. Kelly, *Canadian J. Res.*, **B28**, 561 (1950).

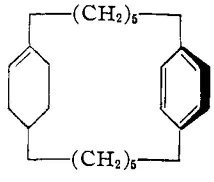


geometry, and if the rings cannot turn over, the configuration is probably that of XI'B. The yield from ester (IXA) of the saturated hydrocarbon, XIA ($n = 3$, $m = 4$), amounted to only 6%, a fact compatible with the more constrained geometry of this cycle. Here the *cis–cis* structure possessing the rotational configuration of XI'A is assumed by analogy with XIIB → XI'B, and with the compound having $n = m = 4$.[3] Both XIA and XIB readily underwent dehydrogenation, with palladium to give XIIA and XIIB, respectively.

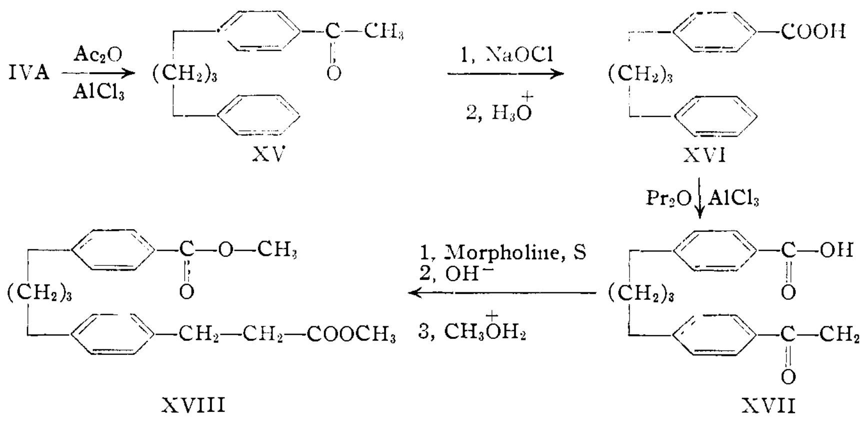


In the case of hydrocarbon XIC ($n = m = 5$) a new situation was encountered. The yield of this material based on diester is sufficiently high (47%) that ring closure of more than the *cis–cis* diester IXC is indicated. This contention is supported by the following additional facts: (1) The hydrocarbon obtained melted over a 50° range. (2) This material was dehydrogenated to the paracyclophane (XIIC) in 95% yield (the product melted over a 1.5° range) (3) Fractional crystallization of the saturated hydrocarbon gave two sharply melting substances, m.p. 140.5° and m.p. 82.6°, both of which gave the correct analysis for XIC. A mixed melting point of these substances did not give a depression, and therefore the higher melting compound is presumed to be a pure component, and the other a eutectic mixture of the higher melting compound and a second isomer. (4) Catalytic reduction of paracyclophane XIIC gave a crystalline mixture of fully hydrogenated hydrocarbons whose melting point was slightly raised by admixture with the above material melting at 140.5°.

The above results are rationalized as follows: Two types of isomerism are possible with compounds of general structure XI, that due to the relative configurations of the points of attachment of the methylene bridges to the cyclohexane rings, and that due to the restricted rotation of the two rings with respect to one another. Scale molecular models suggest that the latter type of isomerism might be possible in XI with $n = m = 4$ or $n = 4$, $m = 5$, but that the rings can probably turn over in XI with $n = m = 5$. Therefore it is probable that the mixture of isomers obtained both by ring closure and by reduction are of the *cis–trans* type. This conclusion means that in the course of the reduction of the two aromatic rings, either catalyst with its absorbed hydrogen had to get between the two rings, or that one ring had to turn over with respect to the other at some point in the course of the reduction (formula XIII illustrates one possible situation). Since the space between the rings is rather constricted, the latter explanation is more compat-

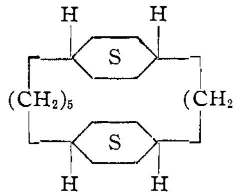


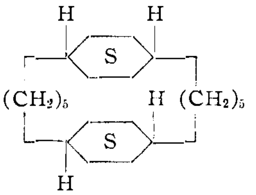
XIII

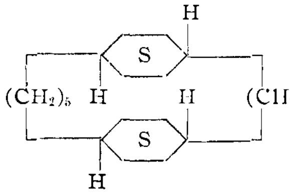


ible with the molecular geometry involved. Since only one reduction product was obtained in the hydrogenation of the paracyclophanes with $n = m = 4$[3] and $n = 4$ and $m = 5$, a geometry similar to that of XIII for both the starting material and the partially reduced intermediates would appear to be denied these ring systems, for steric reasons. This conclusion is consistent with what might be expected from an examination of scale molecular models.

