ml. Pre-incubation of the uterus with XI (60 γ per ml.), did not inhibit the typical uterine response to bradykinin (0.02 γ per ml.).

Acknowledgment.—The author wishes to express his appreciation to Dr. M. Bodanszky for advice and discussion during this work, to Mr. J. Aleino and his group for elemental analyses, to Dr. B. Rubin for the bioassay, to Mr. O. Kosy for electrophoretic studies, and to Mrs. N. Williams for amino acid analyses.

Syntheses Related to Etiojervane. III. The Synthesis of 1,8-Dimethyl-7methoxy-1,2,3,4,4a,9a-hexahydrofluoren-2-one¹

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Received May 3, 1962

The cyclization of 1-(methoxybenzyl)cyclohexanol (I) did not yield a hexahydrofluorene but rather a substance believed to be 2-methoxy-5,6,7,8,9,10-hexahydro-5,9-methanobenzocycloöctene (II). In an alternate approach the alkylation of Hagemann's ester with benzyl chloride was found to take place at the 2-position. The alkylation products from benzyl chloride and substituted benzyl chlorides could be cyclized either before or after reduction of the double bond to fluorene derivatives. The carboxyl group of 7-methoxy-1,8-dimethyl-1,2,3,4,4a,9a-hexahydrofluorene-2-carboxylic acid (XXIII) was degraded to yield 7-methoxy-1,8-dimethyl-1,2,3,4,4a,9a-hexahydrofluoren-2-one, a ketone which should be readily convertible to a degradation product of jervine.

As indicated in previous publications^{3,4} the objective of this investigation has been the preparation of a tricyclic ketone, 1,8-dimethyl-7-methoxy-1,2,3,4,4a,9,9a-hexahydrofluoren-2-one (XX-VII) which should be readily convertible to a degradation product of jervine.

In the present work, a first approach was based on the cyclization of a benzylcyclohexanol containing a methoxyl group on the benzene nucleus.⁵ Although the cyclization of 1-benzylcyclohexanol has been found⁶ to yield 5,6,7,8,9,10-hexahydro-5,9-methanobenzocycloöctene, a consideration of the mechanism suggests that at some time there can be a positive center at C-2 of the cyclohexane ring and it might be possible with a sufficiently active benzene nucleus for a hexahydrofluorene to result. Apparently even with a favorably located methoxyl group, the rate of cyclization was appreciable only with an intermediate having a positive center at C-3. The properties of the cyclization product indicated that alcohol I had behaved exactly as the analogous substance⁶ without the methoxyl group. The product (II) could not be dehydrogenated to a fluorene. Furthermore, the 2,4-dinitrophenylhydrazone of ketone III resulting from the chromic acid oxidation was different from the corresponding derivative of ketone V which was prepared by conventional means from 2-(4-methoxyphenyl)cyclohexanone.

- (3) R. A. Barnes and N. N. Gerber, J. Org. Chem., 26, 4540 (1961).
 (4) R. A. Barnes and R. W. Faessinger, *ibid.*, 26, 4544 (1961).
- (5) Previous studies on the cyclization leading to octahydrophenanthrenes have demonstrated that the products can depend on the reactivity of the benzene ring. See R. A. Barnes, J. Am. Chem. Soc., **75**, 3004 (1953); R. A. Barnes and M. D. Konort, *ibid.*, **75**, 303 (1953).



A second and successful method started with the alkylation of Hagemann's ester (VI). Previous studies⁷ had demonstrated that reaction of VI with an alkyl halide introduced a substituent into the 2-position. To make sure that benzyl halides react in a similar fashion,⁸ alkylation product IX was hydrolyzed to ketone XII. The structure of XII was established by aromatization to phenol XIII which had been prepared previously in another way.⁹ The alkylations with the substituted benzyl chlorides proceeded readily to yield alkylation product X and XI.

Since XI was less readily accessible, preliminary studies of the cyclization to fluorene derivatives were carried out starting from IX and X. Initial attempts to cyclize the cyclohexene derivative XII directly to a dihydrofluorene were not successful. However, reduction to the cyclohexanone derivative XIV followed by treatment with polyphos-

⁽¹⁾ Presented in part at the 138th National Meeting of the American Chemical Society, New York, N. Y., September 15, 1960.

