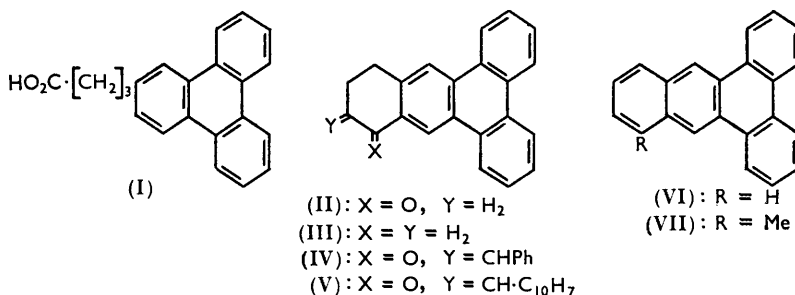


**366.** *A New Synthesis of Dibenz[*a,c*]anthracene, Benzo[*k*]fluoranthene, and Benzo[*b*]fluoranthene.*

By NG. PH. BUU-HOÏ, DENISE LAVIT, and J. LAMY.

$\gamma$ -2-Triphenylenylbutyric acid undergoes cyclisation at the 3-position, providing a new route to dibenz[*a,c*]anthracene, several of whose derivatives have also been prepared. Reaction of fluoranthene with succinic anhydride occurs predominantly at the 11-position, with some substitution at the 4-position. Cyclisation of  $\gamma$ -11-fluoranthenylbutyric acid takes place at the 12-position, and that of the 4-isomer at the 3-position, furnishing a new route to benzo[*k*]fluoranthene and benzo[*b*]fluoranthene.

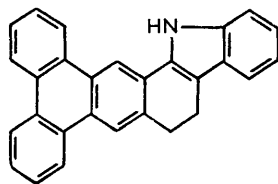
In the Friedel-Crafts reaction with succinic anhydride, triphenylene reacts at the 2-position,<sup>1</sup> the resulting keto-acid being readily reduced to  $\gamma$ -2-triphenylenylbutyric acid (I). Cyclisation of the derived chloride has now been found to occur at the 3-position, giving



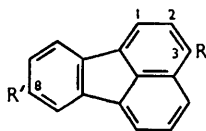
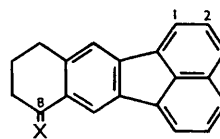
10 : 11 : 12 : 13-tetrahydro-10-oxodibenz[*a,c*]anthracene (II), whose structure was established by Wolff-Kishner reduction and subsequent dehydrogenation by selenium to dibenz[*a,c*]anthracene (VI). The excellent yields recorded at each phase of this synthesis,

<sup>1</sup> Buu-Hoï and Jacquignon, *J.*, 1953, 941.

together with the ready availability of triphenylene, make the present method the most convenient one for the preparation of dibenz[*a,c*]anthracene, a hydrocarbon of biological interest for its reaction with skin proteins<sup>2</sup> in spite of its low carcinogenic activity.<sup>3</sup> A homologue, 10-methyldibenz[*a,c*]anthracene (VII), which can be considered as a derivative of the strongly carcinogenic 8-methylbenz[*a*]anthracene,<sup>4</sup> has also been prepared for biological testing, by selenium dehydrogenation of the crude product of the reaction of methylmagnesium iodide on the ketone (II). Alkali-catalysed condensation of the same



(VIII)

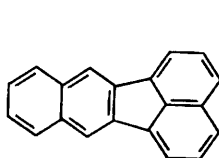
(IX): R = H, R' = CO·[CH<sub>2</sub>]<sub>2</sub>·CO<sub>2</sub>H(X): R = H, R' = [CH<sub>2</sub>]<sub>3</sub>·CO<sub>2</sub>H(XI): R' = H, R = CO·[CH<sub>2</sub>]<sub>2</sub>·CO<sub>2</sub>H(XII): R' = H, R = [CH<sub>2</sub>]<sub>3</sub>·CO<sub>2</sub>H

