Structure of the Cornubert ketone

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The self-condensation of cyclohexanone in diethyl ether catalyzed by sodium amide has been found to provide a one-step route to pyran **3**. Evidence is presented that the Cornubert ketone formed by this reaction corresponds to ketol **2** which readily rearranges under dehydrating conditions to afford pyran **3**. Structural elucidation of pyran **3** was achieved by a combination of degradative (**3** → **5*b***), synthetic (**8** → **5*b***), and spectral methods. Xanthene **7**, a key dehydrogenation product of ketol **2**, was converted by selective reduction to dihydropyran **5*b***. The five-step synthesis of dihydroxypyran **5*b*** from 1-carbomethoxycyclopentanol (**8**) provided unequivocal evidence for the structure assigned pyran **3** and xanthene **7**.

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On a trouvé que l'auto-condensation de la cyclohexanone dans l'éther, catalysée par l'amidure de sodium, fournit une voie d'accès en une étape au pyranne **3**. On prouve que la cétone de Cornubert, formée par cette réaction, correspond au cétol **2** qui se transpose facilement en pyranne **3** dans des conditions de déshydratation. On a caractérisé le pyranne **3** en faisant appel à une combinaison de méthodes de dégradation (**3** → **5*b***), de synthèse (**8** → **5*b***) et spectrales. Par réduction sélective, on a transformé le xanthène **7**, un produit fondamental de déshydrogénation du cetol **2**, en dihydropyranne **5*b***. La synthèse en 5 étapes du dihydropyranne **5*b*** à partir du carbométhoxy-1 cyclopentanol (**8**) fournit la preuve sans équivoque de la structure attribuée au pyranne **3** et au xanthène **7**.

[Traduit par le journal]

Over 50 years ago, while investigating the alkylation of cyclohexanone with methyl iodide using sodium hydride or amide, Cornubert (1) found that a simple mixture of the ketone, sodium amide, and diethyl ether yielded a new substance ($C_{18}H_{28}O_2$) melting at 186°C. After 2 h at 150°C in acetic anhydride – sodium acetate solution the new ketone was recovered unchanged. Failure of this attempt at acetylation suggested an ether group and the new ketone was formulated as tetrahydropyran **1**. In our previous study (2) of cyclohexanone intramolecular condensation reactions, mild treatment with sodium methoxide – dimethylformamide was found to yield a ketone ($C_{18}H_{28}O_2$) melting at 186.5–187°C. Chemical and physical evidence culminating in an X-ray crystal structure determination led to the definitive assignment of structure **2** (2).

To ascertain whether the Cornubert ketone (mp 186°C) actually corresponded to ketol **2**, attempts were made to repeat the sodium amide – ether experiment as originally (but briefly) outlined. The only C_{18} product obtained (and in poor yield) using the original (1) fractional distillation (to 145°C at 0.5 Torr) procedure for isolation was pyran **3** (mp 40.5–41.5°C). Previously (2) we obtained the same pyran (**3**) by potassium hydrogen sulfate dehydration (at 190–200°C) of ketol **2**. Presumably Cornubert actually obtained ketol **2** instead of tetrahydroxy pyran **1** and depending on the isolation conditions, especially elevated temperatures, the ketol was easily rearranged (**2** → **4**) and dehydrated (**4** → **3**).[2]

Evidence for this conclusion was obtained by subjecting the reaction mixture prepared from cyclohexanone, sodium methoxide, and dimethylformamide, and known to yield ketol **2**, to an analogous fractional distillation. By this means a good yield of pyran **3** was obtained. Although the distillation procedure for obtaining **3** proved to be capricious and was not reproducible, it did seem likely that pyran **3** would be the principal result of subjecting ketol **2** to pyrolytic dehydration. By means of this evidence and that noted in the sequel, the structure of pyran **3** was unequivocally established.