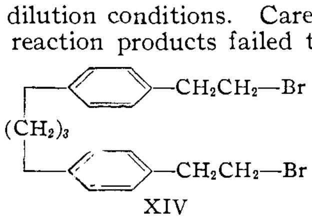
From the ratios of isomers obtained in the reduction of *p*-xylene,[7] which was carried out under the same conditions used to prepare saturated diester IXC from aromatic diester VIIIC, it is estimated that in the final cyclic saturated hydrocarbon XIC obtained from diester IXC, the *cis–cis* predominates over the *cis–trans* isomer, which in turn predominates over the *trans–trans* material.


cis–trans


cis–trans


trans–trans

Two additional synthetic approaches for the preparation of XIIA ($n = 3$, $m = 4$) also were investigated. The Wurtz reaction has been successfully applied to the preparation of the paracyclophanes in which $n = 2$, and $m = 2$, 3 or 4. In all of the syntheses, the starting dibromides were of a benzyl type, and the yields were always less than 5%. Although benzyl halides are known to be particularly good in the Wurtz reaction,[8] the ring closure of an ordinary dibromide had never been attempted. Accordingly compound XIV was submitted to Wurtz reaction under high dilution conditions. Careful examination of the reaction products failed to reveal the presence of the desired paracyclophane, the simple linear reduction product largely accounting for the starting material.


XIV

Although the diester VIIIA fails to cyclize in an acyloin reaction because of its active hydrogens it was hoped that the isomeric diester XVIII would give ketol convertible to the paracyclophanes with $n = 3$, $m = 4$.[9] The ester was prepared by the reaction sequence formulated and submitted to the conditions of the high-dilution acyloin cyclization. The bulk of the starting material was recovered unchanged. One other case is known to the authors in which ester is recovered from this reaction. The substance, methyl *p*-(γ-carbomethoxypropyl)-phenylbutyrate, was recovered unchanged after refluxing with excess sodium or sodium–potassium alloy in xylene for three days.[10]

Experimental

Boiling points are uncorrected, melting points are corrected.

1,5-Diphenyl-2-pentanone.—The cadmium reagent from 200 g. of γ-phenylpropyl bromide was prepared in the usual way[11] and allowed to react with 141 g. of phenylacetyl chloride in benzene. The product was extracted in the usual way[11] and distilled through a Vigreux column to give 150 g. (63%) of a colorless liquid, b.p. 174–176° (4 mm.), $n^{25}D$ 1.5529.

Anal. Calcd. for $C_{17}H_{18}O$: C, 85.67; H, 7.61. Found: C, 85.50; H, 7.78.

1,5-Diphenylpentane (IVB).—The above ketone was reduced to the hydrocarbon by the modified Wolff–Kishner[12] method, yield 88%, b.p. 152–154° (4 mm.), $n^{25}D$ 1.5440 (reported[13] b.p. 185° at 20 mm.).

***p*-Acetyl-1,5-diphenylpentane** (VI).—The hydrocarbon IVB, 160 g. (0.714 mole) and acetic anhydride, 72.9 g. (0.714 mole) were dissolved in 500 ml. of tetrachloroethane. The mixture was cooled to −20°, and 189 g. (1.43 moles) of powdered anhydrous aluminum chloride was added portionwise during 10 minutes, the temperature being kept in the range of −10 to 0°. The mixture was then allowed to stand and come to room temperature for a total time of 1.5 hours. The complex was then decomposed by the dropwise addition of excess dilute hydrochloric acid, the temperature being kept below 0°. The organic phase was separated, washed, and dried, and the solvent was distilled under vacuum. Distillation of the residue through a two-foot Vigreux column at 3.5 mm. gave 40.9 g. (26%) of recovered starting material (b.p. 148–149°), an intermediate fraction (1.9 g.), 89.4 g. (48%) of the monoacetylated product (b.p.

---

[7] O. Miller, *Bull. soc. chim. belg.*, **44**, 513 (1935).

[8] A. A. Morton and F. Fallwell, Jr., THIS JOURNAL, **60**, 1429 (1938).

[9] J. W. Lynn and J. English, *ibid.*, **73**, 4284 (1951), have reported the successful acyloin reaction between benzoate and aliphatic esters.

[10] D. J. Cram and H. Steinberg, unpublished results. K. Wiesner has independently confirmed this result (private communication).

[11] J. Cason and F. S. Prout, *Org. Syntheses*, **28**, 75 (1948).

[12] Huang-Minlon, THIS JOURNAL, **68**, 2487 (1946).

[13] F. Strauss and H. Grindell, *Ann.*, **439**, 306 (1924).