⁽²⁾ Abstracted from a thesis presented by M. Sedlak to the Graduate School for the Ph.D. degree, September, 1957.

⁽⁶⁾ J. W. Cook and C. L. Hewett, J. Chem. Soc., 62 (1936).

⁽⁷⁾ L. I. Smith and G. F. Rouault, J. Am. Chem. Soc., 65, 631 (1943).

⁽⁸⁾ R. Jacquier and S. Boyer, Bull. soc. chim. France. 21, 717 (1954), have previously reported the alkylation of VI with benzyl chloride, but gave no details or proof of structure of the product.

⁽⁹⁾ R. C. Huston and A. L. Houk, J. Am. Chem. Soc., 54, 1506 (1932).



phoric acid produced tetrahydrofluorene XV in reasonable yield. The structure of XV was established by dehydrogenation to the known 1-methylfluorene. To ascertain the effect of the carbethoxyl group on the cyclization, X was treated with polyphosphoric acid directly and after hydrogenation of the double bond. In contrast to the cyclization of XII, X was converted to XVI in good yield; however, XVI was so readily aromatized to XVII that the presence of palladium catalyst in an attempted hydrogenation resulted instead in dehydrogenation. Cyclization products XX and XXI were more stable and either dehydrogenation or hydrogenation could be accomplished as desired.



For further elaboration toward XXVI, it was necessary to degrade the carbethoxyl group of XXII to a ketone. The first method was chosen by analogy with a successful degradation of a steroid with a carbethoxyl group at position 17.¹⁰ A methyl ketone was first prepared by treatment of the acid from XXII with an excess of methyllithium. Attempts to degrade this ketone XXIV using ethyl nitrite,^{11,12} peracids,^{13,14} or by conversion to the enol acetate all produced only recovered ketone or small amounts of uncharacterizable materials.

Assuming *cis* hydrogenation of double bonds from the unhindered side and no rearrangements, acid XXIII should be formed with an all-*cis* arrangement of substituents on the cyclohexane ring. The fact that ketone XXIV is recovered unchanged from reactions during which epimerization could occur, suggests that this process has already taken place to give the more stable configuration indicated. The approach of a reagent to the carbonyl group of XXIV is sterically blocked from several directions, which may explain, at least in part, its lack of reactivity.



A more successful degradation was achieved by reduction of XXII with lithium aluminum hydride to alcohol XXV. The dehydration of XXV was attempted by heating its tosylate with collidine. This process yielded some of olefin XXVI but ozonolysis of the olefinic mixture furnished only 10% of ketone XXVII. Pyrolysis of the xanthogenate of alcohol XXV yielded crystalline olefin XXVI in *ca*. 30% yield. This method failed with a large scale run of the reaction at slightly higher pyrolysis temperature, presumably because either sulfur or sulfur compounds acted as a dehydrogenating agent, converting the olefin to fluorene XXVIII.



- (10) R. A. Barnes and R. Miller, J. Am. Chem. Soc., 82, 4960 (1960).
- (11) W. D. Emmons and G. B. Lucas, ibid., 77, 2287 (1955).
- (12) L. H. Sarrett, ibid., 69, 2899 (1947).
- (13) J. G. Aston and M. G. Mayberry. ibid., 57, 1888 (1935).

(14) M. G. Ettlinger and L. F. Fieser, J. Biol. Chem., 164, 451 (1946).

Experimental¹⁵

1-m-(Methoxybenzyl)cyclohexanol (I).—A Grignard reagent was prepared from m-methoxybenzyl chloride¹⁶ (40 g.), magnesium (6 g.), and dry ether (500 ml.). To this cold solution, cyclohexanone (25 g.) in dry ether (100 ml.) was added dropwise with stirring. The reaction mixture was decomposed by the addition of saturated ammonium chloride solution (250 ml.). The ether layer containing the product was washed with water, dried, and concentrated. Distillation of the residue afforded alcohol I (35.4 g., 64%) which boiled at 138-140° (0.75 mm.), $n^{26.5}$ p 1.5288. An analytical sample was prepared by evaporative distillation at 118° (0.2 mm.).