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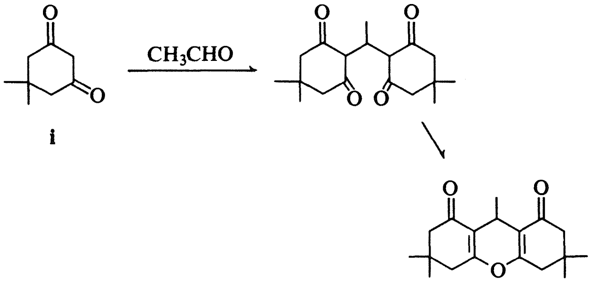
[2] Cyclization of a 1,5-diketone to a 4*H*-pyran system is analogous to the intramolecular condensation reaction observed when dimedone aldehyde derivatives are heated under acid conditions (**i** → **ii**; see ref. 3*a*–*c*).



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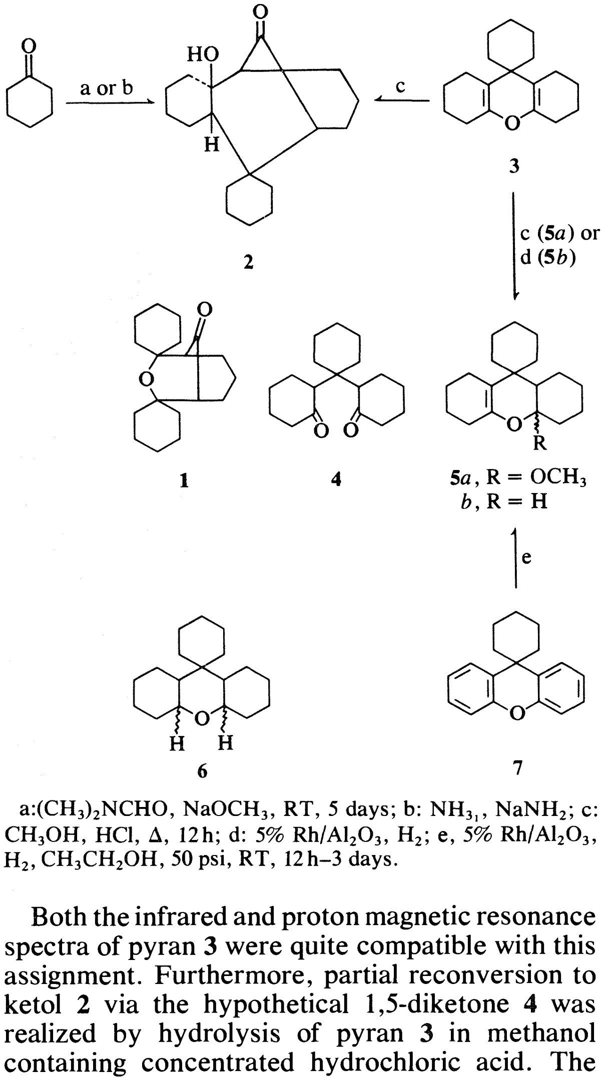

a:$(CH_3)_2NCHO$, $NaOCH_3$, RT, 5 days; b: NH_3, $NaNH_2$; c: CH_3OH, HCl, Δ, 12 h; d: 5% Rh/Al_2O_3, H_2; e, 5% Rh/Al_2O_3, H_2, CH_3CH_2OH, 50 psi, RT, 12 h–3 days.

Both the infrared and proton magnetic resonance spectra of pyran **3** were quite compatible with this assignment. Furthermore, partial reconversion to ketol **2** via the hypothetical 1,5-diketone **4** was realized by hydrolysis of pyran **3** in methanol containing concentrated hydrochloric acid. The main product was ketal **5***a*, and its infrared spectrum showed absorption at 1678 cm^{-1} typical of a dihydropyran.

Complete reduction of pyran **3** employing palladium-catalyzed hydrogenation consumed two moles of hydrogen and provided ether **6**. Selective hydrogenation of pyran **3** using 5% rhodium-on-aluminum oxide led to dihydropyran **5***b*. Meanwhile, in a parallel study of the ketol **2** structure problem (2), xanthene **7** was found to be one of the three products formed by dehydrogenation over 10% palladium-on-carbon (at 290°C). Firm evidence for the structure of xanthene **7** was not obtained until the following experiments were completed. Reduction of xanthene **7** with 5% rhodium-on-aluminum oxide and hydrogen gave as main product dihydropyran **5***b* accompanied by a small quantity of ketol **2**. Isolation of the latter substance suggested that pyran **3** is an important intermediate in the course of hydrogenation and an alternative synthesis of dihydropyran **5***b* was considered necessary.