(XIII): X = O

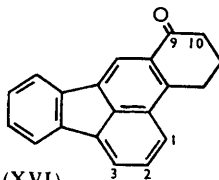
(XIV): X = H<sub>2</sub>

ketone with benzaldehyde and  $\alpha$ -naphthaldehyde readily afforded the arylidene-ketones (IV) and (V) which, surprisingly, resisted cyclodehydration with phosphoric oxide to the expected condensed fluorenes,<sup>5</sup> possibly because of too great steric strain in such hydrocarbons.<sup>6</sup> Supporting this explanation is the fact that the ketone (II) likewise failed to undergo a Pfitzinger reaction which would lead to a compound of molecular structure similar to those fluorenes, although its phenylhydrazone readily underwent the Fischer reaction, the resulting 5:6-dihydrotriphenylene[2,3-*a*]carbazole (VIII) having a more "symmetrical" structure.

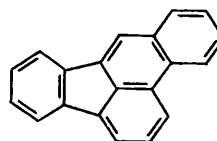
Although the Friedel-Crafts reaction of fluoranthene with phthalic anhydride has often been investigated,<sup>7</sup> its reaction with succinic anhydride had not been reported. This reaction has now been found to give mostly  $\gamma$ -8-fluoranthenyl- $\gamma$ -oxobutyric acid (IX) which was easily purified, although generally the products from Friedel-Crafts reactions with fluoranthene are difficult to isolate in the pure state.<sup>8</sup> The acid (IX) readily underwent Wolff-Kishner reduction to the acid (X), whose cyclisation took place in the 9-position



(XV)



(XVI)



(XVII)

to give 8:9:10:11-tetrahydro-8-oxobenzo[*k*]fluoranthene (XIII); the structure of (XIII) was proved by its reduction to 8:9:10:11-tetrahydrobenzo[*k*]fluoranthene (XIV) followed by selenium dehydrogenation to benzo[*k*]fluoranthene (XV). This reaction

<sup>2</sup> Heidelberger *et al.*, *Cancer Res.*, 1951, **11**, 885; 1956, **16**, 442; *J. Amer. Chem. Soc.*, 1955, **77**, 2877; 1956, **78**, 3671.

<sup>3</sup> Cook, Hieger, Kennaway, and Mayneord, *Proc. Roy. Soc.*, 1932, **B**, **111**, 455.

<sup>4</sup> Barry, Cook, Haslewood, Hewett, Hieger, and Kennaway, *Proc. Roy. Soc.*, 1935, **B**, **117**, 318; Bachmann, Cook, Dansi, de Worms, Haslewood, Hewett, and Robinson, *ibid.*, 1937, **B**, **123**, 343.

<sup>5</sup> Cf. Rapson and Shuttleworth, *J.*, 1940, 636; Buu-Hoï and Cagniant, *Rev. sci.*, 1942, **80**, 319, 384, 436; 1943, **81**, 30; Saint-Ruf, Buu-Hoï, and Jacquignon, *J.*, 1958, 48.

<sup>6</sup> Cf. Buu-Hoï and Saint-Ruf, *J.*, 1957, 3806.

<sup>7</sup> von Braun and Manz, *Annalen*, 1932, **496**, 170; Campbell and Easton, *J.*, 1949, 341; Campbell, Leadill, and Wilshire, *J.*, 1951, 1404.

<sup>8</sup> Cf. D.R.-P. 624,918/1932; B.P. 468,648/1936.

sequence represents a convenient route to hydrocarbon (XV), already prepared by other methods.<sup>9</sup> Starting from the 3-fluoranthanyl acid (XI), obtained in very low yield as a by-product in the reaction of succinic anhydride with fluoranthene, the same reaction sequence led to benzo[b]fluoranthene (XVII), by way of the acid (XII) and 9 : 10 : 11 : 12-tetrahydro-9-oxobenzo[b]fluoranthene (XVI).