Anal. Calcd. for $C_{14}H_{20}O_2$: C, 76.32; H, 9.15. Found: C, 76.20; H, 9.04.

Cyclization of Alcohol I.—Alcohol I (29.24 g.) was added to rapidly stirred 83% sulfuric acid (175 ml.) at -5° . Stirring was continued for 20 min. during which a red-orange color developed and the reaction mixture became homogeneous. The product was extracted with hexane. The hexane solution was washed with 5% sodium bicarbonate solution, dried and concentrated. The residue was distilled to yield 11.86 g. (44%) of cyclization product II. The analytical sample was prepared by allowing a hexane solution to stand over sodium. The clear liquid was decanted, the solvent removed, and the residue evaporatively distilled at 63° (0.05 mm.), n^{25} D 1.5438.

Anal. Calcd. for $C_{14}H_{18}O$: C, 83.12; H, 8.97. Found: C, 82.88; H, 8.97.

The dehydrogenation of this substance was attempted using palladium on charcoal in the presence and absence of diphenylamine as a solvent at 250-300°. Chromatography of the reaction products indicated that only starting material was present.

A solution of II (4.7 g.) in 90% acetic acid (55 ml.) was oxidized with chromium trioxide (3.12 g.). When the exothermic reaction subsided the reaction mixture was heated on the steam bath for 15 min. Water was added to the thick suspension and the product extracted with ether. The infrared spectrum of the liquid remaining after evaporation of the ether had two carbonyl peaks (5.86 and 6.00 μ). Reaction with 2,4-dinitrophenylhydrazine yielded a mixture of two derivatives which could be separated by chromatography on silica gel.

The orange 2,4-dinitrophenylhydrazone (eluted with benzene-hexane, 1:1) melted at 93-94.5° and must have been formed by a considerable degradation of II.

Anal. Calcd. for $C_{12}H_{14}O_4N_4$: C, 51.79; H, 5.07; N, 20.14. Found: C, 50.84; H, 5.61; N, 20.48.

The red 2,4-dinitrophenylhydrazone (eluted with benzene) melted at 191-193° after recrystallization from benzenehexane and is believed to be derived from ketone III.

Anal. Calcd. for $C_{20}H_{20}O_5N_4$: C, 60.60; H, 5.09; N, 14.14. Found: C, 61.15; H, 5.09; N, 13.69.

2,4-Dinitrophenylhydrazone of 7-Methoxy-1,2,3,4,4a,9ahexahydrofluoren-9-one (V).—2-(p-Anisylcyclohexanone (12.9 g.) prepared as previously described¹⁷ was converted to 2-p-anisylcyclohexanecarboxylic acid (1.5 g.) by the pro-

(15) Microanalyses were by W. Manser, Zurich, Switzerland, and G. Robertson, Florham Park, N. J. Melting points were determined using the Kofler hot stage.

(16) J. W. Cornforth and R. Robinson, J. Chem. Soc., 684 (1942).
(17) W. E. Bachman, G. I. Fujimoto, and L. B. Wick, J. Am. Chem. Soc., 72, 1995 (1950).

cedure of Veer and Oud¹⁸ for the analogous 2-phenylcyclohexanecarboxylic acid. This acid was obtained as a partly crystalline material, believed to be a mixture of isomers. A sample (0.87 g.) was cyclized by stirring with polyphosphoric acid (52 g.) on the steam bath for 40 min. The reaction mixture was diluted with water and extracted with ether. Evaporation of the ether left a residue of crude ketone V which was treated with 2,4-dinitrophenylhydrazine to yield 1.6 g. of the derivative. This substance melted at 225-227° after recrystallization from ethyl acetate.

Anal. Caled. for C₂₀H₂₀O₅N₄: C, 60.60; H, 5.09. Found: C, 60.87; H, 5.20.