The route selected for a confirming synthesis was initiated by preparation of 1-carbomethoxycyclopentanol (**8**) by a method developed by Burger and Bennet (4). Cyclopentanone cyanohydrin, obtained by treating cyclopentanone bisulphite addition product with potassium cyanide, was hydrolyzed with concentrated hydrochloric acid to 1-hydroxycyclopentanoic acid. After esterification (Fischer) the ester was treated with *o*-methoxyphenylmagnesium bromide in tetrahydrofuran. The new glycol (**9**, 63%) was converted to the spirocyclohexanone **10** by a pinacol rearrangement (81.5% yield) with iodine in acetic acid. Wolff–Kishner reduction of ketone **10** proved to be somewhat more eventful. In addition to the expected methyl ether (**11**, 34% yield) a minor (13%) product was found to be xanthene **7**.[3]

The next step was intended to yield diketone **4** by a Birch reduction sequence. Attempts at reducing anisole **11** by lithium in liquid ammonia containing *tert*-butyl alcohol according to the Dryden (5)[4] variation of the Birch reduction proved unsuccessful. The Birch reduction appeared to proceed well in only one of the aromatic rings and efforts to hydrolyze the resulting enol ethers to an α,β-unsaturated ketone gave a mixture of ketones unsuitable for the synthetic objective. So the attractive alternative of first demethylating and then reducing the resulting bisphenol (**12**) to a cyclohexanol that could be oxidized to diketone **4** was evaluated. Simple cleavage with hydrobromic or hydriodic acids in hot acid led to mixtures. A reasonable conversion to phenol **12** was realized with refluxing 47% hydriodic acid. In model experiments with bis(2-methoxyphenyl)methane a mixture of sodium and pyridine gave the corresponding bisphenol in 80% yield. When this technique (6) was applied to ether **11** only poor yields of phenol **12** were obtained.

In order to reduce the possibility of competing hydrogenolysis during reduction of phenol **12** a rhodium catalyst was chosen for the reduction step (7). Perhaps due to steric difficulties presented by

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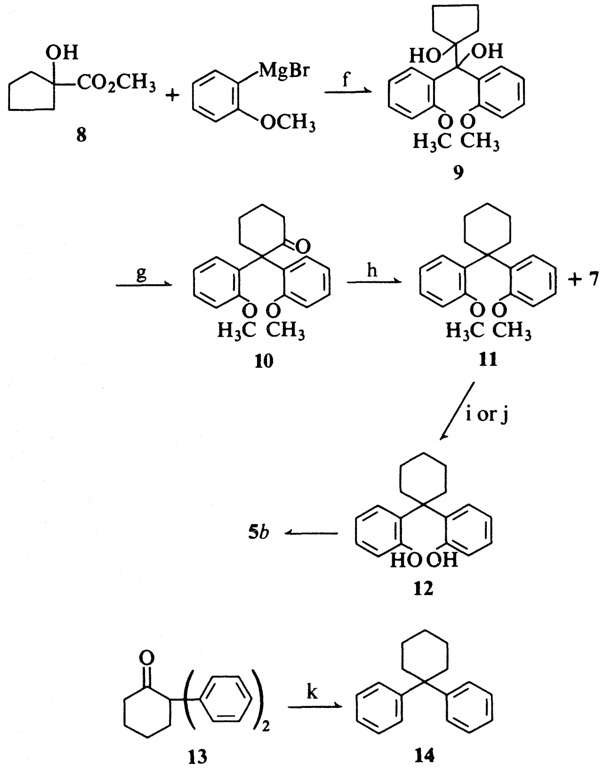
[3] Except for two preliminary attempts, which were unsuccessful, to prepare xanthene by subjecting both bis(2-hydroxyphenyl)methane and bis(2-methoxyphenyl)methane to reaction with potassium hydroxide in diethylene glycol at 190°C, no further effort was devoted to the scope of this potentially useful route to certain diaryl ethers.