#### EXPERIMENTAL

*Cyclisation of  $\gamma$ -2-Triphenylenylbutyric Acid.*—This acid (11.5 g.) was prepared by refluxing for 4 hr. a solution of  $\beta$ -2-triphenylenoylpropionic acid (16 g.; m. p. 224°), 95% hydrazine hydrate (16 g.), and potassium hydroxide (15 g.) in diethylene glycol (250 c.c.); after cooling and dilution with water, the acid was precipitated on acidification with hydrochloric acid, and recrystallised from benzene. The m. p. (173°) is slightly above that previously recorded (168°). This acid (11.8 g.) was converted into its chloride by refluxing for 4 hr. its solution in ether (150 c.c.) with thionyl chloride (6.4 g.) and 6 drops of pyridine. The crude chloride obtained on evaporation of the solvent *in vacuo* was dissolved in anhydrous nitrobenzene (150 c.c.), and to the solution was added aluminium chloride (5.7 g.) in small portions with stirring, and the mixture left for 2 days at room temperature. After decomposition with ice, the solvent was steam-distilled, the brown solid residue was collected, washed with water, dried, and taken up in boiling ethanol (3000 c.c.), and the ethanolic solution was filtered. Concentration of the filtrate yielded, on cooling, 10 : 11 : 12 : 13-tetrahydro-10-oxodibenz[a,c]anthracene (II), which recrystallised from ethanol as cream-coloured needles (8.5 g.), giving an orange halochromy in sulphuric acid (Found: C, 89.0; H, 5.5. C<sub>22</sub>H<sub>16</sub>O requires C, 89.2; H, 5.4%). An attempt to condense this ketone (1 g.) with isatin (0.6 g.) and potassium hydroxide (0.6 g.) in ethanol-dioxan (24 hours' refluxing) failed to furnish the corresponding cinchoninic acid.

10 : 11 : 12 : 13-Tetrahydrodibenz[a,c]anthracene (III).—A solution of the foregoing ketone (1 g.), hydrazine hydrate (1 g.), and potassium hydroxide (1 g.) in diethylene glycol (30 c.c.) was refluxed for 5 hr. and, after cooling, diluted with water; the solid precipitate was collected and recrystallised from cyclohexane, giving needles (0.85 g.), m. p. 202° (Found: C, 93.5; H, 6.6. C<sub>22</sub>H<sub>18</sub> requires C, 93.6; H, 6.4%). This hydrocarbon failed to give a picrate, and the yellow addition compound (m. p. 203°) with 1 : 3 : 5-trinitrobenzene was unstable on recrystallisation from ethanol.

*Dibenz[a,c]anthracene (VI).*—The foregoing tetrahydro-compound (0.75 g.) and selenium powder (0.75 g.) were heated at 350° for 2½ hr.; after cooling, the product was taken up in acetic acid (in which selenium is insoluble). A second crystallisation from the same solvent yielded colourless needles (0.4 g.), m. p. 205°, giving a picrate, m. p. 208° (lit.<sup>10</sup> hydrocarbon, m. p. 205°; picrate, m. p. 207°).

11-Benzylidene-10 : 11 : 12 : 13-tetrahydro-10-oxodibenz[a,c]anthracene (IV).—A solution of ketone (II) (2 g.) and benzaldehyde (0.9 g.) in dioxan (50 c.c.) was mixed with a solution of potassium hydroxide (4 g.) in ethanol (45 c.c.) and refluxed for 10 min. After cooling, water was added, and the solid precipitate was washed with water, then with ethanol, dried, and recrystallised from ethanol-benzene, giving beige needles (2.5 g.), m. p. 225°, with a blood-red halochromy in sulphuric acid (Found: C, 90.3; H, 5.3. C<sub>29</sub>H<sub>20</sub>O requires C, 90.6; H, 5.2%). In an attempt to cyclodehydrate this compound (2.3 g.) by refluxing for 26 hr. its solution in xylene (50 c.c.) with phosphoric oxide (1.7 g.), some of the ketone (1.1 g.) was recovered unchanged, along with a black insoluble residue.

10 : 11 : 12 : 13-Tetrahydro-11- $\alpha$ -naphthylmethylene-10-oxodibenz[a,c]anthracene (V).—Prepared as above from ketone (II) (2 g.) and  $\alpha$ -naphthaldehyde (1.3 g.), this ketone crystallised as beige needles (2.9 g.), m. p. 194–195° (from ethanol-benzene), giving a violet halochromy in sulphuric acid (Found: C, 91.1; H, 5.2. C<sub>33</sub>H<sub>22</sub>O requires C, 91.2; H, 5.1%).

