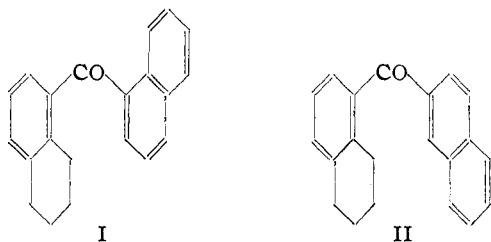


[CONTRIBUTION FROM THE CONVERSE MEMORIAL LABORATORY OF HARVARD UNIVERSITY]

The Pyrolysis of Tetralyl Naphthyl Ketones

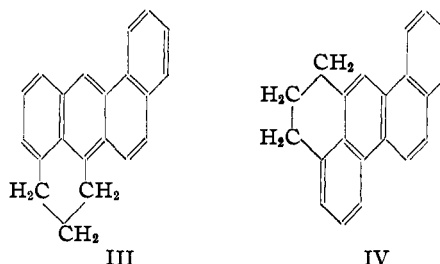
BY LOUIS F. FIESER AND ARNOLD M. SELIGMAN

In a communication¹ announcing the synthesis² of methylcholanthrene, we reported that the modified Elbs reaction employed in the synthesis had been tested in preliminary experiments with the readily available ar- α -tetralyl naphthyl ketones I and II. The indications from the orient-



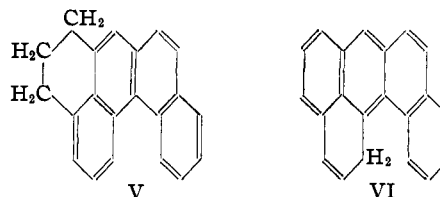
ing experiments were so favorable that we turned at once to the more important applications of the new synthetic method and attended to the completion of the original work only after having used the method for the preparation of several interesting hydrocarbons containing the cholanthrene ring system.³

The pyrolysis of diaryl ketones having a five-membered alicyclic ring ortho to the carbonyl group has given uniformly good results, the reaction affording very pure hydrocarbons in yields unusually high for the Elbs type of condensation. On investigating further the pyrolysis of the ketones containing a six-membered alicyclic ring, the situation was found to be quite different. Cyclization proceeds readily enough, as stated in the early report,¹ but mixtures of hydrocarbons are produced in each instance. Although only one hydrocarbon ($C_{21}H_{16}$) was isolated as a pyrolysis product of ar- α -tetralyl α -naphthyl ketone (I), it was evident that other substances are formed. From the ketone II we obtained three hydrocarbons of the composition $C_{21}H_{16}$ and another substance which apparently contains two less atoms of hydrogen. The hydrocarbon from I evidently does not have the structure III of a 1,2-benzanthracene derivative similar to cholanthrene, for according to observations of Dr. Egon Lorenz the absorption spectrum bears no similarity to that of cholanthrene. On the other hand the



spectrum agrees closely with that of chrysene both as to the width and the number of bands, the only difference being a slight shift in the direction of longer wave length. From this evidence we are inclined to regard the substance as 1,12-trimethylene chrysene, IV. The hydrocarbon on oxidation yields an orange-red compound, $C_{21}H_{12}O_3$, which probably is an ortho quinone with a carbonyl group in the alicyclic ring.

Only one of the four hydrocarbons from the ketone II can be assigned a structure with any degree of assurance, namely, a substance of the expected composition melting at $138-138.5^\circ$ and forming a characteristic picrate (hydrocarbon C). The absorption spectrum is almost identical in the positions and intensities of the bands with that of 6,7-dimethyl-3,4-benzphenanthrene,⁴ but shifted to slightly longer wave lengths. Consequently the substance probably is 8,9-trimethylene-3,4-benzphenanthrene (V), formed from the



primary product of pyrolysis by the migration of hydrogen atoms from the original alicyclic ring to an adjoining nucleus. No evidence was obtained of the presence in the hydrocarbon mixture of the primary product, 8,9-trimethylene-1,2-benzanthracene, but one of the substances isolated appears to be a dehydro derivative of this hydrocarbon. The compound in question (B) has the composition $C_{21}H_{14}$, it yields a ketone ($C_{21}H_{12}O$) on oxidation, and the absorption spectrum re-

(1) Fieser and Seligman, *THIS JOURNAL*, **57**, 228 (1935).(2) Fieser and Seligman, *ibid.*, **57**, 942 (1935).(3) Fieser and Seligman, *ibid.*, **57**, 1377, 2174 (1935); Fieser and Hershberg, *ibid.*, **57**, 1681 (1935).