[4] By this procedure any trace amount of iron that would catalyze a competing reaction between lithium and the *tert*-butyl alcohol is removed by distilling the ammonia (see ref. 5)



f: THF, N$_2$, 10°C, RT, 12 h; g: I$_2$, CH$_3$CO$_2$H, Δ, 5 min, RT, 12 h; h: 85% NH$_2$NH$_2$, (HOCH$_2$CH$_2$OCH$_2$)$_2$, KOH, 195°C; i: 47% HI, Δ, 9 h; j: Na, Py, N$_2$, Δ, 6 h; k: RuO$_2$·x H$_2$O, CH$_3$CH$_2$OH, 1500 psi, 60°C, 43 h.

the spirocyclohexane ring, hydrogenation of bisphenol **12** with 5% rhodium-on-aluminum oxide as catalyst proved unsatisfactory (incomplete reduction). Since hydrogenolysis can also be minimized by using ruthenium oxide as catalyst (8), application of this method at 1500 psi afforded in one step dihydropyran **5*b***, albeit in low (15%) yield. The specimens of dihydropyran **5*b*** obtained by ruthenium oxide catalyzed hydrogenation of bisphenol **12** and by rhodium – aluminum oxide catalyzed hydrogenation of pyran **3** and xanthene **7** were found to be identical.

Completion of the above synthetic interconversions and interpretation of the various physical measurement results firmly established pyran **3** as an important product that may result from the intramolecular self-condensation of cyclohexanone and related ketones.

Experimental

All solvent extracts of aqueous solutions were dried over anhydrous magnesium sulphate. Ether refers to diethyl ether. Solvents employed for chromatography were redistilled and basic alumina refers to either Merck "Suitable for Chromatography" or Alcoa F-20 grades. All melting points are uncorrected. Instruments employed for determining the ultraviolet (95% ethanol solution), infrared (in potassium bromide unless otherwise noted), ^{1}H nmr (deuteriochloroform solution), ^{13}C (deuteriochloroform solution with tetramethylsilane as reference), and mass (electron impact) spectra have been outlined in the introduction to the experimental section of ref. 2. We are pleased to thank Drs. C. L. Herald, R. Hill, G. Slomp, R. O. Mumma, and J. Witschel, Jr. for assistance with these measurements. Other general aspects of this experimental section also appear in ref. 2.

1′,2′,3′,4′,5′,6′,7′,8′-Octahydro-spiro[cyclohexane-1,9′-xanthene] (3)

Method A

Without benefit of details the experiment (that gave a substance melting at 186°C) reported by Cornubert (1) entailing the auto-condensation of cyclohexanone in liquid ammonia solution containing sodium amide was repeated. A mixture of cyclohexanone (20 g), 1.38 g of sodium amide (prepared from 0.815 g of sodium and excess liquid ammonia containing ferric nitrate), and anhydrous ether (80 mL) was stirred (under dry nitrogen) at ca. 25°C for three days. The reaction mixture was cautiously decomposed (in a nitrogen atmosphere) with water, extracted with ether, and purified by distillation. The fraction (0.60 g) boiling at 135–142°C and 0.5 Torr was crystallized from ethanol to afford 0.085 g of plates, mp 34–40.5°C. Recrystallization from ethanol brought the melting point to 40.5–41.5°C, undepressed upon admixture with a sample of 1′,2′,3′,4′,5′,6′,7′,8′-octahydro-spiro[cyclohexane-1,9′-xanthene] (**3**) prepared by method B and previously (2). Comparison infrared spectra confirmed the mutual identity.