2-Benzyl-4-carbethoxy-3-methyl-2-cyclohexen-1-one (IX). —Hagemann's ester, VI (36 g.), and then benzyl chloride (25.2 g.) were added to a solution of sodium ethoxide prepared from sodium (4.6 g.) and absolute ethanol (120 ml.). The reaction mixture was stirred and refluxed for 3 hr. and the alcohol distilled. Water (200 ml.) was added to the residue and the product removed with ether. Evaporation of the ether solution left an oil which was vacuum distilled to yield 30.5 g. (55%) of IX which boiled at 160–164° (0.35 mm.) n^{35} D 1.5392, p_{max}^{lim} 5.80 and 6.01 μ .

Anal. Calcd. for C₁₇H₂₀O₂: C, 74.97; H, 7.40. Found¹⁹: C, 74.27; H, 7.66.

The semicarbazone melted at 131-133° after recrystallization from ethanol and water.

Anal. Caled. for C₁₈H₂₃O₃N₂: C, 65.63; H, 7.04. Found: C, 65.55; H, 7.08.

2-Benzyl-3-methyl-2-cyclohexen-1-one (XII).—Keto ester IX (13.6 g.) was decarboxylated by refluxing for 8 hr. with a solution of potassium hydroxide (3 g.) in ethanol (30 ml.). Water was added and the mixture extracted with ether. The residue remaining after evaporation of the ether distilled at 123-126° (0.3 mm.). There was obtained 6.9 g. of XII which had n^{22} D 1.5610 and ν_{\max}^{fins} 5.98 μ .

Anal. Calcd. for C₁₄H₁₆O: C, 83.96; H, 8.05. Found: C, 83.91; H, 8.09.

The 2,4-dinitrophenylhydrazone was prepared using Johnson's reagent. After three recrystallizations from ethanol-ethyl acetate, this derivative melted at 163-164°.

Anal. Calcd. for $C_{20}H_{20}O_4N_4$: C, 63.15; H, 5.20. Found: C, 63.35; H, 5.35.

Dehydrogenation of XII was accomplished by heating a sample (1 g.) and 10% palladium on charcoal in refluxing *p*-cymene (3 ml.) while a stream of nitrogen was passed through the solution. Distillation of the filtered solution left a tan solid (0.63 g., 63%) which melted at 65-70°. Recrystallization from isoöctane raised the melting point to 73-75° (lit.,⁹ m.p. 71-72°). The dibromo derivative of this phenol melted at 105-107° (lit.,⁹ m.p. 106-107°).

2-(3'-Methoxy)-benzyl-4-carbethoxy-3-methyl-2-cyclohexen-1-one (X).—The alkylation of Hagemann's ester (16.73 g.) with *m*-methoxybenzyl chloride (15.26 g.) was carried out as in the preparation of IX. There was obtained 17.9 g. (64%) of X which boiled at 190°/0.15 mm. (Hickmann still) and had $n^{24.5}$ D 1.5410.

Anal. Caled. for C₁₈H₂₂O₄: C, 71.50; H, 7.33. Found¹⁹: C, 70.55; H, 7.25.

This keto ester did not readily form derivatives with the usual reagents. However, a good yield (80%) of the 4-(2',4'-dinitrophenyl)semicarbazone²⁰ was prepared. The derivative melted at 202-203° after recrystallization from ethanol.

Anal. Caled. for $C_{25}H_{27}O_8N_5$: C, 57.14; H, 5.18. Found: C, 56.98; H, 5.24.

The 2,4-dinitrophenylhydrazone was obtained in very poor yield using Johnson's reagent and could not be puri-

(18) W. L. C. Veer and P. J. A. Oud, Rec. trav. chim., 72, 1083 (1953).

(19) None of the liquid alkylation products could be obtained analytically pure by distillation. However, solid derivatives or subsequent transformation products with the correct analysis could be prepared in good yield.

(20) J. L. McVeigh and J. D. Rose, J. Chem. Soc., 713 (1945).

fied by recrystallization. Chromatography on silica gel and elution with benzene-hexane (1:20) finally yielded a pure derivative which melted at 106-108°.

Anal. Calcd. for C24H26O7N4: C, 59.74; H, 5.43. Found: C, 59.70; H, 5.24.