(4) A synthesis of this hydrocarbon will be reported by one of us with M. Fieser and E. B. Hershberg.

sembled that of 1,2-benzanthracene. A possible structure is that of formula VI. Neither the chief product of the pyrolysis (A) nor a hydrocarbon (D) characterized by its failure to form a picrate, have been identified. They show little resemblance in absorption spectrum to any of the hydrocarbons of known structure investigated in this Laboratory.

It is clear from these experiences that ketones with aliphatic six-rings in the ortho position are not suitable for use in the Elbs synthesis. In two cases the pyrolysis is attended by the aromatization of the originally reduced ring and a wandering of hydrogen to another nucleus, and in one case two hydrogen atoms appear to be eliminated from the alicyclic ring. The hydrocarbon mixtures contain many constituents and a separation is very tedious. It appears that the cholanthrene synthesis owes its success in part to the fact that the alicyclic ring participating in the cyclodehydration cannot be aromatized.

Experimental Part⁵

Preparation of the Ketones.— α -Aminotetralin was obtained in 70% yield by the reduction of redistilled α -naphthylamine with sodium and isoamyl alcohol.⁶ For conversion into α -bromotetralin,⁷ a solution of 43 g. of the amine in 150 cc. of hot 34% hydrobromic acid was cooled to 0°, treated with 100 g. of ice, diazotized and the solution was added with shaking to a suspension at 0° of cuprous bromide from 150 g. of copper sulfate crystals in 150 cc. of 34% hydrobromic acid. After thirty minutes the complex was decomposed and the α -bromotetralin was removed by steam distillation. The product was steam distilled from a solution of alkali and distilled; b. p. 130° at 2 mm.; yield, 34 g. (55%).

The preparation of the Grignard reagent from α -bromotetralin and its condensations with α - and with β -naphthoyl chloride were carried out as in the methylcholanthrene synthesis,³ the yields of the pure ketones being 40 and 44%, respectively. *Ar*- α -tetralyl α -naphthyl ketone (a) forms small, compact, colorless crystals, m. p. 107°, from ether-petroleum ether. *Ar*- α -tetralyl β -naphthyl ketone (b) crystallizes from the same solvent-pair as colorless prisms, m. p. 98°.⁸

Anal. Calcd. for $C_{21}H_{18}O$: C, 88.07; H, 6.34. Found: (a) C, 88.39; H, 6.02; (b) C, 88.28; H, 6.15.

1,12-Trimethylene Chrysene (IV).—The pyrolysis of 5 g. of *Ar*- α -tetralyl α -naphthyl ketone in an atmosphere of nitrogen at 395–400° for forty-five minutes gave, after vacuum distillation, a yellow oil which gave yellow

needles, m. p. 124–127°, on crystallization from alcohol. A high-melting substance present in small amount could not be removed satisfactorily by direct crystallization and the main constituent of the mixture was best purified through the picrate. This formed large, flat, dark-red needles (3.8 g., 44%) from alcohol, and on further crystallization from benzene it formed long, crimson needles, m. p. 170–171°. The hydrocarbon recovered from the pure picrate formed pale yellow needles, m. p. 118–119° from ether-petroleum ether. After passing a benzene solution of this material through an adsorption tower of activated alumina, there was obtained a colorless product which crystallized from alcohol as needles, m. p. 116.5–117°, corr. Dilute solutions of the pure hydrocarbon fluoresce blue; the solution in sulfuric acid is red.