Method B

Cyclohexanone (98.0 g, 1.0 mol) was dissolved in 300 mL of anhydrous *N*,*N*-dimethylformamide. Freshly prepared sodium methoxide (81.0 g, 1.5 mol) was added and the mixture vigorously stirred with cooling (ice-bath). After the temperature was lowered to 10°C it was allowed to rise to ca. 25°C and stirring was continued five days. The sodium methoxide was removed by filtration and the solvent and unreacted cyclohexanone were removed by distillation (atmospheric pressure). Vacuum distillation of the residue gave a fraction (36.9 g) boiling at 148.5–152°C and 1.3 Torr which crystallized from ethanol giving two crops of plates, 22.4 g (mp 40–41.5°C) and 3.1 g (mp 39.5–40.5°C). The first fraction was recrystallized twice from ethanol to afford a pure specimen of pyran **3** (tetranitromethane gave a red-brown color); ν_{max} (CCl$_4$): 1694, 1660, 1228, and 1180 cm^{-1}; ^{1}H nmr δ: 1.52–1.67 (18H, m), 2.16 (8H, m); ^{13}C nmr δ: 22.68 (2C), 23.95 (2C), 24.01, 25.64 (2C), 26.22 (2C), 27.46 (2C), 34.44 (2C), 36.00, 114.48 (2C, C=C), 145.18 (2C, =C—O); mass spectrum *m*/*e*: 258 (M$^+$), 250, 229, 215 (base peak), 207, 202. *Anal.* calcd. for C$_{18}$H$_{26}$O: C 83.66, H 10.14, O 6.18; found: C 83.64, 83.52; H 9.99, 10.01; O 6.39.

Preparation of pyran **3** by this procedure was not routinely reproducible.

Acid hydrolysis of 1′,2′,3′,4′,5′,6′,7′,8′-octahydro-spiro-[cyclohexane-1,9′-xanthene] (3)

To a solution of pyran **3** (1.0 g) in 20 mL methanol was added five drops of concentrated hydrochloric acid. After 12 h at reflux the solution was diluted with an equal volume of water, the products were extracted with ether, and the extract was concentrated to about 2 mL. Upon cooling, crystalline plates (0.190 g) separated and melted at 185–186°C. The melting point upon admixture with spiro*[3,4-cyclohexano-4-hydroxybicyclo-[3.3.1]nonan-9-one-2,1′-cyclohexane] (**2**)* was undepressed. The mother liquor yielded *1′,2′,3′,4′,4a′,5′,6′,7′,8′,9a′-decahydro-spiro[cyclohexane-1,9′-9a′-methoxy xanthene]* (**5*a***) as plates (mp 79–79.5°C) following three recrystallizations from methanol; ν_{max}: 1678, 1146, 1130, 1090 cm^{-1}. *Anal.* calcd. for $C_{19}H_{30}O_2$: C 78.57, H 10.41, *Mol. Wt.*: 290.43; found: C 78.35, H 10.08; *Mol. Wt.* (Rast): 263.

*1′,2′,3′,4′,4a′,5′,6′,7′,8′,8a′,9a′,10a′-Dodecahydro-spiro-[cyclohexane-1,9′-xanthene] (**6**)*

A solution of pyran **3** (2.0 g) in 95% ethanol (75 mL) was shaken with platinum oxide (Adams catalyst 0.10 g) in a Towers atmospheric pressure hydrogenation apparatus for 12 h. The hydrogen uptake (corrected for catalyst) was 372 mL (the volume calcd. for two double bonds was 359 mL). The crude sample (1.85 g, mp 63–73°C) of tetrahydropyran **6** was purified by recrystallization from ethanol. Three recrystallizations yielded rhombahedra; mp 99.5–100.5°C; ν_{max}: 1100, 1056, 1005 (C—O) cm^{-1}. *Anal.* calcd. for $C_{18}H_{28}O$: C 82.38, H 11.52; found: C 82.38, H 11.64.

*Catalytic hydrogenation of spiro[cyclohexane-1,9′-xanthene] (**7**)*

A 0.74 g sample of xanthene **7** (mp 56–57°C) was dissolved in absolute ethanol, 5% rhodium-on-alumina (0.80 g) was added, and the mixture was hydrogenated (50 psi, room temperature, Parr Shaker) for 3 days. To a solution of the crude hydrogenation product in 95% ethanol (15 mL) was added concentrated hydrochloric acid (0.5 mL). After heating 2 h at reflux the mixture was diluted with an equal volume of water, neutralized by adding 5% aqueous sodium bicarbonate, and extracted with ether. The ether was evaporated and the residual oil was triturated with hexane. The remaining solid (0.04 g) gave a melting point of 187–188°C that was undepressed upon admixture with a sample of spiro*[3,4-cyclohexano-4-hydroxybicyclo-[3.3.1]nonan-9-one-2,1′-cyclohexane]* (**2**). Comparison infrared spectra (KBr) confirmed the identity as ketol **2**.