3-Methoxy-2-methylbenzyl Alcohol.-A solution of 3methoxy-2-methylbenzoic acid⁴ (79 g.) in dry ether was added dropwise to a stirred suspension of lithium aluminum hydride (24 g.) in ether. The mixture was stirred for 8 hr. and then decomposed by addition of ethyl acetate and saturated sodium sulfate solution. Evaporation of the ether layer left a residue which could be recrystallized from benzene-hexane to yield 45.8 (63%) of product which melted at 57-60°. The analytical sample, prepared by further recrystallization, melted at 62-63°.

Anal. Calcd. for C₉H₁₂O₂: C, 71.02; H, 7.95. Found: C, 71.01; H, 8.08.

3-Chloromethyl-2-methylanisole.—Thionyl chloride (40.5 g.) in chloroform (50 ml.) was added to a stirred solution of 3-methoxy-2-methylbenzyl alcohol (45 g.) in dry pyridine (27.6 g.) and chloroform (100 ml.) at 0°. When the addition was complete the reaction mixture was allowed to warm to room temperature and water was added. The chloroform layer was separated and dried and the residue distilled to yield 43 g. (84.5%) of product which boiled at 35° (0.03)mm.), n²⁴D 1.5486.

Anal. Calcd. for C₉H₁₁OCl: C, 63.35; H, 6.50. Found: C, 63.31; H, 6.49.

2-(3'-Methoxy-2'-methyl)benzyl-4-carbethoxy-3-methyl-2-cyclohexen-1-one (XI).—Hagemann's ester (213 g.) was alkylated with 3-chloromethyl-2-methylanisole (200 g.) as described in the preparation of IX. There was obtained 310 g. (84%) of product which boiled at 175-178° (0.2-0.25 mm.), n^{28} D 1.5350. An attempt to prepare an analytical pure sample by evaporative distillation at ca. 150° was not successful.

Anal. Calcd. for C₁₉H₂₄O₆: C, 71.12; H, 7.65. Found¹⁹: C, 72.71; H, 8.10.

2-Benzyl-3-methylcyclohexanone (XIV) .- A solution of ketone XII (5.93 g.) in 95% ethanol was hydrogenated at atmospheric pressure in the presence of palladium-on-charcoal catalyst (0.6 g.). The catalyst was filtered and the solvent distilled, leaving a residue (6.06 g., 100%) of a yellow oil. The analytical sample was prepared by evaporative distillation at 82°/0.4 mm., n^{25} D 1.5279, ν_{max} 5.82 μ .

Anal. Caled. for C14H18O: C, 83.12; H, 8.97. Found: C, 83.01; H, 8.81.

The 2,4-dinitrophenylhydrazone melted at 127–129° after recrystallization from ethanol-ethyl acetate.

Anal. Calcd. for C₂₀H₂₂O₄N₄: C, 62.81; H, 5.80. Found: C, 62.80; H, 5.83.

1-Methylfluorene.--A mixture of ketone XIV (1 g.) and polyphosphoric acid (50 g.) was stirred rapidly and warmed on the steam bath for 3 hr. Water and ice were added and the product extracted with benzene. Evaporation of the benzene left a residue of crude 1-methyl-1,2,3,4-tetrahydrofluorene (XV) which was dehydrogenated by heating with palladium on charcoal (0.1 g.) at 280°. Within 1 hr., white needles began to sublime from the reaction mixture but heating was conued for an additional 3 hr. The product was washed out with ether, the solution filtered, and the ether evaporated to yield 300 mg. (30%) of crude 1-methylfluorene, m.p. 73-81°. The melting point was raised to 87.5-88° (lit.,²¹ m.p. 87°) by recrystallization from methanol.

Ethyl 7-Methoxy-1-methyldihydrofluorene-2-carboxylate (XVI).—Keto ester X (4.35 g.) was cyclized at 70° by treating with polyphosphoric acid (98 g.) for 4 hr. The reaction mixture was processed as in the previous experiment to yield 3.77 g. of a solid product. After recrystallization from methanol this product was obtained as yellow plates which melted at 94-95° and had considerable ten-

(21) W. C. Lothrop and P. A. Goodwin, J. Am. Chem. Soc., 65, 363 (1943).

dency to oxidize in air, λ_{max}^{EtOH} 270 mµ (log ϵ 4.90), 362 mµ (log e 4.7).