10-Methylidibenz[a,c]anthracene (VII).—To a Grignard reagent prepared from magnesium (0.36 g.) and methyl iodide (2 g.) in ether (25 c.c.), a solution of ketone (II) (2 g.) in anhydrous benzene (120 c.c.) was added, and the mixture refluxed for 2 hr. After cooling, and decomposition with 10% aqueous sulphuric acid, more benzene was added, the organic solution washed with water and dried (Na<sub>2</sub>SO<sub>4</sub>), the solvent distilled, and the crystalline residue heated with

<sup>9</sup> Cf. Moureu, Chovin, and Pivod, *Compt. rend.*, 1946, **223**, 951; Campbell and Gow, *J.*, 1949, 1555; Orchin and Reggel, *J. Amer. Chem. Soc.*, 1947, **69**, 505.

<sup>10</sup> Cf. Clar, "Aromatische Kohlenwasserstoffe," Springer-Verlag, Berlin, 1952, p. 196.

selenium (2 g.) at 330° for 2 hr. Repeated recrystallisation of the product from benzene afforded needles (0.85 g.), m. p. 201°, which gave no halochromy in sulphuric acid (Found: C, 94.4; H, 5.8.  $C_{23}H_{16}$  requires C, 94.5; H, 5.5%). The *picrate* formed dark red needles, m. p. 185°, from benzene (Found: N, 8.0.  $C_{23}H_{16}O_7N_3$  requires N, 8.0%).

5 : 6-Dihydrotriphenylene[2,3-a]carbazole (VIII).—Ketone (II) (0.35 g.) was heated with phenylhydrazine (1 g.) at 140° for 5 min., and the crude yellow solid phenylhydrazone was treated with a saturated solution of hydrogen chloride in acetic acid (15 c.c.) for 1 hr. The precipitated *carbazole* was washed with water, dried, and recrystallised from toluene, giving beige prisms (0.3 g.), m. p. 282°, whose toluene solutions showed a blue fluorescence (Found: C, 90.7; H, 5.3.  $C_{28}H_{19}N$  requires C, 91.0; H, 5.2%).

Reaction of Fluoranthene with Succinic Anhydride.—To a solution of fluoranthene (100 g.) and succinic anhydride (56 g.) in dry nitrobenzene (1500 c.c.), aluminium chloride (133 g.) was added in small portions with stirring, and the dark green mixture left at room temperature for 4 days. After decomposition with ice and steam-distillation of the solvent, a brown solid was obtained which, after several recrystallisations from acetic acid, yielded  $\gamma$ -8-fluoranthenyl- $\gamma$ -oxobutyric acid (IX), yellow prisms (72 g.), m. p. 209°, giving an orange-red halochromy in sulphuric acid (Found: C, 79.6; H, 5.0.  $C_{20}H_{14}O_3$  requires C, 79.5; H, 4.7%). Dilution of the mother-liquors with water gave a solid, m. p. 179–182°, which, after repeated recrystallisation from acetone, yielded  $\gamma$ -3-fluoranthenyl- $\gamma$ -oxobutyric acid (XI), yellowish prisms (4.5 g.), m. p. 228° (Found: C, 79.2; H, 4.7%), giving a yellow-brown halochromy in sulphuric acid; the m. p. fell below 195° on admixture with a sample of the isomeric acid.

$\gamma$ -8-Fluoranthenylbutyric Acid (X).—The foregoing keto-acid (79 g.), reduced in the usual way with hydrazine hydrate (100 g.) and potassium hydroxide (80 g.) in diethylene glycol (700 c.c.; 7 hr.), yielded an *acid*, crystallising as cream-coloured needles (68 g.), m. p. 135°, from benzene (Found: C, 83.3; H, 5.9.  $C_{20}H_{16}O_2$  requires C, 83.3; H, 5.6%).