The hexane-soluble portion of the hydrolyzate (0.39 g) was chromatographed on 15 g of basic alumina (Alcoa). A colorless oil (0.39 g) eluted by hexane was crystallized from methanol yielding prisms (0.150 g) of *1′,2′,3′,4′,4a′,5′,6′,7′,8′,9a′-decahydro-spiro[cyclohexane-1,9′-xanthene]* (**5*b***, mp 79–82°C). Two recrystallizations from ethanol afforded dihydropyran **5*b*** as prisms melting at 82–82.5°C (Kofler hot stage); ν_{max}: 1672, 1228, 1194, 1172 cm^{-1}. *Anal.* calcd. for $C_{18}H_{28}O$: C 83.02, H 10.84; found: C 83.06, H 10.65, 10.79.

Hydrogenation of 1′,2′,3′,4′,5′,6′,7′,8′-octahydro-spiro-[cyclohexane-1,9′-xanthene] (3)

To a solution of pyran **3** (0.50 g) in absolute ethanol (100 mL) was added 5% rhodium-on-alumina and the mixture was hydrogenated (Parr Shaker, room temperature) at 49 psi for 12 h. The crude oily product crystallized (0.31 g, mp 50–55°C) from ethanol. One recrystallization from ethanol gave prisms, mp 80–81.5°C, and another raised the melting point to 83.5–84°C which was not depressed upon admixture with *1′,2′,3′,4′,4a′,-5′,6′,7′,8′,9a′-decahydro-spiro[cyclohexane-1,9′-xanthene]* (**5*b***) from the hydrogenation of spiro[cyclohexane-1,9′-xanthene] (**7**). Comparison infrared spectra confirmed the mutual identity.

*Di(2-methoxyphenyl)-(1-hydroxycyclopentyl)methanol (**9**)*

The Grignard reagent prepared from magnesium turnings (24.3 g, 0.566 mol), *ortho*-bromoanisole (105.8 g, 0.566 mol, bp 114–115°C and 22 Torr), and tetrahydrofuran under nitrogen, was cooled to 10°C and a solution of 1-carbomethoxycyclopentanol (**8**, 27.1 g, 0.189 mol) (4) in tetrahydrofuran was slowly added (over 15 min) with stirring. The reaction mixture was stirred at room temperature for 12 h and heated at reflux for 6.5 h. The tetrahydrofuran was replaced by benzene and the solution was poured onto ice (500 mL) – concentrated sulfuric acid (50 mL). Following extraction with chloroform the insoluble portion was collected and treated (steam-bath) for 30 min with 6 *N* hydrochloric acid (100 mL). The hydrolyzate was extracted with chloroform and both chloroform extracts were combined, washed with 5% sodium bicarbonate, and solvent was removed. The residual oil was washed with cold (10°C) hexane and the insoluble crude product (42.0 g) was crystallized from ethanol–acetone yielding a crystalline solid (33.9 g, 54.7%), mp 179–180°C. Recrystallization from ethanol gave diol **9**: mp 180.5–181°C (Kofler hot stage); λ_{max}: 272.4 (log ε = 3.55), 278.4 (log ε = 3.52) nm; ν_{max}: 3460 (-OH), 1596, 1580, 1486 (aromatic), 1240 (aryl ether), 1034 (-OCH_3), 770 (1,2-disubstituted phenyl) cm^{-1}. *Anal.* calcd. for $C_{20}H_{24}O_4$: C 73.14, H 7.37; found: C 73.55, 73.40; H 7.39, 7.69.