202–204°, $n^{25}\text{D}$ 1.5572), 2.5 g. of an intermediate fraction, and 36.2 g. (17%) of the diacetylated product, b.p. 254–256°, $n^{25}\text{D}$ 1.5674. For the monoacetylated product:

Anal. Calcd. for $C_{19}H_{22}O$: C, 85.67; H, 8.33. Found: C, 85.85; H, 8.39.

1,5-Bis-(4-acetylphenyl)-pentane (VB).—The diacetylated product, above, solidified upon standing. An analytical sample was crystallized from pentane at −20° to furnish plates, m.p. 42.3–43.0°.

Anal. Calcd. for $C_{21}H_{24}O_2$: C, 81.78; H, 7.84. Found: C, 81.80; H, 8.14.

1,5-Bis-(4-thioacetmorpholidophenyl)-pentane.—The diketone VB, 45.5 g. (0.148 mole), was heated under reflux with 14.2 g. (0.443 mole) of sulfur in 150 ml. of morpholine for 11 hours and the mixture was then poured, while still warm, into 200 cc. of ethanol. After cooling the solution to 0° for several hours the tan crystalline material was collected, wt. 71.0 g., m.p. 94–102°. An analytical sample was recrystallized four times from ethanol, the first time with a charcoal treatment to yield white needles, m.p. 128.2–129.0°.

Anal. Calcd. for $C_{29}H_{38}O_2N_2S_2$: C, 68.19; H, 7.50. Found: C, 68.17; H, 7.60.

1,5-Bis-(4-carbomethoxymethylphenyl)-pentane (VIIIB).—Hydrolysis of 70.0 g. (0.137 mole) of the crude thiomorpholide was accomplished by heating it under reflux for 12 hours with 31.3 g. (0.55 mole) of potassium hydroxide in 500 ml. of 70% ethanol. Removal of the ethanol and acidification of the mixture furnished the acid as a tan powder, m.p. 174–181°. This material was esterified with methanol and sulfuric acid. Distillation gave a yellow oil, wt. 27.7 g., b.p. 140–155° (2 mm.). The crude ester was heated under reflux for 1 hour in 150 ml. of methanol with 1 g. of Raney nickel. The warm solution was filtered free of nickel, and, upon cooling to −5°, deposited white needles, 20.9 g. (39% based on the diketone VB), m.p. 62–64°. An analytical sample was twice recrystallized, blades, m.p. 65.1–65.7°.

Anal. Calcd. for $C_{23}H_{28}O_4$: C, 74.97; H, 7.66. Found: C, 74.67; H, 7.64.

1,5-Bis-(4-carboxymethylphenyl)-pentane.—Saponification of 0.35 g. of the ester VIIIB with ethanolic potassium hydroxide gave the acid, 0.27 g. (84%), a white powder, m.p. 188–191°. Two crystallizations from aqueous acetic acid gave needles, m.p. 190.3–191.5°.

Anal. Calcd. for $C_{21}H_{24}O_4$: C, 74.09; H, 7.11. Found: C, 74.22; H, 7.12.

1,5-Bis-(4-carbomethoxymethylcyclohexyl)-pentane (IXB).—The aromatic ester VIIIB, 15.9 g. (0.0432 mole), was hydrogenated in 60 ml. of acetic acid with 1 g. of platinum oxide at 25° and a pressure of one atmosphere. The theoretical amount of hydrogen was absorbed in five hours. The catalyst was filtered from the solution, the solvent was removed and the product was distilled, wt. 15.2 g. (92%), b.p. 242–245° (4 mm.), $n^{25}\text{D}$ 1.4778.

Anal. Calcd. for $C_{23}H_{40}O_4$: C, 72.59; H, 10.59. Found: C, 72.54; H, 10.34.

2-Hydroxy-3-keto-*p*,*p*′-pentamethylene-1,4-dicyclohexylbutane (XB).—The acyloin condensation was carried out in a manner similar to those previously described.[3] The ester IXB, 15.2 g. (0.040 mole), in 200 ml. of xylene was added to 4.15 g. of sodium in 1500 ml. of xylene during 16 hours. The mixture was heated with stirring for an additional 2 hours, and then cooled. The salts were decomposed and dissolved by the addition of acetic acid followed by water. The xylene phase was separated and dried. Removal of the solvent and distillation of the residue furnished 6.5 g. of a yellow oil, b.p. 204–208 (1 mm.), which solidified upon standing. The crude acyloin crystallized from acetone–hexane and was obtained as fine needles, m.p. 110–116°, wt. 6.0 g. (47%). For analysis a small sample was twice recrystallized, m.p. 117.2–118.6°.

Anal. Calcd. for $C_{21}H_{36}O_2$: C, 78.69; H, 11.32. Found: C, 78.48; H, 11.14.