Anal. Calcd. for C18H20O3: C, 76.03; H, 7.09. Found: C, 76.61; H, 7.17.

Ethyl 7-Methoxy-1-methylfluorene-2-carboxylate (XVII). A. Compound XVI (64 mg.) was dehydrogenated with palladium on charcoal at 230-240° as in the preparation of 1-methylfluorene. There was obtained 31.6 mg. (50%) of white crystals which melted at 128–131°, $\lambda_{\text{max}}^{\text{HOH}}$ 3.08 m μ $(\log \epsilon 4.48), 318 \text{ m}\mu (\log \epsilon 4.51).$ The analytical sample prepared by sublimation melted at 129.5-130.5°.

Anal. Calcd. for C₁₈H₁₈O₃: C, 76.57; H, 6.43. Found: C, 76.50; H, 6.56.

Attempted hydrogenation of XVI at room temperature and atmospheric pressure yielded only XVII identical with the first sample.

B. A sample of ester XX (0.1 g.) was dehydrogenated as in part A to yield XVII having properties identical with the previous samples.

Ethyl 2-(3'-Methoxy)benzyl-3-methylcyclohexanone-4carboxylate (XVIII).—An alcoholic solution of keto ester X (13.52 g.) was hydrogenated as for the preparation of ketone XIV. There was obtained 12.5 g. (92%) of a viscous liquid. The analytical sample was prepared by evaporative distillation at 150° (0.05 mm.), n^{23} D 1.5224.

Anal. Calcd. for C₁₈H₂₄O₄: C, 71.02; H, 7.95. Found: C, 71.02; H, 7.95.

The 2,4-dinitrophenylhydrazone melted at 179-181° after recrystallization from ethanol.

Anal. Calcd. for C24H28O7H4: C, 59.49; H, 5.83. Found: C, 59.40; H, 5.81.

Ethyl 7-Methoxy-1-methyl-1,3,3,4-tetrahydrofluorene-2carboxylate (XX).-The keto ester from the previous experiment (1.2 g.) was cyclized with polyphosphoric acid (52 g.)at 35-40° for 5 hr. in a nitrogen atmosphere. Processing as in the preparation of XVI yielded a red oil (0.97 g, 80%)which crystallized on standing. Recrystallization from ethanol gave product XX which melted at $87-88^\circ$, $\lambda_{max}^{EOH} 266$ $m\mu$ (log ϵ 4.22).

Anal. Calcd. for C₁₈H₂₂O₃: C, 75.49; H, 7.74. Found: C, 75.19; H, 7.42.

Saponification of this ester gave a quantitative yield of the corresponding acid which crystallized from glacial acetic acid as white prisms which melted at 193°.

Anal. Calcd. for C16H18O3: C, 74.38; H, 7.02. Found: C, 74.19; H, 7.09.

Ethyl 2-(3'-Methoxy-2'-methyl)benzyl-3-methylcyclohexanone-4-carboxylate (XIX).-Crude ester XI (67.7 g.) was hydrogenated as in the preparation of XVIII. There was obtained 65.9 g. (96%) of keto ester XIX which boiled at 125°/0.8 mm,

Anal. Calcd. for C19H26O4: C, 71.67; H, 8.23. Found: C, 71.65; H, 8.23.

The 2,4-dinitrophenylhydrazone was obtained as a deep yellow, microcrystalline solid which melted at 217-218° after recrystallization from ethyl acetate.

Anal. Calcd. for C23H30O7N4: C, 60.23; H, 6.07. Found: C, 60.24; H, 6.16.