*2,2-Bis(2-methoxyphenyl)cyclohexanone (**10**)*

To a solution of diol **9** (36.1 g) in hot glacial acetic acid (250 mL) was added iodine (0.250 g), and the solution was heated at reflux for 5 min, then poured onto ice. The mixture was left at room temperature for 12 h and the crude product was collected by filtration. Recrystallization from acetone afforded 28.0 g (81.8%) of ketone **10** melting at 108–111°C. Another recrystallization from ethanol yielded an analytical specimen as plates; mp 110.5–111.5°C (capillary); λ_{max}: 278 (log ε = 3.80), 300 (shoulder, log ε = 2.92) nm; ν_{max}: 1724 (C═O), 1240 (aryl ether), 1025 (-OCH_3), (*o*-substituted phenyl) cm^{-1}. *Anal.* calcd. for $C_{20}H_{22}O_3$: C 77.39, H 7.14; found: C 77.07, H 7.10.

*Wolff–Kishner reduction of 2,2-bis(2-methoxyphenyl)-cyclohexanone (**10**)*

A mixture of ketone **10** (18.2 g), sodium hydroxide (7.4 g), 85% hydrazine hydrate (24 mL), and diethylene glycol (144 mL) was heated at reflux for 30 min. The reflux temperature was then raised to 190°C by removing water and excess hydrazine by distillation. Heating was continued at this temperature for 4.5 h. The reaction mixture was poured into water and concentrated hydrochloric acid was added until a red litmus test was obtained. Products were isolated in a chloroform solution, washed with 5% aqueous sodium bicarbonate, and dried. The solvent was removed *in vacuo* leaving a crude oil (19.0 g) which was dissolved in ether and the solution was extracted with 5% aqueous potassium hydroxide. After solvent removal the residual oil (14.5 g) was dissolved in hot ethanol and upon cooling *2,2-bis(2-methoxyphenyl)cyclohexane* (**11**) (4.5 g, mp 92–95°C) crystallized. Another crystallization from ethanol raised the melting point to 96–96.5°C. The mother liquor residual oil (10.0 g) was chromatographed on basic alumina (Alcoa). The fraction (1.82 g, mp 53.5–55°C) eluted by hexane was recrystallized from ethanol giving plates melting at 55–56°C and identical (by comparison infrared spectra and undepressed mixture melting point) with *spiro[cyclohexane-1,9′-xanthene]* (**7**) obtained from the dehydrogenation of ketol **2**.

A fraction (1.34 g, mp 96–97°C) containing cyclohexane **11** was obtained by elution with 1:9 benzene–hexane. Two recrystallizations from ethanol gave an analytical sample: mp 96.5–97.5°C (Kofler hot stage); λ_{max}: 281 (log ε = 3.56), 274 (log ε = 3.56) nm; ν_{max}: 1594, 1580, 1490 (phenyl), 1248 (aryl ether), 1030 (-OCH_3), 764, 750 (1,2-disubstituted phenyl) cm^{-1}. *Anal.* calcd. for $C_{20}H_{24}O_2$: C 81.04, H 8.16; found: C 81.07, H 8.30.

*Demethylation of bis(2′-methoxyphenyl)cyclohexane (**11**)*

Method A. With hydriodic acid

A mixture of *bis(2-methoxyphenyl)cyclohexane* (**11**, 2.0 g), 47% hydriodic acid (20 mL), and glacial acetic acid (40 mL) was heated at reflux for 9 h, cooled to room temperature, and poured onto ice. An ether extract of the product was washed with 10% aqueous sodium hydroxide and concentrated to an oil (0.93 g neutral fraction). The combined sodium hydroxide extract was acidified with concentrated hydrochloric acid and the acid fraction was isolated in ether. Sublimation of the acid fraction (0.625 g) led to 0.585 g of bis(2′-hydroxyphenyl)cyclohexane (**12**) which did not depress the melting point of phenol **12** prepared by Method B and both specimens showed identical infrared spectra.

Method B. With sodium

A mixture of *bis(2′-methoxyphenyl)cyclohexane* (**11**, 1.50 g), sodium (0.92 g), and dry pyridine (10 mL) was heated (nitrogen atmosphere) at reflux for 6 h. After cooling to room temperature excess sodium was removed by cautiously adding, in succession, pyridine, 1:1 pyridine–water, and water. A neutral fraction (0.90 g, mp 84–88°C), obtained by extracting the mixture with ether, was identified as unreacted starting material. The aqueous phase was adjusted to pH 6 (Hydrion paper) with hydrochloric acid and an acidic fraction (0.178 g) was isolated in ether and recrystallized three times from hexane. The analytical sample of phenol **12** melted at 111–111.5°C (Kofler hot stage); λ_{max}: 282.5 (log ε = 3.98), 277 (log ε = 3.99) nm; ν_{max}: 3390 (-OH), 1366 (phenol), 768, 755 (1,2-disubstituted phenyl cm^{-1}. *Anal.* calcd. for $C_{18}H_{20}O_2$: C 80.56, H 7.51; found: C 80.57, 80.71; H 7.52, 7.53.