***p*,*p*′-Tetramethylene-1,5-dicyclohexylpentane (XIB).**—Amalgamated zinc was prepared with 48 g. of zinc and 1.5 g. of mercuric chloride in 150 ml. of water. After addition of 1 ml. of HCl, the mixture was swirled for 5 minutes. The liquid was then decanted, and the acyloin XB, 5.70 g. (0.017 mole), was added to the zinc along with 150 ml. each of concd. HCl and acetic acid. The mixture was heated under reflux for 40 hours with addition of 20-ml. portions of concd. HCl at 12-hour intervals. The reaction mixture was then cooled and poured into water. The product was extracted with pentane, and the extracts were dried. Removal of the pentane left an oily solid, 4.90 g. This material was dissolved in 40 ml. of ethyl acetate, and to the solution was added 10 ml. of acetic acid and 0.2 g. of platinum oxide. The crude product took up 120 ml. (cor.) of hydrogen at 25° and one atmosphere (31% olefin). The catalyst was removed by filtration, and the product was crystallized by the addition of water, white plates, wt. 2.61 g., m.p. 109–114°. A second crop, 0.80 g., m.p. 98–105° was also obtained. Systematic fractional crystallization of the above material (five recrystallizations for the first crop) from ethanol–ethyl acetate gave 2.05 g. (40%) of the hydrocarbon, m.p. 120–122°. For analysis, a small sample was twice recrystallized from ethanol–ethyl acetate, m.p. 123.3–124.6°, needles.

Anal. Calcd. for $C_{21}H_{38}$: C, 86.81; H, 13.19. Found: C, 86.80; H, 12.92.

***p*,*p*′-Tetramethylene-1,5-diphenylpentane (XIIB).**—The saturated hydrocarbon XIB, 1.41 g., was dehydrogenated at 240–315° with 0.14 g. of 10% palladium on charcoal. The theoretical amount of hydrogen was evolved in 2 hours. After cooling, the crude product was dissolved in pentane and the solution was filtered free of catalyst. The solvent was evaporated and the residue was crystallized from aqueous ethanol to yield 1.10 g. (81.5%), m.p. 124.0–125.7°. For analysis, a sample was twice recrystallized from ethanol, needles, m.p. 125.5–126.3°.

Anal. Calcd. for $C_{21}H_{26}$: C, 90.59; H, 9.41. Found: C, 90.58; H, 9.21.

***p*-Acetyl-*p*′-propionyl-1,5-diphenylpentane (VII).**—*p*-Acetyl-1,5-diphenylpentane (VI), 24.3 g. (0.0914 mole), and propionic anhydride (redistilled, b.p. 166–168°), 12.4 g. (0.0959 mole), were dissolved in 100 ml. of tetrachloroethane and cooled to −20°. Anhydrous aluminum chloride, 38.7 g. (0.292 mole), was added in three portions, the temperature being kept below 0°. The mixture was allowed to stand and warmed to room temperature for a total of 45 minutes. The mixture was then cooled and kept below 0° while excess dilute HCl was added. The organic phase was separated, washed and dried. After removal of the solvent the residue was distilled through a two-foot Podbielniak type column. After a 3.7 g. forerun, the product distilled, b.p. 258–260° (3.5 mm.), wt. 22.4 g. (76%), $n^{25}\text{D}$ 1.5629. An analytical sample was crystallized from acetone–pentane at −80°, m.p. 35.8–37.2°.

Anal. Calcd. for $C_{22}H_{26}O_2$: C, 81.95; H, 8.13. Found: C, 82.07; H, 8.08.

***p*-Carbomethoxymethyl-*p*′-(β-carbomethoxyethyl)-1,5-diphenylpentane (VIIIC).**—The ketone VII, 81.5 g. (0.253 mole), was heated under reflux with 24.3 g. (0.759 mole) of sulfur in 300 ml. of morpholine for 18 hours. The bulk of the morpholine was then distilled, and a solution prepared from 57 g. (1 mole) of potassium hydroxide, 60 ml. of water and 500 ml. of ethanol was added. The mixture was heated under reflux for 12 hours, and the ethanol was then removed by distillation with the simultaneous addition of 300 ml. of water. The solution was then filtered and acidified, the acid separating as a brown oil. The oil was extracted with chloroform, and the chloroform extracts were washed and dried. After removal of the chloroform, 700 ml. of methanol and 30 ml. of concd. sulfuric acid were added to the residual oil, and the solution was heated under reflux for 2 hours, then cooled and poured into 3 liters of water. The oil was extracted with ether, and the extracts were washed with dilute sodium bicarbonate solution and water. After the ether extracts were dried and the solvent was removed, the residue was distilled to yield 41 g. of an orange oil, b.p. 145–185° (3 mm.). The oil was dissolved in 250 ml. of methanol, 2 g. of Raney nickel was added, and the mixture was heated under reflux for 2 hours. The hot solution was then filtered, cooled, and the solid was collected as a cream colored crystalline powder, 18.4 g., m.p. 68.5–71°. The crude ester was taken up in ether and treated with charcoal, then twice recrystallized from methanol to yield needles, 14.6 g. (15%), m.p. 73.6–74.7°. An analytical sample was recrystallized from ether, m.p. 74.2–74.9°.