Ethyl 7-Methoxy-1,8-dimethyl-1,2,3,4,4a,9a-hexahydrofluorene-2-carboxylate (XXII).-Keto ester XIX (65 g.) was cyclized by stirring with polyphosphoric acid (1275 g.) under nitrogen overnight. The reaction mixture was processed as in the preparation of X to yield 60.6 g. (99%) of crude ethyl 7-methoxy-1,8-dimethyl-1,2,3,4-tetrahydrofluorene-2-carboxylate (XXI). This substance (24 g.) was hydrogenated as in the preparation of XIV to yield 20 g. (80%) of an oil. The analytical sample was prepared by evaporative dis-tillation at 175° (0.035 mm.), $n^{24.6}$ D 1.5370, ν_{max} 5.77 μ . Anal. Calcd. for C₁₉H₂₆O₃: C, 75.46; H, 8.67. Found:

C, 75.21; H, 8.53.

Saponification of the ester (XXII) with ethanolic aqueous potassium hydroxide yielded after acidification a liquid acid about 40% of which could be obtained in crystalline form after treatment with acetic acid. The analytical sample melted at 160.5-161° after recrystallization from acetone-hexane.

Anal. Caled. for $C_{17}H_{11}O_3$: C, 74.42; H, 8.08. Found: C, 74.37; H, 8.08.

2-Acetyl-1,8-dimethyl-7-methoxy-1,2,3,4,4a,9a-hexahydrofluorene (XXIV).—A solution of methyllithium was prepared from methyl iodide (26 g.) and lithium (2.84 g. in dry ether (100 ml.). The filtered solution of methyllithium was added dropwise to a solution of the acid from the previous experiment (10 g.) in anhydrous 1,2-dimethoxyethane (200 ml.). Stirring was continued for 12 hr. and then the mixture was hydrolyzed by addition of water. The organic solvents were distilled and the product extracted with ether. Evaporation of the ether left a residue (8.84 g.) which immediately crystallized. Recrystallization from methanol afforded the pure ketone which melted at 116.5–120°. From the aqueous alkaline solution there was recovered by acidification about 10% of the starting acid.

Anal. Calcd. for $C_{18}H_{24}O_2$: C, 79.37; H, 8.88. Found: C, 79.62; H, 9.01.

The 2,4-dinitrophenylhydrazone was obtained as an orange, microcrystalline solid after recrystallization from ethyl acetate, m.p. 233-234°.

Anal. Calcd. for $C_{24}H_{28}O_5N_4$: C, 63.70; H, 6.24. Found: C, 63.50; H, 6.29.

1,8-Dimethyl-2-hydroxymethyl-7-methoxy-1,2,3,4,4a,9ahexahydrofluorene (XXV).—Ester XXIII (19.8 g.) was dissolved in anhydrous ether (50 ml.) and added dropwise to a stirred suspension of lithium aluminum hydride (2.5 g.) in anhydrous ether (200 ml.). The reaction mixture was processed by addition of ethyl acetate and water and then the product extracted with ether. Evaporation of the ether left a viscous liquid (12 g., 70%). A pure sample of this material was prepared via the acid phthalate and then by evaporative distillation at 150°/0.04 mm.

Anal. Calcd. for $C_{17}H_{24}O_2$: C, 78.42; H, 9.29. Found: C, 78.19; H, 9.25.

The acid phthalate was prepared by refluxing crude alcohol XXV (34 g.) with a solution of phthalic anhydride (19.5 g.) in anhydrous toluene (200 ml.) for 2 hr. The crude product was taken up in ether and the acid phthalate extracted with 5% sodium carbonate solution; considerable (5.6 g.) non-alcoholic material remained in the ether solution. Acidification of the alkaline solution and crystallization from acetone-hexane yielded 38 g. (71%) of the acid phthalate which

melted at 170–170.5° after recrystallization from dilute ethanol.

Anal. Calcd. for $C_{25}H_{22}O_5$: C, 73.51; H, 6.91. Found: C, 73.29; H, 6.95.

1,8-Dimethyl-7-methoxy-2-methylene-1,2,3,4,4a,9a-hexahydrofiuorene (XXV).—Alcohol XXV (12 g.) was converted to the methyl xanthate by the procedure of Whitmore and Simpson.²² The crude xanthate (15.7 g., 97%) was heated under nitrogen at 236-240° for 5 hr. The reaction product was taken up in ether and the solution washed with 10% sodium hydroxide solution, saturated lead acetate, and water. The dried solution was concentrated and chromatographed on alumina. Hexane eluted the desired olefin (3.3 g.) having a strong bond in the infrared spectrum at 11.30 μ . Further elution with benzene eluted a pale yellow solid (3.6 g.) and finally chloroform removed some polymeric material (3.4 g.).