*Catalytic hydrogenation of bis(2′-hydroxyphenyl)cyclohexane (**12**)*

A mixture of bisphenol **12** (0.168 g), absolute ethanol (25 mL), and 60.13% ruthenium oxide (0.200 g) (8)[5] was hydrogenated at 1500 psi and 60°C for 43 h (Magnadash autoclave with 250 mL bomb container). The crude product (0.132 g of oil) was chromatographed on basic alumina (5 g). The fraction (0.026 g) eluted by hexane was crystallized from absolute ethanol to provide *1′,2′,3′,4′,4a′,5′,6′,7′,8′,9a′-decahydro-spiro[cyclohexane-1,9′-xanthene]* (**5*b***) as prisms, mp 82–83°C. A mixture melting point with the product (**5*b***) obtained from hydrogenation of spiro[cyclohexane-1,9′-xanthene] (**7**) was undepressed. The infrared spectra (KBr) of both samples were identical.

*2,2-Diphenylcyclohexane (**14**)*

A mixture composed of 2,2-diphenylcyclohexanone (**13**, prepared by the method of Burger and Bennet (4), 3 g, mp 101–102°C), 85% hydrazine hydrate (5 mL), diethylene glycol (25 mL), and potassium hydroxide pellets (3 g) was heated at reflux for 30 min. The reaction temperature was raised to 195°C by removing water and excess hydrazine by distillation and maintained there for 45 min. After cooling to room temperature, the mixture was poured into water (150 mL) and the crude product isolated in ether. The ether solution was concentrated to an oil which was chromatographed on 90 g of basic alumina. Hydrocarbon **14** (1.64 g, mp 45–46.5°C) was eluted by hexane and recrystallized from ethanol giving plates melting at 47–47.5°C (Kofler hot stage); λ_{max}: 269 (log ε = 2.71), 262 (log ε = 2.86), 255 (log ε = 2.80) nm; ν_{max} (CCl_4): 1600, 1504, 1495 (phenyl), 1452 (CH_2), 700 (phenyl) cm^{-1}. *Anal.* calcd. for $C_{18}H_{20}$: C 91.47, H 8.53; found: C 91.52, H 8.59.

Acknowledgments

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1. R. Cornubert. C. R. Acad. Sci. **184**, 1258 (1927); Chem. Abstr. **21**, 2464 (1927).
2. G. R. Pettit and E. G. Thomas. (*a*) J. Org. Chem. **46**, 4167 (1981); (*b*) Chem. Ind. 1758 (1963).
3. (*a*) B. D. Akehurst and J. R. Bartels-Keith. J. Chem. Soc. 4798 (1957); (*b*) G. Klein and H. Linser. Mikrochem. Pregl. Festschr. **1929**, 204 (1929); Chem. Abstr. **24**, 2441 (1930); (*c*) C. F. H. Allen and H. R. Sallans. Can. J. Res. **9**, 574 (1933); Chem. Abstr. **28**, 2006 (1934).
4. A. Burger and W. B. Bennet. J. Am. Chem. Soc. **72**, 5414 (1950).
5. H. L. Dryden, G. M. Webber, R. R. Burtner, and J. A. Cella. J. Org. Chem. **26**, 3237 (1961).
6. V. Prey. Ber. **76**, 156 (1943).
7. H. A. Smith and B. L. Stump. J. Am. Chem. Soc. **83**, 2739 (1961).
8. W. S. Johnson, E. R. Rogier, and J. Ackerman. J. Am. Chem. Soc. **78**, 6322 (1956).

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[5] From Engelhard Minerals and Chemicals, Newark, NJ.