Anal. Calcd. for $C_{24}H_{30}O_4$: C, 75.36; H, 7.00. Found: C, 75.50; H, 8.08.

p-Carboxymethyl p′-(β-carboxyethyl)-1,5-diphenylpentane.—Saponification of 0.13 g. of the ester VIIIC gave 0.10 g. of the acid, m.p. 160.5–162.5°. One crystallization from aqueous acetic acid gave needles, m.p. 161.3–162.4°.

Anal. Calcd. for $C_{22}H_{26}O_4$: C, 74.55; H, 7.39. Found: C, 74.46; H, 7.45.

p-Carbomethoxymethyl-p′-(β-carbomethoxyethyl)-1,5-dicyclohexylpentane (IXC).—The aromatic ester VIIIC, 13.7 g. (0.0358 mole), was hydrogenated as described for its homolog VIIIB. Distillation of the product gave 12.4 g. (88%), b.p. 252–254° (4 mm.), n^{25}D 1.4785.

Anal. Calcd. for $C_{24}H_{42}O_4$: C, 73.05; H, 10.73. Found: C, 73.09; H, 10.63.

2-Hydroxy-3-keto-p,p′-pentamethylene-1,5-dicyclohexylpentane (XC).[14]—The ester IXC, 12.1 g. (0.0308 mole), in 150 ml. of xylene was added to 3.55 g. (0.154 mole) of sodium in 1500 ml. of xylene during 12 hours. After an additional hour of heating, excess acetic acid was added to the cooled mixture, followed by water. The xylene phase was separated, washed with water and dilute sodium bicarbonate and dried. After the solvent was removed, the residue was distilled to give a viscous yellow oil, 6.6 g. (62%), b.p. 212–218° (1.5 mm.), which partially solidified upon standing. No attempt was made to further purify the isomeric mixture.

Anal. Calcd. for $C_{22}H_{38}O_2$: C, 78.98; H, 11.45. Found: C, 78.46; H, 11.41.

p,p′-Pentamethylene-1,5-dicyclohexylpentane (XIC).—The reduction of the crude acyloin XC, 6.5 g., was accomplished by the method described above for the smaller homolog XB. The crude hydrocarbon was obtained in virtually quantitative yield by extracting the reaction mixture with pentane, washing and drying the extracts and evaporating the solvent. The crude material was hydrogenated with platinum in acetic acid–ethyl acetate. The hydrogen uptake corresponded to 18.5% olefin. The product was obtained by dilution with water and crystallization, 4.70 g., m.p. 80–119°. This material was taken up in pentane and chromatographed on 30 g. of alumina of activity I.[15] The desired hydrocarbon was washed through the column with 200 ml. of pentane. Evaporation of the solvent gave the diastereomeric hydrocarbons as a crystalline solid, wt. 4.47 g. (76%), m.p. 81–126°. A 0.53-g. sample of this mixture gave 0.23 g. of one diastereomer essentially pure after two crystallizations from ethanol–ethyl acetate, m.p. 136–139°. For analysis, this material was twice recrystallized, plates, m.p. 139.4–140.5°.

Anal. Calcd. for $C_{22}H_{40}$: C, 86.76; H, 13.24. Found: C, 86.62; H, 13.33.

The first filtrates from the above diastereomer furnished upon dilution with water and crystallization a poorly defined crystalline solid, 0.22 g., m.p. 81.2–82.6°. The melting point was not changed by recrystallization. The mixed melting point with the pure diastereomer obtained above was 83–88°.

Anal. Calcd. for $C_{22}H_{40}$: C, 86.76; H, 13.24. Found: C, 86.65; H, 13.22.

p,p′-Pentamethylene-1,5-diphenylpentane (XIIC).—Dehydrogenation of the diastereomeric mixture of fully saturated hydrocarbons, XIC, 3.33 g., was accomplished by heating with 0.33 g. of 10% palladium on charcoal at 240–320° for 1.5 hours. The theoretical amount of hydrogen was evolved. The reaction product was taken up in 25 ml. of hot ethyl acetate, and the solution was filtered. Addition of 35 ml. of ethanol and cooling of the resulting solution caused the product to crystallize. The white needles were collected, 3.08 g. (96%), m.p. 152.5–154°. For analysis, the material was twice recrystallized, m.p. 154.3–155.3°.