Anal. Calcd. for $C_{21}H_{18}$: C, 93.98; H, 6.02. Found: C, 94.00, 93.96, 94.10; H, 5.72, 6.24, 6.35. *Anal.* (picrate) Calcd. for $C_{27}H_{19}O_7N_3$: N, 8.45. Found: N, 8.58.

Oxidation of the Hydrocarbon.—A suspension of 1 g. of the above hydrocarbon in 20 cc. of glacial acetic acid was shaken with 5 g. of sodium dichromate in the cold for fifteen minutes, boiled for thirty minutes, and cooled. The red material which separated was crystallized from glacial acetic acid and from benzene, when it formed small, orange-red needles melting at 268–270° with decomposition. It is insoluble in alkali, but dissolves, with fading of the color, on warming the alkaline suspension with zinc dust. The solution in sulfuric acid is red; the substance gives no vat test.

Anal. Calcd. for $C_{21}H_{12}O_8$: C, 80.75; H, 3.88. Found: C, 80.63; H, 3.67.

Pyrolysis of *Ar*- α -tetralyl β -Naphthyl Ketone.—The oil obtained on heating the ketone (5.5 g.) at 400° for thirty minutes was distilled *in vacuo* and submitted to crystallization as the picrate from alcohol in the presence of a considerable excess of picric acid (10 g.). Separations were made as follows.

Hydrocarbon A.—The first picrate to crystallize appeared as large, flat, dark-red needles; yield, 3 g. (31%). After further crystallization from benzene it formed small, bright-red needles, m. p. 168–169°. The liberated hydrocarbon formed clusters of fine, lemon yellow needles from alcohol, m. p. 112–114°. Purification with an adsorption tower gave, after crystallization from alcohol, clusters of colorless needles, m. p. 113–115° (corr.). The substance depressed the melting point of the isomeric hydrocarbon IV. Dilute solutions show a blue fluorescence; the solution in sulfuric acid is purplish red.

Anal. Calcd. for $C_{21}H_{16}$: C, 93.98; H, 6.02. Found: C, 94.08; H, 6.35. *Anal.* (picrate) Calcd. for $C_{27}H_{19}O_7N_3$: N, 8.45. Found: N, 8.45.

Hydrocarbon B (Dehydro-8,9-trimethylene-1,2-benzanthracene, VI?).—The next substance to separate, after some concentration, was an orange picrate (1.2 g., 10%) which has a marked tendency to form supersaturated solutions. Recrystallized from alcohol it formed orange micro-crystals melting at 146–147°. The hydrocarbon obtained from the purified picrate formed pale yellow crystals, m. p. 144–145°, from ether-petroleum ether, and after passage through an adsorption tower it crystallized from alcohol as colorless leaflets, m. p. 149–149.5°, corr., green color in sulfuric acid.

(5) Microanalyses by Mrs. G. M. Wellwood.

(6) Bamberger and Althausse, *Ber.*, **21**, 1786 (1888).

(7) Smith, *J. Chem. Soc.*, **85**, 728 (1904).

(8) The value previously reported (Ref. 1) was in error. The hydrocarbon (yellow plates, m. p. 270°; C, 95.3; H, 4.9) isolated in the first experiment on the pyrolysis of the crude ketone was not encountered in later work.

Anal. Calcd. for $C_{21}H_{14}$: C, 94.70; H, 5.30. Found: C, 94.77; H, 5.37. *Anal.* (picrate) Calcd. for $(C_{21}H_{14})_2 \cdot (C_6H_5N_3O_7)_3$: N, 10.34. Found: N, 10.5.

Hydrocarbon C: 8,9-Trimethylene-3,4-benzphenanthrene (V).—A third picrate separated along with picric acid on further concentration of the mother liquor. The combined material was treated with alkali and extracted with ether and the hydrocarbon was distilled and crystallized from ether-petroleum ether. The crude product (0.35 g., 7%), which formed golden yellow plates, was purified by chromatographic adsorption and crystallized from alcohol, when it formed flat, very faintly yellow needles, m. p. 138–138.5° (corr.), yellow in sulfuric acid. The picrate forms long, orange needles, m. p. 125–126°. It is dissociated into the components by washing with alcohol.