8 : 9 : 10 : 11-Tetrahydro-8-oxobenzo[k]fluoranthene (XIII).—The foregoing acid (67 g.) was converted into its chloride by refluxing for 3 hr. its solution in anhydrous ether (500 c.c.) with thionyl chloride (43 g.) and 20 drops of anhydrous pyridine; the crude acid chloride obtained on evaporation of the solvent *in vacuo* was dissolved in nitrobenzene (500 c.c.), and aluminium chloride (37 g.) was added in small portions with stirring. After 3 days at room temperature, the brown-yellow solution was decomposed with ice, the nitrobenzene steam-distilled, and the residue recrystallised from toluene, forming yellow leaflets (33 g.), m. p. 224°, giving a yellowish-brown halochromy in sulphuric acid (Found: C, 88.4; H, 5.2.  $C_{20}H_{14}O$  requires C, 88.7; H, 5.2%).

8 : 9 : 10 : 11-Tetrahydrobenzo[k]fluoranthene (XIV).—The above ketone (3 g.) was heated at 110–120° with hydrazine hydrate (3 g.) in diethylene glycol (100 c.c.) until dissolution occurred; potassium hydroxide (3 g.) was then added, and the mixture was refluxed for 5 hr. After cooling and dilution with water, the yellow precipitate was collected, washed with water, and recrystallised from ethanol, giving yellow needles (2.25 g.), m. p. 122° (Found: C, 93.6; H, 6.3.  $C_{20}H_{16}$  requires C, 93.7; H, 6.3%).

Benzo[k]fluoranthene (XV).—A mixture of the above tetrahydro-compound (1.3 g.) and selenium (1 g.) was heated at 340° for 3 hr. and, after cooling, the product was collected and recrystallised twice from acetic acid, giving yellowish prisms (1.1 g.), m. p. 217°, identical with the hydrocarbon synthesised by Moureu, Chovin, and Pivod's method.<sup>9</sup> Its solutions in acetic acid showed an intense blue fluorescence.

$\gamma$ -3-Fluoranthenylbutyric Acid (XII).—Wolff-Kishner reduction of 3- $\gamma$ -fluoranthenyl- $\gamma$ -oxobutyric acid (2.7 g.) furnished an *acid*, crystallising as cream-coloured prisms (1.8 g.), m. p. 141°, from benzene (Found: C, 83.2; H, 5.8.  $C_{20}H_{16}O_2$  requires C, 83.3; H, 5.6%).

9 : 10 : 11 : 12-Tetrahydro-9-oxobenzo[b]fluoranthene (XVI).—The foregoing acid (1.5 g.) was cyclised as for the homologue (X); the cyclic *ketone* (XVI) obtained formed cream-coloured needles (0.9 g.), m. p. 150–151° (from ethanol), giving a yellowish-brown halochromy in sulphuric acid (Found: C, 88.1; H, 5.4.  $C_{20}H_{14}O$  requires C, 88.7; H, 5.2%).

Benzo[b]fluoranthene (XVII).—Wolff-Kishner reduction of the foregoing ketone (0.8 g.) with hydrazine hydrate (1 c.c.) and potassium hydroxide (1 g.) afforded a viscous oily hydrocarbon which failed to crystallise and was characterised by its *picrate*, orange needles, m. p. 169° (from ethanol). This crude oil (0.45 g.) was dehydrogenated by 3 hours' heating with selenium (0.4 g.) at 350°, and the product was taken up in benzene; after evaporation of the solvent, the residue was recrystallised from ethanol (100 c.c.), giving *benzo[b]fluoranthene* as

almost colourless needles (0.35 g.), m. p. 168° (Found: C, 95.2; H, 4.8. Calc. for  $C_{20}H_{12}$ : C, 95.2; H, 4.8%). The picrate formed yellow needles, m. p. 156°, from ethanol, and the addition product with 1 : 3 : 5-trinitrobenzene formed orange-yellow needles, m. p. 179°, from ethanol. This hydrocarbon was isolated from coal-tar pitch by Kruber and Oberkobusch,<sup>11</sup> who gave m. p. 168°, and m. p. 155—156° for the picrate.

This investigation was supported in part by a research grant from the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service; the authors thank the authorities concerned.

THE RADIIUM INSTITUTE, THE UNIVERSITY OF PARIS.

[Received, December 10th, 1958.]

<sup>11</sup> Kruber and Oberkobusch, *Chem. Ber.*, 1952, **85**, 433.

---