Anal. Calcd. for $C_{22}H_{28}$: C, 90.35; H, 9.65. Found: C, 90.38; H, 9.82.

1,3-Bis-p-(carbomethoxymethylcyclohexyl)-propane (IXA).—The required aromatic ester was prepared in the manner previously used[4] as indicated in the formulations. Hydrogenation of this material was carried out as described for the homolog VIIIB. The product was distilled to give a colorless liquid IXA in 91% yield, b.p. 223–225° (3.5 mm.), n^{25}D 1.4784.

Anal. Calcd. for $C_{21}H_{36}O_4$: C, 71.55; H, 10.29. Found: C, 71.51; H, 10.44.

2-Hydroxy-3-keto-p,p′-trimethylene-1,4-dicyclohexylbutane (XA).—The acyloin was prepared from 42.4 g. (0.120 mole) of the ester IXA in 500 ml. of xylene by adding this solution to 13.85 g. (0.602 mole) of sodium in 1.5 liters of xylene during 34 hours as described previously. After decomposition of the salts, the two phase solution was filtered to give 2 g. of a sticky grey polymer. The xylene phase was separated, washed and dried. After removal of the solvent, the residue was distilled to give a yellow oil, wt. 9.1 g. (26%), b.p. 205–209° (2 mm.). The polymeric still residue weighed 16 g. The distillate gave a positive acyloin test, and a negative ferric chloride test. Further purification was not attempted. The infrared spectrum of this material in carbon tetrachloride showed a strong band at 5.79 μ (ketone) with a shoulder at 5.6 μ (ester).

Anal. Calcd. for $C_{19}H_{32}O_2$: C, 78.03; H, 11.03. Found: C, 77.88; H, 10.64.

p,p′-Trimethylene-1,4-dicyclohexylbutane (XIA).—The impure acyloin XA, 7.15 g., was converted to the hydrocarbon with zinc and acid as described for XB. The product was isolated in the usual way and distilled to give 4.82 g. with a bath temperature of 170–250° (2 mm.). The polymeric residue, a colorless glass, weighed 1.5 g. The distillate was then fractionally distilled through a two-foot column of the Podbielniak type. The following fractions were collected.

Fraction	Wt., g.	B.p. °C.	Mm.	
1	0.18	159–168.5	4	n^{25}D 1.4870
2	0.76	168.5–170.5	4	n^{25}D 1.4911
3	1.62	170.5–172.5	4	Solid
4	0.20	142–167	1	Solid
5	1.11	167–169	1	n^{25}D 1.4824

Fraction 3, which showed no reaction with $KMnO_4$ in acetone at 40°, was hydrogenated in acetic acid–ethyl acetate with 0.10 g. of platinum oxide. The hydrogen uptake was 67 cc. (cor.) at 25°, and was complete in 15 minutes. The catalyst was filtered from the solution, and, after adding ethanol to the filtrate, the product crystallized, m.p. 83–86°, 1.50 g. (23%). For analysis, a sample of this material was twice recrystallized, needles, m.p. 86.2–87.1°.

Anal. Calcd. for $C_{19}H_{34}$: C, 86.94; H, 13.06. Found: C, 86.95; H, 13.01.

The material obtained in fraction 2 was analyzed and found to have the empirical formula $C_{19}H_{36}$.

Anal. Calcd. for $C_{19}H_{36}$: C, 86.28; H, 13.72. Found: C, 86.41, 86.39; H, 13.53, 13.49.

Upon hydrogenation with platinum in acetic acid, it took up one equivalent of hydrogen and gave a product which appeared to be non-homogeneous.

Fraction 5 did not analyze for any reasonable pure compound. The infrared spectrum shows strong bands at 5.71, 8.00 and 9.57 μ, which are characteristic of an ester. The infrared spectrum of the starting ester IXA was somewhat similar.

Anal. Found: C, 79.68, 79.77; H, 12.26, 12.40.

p,p′-Trimethylene-1,4-diphenylbutane (XIIA).—The saturated compound XIA, 0.40 g., was dehydrogenated by heating at 250–320° for 1.5 hours with 40 mg. of palladium on charcoal (10%) to give virtually a quantitative amount of hydrogen. The reaction product was taken up in pentane, filtered free of catalyst and crystallized from ethanol to give plates, wt. 0.34 g. (89%), m.p. 117–117.5°. For analysis, this material was twice recrystallized, m.p. 118.0–118.5°.