Anal. Calcd. for $C_{21}H_{16}$: C, 93.98; H, 6.02. Found: C, 93.88; H, 5.64. *Anal.* (picrate) Calcd. for $C_{27}H_{19}O_7N_3$: N, 8.45. Found: N, 8.61.

Hydrocarbon D.—This substance was obtained in small quantity (80 mg.) from the ether-petroleum ether mother liquors from the crystallization of compound C. The hydrocarbon crystallizes from this solvent mixture as nearly colorless plates, m. p. 96.5–97° (corr.). The substance forms no picrate and it gives a yellow color in sulfuric acid.

Anal. Calcd. for $C_{21}H_{16}$: C, 93.98; H, 6.02. Found: C, 93.91, 93.96; H, 6.47, 6.24.

Oxidation Products.—When oxidized by the procedure given above, hydrocarbon A gave a substance which crystallizes from benzene as fine, orange needles, m. p. 220–223°. The substance gives no vat test.

Anal. Calcd. for $C_{21}H_{10}O_4$: C, 77.28; H, 3.09. Found: C, 77.75, 77.92; H, 3.26, 3.47.

From the hydrocarbon B ($C_{16}H_{14}$) there was obtained, by oxidation with sodium dichromate in a suspension of glacial acetic acid in the cold, a substance which crystallizes from glacial acetic acid in the form of long, yellow needles, m. p. 201°. It is insoluble in alkali and gives no vat test; the solution in sulfuric acid is green.

Anal. Calcd. for $C_{21}H_{12}O$: C, 89.97; H, 4.32. Found: C, 89.96; H, 4.37.

Summary

Tetralyl naphthyl ketones behave abnormally in the Elbs reaction for, although they easily yield hydrocarbons on pyrolysis, the condensation is accompanied by the aromatization of the original alicyclic six-ring with migration of hydrogen to other parts of the molecule. Other changes not yet defined result in the formation of complex mixtures.

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Studies on Sterols. IV.¹ Androsterone Derivatives

BY RUSSELL E. MARKER

In an attempt to prepare water-soluble androsterone derivatives for physiological testing two 17-amino derivatives were made by reducing the oximes of androsterone and 3-chloroandrosterone. The hydrochlorides of these amines were only slightly soluble in water.

17-Aminoandrosterone was diazotized to 3,17-androstanediol which on oxidation gave 3,17-androstanedione. This was identical with androstanedione produced by the oxidation of *iso*-androsterone (*trans*-androsterone). 17-Aminoandrosterone on diazotization gave 17-androstanol identical with the product formed by the reduction of 3-chloroandrosterone by sodium and amyl alcohol.

The physiological activity of these compounds will be reported later. The author wishes to thank Mr. Harry M. Crooks for the microanalyses of the compounds reported.

(1) The first three communications appeared in THIS JOURNAL, 7, 1755, 2358 (1935); and 56, 338 (1936).

Experimental

17-Aminoandrosterone Hydrochloride.—To a solution of 400 mg. of androsterone oxime in 100 cc. of dry amyl alcohol was added 5 g. of sodium in small portions. The amyl alcohol was refluxed until the sodium dissolved. After cooling, water was added and the amyl alcohol layer was separated. This was concentrated under reduced pressure. The resulting oil was distilled in high vacuum at 125°. A portion of the oily distillate was converted into the hydrochloride by dissolving in ether and passing in a small amount of dry hydrogen chloride. The hydrochloride was filtered and crystallized from alcohol-ether; m. p. 340° (dec.).

Anal. Calcd. for $C_{19}H_{34}ONCl$: C, 69.6; H, 10.9. Found: C, 69.1; H, 10.5.

3,17-Androstanediol.—A solution of 200 mg. of 17-aminoandrosterone in 5 cc. of acetic acid was diluted with 15 cc. of water. To this was added 5 drops of sulfuric acid. The solution was cooled and 3 g. of sodium nitrite slowly added. After standing for three hours it was warmed to 60°. Water was added and the product extracted with ether. It was crystallized from ethyl acetate; m. p. 218–220°.