The olefin crystallized when triturated with methanol and after recrystallization from this solvent melted at 83-85°.

Anal. Caled. for $C_{17}H_{22}O$: C, 84.25; H, 9.15. Found: C, 84.12; H, 9.05.

The pale yellow solid was purified by recrystallization from acetone-methanol and melted at 194-196°, λ_{max}^{EtOH} 220 m μ , 276 m μ .

Anal. Calcd. for C₁₇H₁₈O: C, 85.67; H, 7.61. Found: C, 85.40; H, 7.72.

A pyrolysis of 93 g. of xanthate at 235-275° yielded only 40.8 g. of this same material, 1,2,8-trimethyl-7-methoxyfluorene (XXVIII).

1,8-Dimethyl-7-methoxy-1,2,3,4,4a,9a-hexahydrofluoren-2-one (XXVII).—A solution of olefin XXVI (1.8 g.) in methylene chloride (100 ml.) was cooled to 0° and ozone introduced until it was no longer absorbed. Zine dust (2 g.) and acetic acid (10 ml.) were added and the solution warmed to remove the methylene chloride. The solution was filtered and water was added. The product was removed with ether and from the ether extract there was obtained 1.48 g. (81%) of ketone XXVII which melted at 131–132° after recrystallization from methanol.

Anal. Caled. for $C_{16}H_{20}O_2$: C, 78.65; H, 8.25. Found: C, 78.50; H, 8.32.

(22) F. C. Whitmore and C. T. Simpson, J. Am. Chem. Soc., 55, 3809 (1933).

Desulfurization with Raney Nickel. II. Sulfonamides^{1,2}

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Received July 9, 1962

Several representative alkyl halides have been condensed with sodium saccharin and the resulting 1,1,3-trioxo-2-alkylbenzo[d]isothiazolines (Ia-f) desulfurized using Raney nickel. Employing common desulfurization methods, the reduction reaction was found to give cyclohexylcarboxamides (e.g., IV) and under very mild conditions, benzamides (Va-e). In comparative alkylation reactions the sodium derivatives of benzenesulfonylbenzamide (IIa), N,N-dibenzenesulfonyloxamide (IIIa) and dibenzenesulfonamide (VIb) were, in general, less satisfactory than sodium saccharin. Reaction between benzenesulfonamide and dimethylformamide in the presence of either benzenesulfonyl chloride, benzoyl chloride, carbobenzoxy chloride, or phosphorus oxychloride was shown to yield N,N-dimethyl-N'-benzenesulfonylformamidine (VII).

Among the various organo-sulfur compounds which have been subjected to desulfurization with Raney nickel, those containing bivalent sulfur are

(1) A review of desulfurization with Raney nickel by G. R. Pettit and E. E. van Tamelen, "Organic Reactions," Vol. 12, J. Wiley & Sons, Inc., New York, N. Y., 1962, p. 356, may be considered part I of this study.

(2) This investigation was supported in part by National Science Foundation Research Grants G-9585 and G-19500 and by the Upjohn Co., Kalamazoo, Mich. most frequently represented. For example, over three hundred and fifty thioketals^{3a} and thiophenes^{3b}

(3) For recent examples refer to (a) P. M. Rao and H. R. Gollberg, Chem. Ind. (London), 1317 (1961); H. P. Gervais and A. Rassat, Bull. soc. chim. France, 743 (1961); K. Kotera, Tetrahedron, 12, 240 (1961); J. C. Craig, D. M. Temple, and B. Moore, Australian J. Chem., 14, 84 (1961); L. F. Fieser, C. Yuan, and T. Goto, J. Am. Chem. Soc., 82, 1996 (1960); and (b) Ya. L. Gol'dfarb and B. P. Fabrichnyi, Zh. Obshch. Khim., 31, 2057 (1961); Ya. L. Gol'dfarb and S. Z. Taits, Izv. Akad. Nauk SSSR, Otd. Khim. Nauk, 1698 (1960).