Anal. Calcd. for $C_{19}H_{22}$: C, 91.17; H, 8.83. Found: C, 91.12; H, 8.77.

p,p′-Pentamethylene-1,5-dicyclohexylpentane (XIC).—Hydrogenation of 131 mg. of XIIC with 100 mg. of platinum oxide in acetic acid–ethyl acetate gave after removal of the catalyst, addition of a little water, and crystallization, a white crystalline powder, 116 mg., m.p. 117–128° (pure XIC has m.p. 139.4–140.5°), mixed m.p. 128–134°. The

---

[14] This structure has not been differentiated from the other possible isomer, namely, 3-hydroxy-2-keto-p,p′-pentamethylene-1,5-dicyclohexylpentane, either here or in formula XC.

[15] H. Brockmann and H. Schodder, *Ber.*, **74B**, 73 (1941).

ultraviolet spectrum showed less than 0.1% of the starting material.

Anal. Calcd. for $C_{22}H_{40}$: C, 86.76; H, 13.24. Found: C, 86.84; H, 13.24.

***p*,*p*'-Tetramethylene-1,5-dicyclohexylpentane (XIB).**—Hydrogenation of 100 mg. of XIIB was carried out as described for XIC and gave needles, 80 mg., m.p. 122.0–123.6°.

Attempted Wurtz Cyclization with 1,3-Bis-(β-bromoethylphenyl)-propane (XIV).—The necessary bromide was prepared from ester VIIIA by $LiAlH_4$ reduction to the alcohol followed by treatment with HBr as previously described.[4]

The Wurtz reaction was carried out in the usual way,[4] 27.2 g. of the bromide XIV in 1 liter of xylene being added to 4.58 g. of sodium in 2 liters of xylene during 62 hours. The excess sodium was destroyed with methanol and the mixture was filtered. The blue-grey polymer, after being washed free of sodium bromide and dried, weighed 2.86 g. The xylene was removed from the filtrate, and the residue was distilled at 1.5 mm., the following fractions being collected: (1) 1.90 g., b.p. 145–150°; (2) 2.63 g., b.p. 150–152°; (3) 3.17 g., b.p. 152°; (4) 2.64 g., b.p. 152–154°; (5) 1.11 g., b.p. 154–222°; (6) 2.08 g., b.p. 222–232°; (7) 0.90 g., b.p. 232–240°. The brown residue weighed 4.47 g.

Fraction 1 upon standing slowly deposited a few dense prisms which were removed with a spatula and dried on filter paper, wt. 7.8 mg., m.p. 120–124.5°. Recrystallization of this material from hexane gave 6.0 mg., m.p. 125.8–126.6°, mixed melting point with *meso*-2,3-diphenylbutane (m.p. 125.8–126.8°) was 125.8–126.8°. Fractions 1–5 were crystallized separately from ethanol (−80°) to give a total of 6.98 g. (42%) of white plates with melting points from 31.5–33.5° to 33.0–34.0°. No melting point depression was observed with these materials and authentic bis-1,3-(*p*-ethylphenyl)-propane[4] (m.p. 34.4–35.0°). The filtrates from fractions 1 and 2 were taken up in pentane, washed, dried and chromatographed on 150 g. of alumina. Elution was carried out with pentane, thirty-four 100-ml. fractions being taken. From fractions 1–12 was obtained 130 mg. of bis-1,3-(*p*-ethylphenyl)-propane, m.p. 30–33°. The remaining fractions contained a total of 0.69 g. of oils which could not be crystallized at −80°. The remaining distillation fractions were treated in a similar manner, and yielded an additional 0.91 g. of bis-1,3-(*p*-ethylphenyl)-propane and additional uncrystallizable oils.

***p*-Acetyl-1,3-diphenylpropane (XV).**—1,3-Diphenylpropane was obtained as previously described[4] and acetylated as described for IVA. Fractional distillation of the product gave the monoacetyl compound in 50% yield, b.p. 156–158° (1.5 mm.), $n^{25}D$ 1.5695.

Anal. Calcd. for $C_{17}H_{18}O$: C, 85.67; H, 7.61. Found: C, 85.47; H, 7.66.

***p*-Carboxy-1,3-diphenylpropane (XVI).**—The ketone XV, 109 g., was added dropwise to a solution of potassium hypochlorite prepared from 284 g. of HTH[16] in 1600 ml. of water, which was previously heated to 85°. The solution was vigorously stirred, and the rate of addition of the ketone was adjusted so as to maintain the temperature at 75–80°. The addition time was 15 minutes, and the solution was heated an additional hour at 75–80°. The solution was then cooled and sodium bisulfite was added until an aliquot of the solution showed the absence of hypochlorite by testing with acidified potassium iodide solution. The solution was acidified, and the precipitate collected, wt. 110 g. The crude material was dissolved in 600 ml. of hexane–acetone (5:1), and the solution was filtered free of a small amount of insoluble material. The product separated from the cooled solution and was collected, white plates, 94.5 g. (86%), m.p. 112.5–114°. An analytical sample was recrystallized, m.p. 113.5–114.5°.

Anal. Calcd. for $C_{16}H_{16}O_2$: C, 79.97; H, 6.71. Found: C, 79.90; H, 6.85.

***p*-Propionyl-*p*'-carboxy-1,3-diphenylpropane (XVII).**—Nitrobenzene, 100 ml., anhydrous aluminum chloride, 48.2 g. (0.363 mole), propionic anhydride, 15.0 g. (0.115 mole), were mixed at 0°. The acid XVI, 24.0 g. (0.100 mole), was added, and the resulting solution was stirred for 5 minutes. The mixture was then heated at 50–60° for 3 hours. The complex was decomposed by pouring the cooled solution with stirring on to a mixture of 300 g. of ice and 50 ml. of concentrated hydrochloric acid. The organic material was extracted with ether, and the extracts were washed and dried. The solvent was removed in vacuum, and the solidified residue was taken up in hot benzene. After treatment with norite, the hot benzene solution was diluted with hexane and the product allowed to crystallize. Filtration of the mixture gave a colorless crystalline powder, wt. 20.7 (70%), m.p. 130–132°. For analysis, a sample was recrystallized twice, needles, m.p. 133.0–134.1°.

Anal. Calcd. for $C_{19}H_{20}O_3$: C, 77.00; H, 6.80. Found: C, 76.63; H, 7.01.

***p*-Carbomethoxy-*p*'-(β-carbomethoxyethyl)-1,3-diphenylpropane (XVIII).**—The Willgerodt reaction was carried out in a manner similar to that described for VII. From 18.3 g. of XVII was obtained 5.3 g. (25%) of the diester, m.p. 65–66°. Two recrystallizations from methanol gave plates, m.p. 66.3–67.5°.

Anal. Calcd. for $C_{21}H_{24}O_4$: C, 74.09; H, 7.11. Found: C, 73.97; H, 7.18.

***p*-Carboxy-*p*'-(β-carboxyethyl)-1,3-diphenylpropane.**—Saponification of 1.0 g. of the ester XVIII with alcoholic potassium hydroxide furnished, after recrystallization from acetic acid, 0.80 g. of the acid, needles, m.p. 203.4–205.0°.

Anal. Calcd. for $C_{19}H_{20}O_4$: C, 73.06; H, 6.45. Found: C, 72.88; H, 6.62.

Attempted Acyloin Condensation with Ester XVIII.—The ester XVIII, 14.3 g., in 1 liter of xylene was added to the sodium (4.06 g.) in 1 liter of xylene during 79 hours. The usual isolation procedure gave 1.21 g. of a brown insoluble polymer. The xylene was removed from the organic phase, and the residue taken up in 75 ml. of hot hexane. Decantation left 0.93 g. of an insoluble brown gum. The hexane solution, upon cooling, deposited a white cryst. powder, 8.16 g., m.p. 63.4–65.8°. Recrystallization of this material gave plates, wt. 7.42 g., m.p. 66.4–67.5°, undepressed when mixed with the starting material XVIII. From the above filtrates, an additional 0.80 g. of the same material, m.p. 64.3–66.5°, was also obtained. The resulting filtrates were chromatographed on 50 g. of alumina with hexane, benzene and ether in turn. A total of 16 fractions (25 ml.) were taken. Fractions 1–5 contained 70 mg. of a semi-solid, which was twice recrystallized from hexane to give prisms, 30.5 mg., m.p. 125.6–126.2°. The melting point showed no depression when the material was mixed with *meso*-2,3-diphenylbutane. Fraction 6 contained nothing. Fractions 7–10 contained 1.34 g. of colorless oil from which could be separated by crystallization, 0.39 g. of starting material. The filtrates gave a negative acyloin test. Fractions 11–15 contained 0.19 g. of a brown gum, negative acyloin test.

***meso*-2,3-Diphenylbutane.**—This material was prepared from α-phenylethyl bromide and magnesium[17]; m.p. 125.8–126.8°, reported[18] m.p. 125°.

LOS ANGELES, CALIFORNIA

---

[16] M. S. Newman and H. L. Holmes, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 428.

[17] A. I. Lepin, *J. Russ. Phys. Chem. Soc.*, **44**, 1190 (1912).

[18] W. T. Somerville and P. E. Spoerri, THIS JOURNAL, **74**, 3803 (1952).